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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

JUMIO CORPORATION,
Petitioner

v.

FACETEC, INC.,
Patent Owner

Case IPR2025-00106, -00107, -00108, -00109

U.S. Patent Nos. 10,776,471; 11,157,606; 11,693,938; 11,874,910

EXPERT DECLARATION

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FACETEC EXHIBIT 2061
JUMIO v. FACETEC
IPR2025-00106

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I. Introduction

1. I submit this declaration to state my opinions on the matter described below.

2. I have been retained by counsel for Patent Owner FaceTec, Inc. ("FaceTec" or "Patent Owner") as an independent technical expert in this proceeding before the United States Patent and Trademark Office. I am being compensated at my usual and customary hourly consulting rate, no part of my compensation depends on the outcome of this proceeding, and I have no other financial interest in the parties involved in this proceeding.

3. I understand that these proceedings involve U.S. Patent Nos. 10,776,471, 11,157,606, 11,693,938, and 11,874,910 (which I will refer to as the "Challenged Patents"). I have been asked to consider the patentability of the claims of these patents in view of certain prior art references. I have also been asked to consider the state of the art and prior art available as of August 28, 2014. Based on the prior art discussed in this declaration, it is my opinion that claims 1-20 of the '471 Patent, claims 1-20 of the '606 Patent, claims 1-24 of the '938 Patent, and claims 1-24 of the '910 Patent (which I will refer to as the "Challenged Claims") are patentable for the reasons provided below.

II. Qualifications and Background

4. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and professional experience, including my 25+ years of

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experience in biometrics, biometric security, facial authentication, and computer vision, including three-dimensional computer vision.

5. I am a Professor Emeritus at the University of California, Santa Barbara and the former President of the Toyota Technological Institute at Chicago (TTIC), a graduate-level academic institution that focuses on research in computer science and artificial intelligence. I have worked and studied in the field of computer vision, including face recognition technology, since 1984. The field of computer vision is concerned with determining how computers can extract, analyze, and understand information from images or video. My complete curriculum vitae is attached as Appendix I, although I discuss some of the relevant highlights below.

6. I received my doctorate degree in Media Arts and Sciences from the Massachusetts Institute of Technology in 1991. My doctoral work was in the area of computer vision, specifically concerning automatic face recognition. I received my Master of Science degree in Electrical and Computer Engineering from Carnegie Mellon University in 1984. My Master's work was in the area of robot fine motion planning. I received my Bachelor of Science degree in Electrical Engineering from Virginia Tech in Blacksburg, Virginia in 1982, where my senior honors thesis was on computer vision and image processing.

7. In 1991, I published the paper "Eigenfaces for Recognition," which I co-authored with my Ph.D. advisor, Dr. Alex Pentland. The research reported in this

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paper helped lead to practical automated face recognition systems that are used in today's security and surveillance systems, as well as in consumer applications. My work on Eigenfaces has received several awards, including an Institute of Electrical and Electronics Engineers ("IEEE") Computer Society Outstanding Paper award at the IEEE Conference on Computer Vision and Pattern Recognition in 1991 and a "Most Influential Paper of the Decade" award from the International Association for Pattern Recognition (IAPR) Workshop on Machine Vision Applications (MVA 2000). According to Google Scholar, "Eigenfaces for Recognition" has been cited over 21,000 times. Further, not only did the Eigenfaces approach capture much of the initial attention regarding automated facial recognition, but it continues to be taught and used as a benchmark for face recognition systems more than thirty years later.

8. Along with my co-authors, I have received several other awards at professional conferences and workshops for my work in computer vision, image processing, and augmented reality, including several best paper awards and winning the Association for Computing Machinery Multimedia Open Source Competition in 2015.

9. My industry experience includes working for Martin Marietta Denver Aerospace from 1984 to 1987, where I worked primarily on computer vision for autonomous vehicle navigation as part of the Defense Advanced Research Projects

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Agency's Autonomous Land Vehicle program. In 1992, I was a visiting researcher at LIFIA/ENSIMAG in Grenoble, France, and from 1993-1994 I worked for Teleos Research in Palo Alto, CA; in both of those positions I worked on computer vision methods for recognizing human faces, gestures, and activity. From 1994 to 2000, I was a researcher for Microsoft Research, where I was a founding member of the Vision Technology Research Group and conducted research in vision-based human computer interaction and other related areas.

10. In 2000, I joined the faculty of the University of California, Santa Barbara ("UCSB"), as an Associate Professor. In 2005, I was promoted to Full Professor and served as the Chair of the Media Arts and Technology Graduate Program from 2005 to 2010. In 2017, I was appointed as Chair of the Department of Computer Science. At UCSB, I have taught graduate and undergraduate courses related to computer vision, computer imaging, human computer interaction, probabilistic models and methods, artificial intelligence, computer graphics, machine learning, and other areas, including automatic face recognition.

11. In 2003, I co-founded and began co-directing the Four Eyes Lab at UCSB, where our research focus is on the "four I's": Imaging, Interaction, and Innovative Interfaces. The Four Eyes Lab researches a variety of topics, including computer vision, pattern recognition, and face processing technologies, including face recognition and facial expression analysis.

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12.In 2014, I co-founded a startup company, Caugnate, to commercialize computer vision and augmented reality technology for remote collaboration. Caugnate was acquired by PTC Inc. in 2016.

13.I became the third President of the Toyota Technological Institute at Chicago in 2019 and a Board Councilor of the Toyota Technological Institute in Nagoya, Japan in 2020.

14.As a result of my work and research, I am a named inventor of U.S. Patent Number 5,164,992 entitled "Face Recognition System," U.S. Patent Number 6,674,877 entitled "System and Method for Visually Tracking Occluded Objects in Real Time," and U.S. Patent Number 9,495,761 entitled "Environment mapping with automatic motion model selection."

15.I was a founding member of the Advisory Board for the International Conference on Multimodal Interfaces (ICMI), which provides a venue for disseminating recent advances in multimodal interaction research, systems, and methods, which includes combining visual modalities (such as face recognition, facial expression analysis, and body tracking) with audio, haptic, or other modalities. I served as the Chair of the ICMI Advisory Board from 2006 to 2009. Additionally, I was a founding member of the Advisory Board for the IEEE International Conference on Automatic Face and Gesture Recognition and served as the General Chair for the conference in 2011. I also served as General Chair for

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the 2014 IEEE Conference on Computer Vision and Pattern Recognition, the primary annual conference in the field of computer vision, with over 2000 attendees, and I served as Program Chair for the 2017 IEEE Winter Conference on Applications of Computer Vision. In 2022, I was appointed to the Computing Community Consortium Council, which is charged with catalyzing and empowering the United States computing research community to articulate and advance major research directions for the field.

16. I am an Associate Editor of the ACM Transactions on Intelligent and Interactive Systems and the International Journal of Computer Vision and Signal Processing. I also formerly served as an Associate Editor of the Journal of Vision and Image Computing, and as a guest editor of several other journals related to computer vision, machine learning, and facial recognition.

17. In 2015, I gave the keynote presentation at the IEEE Conference on Automatic Face and Gesture Recognition (FG2015), entitled "Face and Gesture Processing: A Personal Historical Perspective." I also gave keynote presentations at the IEEE Conference on Automatic Face and Gesture Recognition in 2020, the IEEE International Workshop on Machine Learning for Signal Processing in 2021, and the IEEE International Conference on Face and Gesture Recognition in 2023. In addition, I gave keynote presentations at the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV) Workshop on Real-World Surveillance

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Applications and Challenges in 2022 and the WACV Workshop on Demographic Variations in Performance of Biometric Algorithms in 2023.

18. I am the recipient of the 2011-2012 Fulbright-Nokia Distinguished Chair in Information and Communications Technologies. In 2013, I was elected as a Fellow of the IEEE for my contributions to computer vision and perceptual interfaces, an award conferred by the Board of Directors of the IEEE upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. The total number of IEEE fellows selected in any one year does not exceed one-tenth of one percent of the total voting Institute membership. In 2014, I was also elected as an IAPR Fellow for my contributions to computer vision and vision-based interaction. In 2020, I was elected as an ACM Fellow for my "contributions to face recognition, computer vision, and multimodal interaction." In 2022, I was elected a Fellow of the Asia-Pacific Artificial Intelligence Association (AAIA). In 2023, I was elected as a Fellow of the Artificial Intelligence Industry Alliance (AIIA).

III. Materials Considered

19. In reaching the conclusions described in this declaration, I have relied on the '471 Patent, the '606 Patent, the '938 Patent, and the '910 Patent (each being Ex. 1001), the prosecution history of each Patent (each being Ex. 1004), and other documents listed below. These materials comprise patents, related documents, and

printed publications. In quoting the cited references, all emphasis is mine unless otherwise noted.

20.I have also relied on my education, training, research, knowledge, and personal and professional experience in the relevant technologies and systems that were already in use prior to August 28, 2014, which is the earliest asserted filing date of the Challenged Patents.

21.The documents I have considered include:

Exhibit	Reference
1001	U.S. Patent Nos. 10,776,471, 11,157,606, 11,693,938, and 11,874,910
1002	File History of Patent Nos. 10,776,471, 11,157,606, 11,693,938, and 11,874,910
1003	Declaration of Dr. Chris Daft
1004	Dr. Chris Daft Curriculum Vitae
1005	U.S. Patent 8,437,513 ("Derakhshani")
1006	U.S. Patent Application Publication 2011/0299741 ("Zhang")
1007	U.S. Patent Application Publication 2002/0113884 ("Tanii")
1008	U.S. Patent Application Publication 2014/0028823 ("Tahk")
1009	U.S. Patent Application Publication 2004/0239799 ("Suzuki")
1010	U.S. Patent Application Publication 2010/0014720 ("Hoyos")
1011	U.S. Patent 9,077,891
1012	U.S. Patent 8,965,064
1013	Zhengyou Zhang et al., *A Robust Technique for Matching Two Uncalibrated Images Through the Recovery of the Unknown Epipolar Geometry*, Institut National De Recherche En Informatique Et En Automatique (May 1994)
1014	U.S. Patent Application Publication 2010/0158319
1015	U.S. Patent Application Publication 2007/0127787
1016	U.S. Patent Application Publication 2004/0036574

[redacted]

Exhibit	Reference
1017	Eugene Hect & Alfred Zajac, *Optics*, Addison-Wesley Publishing Co. (1974)
1018	Anil K. Jain et al., *Introduction to Biometrics*, Springer (2011)
1019	B. Honlinger & H.H. Nasse, *Distortion*, Zeiss (Oct. 2009)
1020	Hue and Hatchet, *What is the Focal Plane?*, https://hueandhatchet.com/what-is-the-focal-plane/
1021	Introduction to Astronomy, https://physics.weber.edu/palen/phsx1040/lectures/ldistcomp.html
1022	Daniel Baker, Face distortion is not due to lens distortion, (May 5, 2012), https://bakerdh.wordpress.com/2012/05/05/face-distortion-is-not-due-to-lens-distortion/
1023	Richard Hartley & Andrew Zisserman, Multiple View Geometry in Computer Vision, Cambridge Univ. Press (2nd ed. 2011)
1024	Daniel Moreno & Gabriel Taubin, Simple, Accurate, and Robust Projector-Camera Calibration, Brown Univ., mesh.brown.edu/calibration/
1025	Serge Belongie, CSE 252B: Computer Vision II, Lecture 4: Planar Scenes and Homography (Apr. 7, 2004)
1026	Merriam-Webster's Collegiate Dictionary (11th ed. 2014)
1027	Laurenz Wiskott, Face Recognition by Elastic Bunch Graph Matching (1999)
1028	Axis Communications, CCD and CMOS sensor technology: Technical White Paper (2010)
1029	Jeff Meyer, What is Depth of Field? How aperture, focal length and focus control sharpness, Digital Camera World (July 17, 2013), https://prism.org.gg/wp-content/uploads/2016/07/Depth-of-Field.pdf
1030	Brian Klug, Understanding Camera Optics & Smartphone Camera Trends, A Presentation by Brian Klug, Anandtech (Feb. 22, 2013), https://www.anandtech.com/Show/Index/6777?cPage=2&all=False&sort=0&page=2&slug=understanding-camera-optics-smartphone-camera-trends
1031	Portrait mode now available on iPhone 7 Plus with iOS 10.1, Apple (Oct. 24, 2016)
1032	The Timeline of Evolution of the Camera from the 1600s to 21st

[redacted]

Exhibit	Reference
	Century, Capture.com (May 5, 2023), https://www.capture.com/blogs/insights/evolution-of-the-camera
1033	John Biggs, A Nokia Camera Phone That's More Like a Camera With a Phone Attached, The New York Times (Nov. 29, 2007), https://www.nytimes.com/2007/11/29/technology/personaltech/29phone.html
1034	U.S. Patent 7,412,081
1035	U.S. Patent 8,457,367
1036	U.S. Patent 8,260,008
1037	Zac Hall, Over a decade of selfies, starting with iPhone 4, 9to5Mac (July 1, 2021), https://9to5mac.com/2021/07/01/iphone-4-selfie-celebration/
1038	Duane C. Brown, Decentering Distortion of Lenses, Photogrammertic Engineering (1966)
1039	Complaint, FaceTec, Inc. v. iProov Ltd., C.A. No. 2:21-cv-02252, ECF No. 1 (D.N.V. Dec. 28, 2021)
1040	First Amended Complaint, FaceTec, Inc. v. iProov Ltd., C.A. No. 2:21-cv-02252, ECF No. 18 (D.N.V. Feb. 24, 2022)
1041	Minute Entry, FaceTec, Inc. v. Jumio Corp., C.A. No. 24-cv- 03623, ECF No. 38 (N.D. Cal. Sept. 18, 2024)
1042	Opposition to Motion to Intervene, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623, ECF No. 40 (N.D. Cal. Sept. 30, 2024)
1043	Request for Voluntary Dismissal Without Prejudice, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623, ECF No. 45 (N.D. Cal. Oct. 10, 2024)
1044	Opposition to Request for Voluntary Dismissal Without Prejudice, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623, ECF No. 49 (N.D. Cal. Oct. 18, 2024)
1045	Reply in Support of Request for Voluntary Dismissal Without Prejudice, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623, ECF No. 51 (N.D. Cal. Oct. 25, 2024)
1046	Complaint, FaceTec, Inc. v. Jumio Corp., C.A. No. 24-cv-03623, ECF No. 1 (N.D. Cal. June 14, 2024)
1047	Motion to Intervene, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-

[redacted]

Exhibit	Reference
	03623, ECF No. 36 (N.D. Cal. Sept. 16, 2024)
1048	Order Denying Motion to Voluntarily Dismiss Without Prejudice, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623, ECF No. 52 (N.D. Cal. Nov. 1, 2024)
1050	Docket, *FaceTec, Inc. v. Jumio Corp.*, C.A. No. 24-cv-03623 (N.D. Cal.)
2001	10 Reasons to Become an iProov Partner, iProov (Jan. 24, 2022), https://www.iproov.com/blog/10-reasons-to-become-an-iproov-partner (last visited Mar. 5, 2025)
2002	Docket from FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.), as of Mar. 6, 2025
2003	iProov Ltd.'s Non-Infringement, Invalidity, and Unenforceability Contentions Pursuant to Local Patent Rule 1-8, served on Sept. 27, 2022, in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2004	Exhibit 471-C to iProov Ltd's Non-Infringement, Invalidity, and Unenforceability Contentions Pursuant to Local Patent Rule 1-8, served on Sept. 27, 2022, in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2005	U.S. Patent No. 9,971,920 to Derakhshani et al.
2006	iProov Ltd.'s Reply to Plaintiff's Opposition to Opposed Motion to Intervene (Dkts. 47 and 47-1), filed on Oct. 14, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2007	In re Subpoena FaceTec, Inc., No. 23-mc-80263-VKD, 2024 WL 348829 (N.D. Cal. Jan. 30, 2024) (Order re Jumio Corporation's Motion to Quash Subpoena in the matter FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.))
2008	Docket from FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.), as of Mar. 6, 2025
2009	iProov Ltd.'s Notice of Motion and Opposed Motion to Intervene (Dkt. 36), filed on Sept. 16, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2010	Order Denying Motion to Voluntarily Dismiss Without Prejudice and Granting Motion to Intervene (Dkt. 52), filed on Nov. 1, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)

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Exhibit	Reference
2011	Excerpts of iProov Ltd.'s Non-Infringement, Invalidity, and Unenforceability Contentions, served on Jan. 17, 2025, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2012	Excerpts of Jumio Corp.'s Non-Infringement, Invalidity, and Unenforceability Contentions, served on Jan. 17, 2025, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2013	Excerpts of File History of U.S. Application No. 14/839,505 (the "'505 application") which issued as U.S. Patent No. 9,953,149 to Tussy (the "'149 patent")
2014	U.S. Patent No. 9,953,149 to Tussy (the "'149 patent")
2015	U.S. Patent Application Publication No. 2014/0198959 A1 to Derakhshani et al.
2016	FaceTec, Inc.'s Memorandum in Opposition to Motion for Stay (Dkt. 62), filed on Dec. 16, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2017	Jumio Corporation's Reply in Support of its Motion to Stay Case Pending Inter Partes Review (Dkt. 67), filed on Dec. 23, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2018	U.S. Patent Application Publication No. U.S. 2014/0169643 A1 to Todoroki
2019	U.S. Patent No. 8,280,120 to Hoyos et al.
2020	Jumio Corporation's Notice of Motion and Motion to Stay Case Pending Inter Partes Review (Dkt. 54), filed on Nov. 27, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2021	FaceTec, Inc.'s Request for Voluntary Dismissal Without Prejudice Under Fed. R. Civ. P. 41(a)(2) (Dkt. 45), filed Oct. 10, 2024, in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2022	Jumio Corporation's Opposition to FaceTec, Inc.'s Request for Voluntary Dismissal Without Prejudice (Dkt. 49), filed Oct. 10, 2024, by FaceTec, Inc., in FaceTec, Inc. v. Jumio Corp., No. 3:24-cv-03623-RFL (N.D. Cal.)
2023	Discovery Plan and Scheduling Order (Dkt. 37), filed Jul. 20, 2022, in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2024	Complaint (Dkt. 1), filed Dec. 28, 2021, in FaceTec, Inc. v. iProov

Exhibit	Reference
	Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2025	iProov's Acceptance of Service (Dkt. 13), filed Jan. 26, 2022, in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2026	First Amended Complaint in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2027	Excerpts of File History of U.S. Application No. 15/900,681 (the "'681 application") which issued as U.S. Patent No. 10,614,204 to Tussy (the "'204 patent")
2028	Exhibit 606-C in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2029	Defendant iProov's Motion for Partial Stay (Dkt. 151), filed on Feb. 10, 2025, in FaceTec, Inc. v. iProov Ltd., No. 2:21-cv-02252-ART-BNW (D. Nev.)
2033	U.S. Patent Application Publication No. 2025/0161718
2034	Memorandum Opinion and Order, Howe v. Speedway LLC, No. 1:19-CV-01374, 2024 WL 4346631 (N.D. Ill. Sept. 29, 2024)
2035	CPC Patent Technologies Pty. Ltd.'s Motion to Exclude the Testimony of Dr. Christopher Daft, CPC Patent Technologies Pty Ltd. v. HMD Global OY, 2023 WL 4552543 (W.D. Tex.)
2036	Biometric Update, "FaceTec Embraces New ISO-Based Anti-Spoof Testing for Face Biometrics," dated Nov. 13, 2018
2037	iBeta Quality Assurance, Letter from G. Audette regarding Level 2 Testing (Feb. 7, 2019)
2038	BixeLab Pty Ltd, Letter of Confirmation from S. Singh and T. Dunstone regarding Level 2 Testing (June 27, 2023)
2039	BixeLab Pty Ltd, Letter of Confirmation from S. Singh and T. Dunstone regarding 3D:2D Face Matching Test (June 29, 2023)
2040	Praetorian, 2024 FaceTec SDK Blackbox Engagement (Apr. 15, 2024)
2041	Biometric Update, "FaceTec Reveals Liveness Check Milestone, High Marks in BixeLab Test," updated Oct. 21, 2023
2042	Jumio Press Release, "Jumio Go Says No-Go to Deepfakes, Bots and Sophisticated Spoofing Attacks," dated Oct. 28, 2019
2043	Jumio Press Release, "Will Deepfake Technology Defeat Biometric

[redacted]

Exhibit	Reference
	Authentication?," dated Oct. 10, 2019
2044	Jumio Product Information Sheet, "Identity Verification"
2045	Jumio Press Release, "FaceApp: Photoshopping on Steroids," dated July 19, 2019
2046	FaceTec's $600,000 Spoof Bounty Program, established Oct. 24, 2019
2047	J. Galbally et al., Biometric Antispoofing Methods: A Survey in Face Recognition, 2 IEEE Access 1530 (Dec. 18, 2014)
2048	Finovate, "Jumio Adds Biometric Facial Recognition to Netverify," dated Oct. 24, 2016
2049	Jumio Product Information Sheet, "Liveness Detection"
2050	MIT Technology Review, "This Startup Wants to Bring Face Recognition to All Kinds of Smartphones," dated Oct. 4, 2017
2051	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2052	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2053	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2054	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2055	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2056	CONFIDENTIAL Exemplary Sessions (Under Seal and Public Versions)
2057	FaceTec, Jumio & FaceTec Launch - Finovate 2019, available at https://www.youtube.com/watch?v=Gi0NZyZJNtI&t=652s
2058	CONFIDENTIAL FaceTec, Inc., Sales Transactions for Jumio (Under Seal and Public Versions)
2059	CONFIDENTIAL Declaration of Josh Rose (Under Seal and Public Versions)
2060	Declaration of Mina Ching, attaching iProov, Liveness Assurance, available at https://web.archive.org/web/20210126190119/https:/www.iproov.com/iproovsystem/technology/liveness-assurance#expand

[redacted]

Exhibit	Reference
2061	CONFIDENTIAL Declaration of Matthew Turk (Under Seal and Public Versions)
2062	FaceTec, FaceTec Explainer – 2019, available at https://www.youtube.com/watch?v=uBrky5_g0-w
2063	FaceTec 3D:2D IDScan, Face Matching Accuracy Report, June 28, 2023
2064	DATANAMIX News, FaceTec 3D Liveness: A Cut Above the Rest, Sept. 15, 2021
2065	iProov, Leadership
2066	Aarti Samani LinkedIn Profile
2067	CONFIDENTIAL FaceTec Software Explanation (Under Seal and Public Versions)
2068	FaceTec, Request a Pricing Quote
2069	FaceTec, IDV/KYC Software Suite Tour with CTO Josh Rose, available at https://www.youtube.com/watch?v=IUOygMbhNO4
2070	Jumio, Jumio Liveness – Advanced Deepfake Detection, available at https://www.youtube.com/watch?v=TWfUaEkZpwo
2071	iProov, Secure, Frictionless Access with iProov & Ping Identity | Biometric Login with DaVinci, available at https://www.youtube.com/watch?v=3nAFRNkflcg
2072	Video Showing FaceTec and Jumio Software Operations
2073	CONFIDENTIAL FaceTec Services Agreement dated Oct. 8, 2018 (Under Seal and Public Versions)
2074	Jumio, Technology
2075	FaceTec, "Bias in 2D Face Matching vs. 3D Face Matching"
2076	Jumio, "Face-Based Biometrics"
2077	Jumio Press Release, "New Anti-Spoofing Solutions Deliver High Conversion and Fast Onboarding While Effectively Deterring Online Fraud," dated Apr. 7, 2021
2078	iBeta Quality Assurance, Letter from G. Audette regarding Level 1 Testing (Aug. 20, 2018)
2079	Jumio Press Release, "Stay Secure with Jumio's Certified 3D Liveness Detection," dated Oct. 22, 2018
2080	iProov Biometric Solutions Suite, "Frictionless, Deviceless

[redacted]

Exhibit	Reference
	Authentication"
2081	U.S. Patent Application Publication No. 2025/0121215 to Daft (Ex. 2032 to the deposition of Dr. Christopher Daft, taken on Aug. 29, 2025)
2082	Deposition transcript of Dr. Christopher Daft, taken on Aug. 29, 2025

IV. Legal Standards

22. I am not an attorney and have not been asked to offer my opinion on the law. However, as an expert offering an opinion on whether the claims in the Challenged Patents are patentable, I have been told that I am obliged to follow existing law.

A. Anticipation

23. I have been told that for a claim to be anticipated, every limitation of the claimed invention must be disclosed by a single prior art reference, viewed from the perspective of a person of ordinary skill in the art.

B. Obviousness

24. I understand that the claims define the invention. I also understand that an unpatentability analysis is a two-step process. First, the claims of the patent are construed to determine their meaning and scope. Second, after the claims are construed, the content of the prior art is compared to the construed claims. I understand that a claimed invention may be patentable when it is new or nonobvious in light of the "prior art."

25. It is my understanding that a claimed invention is patentable if the

differences between the invention and the prior art are such that the subject matter as a whole would not have been obvious to a person having ordinary skill in the art to which the subject matter pertains at the time the invention was made.

26.I have also been advised that several factual inquiries underlie a determination of obviousness. These inquiries include (1) the level of ordinary skill in the field of the invention, (2) the scope and content of the prior art, (3) the differences between the claimed invention and the prior art, and (4) the presence of certain objective indicia of nonobviousness, such as, for example, copying, praise by others, commercial success, long-felt but unresolved need, failure by others, and unexpected results. I have been advised that such objective indicia are relevant if the patent owner shows that they are attributable to (*i.e.*, if there is some direct "nexus" with) the claims of the asserted patents. These secondary considerations must be considered in analyzing obviousness and, as I have been informed, may often be the most probative evidence in the record. Their presence can confirm the validity of a claim even if an alleged combination of references establishes a *prima facie* case that the asserted claims would have been obvious to a person of skill in the art.

27.I understand that where the prior art fails to disclose a claim element or fails to provide an apparent reason to modify existing prior art in a manner to meet a missing claim limitation, the claimed invention likely is not obvious. To be clear,

[redacted]

even if one of ordinary skill in the art would be motivated to combine two references, a claim is likely not obvious if the combination does not produce the claimed invention.

28.I also understand that the existence of each and every element of the claimed invention in the prior art does not necessarily prove obviousness and that most, if not all, inventions rely on building blocks of prior art.

V. Technology of the Challenged Patents

29.The Challenged Patents are directed to biometric authentication systems, and more specifically to facial recognition systems with enhanced security measures to confirm a user's identity as well as the liveness and realness of that individual. Biometric security is a distinct subset of the broader biometrics field, which encompasses a wide range of human measurement technologies, including gait analysis, voice recognition, and DNA profiling. Not all biometric systems are designed for security purposes. For example, systems that analyze biometric data for medical diagnostics or demographic research do not perform authentication or access control. The Challenged Patents use biometric data to perform secure authentication; contrary to Dr. Daft's apparent misunderstanding, it is not concerned with securing biometric data.

30.To perform liveness detection, the Challenged Patents teaches examining optical phenomena such as perspective distortion to verify the three-dimensionality

[redacted]

of a purported user seeking to access a sensitive online resource. The patent collects one or more images of the user taken at a first distance between the user and the camera, collects one or more additional user images at a second distance from the camera, and then compares data based on these images to confirm whether there are appropriate indicia of the user's three-dimensionality. *See, e.g.*, Ex. 1001 ('471 patent), claim 1.

31. These indicia are referred to in the Challenged Patents as "expected differences" or "expected distortion," and they include perspective distortion (also referred to in the patent as the "fish-eye effect"), which can indicate that a three-dimensional user is being imaged by the device camera. *See, e.g.*, *id.*, 29:11-15, 29:65-30:5, 30:13-18, claims 1 and 10.

32. The images below provide examples of some of the "expected differences" and "expected distortion" that can be seen when images of a three-dimensional user are captured at a first and then a second distance between the user and the camera.



For example, the user's nose appears to swell in proportion to the rest of her face, and the relative distance between his eyes appears to change. As the Challenged Patents explain, if this user's face were a two-dimensional picture, the expected distortion would not be present. There are also other subtle but detectable distortions in the second image relative to the first.

33. The '471 patent teaches how to obtain user images at a first distance and

[redacted]

then at a second distance. For example, as shown in Figures 13A and 13B (from the patent) below, an oval can be presented on the user's screen, guiding the user to fill that oval with his or her face during image capture. *See, e.g.*, Ex. 1001 ('471 patent), 27:48-31:12. The size of the oval can be changed, which guides the user to change the distance between his or her face and the camera so the facial image corresponds to the size of the resized oval. *Id.*

FIG. 13A

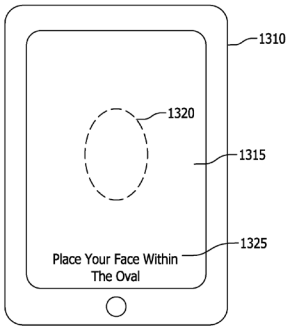
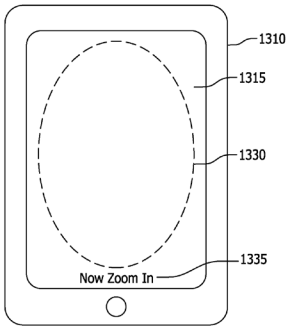


FIG. 13B



34. After capturing images at different distances, "processing occurs on both images." Ex. 1001 ('471 patent), 31:26-28. "The processing may include calculations to verify a difference between the two images, or a difference in biometrics obtained from the two images, that indicates that a real person is being imaged." *Id.*, 31:29-32. The processing "may occur on only the mobile device,

[redacted]

only a remote server, or a combination there[of]." *Id.*, 31:48-49.

35.The field of biometric authentication has faced a longstanding challenge regarding fraud prevention and, more specifically, how to reliably distinguish between a live user and a spoofed image or video. Conventional facial recognition systems often rely on single images, which can be easily spoofed using photographs, videos, or screen captures. Other conventional systems that may provide more security require expensive biometric sensors and complex systems. Ex. 1001, 5:33-38.

36.The Challenged Patents solve these problems through a novel facial liveness detection system. Ex. 1001 ('471 patent), 14:16-23. Importantly, the techniques described and claimed in the Challenged Patents avoid the need for specialized hardware to perform liveness detection, such as complex and expensive three-dimensional camera systems or infrared cameras (such as those built into Apple's iPhones™ used in Face ID™). In contrast, my understanding of the technology in the Challenged Patents (and FaceTec's technology more broadly) is that it is usable on virtually any device having a two-dimensional camera and a display screen.

VI. Level of Ordinary Skill in the Art

37.I have been asked to provide a definition for the level of ordinary skill in the art. I have been informed that several factors are considered in assessing the level of ordinary skill in the art, including: (1) the types of problems encountered in the

art; (2) the prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the educational level of active workers in the field.

38.I understand that the Petition has proposed that the hypothetical person of ordinary skill in the art ("POSITA") would have at least a Bachelor's degree in electrical engineering, computer engineering, computer science, physics, or a related field, and two years' work experience related to biometrics, facial authentication, computer vision, and/or optics, such that they would have had significant academic and/or work experience in both software development and optics. Pet., 5. In my opinion, this is incorrect.

39.As one example: let's take a college graduate with a Bachelor's degree in physics and two years' work experience in two-dimensional computer vision techniques or with handwriting- or iris-based biometrics. In my opinion, that graduate would not be an artisan of ordinary skill in the art of the Challenged Patents. A lack of experience with facial biometrics for identity verification *and* three-dimensional computer vision, which are technologies at the heart of the Challenged Patents, would be a problem for that graduate because without this expertise, an individual would not have the necessary understanding of image-based facial biometric authentication, three-dimensional image processing, and image comparisons of three-dimensional objects with expected distortions and

[redacted]

complex geometry.

40. With respect to "optics" being one of the alternative fields of work experience, I believe that is an overbroad addition. As another example, take an eye doctor with a few years of practice, holding a Bachelor's in physics and some software development experience, who has never used a biometrics system. That doctor would qualify under this proposed level of skill. But, in my opinion, just because someone understands the broad field of "optics" does not mean that person would understand the necessary mathematics and science behind understanding the "expected differences" / "expected distortion" of faces in images. Moreover, in my opinion, that person would not understand the problems faced in the biometric security industry. Including the broad field of "optics" would also include many other artisans, none of which (in my opinion) would qualify as a person of ordinary skill in the art, including those working in laser development, optical communications, optical materials (such as semiconductor optoelectronics), quantum optics, illumination systems, or optical metrology.

41. With respect to the inclusion of the broad field of "computer vision," I believe that would not be sufficient. For example, a software developer working on Optical Character Recognition (OCR) systems who has never implemented three-dimensional vision systems would qualify under this proposed level of skill. I believe that would not be sufficient. One critical subset of computer vision to

[redacted]

understand the Challenged Patents is *three-dimensional* computer vision. In my opinion, even a deep understanding of two-dimensional vision systems would not aid in understanding the necessary mathematics and science behind understanding the "expected differences" / "expected distortion" of faces in images under perspective distortion. Unlike two-dimensional computer vision, three-dimensional computer vision involves reconstructing or reasoning about the spatial structure of real-world objects. This requires knowledge of geometric transformations, camera models, depth estimation, and perspective distortion, which are topics outside the scope of conventional two-dimensional image processing.

42. I note that this level of skill does not include experience with facial authentication biometric security. Each of the Challenged Patents states that it relates to "biometric security" and "facial recognition authentication systems." Ex. 1001 ('471 patent), 1:28-30. I agree that the Challenged Patents relate to these concepts.

43. Moreover, while the level of skill includes "biometrics," this is a *very* broad field. Many types of biometric identifiers are usable – including fingerprints, palmprints, faces, irises, retinas, ears, voices, signatures, gaits, hand veins, odor, and DNA. (Ex. 1018, 3.) In my opinion, two years of experience with identifiers unrelated to the face would qualify someone under this chosen level of skill, but would not equip them with the necessary skills to understand and implement the

[redacted]

Challenged Patents. For example, someone having experience with fingerprint biometrics would not have the necessary experience to understand the facial biometrics involved in the Challenged Patent.

44. In my opinion, the need for industry experience with three-dimensional computer vision systems allows an ordinary artisan to appreciate the understandings and tendencies unique to the industry and the problems faced in the industry (like the problems giving rise to the invention disclosed and claimed in the Challenged Patents).

45. In my opinion, a more appropriate level of ordinary skill would be "a Bachelor's degree in electrical engineering, computer engineering, computer science, physics, or a related field, and two years' work experience related to biometric **security**, facial authentication, **and three-dimensional** computer vision such that they would have had significant academic and/or work experience in both **facial** biometrics and **computer vision**."

46. In my opinion, facial biometric security is a requirement because the broad field of biometrics includes many areas of biometrics that would not be relevant to the Challenged Patents, like gait or DNA analysis. A POSITA must have specialized knowledge in biometric security systems that operate on facial image data, not merely general familiarity with the broader biometrics field. In my opinion, three-dimensional computer vision is also required because of the need to

[redacted]

understand how *computers* process distortion that comes from two objects being at different distances from a sensor. This could involve familiarity with techniques such as stereo matching, epipolar geometry, structure from motion, multi-view stereo, shape modeling and representation, and depth estimation, all of which are not part of two-dimensional image analysis.

47. Regardless of which level of skill were chosen, my conclusion that the patent claims are valid would remain the same.

48. I have not analyzed the priority date of the Challenged Patents, but I note that the earliest claim of priority listed on the face of the Challenged Patents is August 28, 2014, the filing date of U.S. Provisional Patent Application No. 62/043,224. Because all of the prior art discussed in this declaration predates August 28, 2014, I have assumed for simplicity that August 28, 2014, is the priority date for the Challenged Patents. I have therefore also treated this date as the date from which to assess the knowledge available to a person of ordinary skill in the art. I note that I was at least a person of ordinary skill in the art as of this date and still am.

VII. Dr. Daft's Experience in Purportedly Related Fields is Unrelated to the Challenged Patents

49. In my opinion, Dr. Daft's experience with fingerprinting and ultrasonic imaging is not relevant to the teachings of the Challenged Patents. His experience with capturing images of fingerprints or the inside of a body is not relevant to

[redacted]

capturing images of a user (*outside* of a body) and determining whether expected distortions result from movement of the camera or the user relative to one another. Indeed, it is my understanding that despite Dr. Daft's implication that his experience in a related field is relevant, the physics involved are not the same. Ex. 2082, 71:2-16. For example, ultrasonic imaging relies on the propagation of sound waves through tissue to measure internal structures; fingerprinting involves capturing ridge patterns at extremely close range (often less than a centimeter) using specialized sensors to detect pressure, capacitance, or optical reflection under controlled lighting and contact conditions. Neither relies on the necessary physics to capture surface geometry, light intensity, or distortions of a face from images taken from ranges closer to 20 or 30cm from the face.

50.I believe that Dr. Daft has made several mistakes in understanding the relevant technology and science.

51.Dr. Daft's confusion with respect to "biometric security" is one example. During his deposition, I understand that Dr. Daft attempted to link one of his past patent applications to the field of "biometric security" by repeatedly stating that it relates to securing biometric data. Ex. 2082, 35:13-38:25. In my opinion, this is wrong. What Dr. Daft describes as his experience relates more broadly to "data security" – securing data that happens to include biometric data. But securing data from measurements of a human body is very different from the field of biometric

[redacted]

security that is at the core of the Challenged Patents.

52.In my opinion, Dr. Daft's attempt to relate his past work to "biometric security" deposition is also at odds with his *declaration's* definition. In paragraph 38 of his declaration (Ex. 1003) he relates biometric security to the use of biological information to secure access to something:

> Biometric security refers to the *use of unique biological information* (such as the unique layout of facial features or fingerprints, characteristics of the voice, among many others) to authenticate the identity of an individual and *serve as a "key" to provide access to some resource . . . .*

53."Biometric security" is not so broad as to encompass mere securing of biometric data. Moreover, experience with securing biometric data would not be any more relevant to the Challenged Patents than securing any other kind of data.

VIII. Claim Construction

54.Respectfully, I do not believe that claim construction is required at this time because Petitioner's grounds fail regardless of Petitioner's proposed interpretations or any specific meaning of a claim term. Nonetheless, I reserve all rights to reconsider claim construction of any term should it be necessary at a later time.

IX. Overview of the Cited Prior Art

A. Derakhshani

55.Derakhshani is directed to biometric spoof detection that uses images of the eye to determine whether a user's eye is real or fake. Ex. 1005, Abstract, 1:6-7. It

[redacted]

does this by evaluating "[d]istinctive features of an individual's visible vasculature in the white of the eyes" to "identify or authenticate the individual." *Id.*, 4:19-24.

56. Figure 6 depicts a process of authenticating a user based on "one or more images of the white of an eye." *Id.*, 9:59-67. There are two parts to the process: eye liveness detection (steps 602-606) and user authentication (steps 620-632):

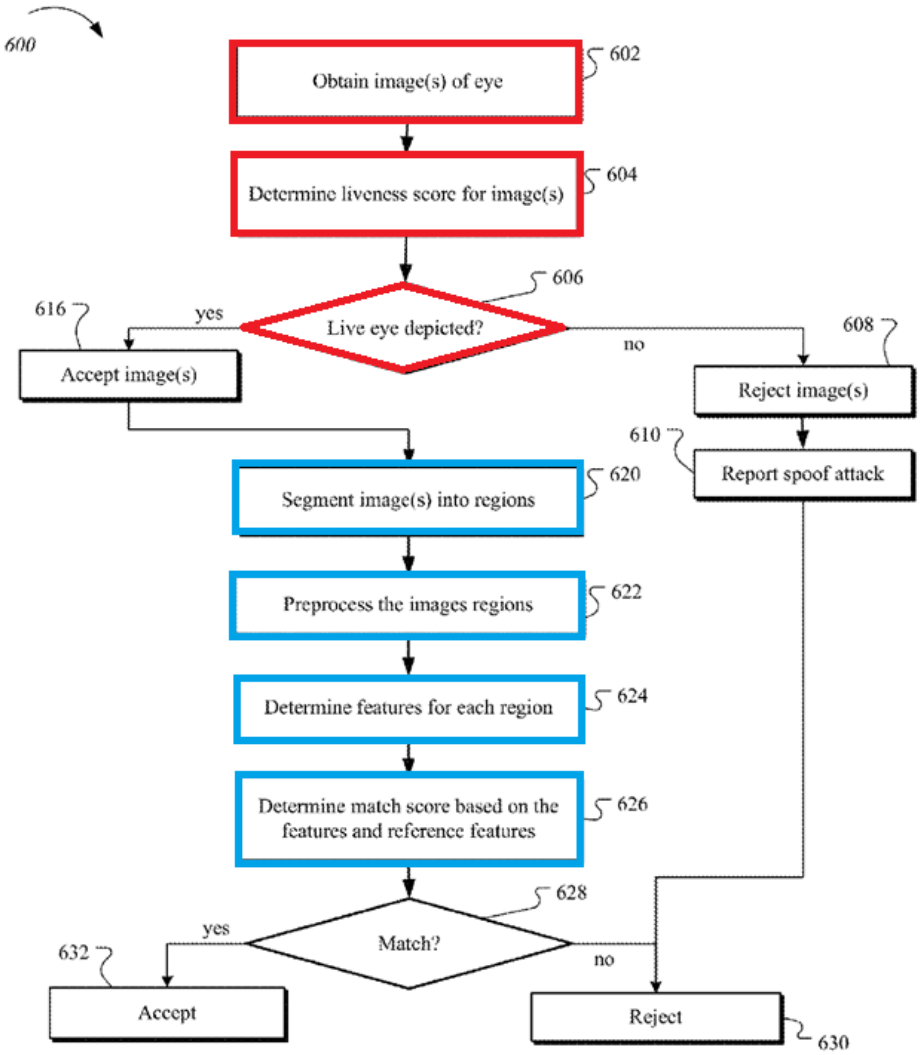


Fig. 6.

57. The first part of Fig. 6 (steps 602-606) determines liveness. *Id.*, 9:61-62.

[redacted]

Step 602 starts with obtaining images of the user's eye. *Id.*, 10:25-50. Step 604 involves determining liveness score based on the images. *Id.*, 10:51-11:4. The liveness score is determined based on behavioral, spatial, and reflectance metrics of the images of the eye. *See id.*, Abstract, 1:6-43, 11:5-8 (referencing Fig. 7); Fig. 7. The behavioral metric is based on detected movement of the eye across a sequence of images. *Id.*, 1:26-30. The spatial metric is derived from the apparent distance between the camera and one or more image "landmarks" appearing in a plurality of images at different focus distances. *Id.*, 1:30-34; 2:17-21; 16:41-18:7. The reflectance metric is based on changes in surface glare or specular reflection patterns on the eye's surface. *Id.*, 1:34-39.

58. The spatial metric (used to determine eye liveness) relates to deviation of a captured subject from a two-dimensional plane or an expected three-dimensional shape. *Id.*, 3:1-5. In contrast to the authentication-related segmenting (steps 620-622) of eye images (discussed below) which uses "*anatomical* landmarks" to identify regions of interest in the eye and features for authenticating a user, the spatial metric used to determine eye liveness requires capturing *image* landmarks – including non-anatomical landmarks, e.g., "background objects." *Id.*, 16:51-54. The system compares the degree of focus of a landmark across multiple images to determine the depth of the eye relative to the camera's focal plane. *Id.*, 16:44-17:2. Different focus distances are used to evaluate depth, relying on the camera's ability

[redacted]

to adjust its focal plane—rather than physical movement of the camera or user. *Id.*, 16:44-66. The system may also determine the parallax (*i.e.*, the apparent displacement of an observed object due to a change in position by the observer) caused by slight movements of the camera or user. *Id.*, 17:45-18:4.

59. Derakhshani combines behavioral, spatial, and reflectance metrics into a composite score used to accept or reject the image(s) of the user's eye. *Id.*, 1:39-43.

60. The liveness score based on these metrics is used to determine if the images are likely to represent a live eye. *Id.*, 11:13-16; Fig. 6, step 606. After determining that the score represents high likelihood of a live eye (step 616), Derakhshani begins an authentication process to compare the eye to a reference record. *Id.*, 9:63-66, 11:42-14:58; Fig. 6, steps 616, 620-632. In step 620, Derakhshani segments the images to identify regions including "the best views of vasculature in the white of [the] eye." *Id.*, 11:46-51. Unlike the image landmarks used to determine eye liveness in steps 602-606, segmentation involves extracting "anatomical landmarks" such as the iris, eye corners, or other features of the eye, to identify the regions of interest (including the sclera). *Id.*, 11:46-51; Fig. 6, step 620. The regions are preprocessed in step 622 and biometric features are determined for each region in step 624. *Id.*, 12:23-24, 13:9-14. In step 626, the determined biometric features are then matched against features stored in a

[redacted]

reference record. *Id.*, 13:62-66. If the match score is sufficiently high, the user is accepted as matching the reference record (step 632). *Id.*, 14:25-58; Fig. 6, steps 628-632.

61. Derakhshani does not describe processing of facial images or authentication based on facial images. Its focus remains on ocular features, authentication, and spoof detection using the "visible vasculature in the whites of the eyes." *Id.*, 4:19-24.

62. I note that the faces in the Petition and Dr. Daft's declaration do not appear in Derakhshani. Pages 8-9 of the Petition depict faces from Exhibits 1011 and 1012, pages 10 and 29 depict images created by Dr. Daft (as he admitted in his declaration, Ex. 1003, ¶¶107-08), and page 23 depicts images created by Dr. Daft (as he admitted in His declaration, Ex. 1003, ¶¶167-68).

B. Zhang

63. Zhang is directed to systems and methods for distinguishing live human faces from flat representations, such as photographs. *See* Ex. 1006, Abstract; ¶¶[0003]-[0004]. Zhang's system captures multiple images of a face presented by a user and analyzes those images to determine whether the face is a three-dimensional structure or a flat surface. *Id.* Fig. 3 represents a process for determining whether a face is a 3D structure. Ex. 1006, ¶[0026].

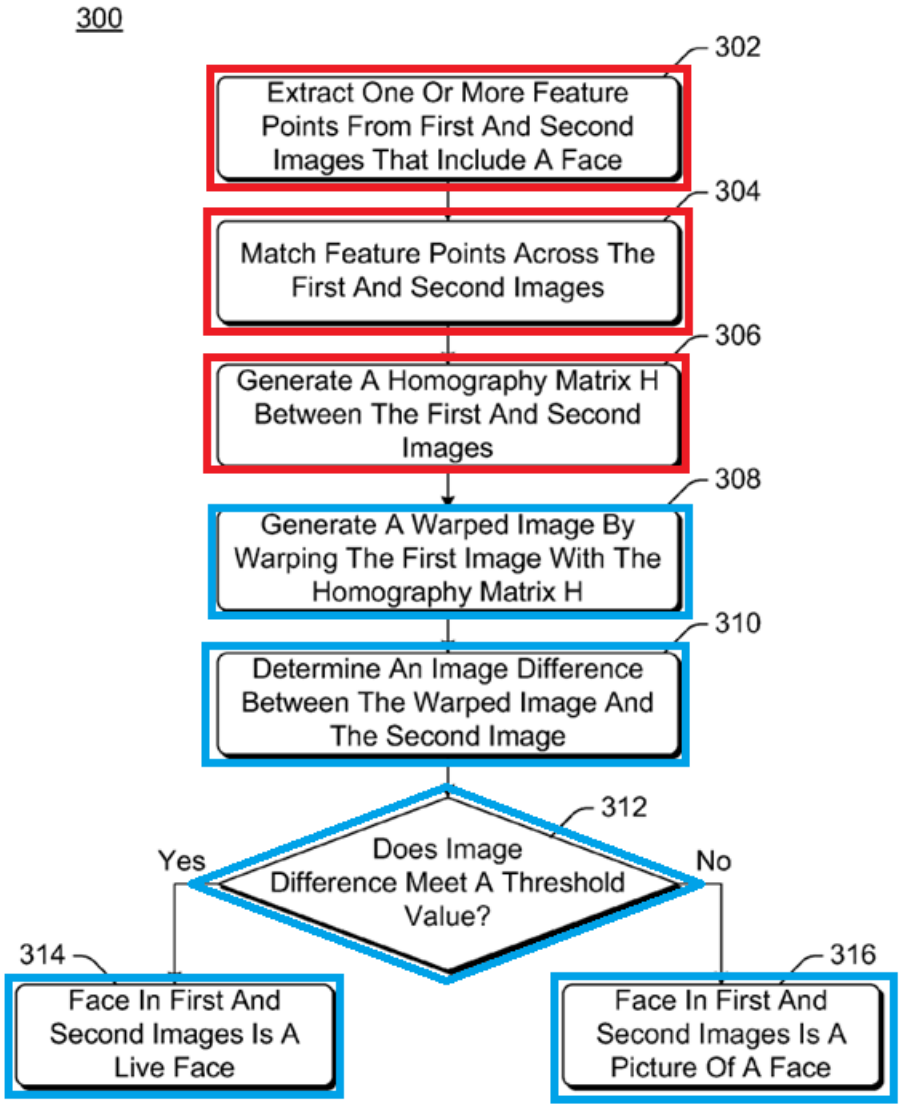


Fig. 3

64.Process 300 has two phases: generating a matrix *H* using feature points in first and second images (steps 302-306) and using matrix *H* to compare images at selected locations in first and second images (steps 308-316).

65.In the first phase of process 300, Zhang extracts regions of pixels known as "feature points" (such as "a corner of an eye, a corner of a mouth, a tip of a nose")

[redacted]

from two images, and matches those points across the images (steps 302-304). *Id.*, ¶¶[0024]-[0029]. These pixel regions may be as small as a single pixel. *Id.*, ¶[0027]. Feature points are used for image warping, not for identity verification. *Id.*, ¶¶[0026]-[0030].

66.In step 306, Zhang assumes the features lie on a flat surface and creates a homography matrix (*H*) using the extracted feature points. *Id.*, ¶¶[0025], [0029]-[0030]; claim 3. *H* represents the relationship between feature locations in the first image (known as $\tilde{x}$) and the same location in the second image ($\tilde{x}'$). *Id.*, ¶[0029]. This matrix is calculated by determining values for *H* such that the distance between those locations across the images is small. *Id.*, ¶[0029]. In the second phase of process 300, Zhang uses the matrix *H* to transform the first image to create a "warped" first image, simulating how a flat surface would appear from a second perspective (step 308). *Id.*, ¶¶[0025,] [0030].

67.In step 310, the warped image is then compared to the second image by calculating pixel-level differences in color or intensity at corresponding "selected locations." *Id.*, ¶¶[0030]-[0032]. These locations are **not** the feature points used to generate homography matrix H but are used in step 310 to determine differences in color/intensity at the same location in multiple images. *Id.*, ¶[0030]-[0033]. If the overall difference exceeds a specified threshold—*i.e.*, the planar image warping did not match the actual face image well—the face is deemed to be a live, three-

[redacted]

dimensional structure (step 314); otherwise, it is considered a flat image (step 316). *Id.*, ¶[0030]-[0034].

68. Zhang's approach relies on the principle that two views of a flat object can be aligned using a homography matrix, where a warped first image and second image will have minimal pixel differences, but a three-dimensional image will not be well-aligned using the matrix. *Id.*, ¶[0025]. Zhang's method does not predict how a three-dimensional face will distort across views—it merely assumes flatness and tests that assumption using a homography matrix.

C. Tanii

69. Tanii is directed to systems for correcting warp of images caused when capturing images at close range. Ex. 1007, Abstract, ¶[0003]. It corrects peripheral areas of an image relative to the center to produce a more visually aesthetic image. *Id.*, ¶[0056]. The farther a portion of an image is from the center of the image, the greater the enlargement of that portion. *Id.*, ¶[0056], Fig. 8.

70. Tanii does not detect whether or not a face is in an image. Indeed, Tanii repeatedly discusses capturing images of "object[s]" rather than faces (for example, in ¶¶[0006], [0009]-[0013], [0045], [0047]-[0049], [0061]-[0063], among many others). And Tanii's method relies on the object in the image being in the exact center of all captured images. *Id.*, ¶[0072].

71. In my opinion, Tanii does not perform any detection to determine what is in

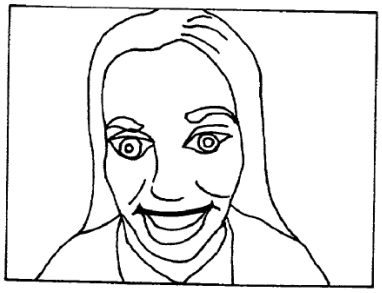
[redacted]

the image, or whether a correction is needed in the first place. Instead, Tanii simply enlarges the peripheral areas of *any* image at a rate that is proportional to its distance from the center of the image. *Id*., ¶[0056], Fig. 8. Because Tanii does not detect centeredness or detect the presence or absence of faces, ears, or any other objects, it is my opinion that it would perform the same enlargement process, whether it were presented with a face in the center of an image with one ear or a non-face with no ears that is off-center. Indeed, Tanii does not analyze the content of an image or predict its expected distortions. Rather, it corrects distortions in a purely cosmetic way in order to make images more viewer-friendly if the conditions it assumes are correct.

72. Moreover, because Tanii simply enlarges the peripheral areas of whatever image it receives, it is my opinion that Tanii's figure are misleading. For example, Fig. 4B depicts a warped image where a person's face is visible. Fig. 9 depicts a "corrected" version of a warped image, depicting how the warped image would appear after correction. Fig. 4B does not depict any ears while Fig. 9 depicts an ear on one side of the person's face.

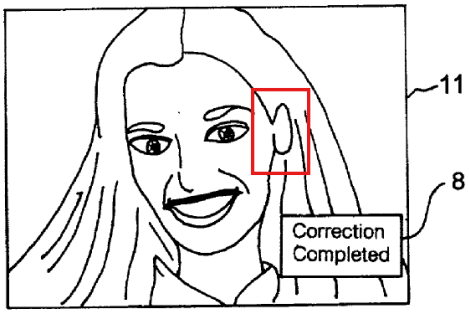
[redacted]

Fig.4B



"warped image"

Fig.9



"corrected image"

73. The techniques disclosed in Tanii would not be able to generate an ear from a warped image that does not have an ear. Indeed, the geometry of imaging produces visibly apparent perspective distortion when taking a picture of an object from different distances. For example, Figure 1 *(below)* shows the same face taken by a camera at four distances, from near (far left) to distant (far right). The more distant image generally exhibits the relative locations of and distances between facial features as if the face were projected directly (all rays in parallel) onto a two-dimensional plane, and it approximates a typical viewpoint of the face. The close-up image on the left exhibits significant perspective distortion since the camera was quite close to the face. Tanii's proposed method aims to "correct warp" and generate "corrected image data." A technique that corrected this perspective distortion would aim to produce the face image on the right, given as input the face image on the left. This correction would modify the image so that the facial

features look undistorted, the hair looks undistorted, and both ears are visible.

Figure 1

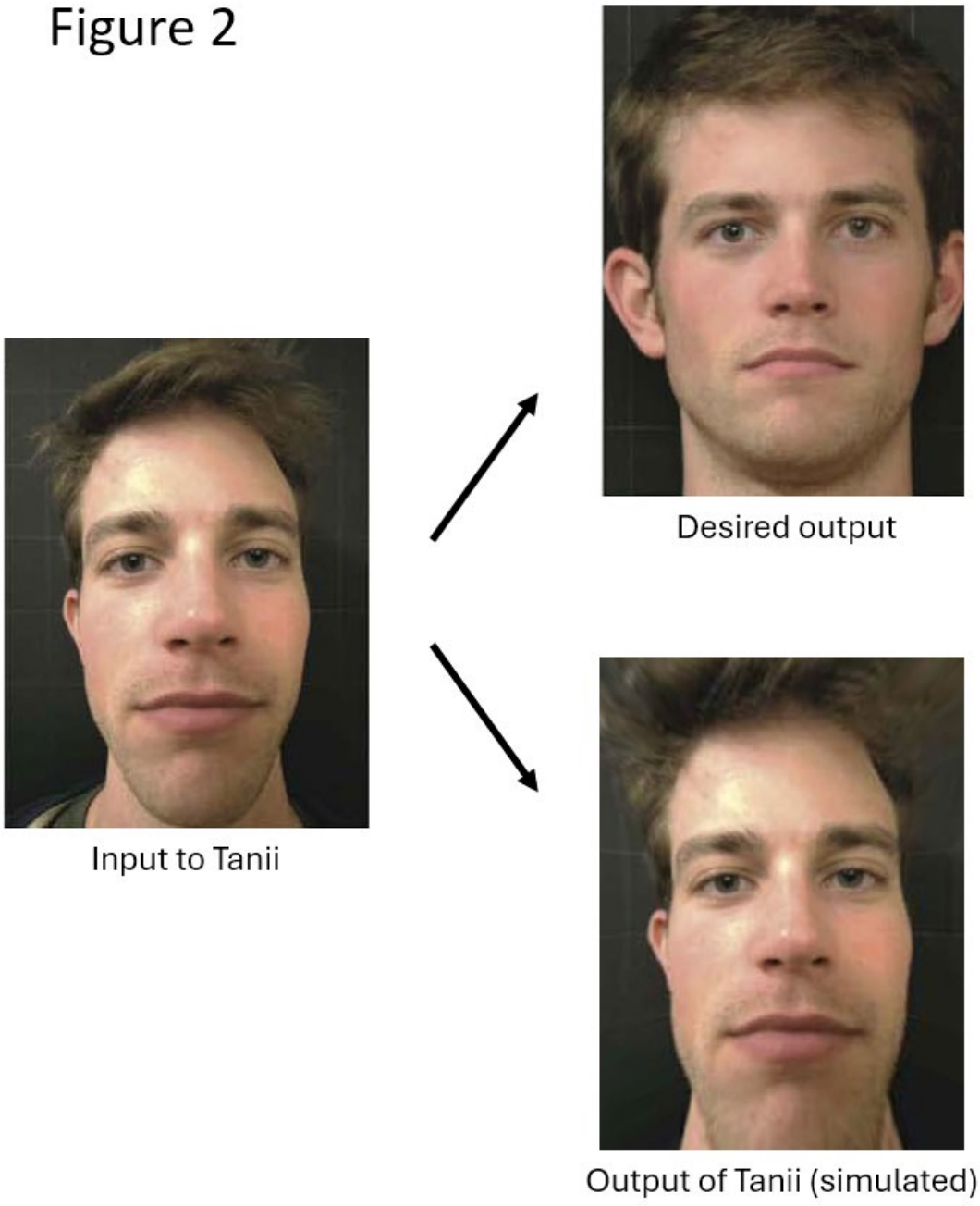


Very near camera Distant camera

However, Tanii's "distortion corrector" would do none of this, since it treats the face and head as a plane and merely stretches the pixels on that flat surface to different locations, based on the distance of each pixel to the center of the image. Figure 2 *(below)* shows the desired output again and compares it to a simulated Tanii output, which I created using Photoshop to apply an enlargement rate that increases with the distance away from the center.

[redacted]

Figure 2

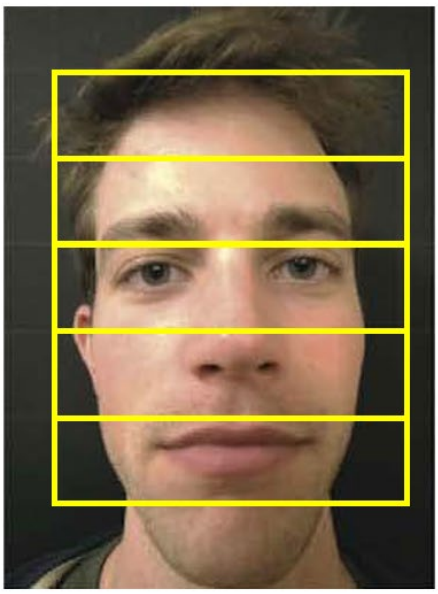


As can be seen, areas far from the image center, such as the chin and the hair, look further distorted, and the occluded ears remain (partially and fully) occluded. It can also be seen that the faint vertical and horizontal lines in the background are no longer lines in the simulated output, but curves (Figure 3 (*below*)). This results

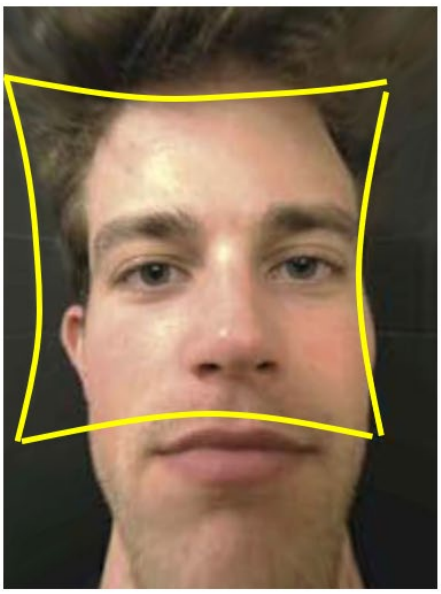
[redacted]

from Tanii's method of enlarging based on radial distance from the image center, which causes further distortions.

Figure 3



Input to Tanii



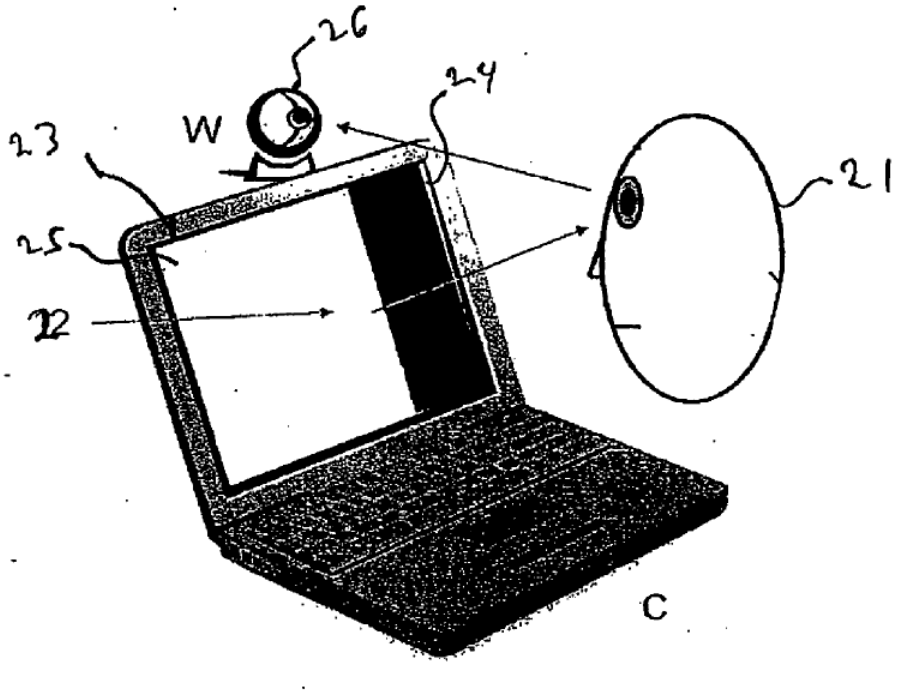
Output of Tanii (simulated)

D. Hoyos

74. Hoyos teaches a system for biometric authentication that combines a measure of liveness with a biometric match. Ex. 1010, ¶¶[0011]-[0014]. Hoyos acquires biometric data from a person and calculates the probability of liveness (Pp) and the probability of a match (Pm). *Id.*, ¶[0017]. The probability of liveness (Pp) is calculated by presenting a first image on a screen, capturing a first reflection, presenting a second image, capturing a second reflection, and comparing the first and second reflections to determine if they were formed by a

[redacted]

"curved surface consistent with a human eye." *Id.*, ¶[0019], Fig. 2:



75.Reflection of two images (including image 22) off the cornea of the eye is measured, and the difference between the two reflected images is used to determine the probability of liveness (Pp) of the user. *Id.*, ¶¶[0034]-[0035]. In contrast, the probability of a match (Pm) is based on the user's face. *Id.*, ¶[0038].

X. The Challenged Claims Are Not Unpatentable

76.I understand that the Petitions presented obviousness challenges that rely on several combinations including at least Derakhshani, Zhang, Tahk, and Tanii. In my opinion, each of these challenges fails. At least Derakhshani, Zhang, and Tanii separately fail to disclose or render obvious key limitations of the challenged claims. Moreover, in my opinion, the proposed combinations lack sufficient

[redacted]

rationale or motivations to combine at least because Tanii is not analogous art.

A. '471 Patent

1. '471 Grounds 1A-1C: The Proposed Derakhshani Combination Fails to Show All of the Claimed Elements

77. In my opinion, Derakhshani detects spoofing based on the visible vasculature (blood vessels) of a user's eye, not a user's face. The reference itself does not even include facial images. While the Petition includes facial images throughout its discussion of that reference, I understand that these images come from, for example, exhibits 1011 and 1012 (unrelated patents (Baldwin and Hanna)) on pages 8 and 9 of the Petition) or were created by Dr. Daft (pages 10 and 29; *see* Ex. 1003 ¶¶107-108).

78. In my opinion, any distance-induced distortions found in Derakhshani would occur at very close range, as all of the images need to capture the vasculature of the eye with sufficient clarity to authenticate the user. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features (aside from the eye) in either image.

79. In my opinion, Tanii does not make up for the deficiencies in Derakhshani. I understand that the Board earlier found that the Petition relies on Tanii only for "its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object" (Paper No. 17, 33). The mere concept of evaluating distance induced distortions in a face does not make up for

[redacted]

the missing elements of Derakhshani.

80.In my opinion, Tanii does not, in fact, "evaluat[e]" whether one or more images exhibit different degrees of distance-induced distortions as the Board found critical to Petitioner's position. Instead, Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. And as I discuss in Section X.A.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Derakhshani's "Spatial Metric" Does Not Represent the Face's Three-Dimensionality

81.The Petition contends that Derakhshani's "spatial metric" represents whether a subject's face is three-dimensional. Pet., 16. I disagree.

82.Derakhshani's spatial metric is not a measure of any aspect of a user's face, including three-dimensionality of a face, as required by at least [1pre], 1[d6] ("comparing"), 1[d7], 10[pre], 10[f], and 10[g]. Derakhshani's spatial metric is based on images of the eye taken at different focus distances (Ex. 1005, 1:56-2:3), each distance needing to be close enough to capture the characteristics of the eye.

83.As I expand further below, Derakhshani is designed around capturing the vasculature (blood vessels) of a user's eye; it does not involve facial recognition or depth analysis of the user's head or face. In my opinion, this reference is unrelated to the teachings of the '471 patent, which require authenticating a user's three-dimensionality and liveness as a function of the expected distortion between two

[redacted]

images of the user's face resulting from the movement of a camera from a first location to a second location (Ex. 1001, 38:7-45 (claim 1).

84.Moreover, the spatial metric is "a measure of deviation of the subject from a *two-dimensional plane* . . . [or] an *expected three-dimensional shape*." Ex. 1005, 3:1-6 (emphasis added), 17:27-36. In my opinion, this expectation in Derakhshani presumes a known plane or known model of an "expected" shape, and compares captured images to that expected plane shape. The claims of the '471 patent, however, performs what I see as a different process: detecting if differences between data based on captured images have the "expected distortions" resulting from the movement of a camera in between taking the images.

b. **Derakhshani Captures Only the Vasculature of a User's Eyes, Not the User's Face**

85.In my opinion, Derakhshani does not teach facial liveness detection by determining a user's three-dimensionality, as required by at least [1pre], 1[d6], 1[d7], 10[pre], 10[f], and 10[g]. Derakhshani is directed to biometric authentication using eye vasculature. Indeed, it is explicitly directed to "biometric authentication based on *images of the eye*." Ex. 1005, Abstract; 1:5-7 (emphasis added). The system captures images of the white of the eye (sclera) 230, iris 220, and pupil 210, and analyzes vasculature patterns 240 in the conjunctiva and episcleral. *Id.*, 5:1-41, Fig. 2:

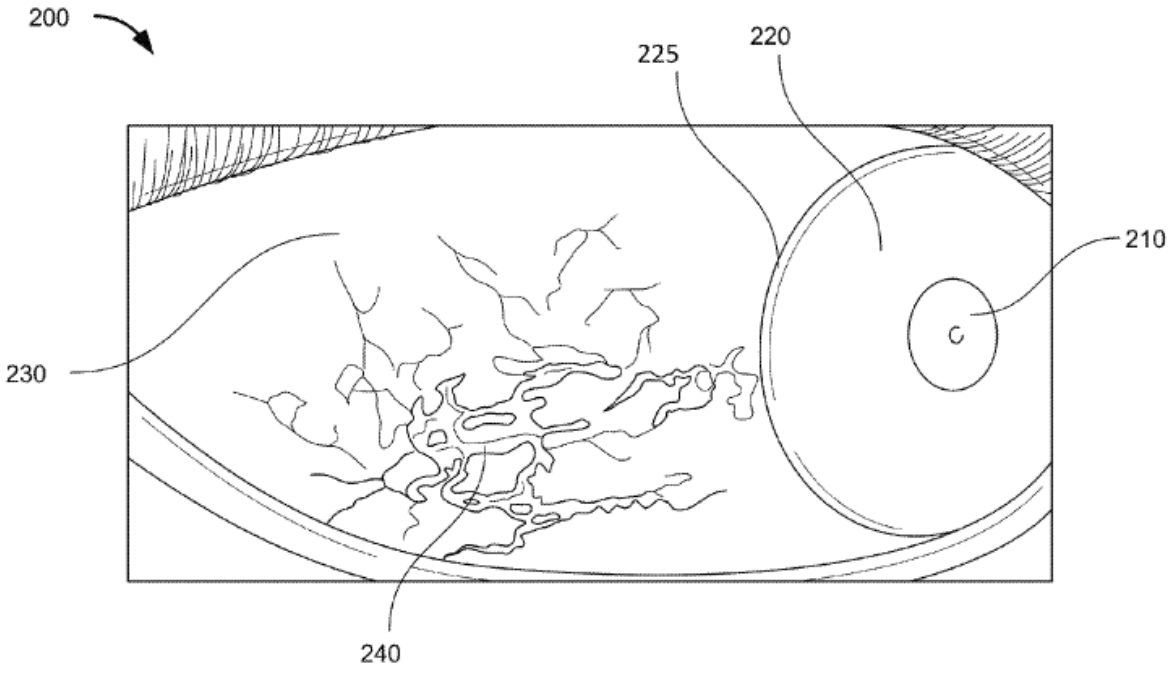


FIG. 2

86.Derakhshani describes three types of metrics associated with images of the eye: behavioral, spatial, and reflectance. "Behavioral" metrics are based on detected movement of the eye, such as pupil constriction or gaze transitions, and are measured by analyzing sequences of images (Ex. 1005, 2:12-17, 15:51-16:43); "spatial" metrics are derived from the apparent depth of image landmarks in an image of the eye based on different focus distances (*Id.*, 2:17-21, 16:44-18:7); and "reflectance" metrics are based on changes in glare or specular reflection patterns on the eye's surface (*Id.*, 2:21-26, 18:8-19:11). Each of these methods relies on characteristics of a user's eye. *See*, *e.g.*, *id.*, 4:19-21 (capturing "features of an individual's visible vasculature in the whites of the [individual's] eyes … to identify or authenticate the individual").

[redacted]

87.The focus on the eye is consistent with Derakhshani's purpose to identify and evaluate the vasculature of the user's eye for authentication – not a face. Contrary to the Petition's suggestion, Derakhshani's disclosure is silent as to capturing images of the user's face or head, and it does not suggest that the system could be adapted to capture these features. Indeed, despite the assertion that faces are imaged in Derakhshani, there are no images of any faces in the reference. *See, e.g.*, *id.*, Figs. 1-4 (depicting eyes and/or cross-sections of eyes):

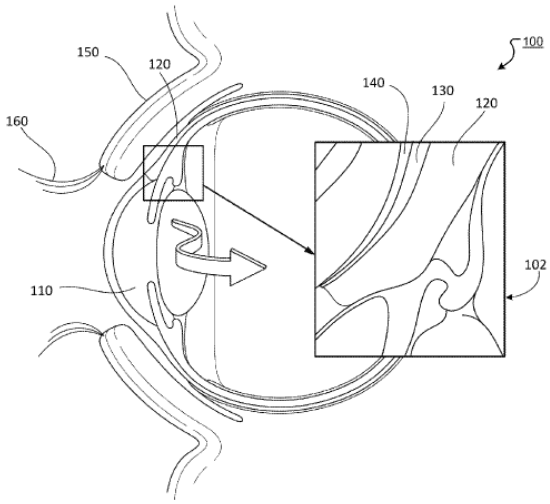


FIG. 1

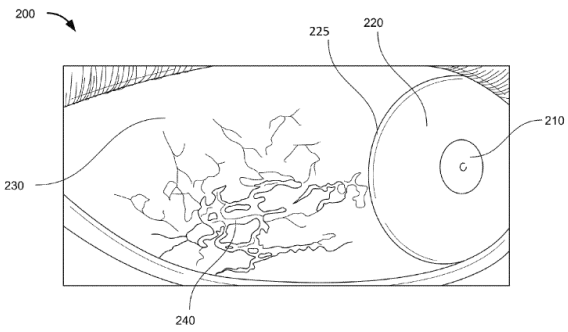
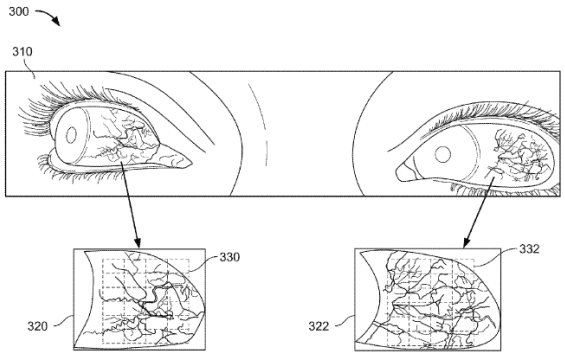
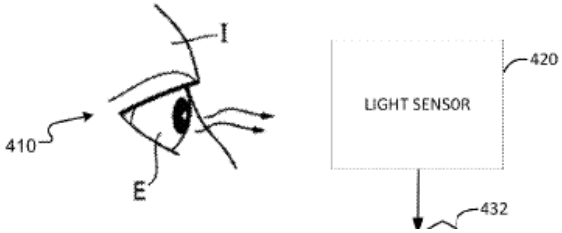


FIG. 2





88.Each figure of the user is focused only on the user's eye. It stands to reason,

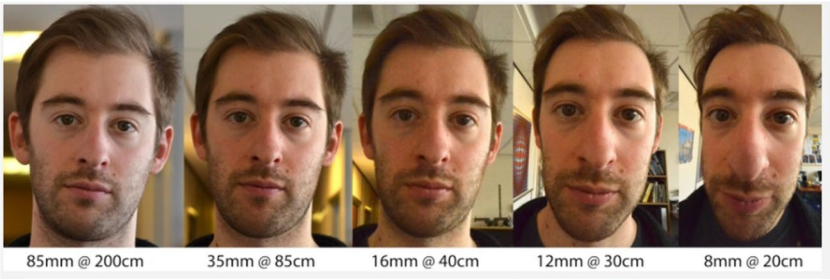
[redacted]

in my opinion, that these figures represent images that would have to be taken from a distance that would support measuring the vasculature of that eye. Among the few references to a "face" involve presenting a picture of a face as one way to *spoof* the system rather than a legitimate presentation of the user for authentication (*id.*, 4:24-31) and prompting a user to "face" a sensor in order to picture the user's sclera (*id.*, 9:10-26).

89. Moreover, Derakhshani's focus on capturing the vasculature of the eye effectively excludes the possibility of capturing the user's face or his or her three-dimensionality, and thereby authenticating the user, as claimed in the '471 patent. In my opinion, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '471 patent (August 2014).

90. Just as one example, the Petition provided exemplary images of a user's face at varying distances. Ex. 1022. The closest distance provided is 20 cm. 20 centimeters is about 2-3x further away than Derakhshani's envisioned distance.

[redacted]



91. And the type of sensors used to capture eye vasculature at the time of the invention of the '471 patent would not be able to simultaneously capture the vasculature of an eye *and* a face with enough precision to enable determination of three-dimensionality or authentication. For example, the sensors capable of detecting the fine vasculature of an eye required close-range, high-resolution optics, and were designed to capture images from a very short distance. When that sensor is moved back to capture a user's face, the resolution becomes inadequate to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality. Thus, in my opinion, attempting to use the sensors in Derakhshani to capture a face as proposed by the Petition, or modifying them to do so, would prevent capture of the vasculature of the eye. In my opinion, this would also render Derakhshani's system inoperable for its original purpose.

92. In my opinion, Derakhshani is narrowly focused on ocular biometrics and analyzing vasculature patterns of the eye. For example, Derakhshani's spatial metric is based on deviations of a user from an expected three-dimensional shape.

[redacted]

See, e.g., Ex. 1005, 17:27-36. The deviation is measured based on differences between a detected location and an estimated location of an image landmark, such as an eye corner or background object. *Id.*, 16:51-54, 17:2-11. Any capture of part of a user's face (other than the eye) is incidental, only helps to orient the system to determine distance, and must give way to the primary purpose of capturing the eye's vasculature.

93. Thus, in my opinion, Derakhshani does not disclose or teach determining a user's three-dimensionality by comparing the first data to the second data, as required by elements 1[d5] and 10[f].

94. In my opinion, for similar reasons, Derakhshani also does not disclose or teach claims explicitly requiring a user's "face," including claims 9, 14, 18, or 19. Derakhshani for example does not teach or suggest that either of the "first image" or "second image" are "of the user's face" (as required by claim 9), that a "face of the user is placed" into an oval during capture (as required by claim 14), that a "reflection of [a] displayed image" is captured "off of the user's face" (as required by claim 18), or that a "user's face is held steady" (as required by claim 19). . Again, as I explained above, the images in Derakhshani are of the eyes. Any captured images of a face are partial, at best, and Derakhshani does not teach capturing the face along with the vasculature of the user's eye. Nor, as I discussed above, would it be possible for Derakhshani to capture both the vasculature of the

[redacted]

eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality.

95.In my opinion, with the sensors in use at the time of the invention of the '471 patent, capturing a user's face with sufficient clarity would not make possible capturing the user's eye vasculature with sufficient clarity. Thus, in my opinion, a person of ordinary skill in the art would not have found it obvious or have found any reason to modify Derakhshani to capture images of a user's face. Moreover, in my opinion, modifying Derakhshani to capture images of a user's face would render Derakhshani's system inoperable for its original purpose: measuring the vasculature of a user's eye.

c. Tanii Fails to Make Up for the Deficiencies of Derakhshani

96.I understand that the Board found that the Petition's case relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. Paper No. 17, 32-33. In my opinion, this finding makes it clear that Tanii does not make up for the deficiencies of Derakhshani. As I explained above, Derakhshani does not identify a face, determine three-dimensionality, or evaluate any expected distortions based on how a live, three-dimensional face would appear from different perspectives. Tanii likewise fails to perform any analysis or evaluations. Rather, it aesthetically corrects images captured at close range by enlarging peripheral regions relative to

[redacted]

center. Ex. 1007, ¶[0006]. But this teaching fails to make up for the deficiencies in Derakhshani, as Tanii's process of enlargement does not involve detecting a user's face, three-dimensionality, or expected distortion patterns. In my opinion, Tanii's purported evaluation of distance-induced distortions does not make up for Derakhshani's spatial metric not being related to the three-dimensionality of a face. In my opinion, this purported evaluation of distance induced distortions also does not make up for Derakhshani not determining three-dimensionality of a user.

97. Moreover, contrary to the Board's statements about Tanii, it is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 32-33. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Sections IX.C and X.A.1, it is my opinion that Tanii would operate the same way whether a face or a non-face was presented. Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to

[redacted]

make up for the deficiencies in Derakhshani.

98.Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

99.Additionally, Petitioner's suggestion that images of different distances from the sensor have different distortion (Pet., 13) is not a motivation to combine. The inventor of the '471 patent already recognized that distortion effects are "more pronounced" the closer a face is to a lens. Ex. 1001, 28:36-58. This observation does not provide a reason to combine Tanii's distortion correction with Derakhshani's eye-vasculature authentication.

[redacted]

d. The '471 Petition Has Separately Failed to Show that Dependent Claims Are Obvious

i. Interpolation Claims (Claims 2, 11)

100. Claims 2 and 11 of the '471 patent require interpolating the first data and second data to obtain "estimated intermediate data," capturing a third image of a user at a "third distance from the user" that is between the first and second distances, processing the third image to obtain third data, and comparing the estimated intermediate data to the third data. In my opinion, the Petition fails to demonstrate that these claims are unpatentable.

101. For claim element 2[a], the Petition asserts that a two-dimensional plane is "generated by interpolating the position of facial landmarks onto a single intermediate plane." Pet. 28 (*citing* Ex. 1005, 17:12-16). In my opinion, this misunderstands Derakhshani's discussion of the spatial metric. Derakhshani states that the locations of multiple landmarks are fit to a "closest" two-dimensional plane and the average distance is used to create the spatial metric. Ex. 1005, 17:19-22. There is no interpolation of any data to *generate* any planes; the landmarks are simply fit to an existing plane.

102. The Petition also argues that a POSITA would have been motivated to interpolate intermediate biometric data when modifying Derakhshani in view of Tanii. Pet., 29-30. In my opinion, this is also wrong. First, as explained above, Petitioner relies on "Derakhshani's interpolated modeling approach," which does

[redacted]

not exist. Second, there would have been no motivation to combine Derakhshani with Tanii for the reasons that I explain further below in Section X.A.3.

ii. Claims Requiring the Ears (Claims 3 and 12)

103. Claims 3 and 12 require verifying the presence of a user's ears in an image and verifying the absence or reduced visibility of those ears in the second image. In my opinion, this limitation is not taught or suggested by either Derakhshani or Tanii, nor would a POSITA have been motivated to incorporate such functionality. In my opinion, Derakhshani does not teach verifying the presence, absence, or reduced visibility of any portion of the ear, nor does it suggest doing so. The reference is limited to capturing the vasculature of the eye, and any incidental capture of an ear is not used by the system to verify anything about that ear.

104. Derakhshani states that the eye images it captures could include a portion of an ear. *See*, *e.g.*, Ex. 1005, 16:51-54. But any incidental capture of the ear is as an *image* landmark used for estimating distance from a sensor to that landmark. *Id.*, 16:51-17:2. In my opinion, an image including an ear does not mean *verifying* the presence, absence, or reduced visibility of an ear in any image, and nothing else in Derakhshani makes up for this deficiency. Moreover, Derakhshani's discussion using image landmarks for determining a spatial metric undercuts the idea of an ear being absent or having reduced visibility in an image.

[redacted]

According to Derakhshani, image landmarks need to be visible for the spatial metric determination to take place. *Id.*, 16:51-17:2.

105. The Petition separately states that an ear would be blurry, and thus have "reduced visibility," if it were outside of the focal plane. Pet. 32-33. In my opinion, a blurry ear in a picture would not allow for calculation of Derakhshani's spatial metric. And regardless, as explained above, Derakhshani is merely using landmark as a method to estimate the degree of focus. In my opinion, Derakhshani does not *verify* the presence, reduced visibility, or absence of any ear.

106. The Petition suggests that Tanii teaches "the absence or presence of an ear is a natural result of changing the distance between the user and camera." Pet., 33. I do not disagree that ears can be present or absent in an image based on distance between the user and the camera. But there also is nothing in Tanii suggesting *verifying* presence, reduced visibility, or absence of ears in an image. As I discussed above, Tanii simply enlarges portions of an image proportionally to its center. The suggestion that a POSITA would have found it obvious to *verify* ears lacks any support in Tanii or Derakhshani. In my opinion, the combination also would not have been obvious given that there is no teaching in Derakhshani or Tanii of identifying an ear's absence or reduced visibility.

iii. "Comparing" First Data to Enrollment Image (Claim 5)

107. The Petition fails to demonstrate unpatentability of claim 1 and claim

[redacted]

5 because it confuses biometric features used for enrollment and image landmarks used for determining a spatial metric.

108. Claim 1 requires, in part, "processing the at least one first image or a portion thereof to create first data" (1[d2]) and "processing the at least one second image or a portion thereof to create second data" (1[d5])[1]. Ex. 1001, 38:21-22, 33-34 (emphasis added).

109. The Petition asserts Derakhshani's "landmarks" are the claimed "first data" and "second data." Pet., 21-22 ("A POSITA would have understood Derakhshani's identification of landmarks constitutes creating data (specifically, biometric data)") (emphases added), 24-25 ("identify data 'landmarks' in the face ('second [biometric] data')") (emphases added), citing column 16, lines 44-54 and column 17, lines 45-64. The "landmarks" in columns 16 and 17 of Derakhshani are *image* landmarks that are in multiple images like "an eye corner" or "a background object," and are used to estimate depth and spatial metrics. Ex. 1005, 16:51-54. These *image* landmarks do not constitute biometric data. Image landmarks in Derakhshani that could correlate to a user's features (such as an iris,

[1] I assume, based on a review of the expert declaration and other documents, that "1[d5]" is the element that contains "processing the at least one second image or a portion thereof to create second data."

[redacted]

the corner of an eye, or an ear) are not biometric data because they are not used to identify a user. They are merely used in Derakhshani as reference points.

110. Claim 5 depends on claim 1 and further requires "only authenticating the user when the first data, the second data, or both match the enrollment data within a predetermined threshold" (element 5[b])). Ex. 1001, 39:5-7 (emphases added). In contrast to claim 1, where the Petition asserts that the image landmarks (in columns 16-18) teach the "first data" and "second data,", the Petition identifies biometric "features" (in column 13:9-61, among other places) used to match a user to existing enrollment data as the "first data" and "second data." Pet., 36 (emphasis added):

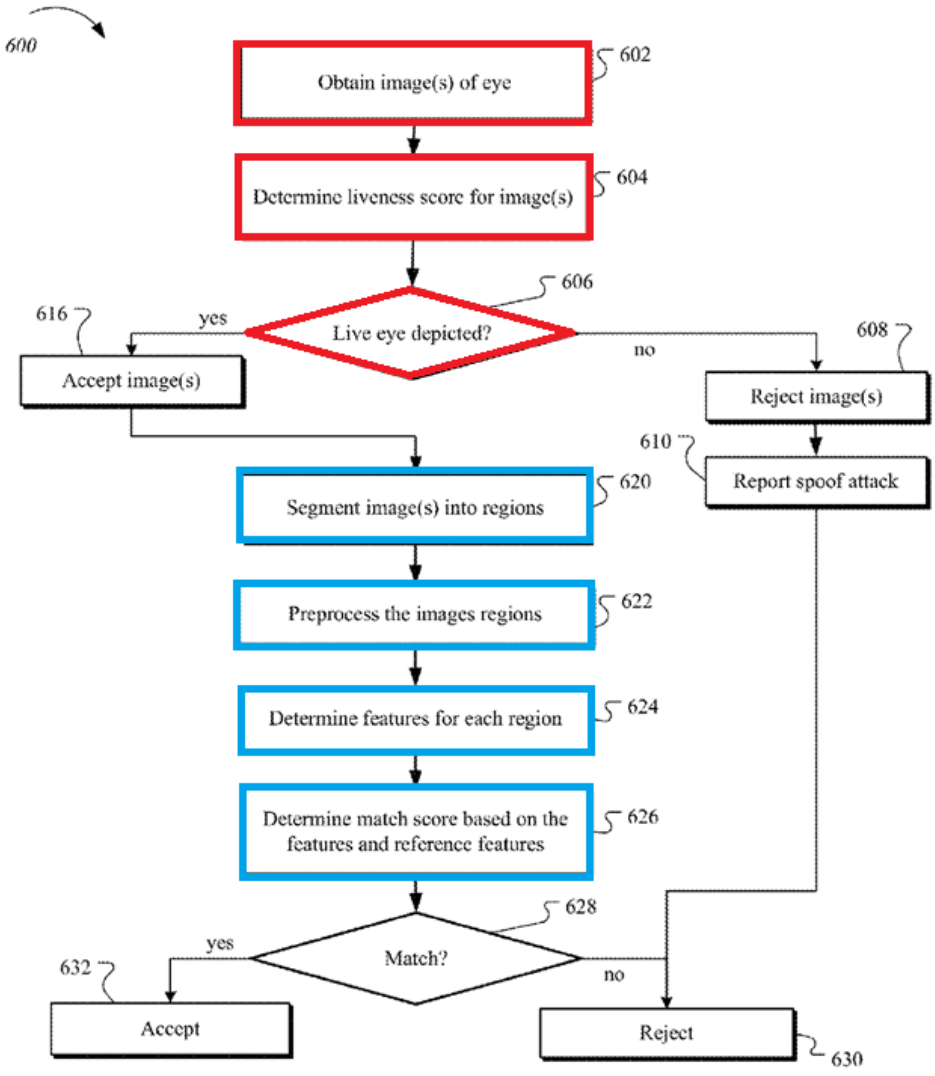
> Derakhshani calculates a match score based on the comparison of features extracted from the first and second image to the corresponding features in an enrollment reference record.

111. In my opinion, the image "landmarks" used to generate a spatial metric are *not* "features" as used in Derakhshani.

112. Derakhshani uses, among other things, three different parts of images of the user's eyes: **image landmarks**, **anatomical landmarks**, and **biometric features**. Image landmarks are used to generate a spatial metric, for example, during determination of liveness of the user's eye. Ex. 1005, 16:51-54; Fig. 6, step 604. (While Derakhshani does not refer to these as "image landmarks," I add the word "image" to distinguish them from "*anatomical* landmarks.") Anatomical

[redacted]

landmarks are used to identify regions of interest in the vasculature (white) of an eye in order to determine regions of interest in the vasculature. Ex. 1005, 11:46-53; Fig. 6, steps 620-622. Biometric features are pulled from the identified regions and used to authenticate a user based on a stored reference record. Ex. 1005, 13:9-14:24; Fig. 6, steps 624, 626.



113. Eye liveness detection in Derakhshani uses image landmarks to determine a spatial metric. *Id.*, 10:25-11:16; 16:44-17:11; Fig. 6, steps 602-606.

[redacted]

An image landmark may be a *non*-facial (and *non*-biometric) feature such as "a background object." Ex. 1005, 3:13-14, 16:44-54 (focus distance approach), 17:45-64 (parallax approach).

114. The authentication process, on the other hand, extracts biometric features "from each image region that reflect structure or properties of the vasculature visible in that region of the user's eye" (step 624), matches the extracted features against features stored in "a reference record" (step 626), and either accepts or denies authentication (steps 628-632). *Id.*, 12:23-24, 13:9-14, 62-66, 14:25-58. These "features" the Petition referenced with respect to claim 5 come from images of the *white of the eye*; the "enrollment reference record" that the Petition are compared to the extracted biometric features comprises "data derived from one or more *images of the white of an eye* for a registered [or] authorized user." *Id.*, 7:20-23; *see also* 9:18-26 (discussing authentication relating to the "white of the user's eye" and capturing it by prompting the user to "face the sensor and direct their gaze left or right to expose large portions of the white of an eye to the sensor"); 4:19-24 ("[d]istinctive features of an individual's visible vasculature in the whites of the eyes may be used to *identify or authenticate* the individual").

115. I understand that the Board found that the Petition uses "landmarks" and "features" synonymously. Paper No. 17, 49-50. In particular, I understand

[redacted]

that this panel found that the Petition describes processing the images to identify "feature landmarks" and thus views the Petition's position as consistent. *Id*. I do not agree. Derakhshani distinguishes between "features," image "landmarks," and "anatomical landmarks" for the reasons I discussed above. In my opinion, the Petition's confusion of landmarks and features is fatal to the Petition's case for claim 5. The Petition even seems to admit that image landmarks and features are not the same, as it discusses distinct portions of Derakhshani for claims 1 and 5. Compare Pet., 22 (citing columns 16-17 for claim 1's recitation of "first data"), with 36 (citing columns 13-14 for claim 5's recitation of "first data"). Thus, the Petition does not demonstrate that Derakhshani's purported "first data" and "second data" used for liveness detection are the same data used for authentication against enrollment records.

116. Thus, because Derakhshani's "features" are used for authentication, not for spatial metric or liveness determination, and because the Petition conflates the two, it is my opinion that the Petition has failed to demonstrate that Derakhshani teaches or suggests claim 5.

iv. Claims Requiring "First Data" and "Second Data" Comprise Biometric Data (7, 16) or Facial Features (8, 17)

117. The Petition's misunderstanding permeates its faulty analysis of claims 7-8 and 16-17. Claims 7 and 16 require that "the first data and the second

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data comprise biometric data." Ex. 1001, claims 7, 16. The Petition identifies image landmarks, such as the corner of an eye, as teaching that "the first data and the second data comprise biometric data" as required by claims 7 and 16. For the reasons I discussed above in Section X.A.1.d.iii, it is my opinion that this is wrong.

118. Image landmarks identified to determine a spatial metric are not "biometric data" in the context of Derakhshani—they are pixel regions in multiple images that have different focus depths. Ex. 1005, 16:51-54. This is, in part, because these image landmarks can be "a background object." *Id*. As explained above, even the landmarks identified that could be part of a user – including an iris, eye corner, or ear – are not "biometric data" in the context of Derakhshani because there is no discussion of how to identify a user using those landmarks.

119. In my opinion, the image landmarks used to determine a spatial metric are also not a "mapping of facial features" as required by claims 8 and 17. Derakhshani does not take images of faces; it captures only the user's eye from 6-12 cm away. Therefore, as I mentioned in Section X.A.1.b, because Derakhshani does not take images of faces, a mapping of image landmarks would not be a "mapping" of *facial* features. *See, e.g.*, Ex 1001, 7:31-38.

v. "Detect a Reflection" Off a Face (Claim 18)

120. This claim requires "detecting a reflection of [a] displayed image off of the *user's face*." Ex. 1001, 40:37-42. The Petition asserts Derakhshani uses the

[redacted]

device's screen as a "light source to reflect off of the user's face," citing 5:22-27, 6:3-5, 8:11-28, 9:10-22, 16:44-18:29, and Fig. 7 of Derakhshani. But none of these parts of Derakhshani, or any part of Derakhshani, discusses reflections from a face. Nor do they even use the word "face" as a noun. 5:22-27 and 6:3-5 discuss the capturing the "vasculature" or "white of the eye," 8:11-28 generally discusses computing devices, and 9:10-22 discusses asking a user to face a sensor and direct their gaze left or right to expose portions of the white of their eye. None of these portions discuss detecting reflections from a face.

121. As I discussed above in Sections IX.A and X.A.1.b, 18:8-18:29 (and Fig. 7) of Derakhshani does refer to a "reflectance metric." But that metric relates involves capturing "surface glare or specular reflection patterns on a surface of the *eye*" – not of a face. Capturing reflections from an eye is materially different from analyzing reflections from the face. The human eye is a smooth, curved, and highly reflective surface that behaves similarly to a mirror or calm water. For example, the eye exhibits specular reflection that preserves the shape and pattern of the light source. In contrast, facial skin is a complex, textured surface that acts as a diffuse reflector. This fundamental difference in surface properties means that the techniques used to process reflections from the eye are not transferable to facial reflection analysis. Moreover, the face includes heterogeneous regions (such as hair, nostrils, and blemishes) that reflect light differently or not at all. Additionally,

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the eye occupies a relatively small area of the face, requiring close-range optics and high resolution for reflectance analysis. These constraints make it impractical to apply Derakhshani's eye-based reflectance metric to broader facial imaging scenarios. Indeed, eyes can also reflect things like QR codes while it would be more difficult to read a QR code reflected off of a face. Ex. 1001, 3:35-43 (discussing reflecting a QR code off of a user's eye).

122. The Petition's reliance on Hoyos is also misplaced because, like Derakhshani, Hoyos is focused on reflections from the eye (specifically, the cornea). Ex. 1010, ¶¶[0034]-[0035]. Thus, Hoyos also fails to teach or suggest detecting reflections off the face. And the Petition does nothing to relate the unique reflective properties of the eye to those of a face. In my opinion, as laid out above, capturing reflections from an eye is not the same as capturing a face.

2. '471 Grounds 2A-2C: The Proposed Zhang Combination Fails to Show All of the Claimed Elements

123. The Petition relies on Zhang as the foundation for each of its proposed Ground 2 combinations. In my opinion, this reference is insufficient. Zhang's comparison of color/intensity between a first warped image and a second image is different from the claims of the '471 patent. Regardless of what images or points are compared in Zhang, Zhang does not determine whether differences between two images have distortion expected based on a change in distance. It determines if color/intensity of distinct pixel regions as small as a single pixel ("feature

points") match one another by more or less than some threshold. In my opinion, this is different from the '471's process of creating data from processing images and comparing that data to determine whether differences have the expected distortion resulting from camera or user movement between the images.

124. In my opinion, Tanii does not make up for the deficiencies in Zhang. Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. Even if it does, the mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Zhang. Indeed, Tanii's purported distortion-correction process cannot warp a close image to accurately compare it to a further image as an indication of three-dimensionality. Tanii's warping at close range will fail to resemble the realities of a three-dimensional subject. And as I discuss further below in Section X.A.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Zhang Does Not Determine Expected Differences or Distortions Based on Movement of Camera or User

125. The claims require comparing authenticating data from two images to determine whether they exhibit expected differences or distortions consistent with the shape of a face, due to movement of the camera or user. Ex. 1001, 1[d6], 10[f]. This comparison relates to authenticating the three-dimensionality and liveness of the user. Ex. 1001, 1[d7], 10[g].

126. I understand that the Board found that the Petition had shown a

[redacted]

reasonable likelihood of prevailing on claim 1. I further understand that it did so without identifying any disclosure in Zhang of "expected distortion" as required by the independent claims. *See* Paper No. 17, 42-46. In summarizing the Petition's argument that Zhang compared images to determine whether expected differences exist, the Board noted that Zhang "compares the facial feature locations in the first warped image to the facial feature locations in the second image to determine whether differences between the two exist." Paper No. 17, 45. In my opinion, this is a mere detection of *differences*, not a determination of expected distortion resulting from movement of the camera or user.

127. Moreover, in my opinion, Zhang does not determine whether images exhibit expected differences or distortions consistent with the shape of a face due to movement of the camera or user. Zhang matches feature points across two images and compares pixel-level intensity differences around those points in a warped first image and a second image. Ex. 1006 ¶¶[0030]-[0034]. The comparison is based on whether the color or intensity difference exceeds a threshold. *Id.* The color/intensity difference identified in Zhang does not relate to expected distortion that is based on movement of the camera or the user. In my opinion, Zhang makes no prediction of how an image would change due to this movement, and no analysis of whether the observed differences conform to such a prediction.

[redacted]

128. Zhang's system simply compares pixel regions ("feature points") across two images and checks whether the pixel difference exceeds a numerical threshold. Ex. 1006, ¶[0033] ("If the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a face that is a live face."). In my opinion, determining pixel regions of two images differing by color/intensity does not teach the requirement in 1[d6] to determine "expected distortion," because determining pixel differences alone does not evaluate whether observed differences are consistent with what would be expected from a *change in distance* (*i.e.*, distortion due to perspective, parallax, or other depth-related effects). *See* Ex. 1001, 38:24-30.

b. **Petitioner Inconsistently Treats the Claimed "First Data" as Both Feature Points and Facial-Feature Locations**

129. Claim 1 requires at least:

> processing the at least one first image or a portion thereof to create first data . . . ;
> processing the at least one second image or a portion thereof to create second data; [and]
> comparing the first data to the second data to determine whether expected differences exist between the first data and the second data which indicated three-dimensionality of the user;

130. Ex. 1001, claim 1 (emphasis added). Claim 10 likewise requires

[redacted]

comparing data processed from images. Ex. 1001, 39:39:26-27, 38-43.

131. Like with its position on Derakhshani, the Petition and Dr. Daft confuse a "feature point" with a "selected location." Pet., 61. Therefore, similar to my opinion regarding Derakhshani, this ground fails as well.

132. As I discussed above in Sections IX.B and X.A.2.a, feature points are used to generate a matrix *H* while selected locations (or "facial-feature locations" as Petitioner mistakenly calls them) are used to compare images *using* matrix *H*. Ex. 1006, ¶¶[0026]-[0034], claim 3, Fig. 3.

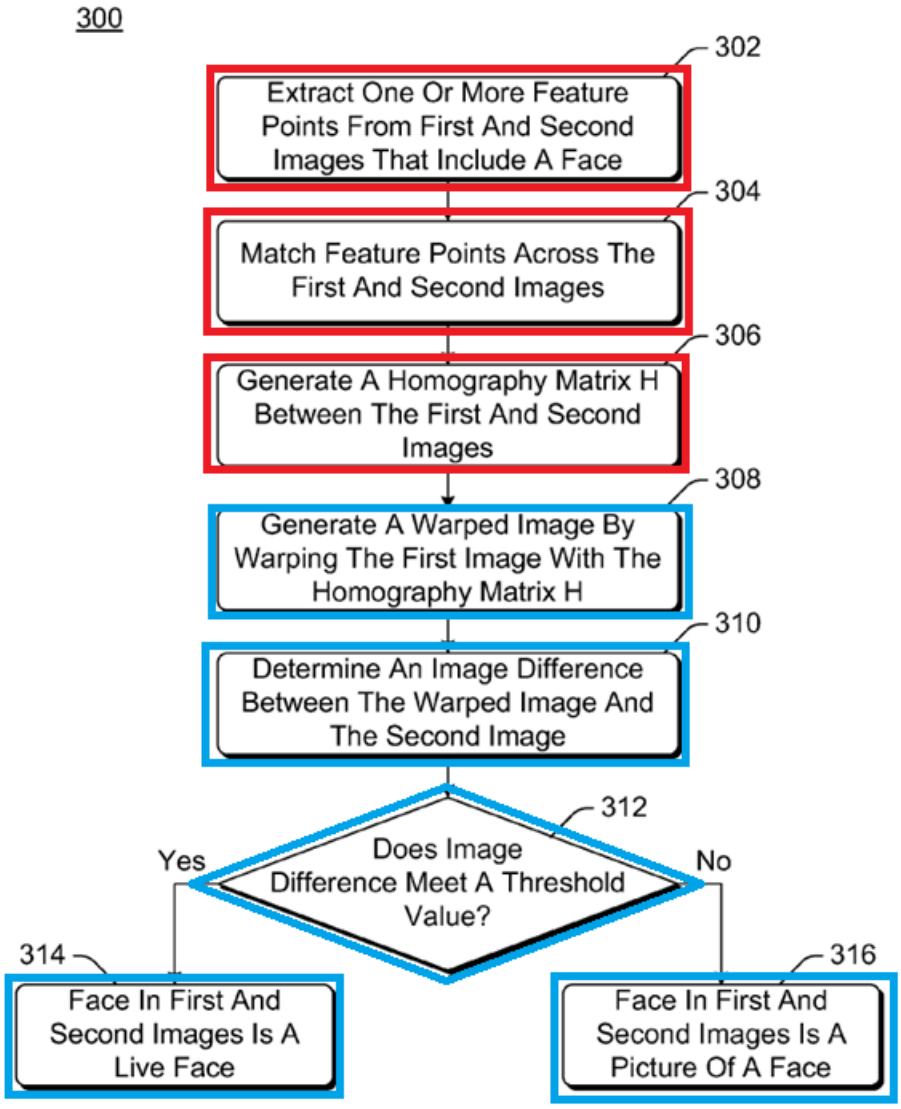


Fig. 3

133. For the "processing" steps, Petitioner maps Zhang's "*feature points*" from a first image and a second image to "first data" and "second data," respectively. Pet., 57 ("Zhang discloses *processing the first image* to extract '*feature points*'…POSITA would have understood these *extracted feature points* to be data….") (emphases added), 60 ("Zhang discloses *processing the second image*

[redacted]

to obtain second feature-point data from the image") (emphasis added); Ex. 1003, ¶¶288-90, 297-98. The Petition admits that "*feature points*" are specific markers in individual images: "a corner of an eye, a corner of a mouth, [or] a tip of a nose." Pet., 57 (*quoting* Ex. 1006, ¶[0027]). They may be as small as a single pixel. Ex. 1006, ¶[0027].

134. But when mapping "first data" in the "comparing" element (1[d6]) Petitioner abandons its earlier position, asserting instead that "first data" is "*selected locations*"—what it refers to without *any* textual support as "*facial-feature locations*"—in a warped first image. Pet., 61 (referring to comparison between "*selected locations*"). Unlike "feature points" which are specific markers in individual images, "*selected locations*" are locations that are compared across *both* the warped and second images. Ex. 1006, [0032].

135. Thus, regardless of whether the Petition believes "feature points" from a first image *or* "selected locations" across the warped and second image constitute the "first data" in 1[d6], the two are not equivalent to one another and the Petition's treating of them identically is fatally incorrect.[2]

[2] Petitioner's citations to entirely different portions of Zhang for "first data" in 1[d2] and 1[d6] is further evidence that "feature points" and "selected locations" are not synonymous. *Compare* Pet., 57 ("feature points" in ¶[0027] for 1[d2]'s

[redacted]

c. Zhang in view of Tanii fails to teach the independent claims

136. It is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 32-33. Tanii detects the size of an "object" in the frame and a "distance" to the object. See, e.g., Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Section X.A.1.c, it is my opinion that Tanii would operate the same way whether a face or a non-face were presented. Indeed, Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Zhang.

137. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected

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"first data"), *with* 61 ("selected locations"/"facial-feature locations" in ¶¶[0031]-[0032] for 1[d6]'s "first data").

[redacted]

distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences or distortions, or determining three-dimensionality. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

d. The Petition Has Separately Failed to Show that Certain Dependent Claims Are Obvious

i. Interpolation Claims (claims 2 and 11)

138. For reasons similar to those discussed above with respect to Derakhshani, Zhang also fails to teach dependent claims 2 and 11 which require interpolation or modeling of expected distortion between images. Zhang does not interpolate between images or model expected distortion.

139. Instead, as discussed above, Zhang compares a warped version of a first image to a second image using pixel-level intensity differences. Ex. 1006, ¶¶[0030]-[0034]. The comparison is threshold-based, such that if the difference exceeds a threshold, the face is deemed live; otherwise, it is deemed flat. *Id.* But this comparison between pixel regions means Zhang does not model expected distortion, interpolate between data sets, or predict how the image should change due to movement. Indeed, Zhang's process estimates planar motion between two

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images, but does not model the expected distortion that would result from movement of a nonplanar, three-dimensional face. Zhang's alleged interpolation aligns one image to another under the assumption that the feature points lie on a flat surface. It does not interpolate to generate intermediate data or predict how the image should change due to actual movement of a three-dimensional object. Thus, Zhang's interpolation is fundamentally different from the interpolation recited in claim 2, which involves modeling expected distortion patterns between images.

ii. Claims Requiring the Ears (Claims 3 and 12)

140. As I discussed above with respect to Derakhshani, these claims require verifying the presence of a user's ears in an image and verifying the absence or reduced visibility of those ears in the second image. See above, Section X.A.1.d.ii. The Petition agrees that Zhang fails to teach verifying presence, absence, or reduced visibility of ears. Pet., 68. The Petition then asserts that Tanii makes up for the deficiencies in Zhang, making a similar case as it did with Derakhshani (discussed above in Section X.A.1.d.ii). (*Compare* Pet. 33-35 *with* 68-69.)

141. For reasons similar to those I discussed above in Section X.A.1.d.ii, it is my opinion that Tanii fails to make up for the deficiencies in Zhang. For example, Tanii simply enlarges portions of an image proportionally to its distance from the center. The suggestion that a POSITA would have found it obvious to

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verify ears lacks any support in Tanii or Zhang. In my opinion, the combination also would not have been obvious given that there is no teaching in Zhang of identifying an ear's absence or reduced visibility.

iii. Zhang Does Not Capture "Biometric Data" as Required by Claim 7 and 16

142. Claims 7 and 16 explicitly require "biometric data." The Petition relies on Zhang's disclosure of "feature points" as satisfying the biometric data limitation. *See* Pet. 57, 60 (*citing* Ex. 1006, ¶¶[0026]-[0027]). As I explained above, Zhang's feature points may be as small as a single pixel. Ex. 1006, ¶[0027]. These points are merely "a single pixel or a region of multiple pixels" that identify "a corner of an eye, a corner of a mouth, a tip of a nose, and so forth." Ex. 1006, ¶¶[0026]-[0027]. There is no indication that these pixels are used, for example, for authentication or matched against stored biometric templates. They are only used for warping purposes. Zhang's system is designed to detect spoofing by comparing pixel-level differences from a warped image to a second image and concludes whether a face is live or flat. Ex. 1006, ¶¶[0030]-[0034].

143. I understand that the Board described Zhang's process as one where "feature points are matched across the first and second images to determine whether the first and second images include the same face." Paper No. 17, 42-47. But in my opinion, this describes a geometric comparison, not a facial liveness detection or a biometric authentication.

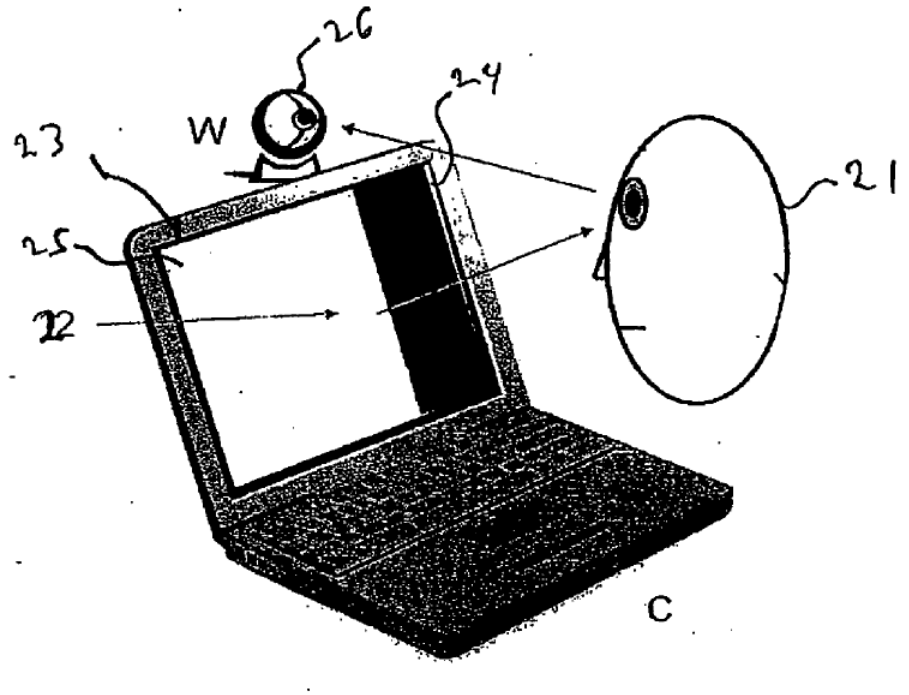
[redacted]

144. Accordingly, Zhang cannot satisfy the biometric data requirements of claims 7 and 16.

iv. Reflections from Illuminations of Face (Claim 18)

145. Claim 18 of the '471 patent require analysis of a "reflection of [a] displayed image off of the user's face." The Petition admits that Zhang does not teach claim 18 and relies on Hoyos as teaching claim 18. In my opinion, Hoyos does not teach claim 18.

146. Hoyos presents a first image on a screen, capturing a first reflection, presenting a second image, capturing a second reflection, and comparing the first and second reflections to determine if they were formed by a "curved surface *consistent with a human eye*." Ex. 1010, ¶[0019], Fig. 2:



147. Hoyos detects reflections from human eyes, not a *face*, as required by the explicit language of claim 18. Capturing reflections from an eye is materially different from analyzing reflections from the face. The human eye is a smooth, curved, and highly reflective surface that behaves similarly to a mirror or calm water. For example, the eye exhibits specular reflection that preserves the shape and pattern of the light source. In contrast, facial skin is a complex, textured surface that acts as a diffuse reflector. This fundamental difference in surface properties means that the techniques used to process reflections from the eye are not transferable to facial reflection analysis. Moreover, the face includes heterogeneous regions (such as hair, nostrils, and blemishes) that reflect light differently or not at all. Additionally, the eye occupies a relatively small area of the

face, requiring close-range optics and high resolution for reflectance analysis. Eyes can also reflect things like QR codes while it would be more difficult to read a QR code reflected off of a face. Ex. 1001 ('471 patent), 3:35-43 (discussing reflecting a QR code off of a user's eye).

148. Moreover, Hoyos' only use of a face is to calculate the probability of a biometric match (Pm). Ex. 1010, ¶¶[0033], [0038]. Because Hoyos does not "detect a reflection of [any] displayed image off of the user's *face*," it is my opinion that Hoyos fails to teach claim 18.

3. Tanii Cannot Cure the Deficiencies of the Other References

149. As explained, Tanii performs aesthetic image correction; it does not evaluate distortions. It is also not analogous art to the challenged patent. It purports to remove distortion, which Derakhshani and Zhang use to operate. The Petition's proposed combinations would require significant distortions of Derakhshani and Zhang. And those in the field of biometric security—unlike Dr. Daft—would have had no reason to look to Tanii, which focuses on making images visually pleasing.

a. **Tanii is Not Analogous Art**

i. Tanii Is Not from the "Same Field of Endeavor"

150. In my opinion, Tanii is not from the same field of endeavor as the '471 patent. Indeed, I understand that Dr. Daft does not argue that Tanii is from the same field of endeavor as the '471 patent. Ex. 1003, ¶110.

151. And that is correct. While I understand that the Petitioner asserted

during this proceeding that Tanii is analogous because it and the '471 patent are both "concerned with identifying and accounting for distortions of [3D] faces in images captured using a camera," Pet. Reply 5, this is too simplistic of an understanding of the '471 patent. The '471 patent uses the distortion that Tanii tries to remove. In my mind, it cannot be said that the two are from the same field of endeavor.

152. Some analogies may help here. Imagine two systems: the first removes color from color images, and the second uses color from color images to segment them into meaningful regions. While both of these hypothetical systems identify color, only the second hypothetical system meaningfully "accounts" for color. The first hypothetical system acknowledges and processes color only to remove it, while the second is an "accounting" of color by using it to determine the contents of images. Notably, in this analogy, the first system's removal of color prevents the second system's use of that color for segmentation, but not vice versa.

153. Another analogy is in the area of animal husbandry: one disclosure relates to milking a dairy cow while another relates to slaughtering a cow for beef. Again, while both "account" for cows on a farm, the way that they are accounted for are fundamentally different – and result in vastly different outcomes for the cow. Indeed, a dairy cow is leveraged for its milk production, whereas a beef cow is processed in a destructive way, slaughtering the cattle. Each of these analogies

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is instructive in evaluating Tanii's treatment of distortion because Tanii does not "account for" distortion in the sense required by the claims. Rather, Tanii assumes distortion exists and then corrects for it by warping the image to produce a natural, more user-friendly image for a viewer. "Accounting for" requires more, such as modeling, measuring, or using distortion to extract or analyze information. Tanii does not do this.

154. In my opinion, one of ordinary skill in the art would not believe that Tanii is from the same field of endeavor as the '471 patent.

ii. Tanii's Distortion Correction Shows That It Is Not "Reasonably Pertinent" to the Problems Faced in the '471 Patent

155. The Petition admits that the problem faced by the '471 patent's inventor claims a system to "distinguish a three-dimensional face from a two-dimensional picture of a face." Pet., 4. Facial-recognition systems can be fooled (or "spoofed") by an impostor presenting a picture of an authorized face. *Id.*; *see also* Ex. 1003, ¶55 ("the '471 Patent describes countermeasures to prevent 'spoofing' attacks on facial-recognition systems …").

156. In my opinion, Tanii does not teach anything that would be reasonably pertinent to this problem. I understand that the Board found Tanii reasonably pertinent, stating that its "relevant teaching" is that "a three-dimensional face exhibits distortions when a cellular phone camera and a face are close together

during image capture." Paper No. 17, 47-48. In my opinion this alleged teaching would not be helpful. The inventor had already recognized this long-understood issue as a problem, and the '471 patent uses that distortion to meet its ends. *See*, *e.g.*, Ex. 1001, 28:36-58 (explaining that distortion effects "become[] more pronounced on an image of a person's face when the person images his or her face close to the lens").

157. The '471 patent solves the spoofing problem by "looking for" the perspective distortion that occurs because of the distance between a three-dimensional face and a camera. Pet., 4-5; Ex. 1003, ¶56; *see also* Ex. 1001, 29:3-19 (the "expected" "fish-eye effect" is used to "prevent a two-dimensional picture…from being used for authentication") and 29:65-30:41 (determining that a "two-dimensional picture" is not being presented by validating an "expected distortion of [] intermediary images" at different distances).

158. Tanii, on the other hand, does not do anything to solve the problem faced by the '471 patent: preventing spoofing. Tanii does not even detect distortions. Tanii assumes and corrects distortion by enlarging the peripheral areas of an image, regardless of whether the image is of a distorted face.

159. In my opinion, the Board's discussion of combining Tanii with Derakhshani makes clear that Tanii does not solve this problem nor is it in any way relevant to it. The Board found that Tanii was only relied upon for "its teaching of

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evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 33. This single concept of evaluating distortions does not provide any solution to the spoofing problem.

160. Tanii works against the challenged claims, by removing the very thing that enabled the patent's inventor to solve the spoofing problem. The "critical feature" the Petition acknowledged (correcting image distortion, Ex. 1003, ¶113) would prevent each reference from operating as taught by the '471 patent. Thus, a POSITA would not have reasonably expected to solve the '471 patent's spoofing problem using Tanii and would not have looked to Tanii for any teaching to do so.

161. In my opinion, Tanii is also not reasonably pertinent for the additional reason that it does not have the "same purpose as the claimed invention" of the '471 patent. Tanii's purpose is to correct image distortion, rather than use it. *See*, *e.g.*, Ex. 1003, ¶¶110, 113. Whereas the claimed invention's purpose is to determine three-dimensionality *using* image distortion. *See*, *e.g.*, Ex. 1001, 38:35-45 (comparing expected differences and distortions). Thus, Tanii's competing purpose would have also prevented a POSITA from considering it and would have rendered Tanii not reasonably pertinent to the '471 patent.

b. A POSITA Would Not Have Combined the References as the Petition Suggests in Either Grounds 1 or 2

162. Even if Tanii were analogous art here, it is my opinion that there

[redacted]

would have been no motivation to combine it with Derakhshani or Zhang. In my opinion, either combination would destroy the basic objective of the respective primary reference, rendering it inoperable for its intended purpose.

163. The Petition admits that Derakhshani and Zhang require distortions to operate. Derakhshani allegedly determines whether a face is three-dimensional using distortions—"different amounts of blur" or "parallax"—across multiple images. Pet., 7-8; Ex. 1003, ¶¶182 ("Derakhshani's focus-distance approach *looks for expected distortions in the blurriness* or clearness of facial landmarks . . . "), 400 ("there may be other optical effects (e.g., *distance-induced distortion*) that are more apparent in the closer image than the further one"), 885 ("*more parallax*" between images helps to "verify the face as three-dimensional") (emphases added). And Zhang allegedly generates a "warped" first image of a face, matching it to a second image to determine whether the differences meet a threshold; if so, the warped image is determined to represent a real (three-dimensional) face. Pet., 51-52.

164. The Board noted that

> Petitioner proposes to modify 'Derakhshani . . . to capture at least two images at different actual distances and evaluate whether they exhibit different degrees of distance-induced (barrel/fish-eye) distortion, as Tanii suggests.' Id. at 14–15 (citing Ex. 1003 ¶141). Thus, the

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> Petition relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's distance from the object. Pet. 12. Petitioner does not propose to modify Derakhshani by incorporating Tanii's teaching of correcting the distortion.

165. Paper No. 17, 32-33. For reasons similar to those I discussed above, I disagree that Tanii teaches "*evaluating* distance-induced distortions in a face caused by the camera's distance from the object." Indeed, it does not identify distance-induced distortions, as the Petition contends. Pet., 51; Paper No. 17, 40. Its teachings relate to correction of images by removing the distortion Derakhshani and Zhang allegedly use. The Petition specifically asserts that Tanii's "*critical feature*" is to provide a "procedure to *correct* . . . distance-induced *distortion* . . . to produce an *undistorted image*," *i.e.*, provide a natural-appearing (undistorted) image for a viewer. Ex. 1003, ¶113 (emphases added); *see also* ¶¶110-112; Pet. 11-12. And Tanii's teaching is further limited because it does not determine whether an image requires correction (Ex. 1007, ¶[0058]); it merely assumes it does.

166. In my opinion, doing so on images captured by Derakhshani and Zhang would prevent detection of three-dimensionality, rendering a system which is non-functional for its intended purpose and would destroy the principle of operation of those references.

[redacted]

167. Additionally, as it relates to Derakhshani, the suggestion that images of different distances from the sensor have different distortion is not a motivation to combine. Indeed, the inventor of the '471 patent already recognized that images have a distortion effect that is "more pronounced" the closer that a face gets to a lens. Ex. 1001, 28:36-58. This is a concept that has been known for centuries.

168. In my opinion, POSITA would not have been motivated to combine Derakhshani with Tanii for additional reasons. For example, as I discussed above (Sections IX.A and X.A.1.c), any distance-induced distortions found in Derakhshani would be in pictures that are taken at very close range. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features—let alone an entire face or a head—in any image.

169. To be clear, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '471 patent (August 2014). In contrast to Derakhshani, Tanii's correction method is designed for images captured at arm's length using wide-angle lenses. Ex. 1007, ¶¶[0007],

[redacted]

[0047]. Thus, the incompatibility between Derakhshani and Tanii is further recognized by the differing imaging requirements and Derakhshani's needs to capture images of the eye vasculature from a close distance.

170. For at least these reasons, it is my opinion that a person having ordinary skill in the art would not have combined Derakhshani with Tanii.

171. As it relates to Zhang, it is also my opinion that a POSITA would not be motivated to combine. I understand that the Petition identified three different possible ways in which a person of ordinary skill in the art would have been motivated to combine Zhang and Tanii. Petition, 50-53; Paper No. 17, 40-41 (identifying the three ways). In my opinion, a person of ordinary skill in the art would not have been motivated to combine these references for the identified three reasons or any other reason.

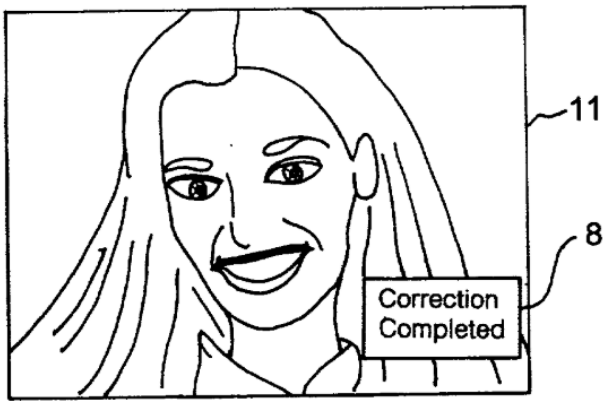
172. The first reason for allegedly combining Zhang and Tanii identified in the Petition is that

> a POSITA would have been motivated to use Zhang's existing process, but take advantage of the *distance-induced distortions identified by Tanii* by using a (wide-angle) camera that induces these distortions at different distances, and capturing two images of the face at different distances, because Zhang's procedure would identify the two images as different due to the differences in distance-induced distortion and verify three-dimensionality.

[redacted]

173. Pet., 51; Paper No. 17, 40. In my opinion, this is incorrect. As I discussed above, Tanii does not teach identifying the distance induced distortions that the Petition asserts it does. See, for example, Sections X.A.1.c and X.A.2.c. Tanii is limited to warping/correcting an image regardless of whether distortions are present or not. In my opinion, this is the motivation behind the "Correction Completed" annotation on the corrected image in Figure 9 of Tanii:

Fig.9



174. Tanii explains that this annotation enables the user to "easily recognize whether or not warp correction was performed." Ex. 1007, ¶[0058]. In my opinion, this is because the system in Tanii cannot determine whether an image requires correction or not.

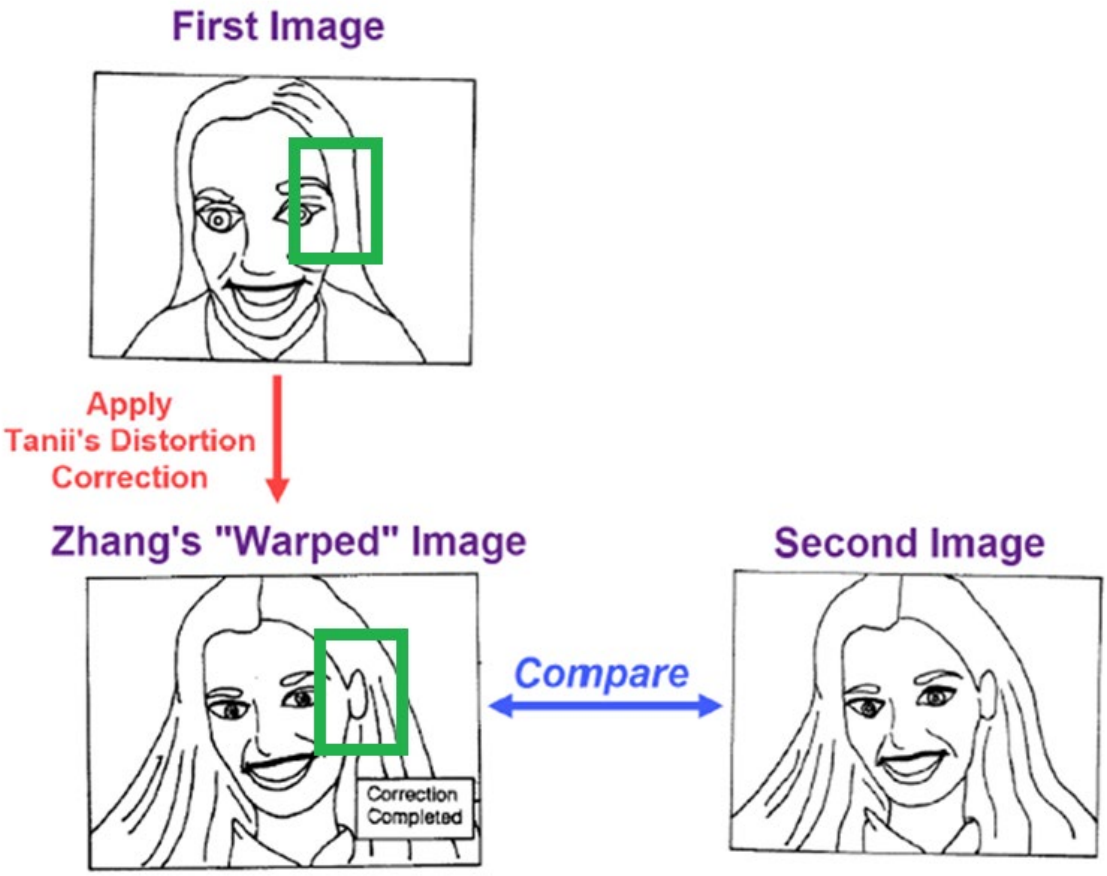
175. The second reason for allegedly combining Zhang and Tanii identified in the Petition is

> a POSITA would "warp" (i.e., correct) the "close" image using Tanii's distortion-correction procedure to compare

[redacted]

> it to the "far" image and evaluate the two for differences . . . if the "warped" (corrected) image and second image are sufficiently similar, that indicates a three-dimensional face. . . . A POSITA would have appreciated this modification would reduce spoofing of Zhang's system (which only evaluates whether a face is non-planar, which can be spoofed), and provides a simpler mathematical operation that may require less computational resources.

176. Pet., 51-53; Paper No. 17, 40-41. In my opinion, this is incorrect. The proposed process would not work. For example, the Petition asserts that applying Tanii's distortion correction would lead to a "warped" image that can be compared to a second image. But the Petition depicts ears that cannot be seen in the First Image appearing in the "Warped" image without explanation, as I have annotated below:



Pet., 52 (ear locations annotated in **green**). Ears that cannot be seen from a short-range image would not miraculously appear after Tanii's purported distortion correction. Tanii's system would merely make the warped image appear more natural. Thus, Petitioner relies on a modification that is neither taught nor suggested by the references.

177. The third reason for allegedly combining Zhang and Tanii identified in the Petition is

> when evaluating two images for different degrees of distance-induced distortion, the two images (one "close",

[redacted]

> one "far") could be compared directly to determine whether they exhibit expected differences in degree of distance-induced distortions.

Pet., 53; Paper No. 17, 41. In my opinion, this is incorrect. There would be no way to "eliminat[e] the need to mathematically transform an image" and directly compare two images without performing the same basic calculations. The Petition fails to explain how two images could be directly compared to one another – particularly because one of the images is distorted and merely overlaying the images as the Petition has done would not yield the result that the Petition implies.

178. Dr. Daft's declaration vaguely asserts that this third combination requires that "facial features would be mapped in each image, matched between the two images, and evaluated to determine whether differences attributable to distance-induced distortion appear." Ex. 1003, ¶268. None of these facial-feature-matching steps even appear in Zhang or Tanii. Dr. Daft does not assert that they do, instead inventing an entire set of operations, matching, and evaluations out of whole cloth. Ex. 1003, ¶¶268-69. And while Dr. Daft asserts that a POSITA would have been motivated to combine the references with Tanii, in my opinion, an actual POSITA in the relevant field would have had no reason to look to Tanii in the first place. Tanii's teachings relate to correcting image distortion to create a more pleasing picture. Ex. 1007, ¶[0056]. Making visually aesthetic images is irrelevant to the problems faced in the biometric security field, and Dr. Daft's

[redacted]

spurious reasoning—that it allegedly teaches evaluating distortions—falls flat because Tanii does not teach evaluating distortions at all. Even if Tanii "evaluat[es]" distance induced distortions, that concept would not provide a reason for POSITA to use that reference to teach the claims. Including the concept of evaluating distortions would still leave significant gaps in the claims.

B. '606 Patent

1. '606 Grounds 1A-1C: The Proposed Derakhshani Combination Fails to Show All of the Claimed Elements

179. In my opinion, Derakhshani detects spoofing based on the visible vasculature (blood vessels) of a user's eye, not a user's face. The reference itself does not even include facial images. While the Petition includes facial images throughout its discussion of that reference, I understand that these images come from, for example, exhibits 1011 and 1012 (unrelated patents (Baldwin and Hanna)) on pages 8 and 9 of the Petition) or were created by Dr. Daft (pages 10 and 29; *see* Ex. 1003 ¶¶107 108).

180. In my opinion, any distance-induced differences found in Derakhshani would occur at very close range, as all of the images need to capture the vasculature of the eye with sufficient clarity to authenticate the user. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features (aside from the eye) in either image, including a user's face (as required by claims 1, 10, and 19).

[redacted]

181. In my opinion, Tanii does not make up for the deficiencies in Derakhshani. I understand that the Board earlier found that the Petition relies on Tanii only for "its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object" (Paper No. 17, 13 (citing IPR2025-00106, Paper No. 17, 33)). The mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Derakhshani.

182. In my opinion, Tanii does not, in fact, "evaluat[e]" whether one or more images exhibit different degrees of distance-induced distortions as the Board found critical to Petitioner's position. Instead, Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. And as I discuss in Section X.B.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Derakhshani's "Spatial Metric" Does Not Represent the Face's Three-Dimensionality

183. The Petition contends that Derakhshani's "spatial metric" is calculated "for the entire face" and represents whether a subject's face is three-dimensional. Pet., 16. I disagree. It is not calculated for the entire face—no "entire face" is ever captured—and does not represent three-dimensionality.

184. Derakhshani's spatial metric is not a measure of any aspect of a user's face, let alone a user's "entire face", and is not indicative of the three-

[redacted]

dimensionality of a face, as required by at least 1[pre], [1f-i], 10[pre], 10[g-h2], 19[pre], and 19[d-e2]. Derakhshani's spatial metric is based on images of the eye taken at different focus distances (Ex. 1005, 1:57-2:3), each distance needing to be close enough to capture the characteristics of the eye.

185. As I expand further below, Derakhshani is designed around capturing the vasculature (blood vessels) of a user's eye; it does not involve facial recognition or depth analysis of the user's head or face. In my opinion, this reference is unrelated to the teachings of the '606 patent, which require authenticating a user's three-dimensionality and liveness as a function of the expected distortion between two images of the user's face resulting from the movement of a camera or a user to a second distance (*e.g.*, Ex. 1001, claim 1).

186. Moreover, the spatial metric is "a measure of deviation of the subject from a *two-dimensional plane* . . . [or] an *expected three-dimensional shape*." Ex. 1005, 3:1-6, 17:27-36 (emphasis added). In my opinion, this expectation in Derakhshani presumes a known plane or known model of an "expected" shape, and compares captured images to that expected plane shape. The claims of the '606 patent, however, performs what I see as a different process: detecting if differences between data based on captured images have the "expected differences" resulting from the movement of a camera in between taking the images.

[redacted]

b. **Derakhshani Captures Only the Vasculature of a User's Eyes, Not the User's Face**

187. In my opinion, Derakhshani does not teach facial liveness detection by determining a user's three-dimensionality, as required by at least 1[pre], [1f-i], 10[pre], 10[g-h2], 19[pre], and 19[d-e2] . Derakhshani is directed to biometric authentication using eye vasculature. Indeed, it is explicitly directed to "biometric authentication based on *images of the eye*." Ex. 1005, Abstract; 1:5-7 (emphasis added). The system captures images of the white of the eye (sclera) 230, iris 220, and pupil 210, and analyzes vasculature patterns 240 in the conjunctiva and episcleral. *Id.*, 5:1-40, Fig. 2:

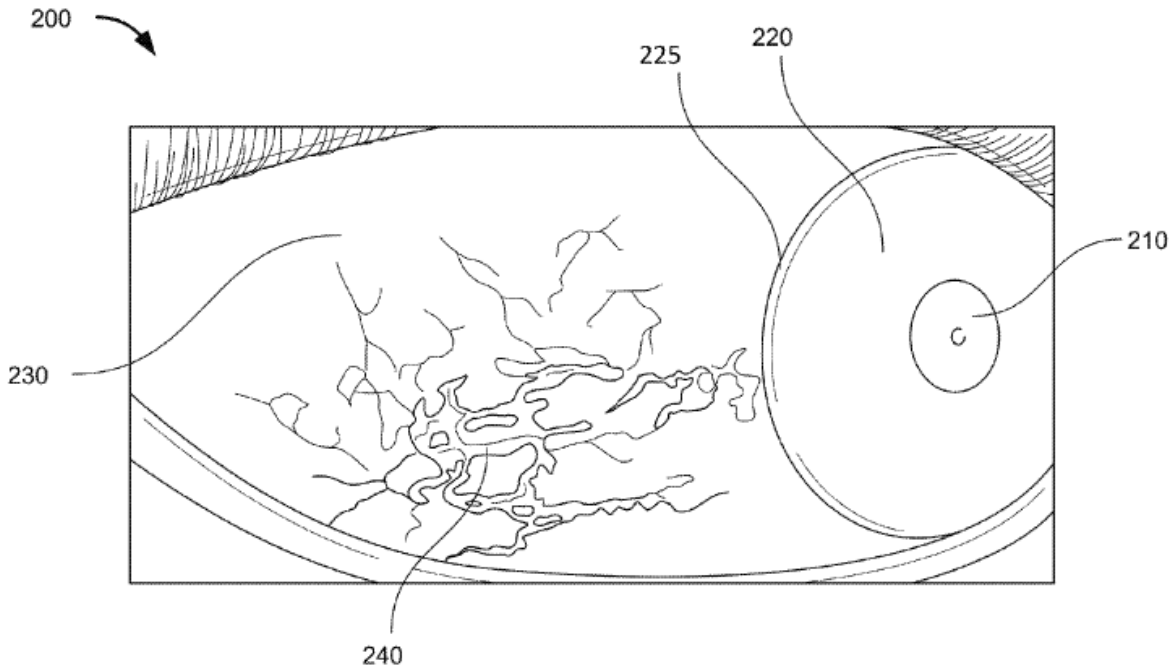


FIG. 2

188. Derakhshani describes three types of metrics associated with images

[redacted]

of the eye: behavioral, spatial, and reflectance. "Behavioral" metrics are based on detected movement of the eye, such as pupil constriction or gaze transitions, and are measured by analyzing sequences of images (Ex. 1005, 2:12-17, 15:51-16:43); "spatial" metrics are derived from the apparent depth of image landmarks in an image of the eye based on different focus distances (*Id.*, 2:17-21, 16:44-18:7); and "reflectance" metrics are based on changes in glare or specular reflection patterns on the eye's surface (*Id.*, 2:21-26, 18:8-19:11). Each of these methods relies on characteristics of a user's eye. *See*, *e.g.*, *id.*, 4:19-21 (capturing "features of an individual's visible vasculature in the whites of the [individual's] eyes … to identify or authenticate the individual").

189. The focus on the eye is consistent with Derakhshani's purpose to identify and evaluate the vasculature of the user's eye for authentication – not a face. Contrary to the Petition's suggestion, Derakhshani's disclosure is silent as to capturing images of the user's face or head, and it does not suggest that the system could be adapted to capture these features. Pet., 16-23. Indeed, despite the assertion that faces are imaged in Derakhshani (*see, e.g.*, Pet., 16, 17, 22-23), there are no images of any faces in the reference. *See, e.g.*, *id.*, Figs. 1-4 (depicting eyes and/or cross-sections of eyes):

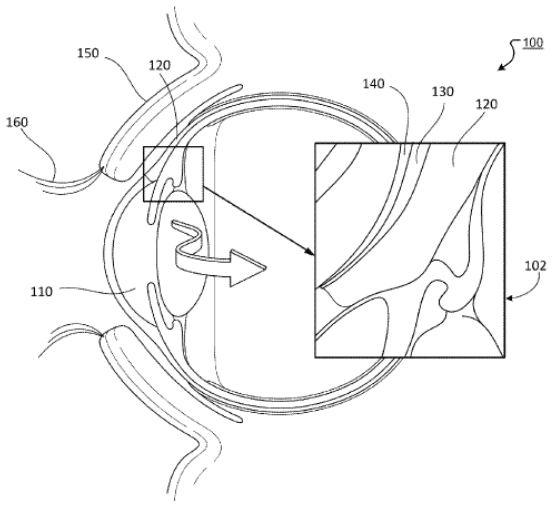


FIG. 1

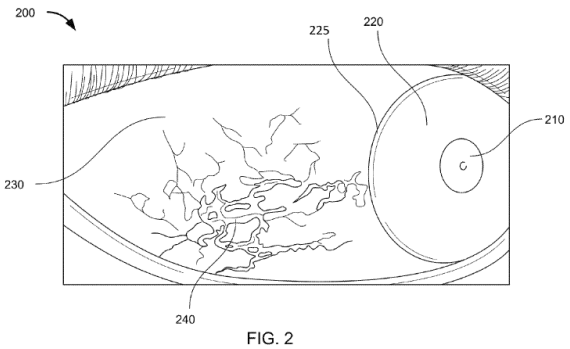
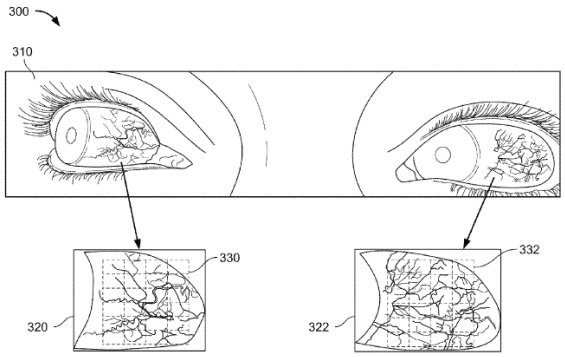
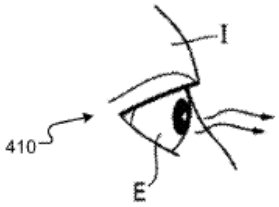
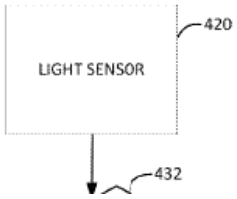


FIG. 2







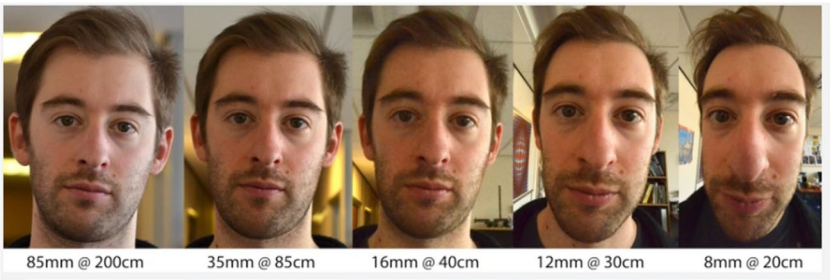
190. Each figure of the user is focused only on the user's eye. It stands to reason, in my opinion, that these figures represent images that would have to be taken from a distance that would support measuring the vasculature of that eye. Among the few references to a "face" involve presenting a picture of a face as one way to *spoof* the system rather than a legitimate presentation of the user for authentication (4:24-31) and prompting a user to "face" a sensor in order to picture the user's sclera (9:10-26).

191. Moreover, Derakhshani's focus on capturing the vasculature of the

[redacted]

eye effectively excludes the possibility of capturing the user's face or his or her three-dimensionality, and thereby authenticating the user, as claimed in the '606 patent. *See* Ex. 1001, [1pre], 1[a]-1[i]. In my opinion, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '606 patent (August 2014).

192. Just as one example, the Petition provided exemplary images of a user's face at varying distances. Ex. 1022. The closest distance provided is 20 cm. 20 centimeters is about 2-3x further away than Derakhshani's envisioned distance.



193. And the type of sensors used to capture eye vasculature at the time of the invention of the '606 patent would not be able to simultaneously capture the vasculature of an eye *and* a face with enough precision to enable determination of three-dimensionality or authentication. For example, the sensors capable of

[redacted]

detecting the fine vasculature of an eye required close-range, high-resolution optics, and were designed to capture images from a very short distance. When that sensor is moved back to capture a user's face or head, the resolution becomes inadequate to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality. Thus, in my opinion, attempting to use the sensors in Derakhshani to capture a face or head as proposed by the Petition, or modifying them to do so, would prevent capture of the vasculature of the eye. In my opinion, this would also render Derakhshani's system inoperable for its original purpose.

194. In my opinion, Derakhshani is narrowly focused on ocular biometrics and analyzing vasculature patterns of the eye. For example, Derakhshani's spatial metric is based on deviations of a user from an expected three-dimensional shape. *See, e.g.*, Ex. 1005, 17:27-36. The deviation is measured based on differences between a detected location and an estimated location of an image landmark, such as an eye corner or background object. *Id.*, 16:51-54, 17:2-11. Any capture of part of a user's face or head (other than the eye) is incidental, only helps to orient the system to determine distance, and must give way to the primary purpose of capturing the eye's vasculature.

195. Thus, in my opinion, Derakhshani does not disclose or teach determining a user's three-dimensionality by comparing the first data to the second

[redacted]

data, as required by elements 1[pre], [1f-i], 10[pre], 10[g-h2], 19[pre], and 19[d-e2].

196. In my opinion, for similar reasons, Derakhshani also does not disclose or teach claims explicitly requiring a user's "face," including claims 5 or 14. Derakhshani for example does not teach or suggest that a "face of the user is placed" into ovals on a screen (claim 5) or "determining that the user's face is three-dimensional occurs at a server" (claim 14). Again, as I explained above, the images in Derakhshani are of the eyes. Any captured images of a face are partial, at best, and Derakhshani does not teach capturing the face along with the vasculature of the user's eye. Nor, as I discussed above, would it be possible for Derakhshani to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality.

197. In my opinion, with the sensors in use at the time of the invention of the '606 patent, capturing a user's face with sufficient clarity would not make possible capturing the user's eye vasculature with sufficient clarity. Thus, in my opinion, a person of ordinary skill in the art would not have found it obvious or have found any reason to modify Derakhshani to capture images of a user's face. Moreover, in my opinion, modifying Derakhshani to capture images of a user's face would render Derakhshani's system inoperable for its original purpose:

[redacted]

measuring the vasculature of a user's eye.

c. **Derakhshani's "Landmarks" Are Not Biometric Data**

198. Independent claims 1, 10, and 19 require "first biometric data" (1[b], 10[c], 19[a]) and "second biometric data" (1[d], 10[e], 19[b]). Petitioner incorrectly asserts Derakhshani's "landmarks" are the claimed "first biometric data" and "second biometric data." Pet., 16 ("A POSITA would have understood Derakhshani's *facial-landmark* identification constitutes deriving "biometric *data*"") (emphases added), 17. In my opinion, this is incorrect.

199. Derakhshani's *image* landmarks do not constitute biometric data. Instead, they refer to objects (*i.e.,* an eye corner or background object) used to estimate depth and spatial metrics. Ex. 1005, 16:51-54; Fig. 6; *supra* §IX.A (discussing use of image landmarks for spatial metric). Even those *image* landmarks in Derakhshani that could correlate to a user's features (*i.e.*, an iris, eye corner, or ear) are not "biometric data" because they are not used to identify a user. Instead, Derakhshani merely uses these "landmarks" as reference points, not as identifying features of a user for authentication.

d. **Tanii Fails to Make Up for the Deficiencies of Derakhshani**

200. I understand that the Board found that the Petition's case relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. IPR2025-00106, Paper No. 17,

[redacted]

33. In my opinion, this finding makes it clear that Tanii does not make up for the deficiencies of Derakhshani. As I explained above, Derakhshani does not identify a face, determine three-dimensionality, or evaluate any expected distortions based on how a live, three-dimensional face would appear from different perspectives. Tanii likewise fails to perform any analysis or evaluations. Rather, it aesthetically corrects images captured at close range by enlarging peripheral regions relative to center. Ex. 1007, ¶[0056]. But this teaching fails to make up for the deficiencies in Derakhshani, as Tanii's process of enlargement does not involve detecting a user's face, three-dimensionality, or expected distortion patterns. In my opinion, Tanii's purported evaluation of distance-induced distortions does not make up for Derakhshani's spatial metric not being related to the three-dimensionality of a face. In my opinion, this purported evaluation of distance induced distortions also does not make up for Derakhshani not determining three-dimensionality of a user.

201. Moreover, contrary to the Board's statements about Tanii, it is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." IPR2025-00106, Paper No. 17, 33. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-

[redacted]

planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Sections IX.C and X.B.1, it is my opinion that Tanii would operate the same way whether a face or a non-face was presented. Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Derakhshani.

202. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality in [1f-i], 10[g-h2], and 19[d-e2]. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

203. Additionally, Petitioner's suggestion that images of different distances from the sensor have different distortion (Pet., 14) is not a motivation to combine.

[redacted]

The inventor of the ’606 patent already recognized that distortion effects are “more pronounced” the closer a face is to a lens. Ex. 1001, 29:10-43. This observation does not provide a reason to combine Tanii’s distortion correction with Derakhshani’s eye-vasculature authentication.

e. **The Petition Has Separately Failed to Show that Dependent Claims Are Obvious**

i. Interpolation Claims (Claims 2, 11)

204. Claims 2 and 11 of the ’606 patent require interpolating the first data and second data to obtain “estimated intermediate biometric data,” capturing a third image of a user at a “third distance from the user” that is between the first and second distances, processing the third image to obtain third biometric data, and comparing the estimated intermediate biometric data to the third biometric data. In my opinion, the Petition fails to demonstrate that these claims are unpatentable.

205. For claim element 2[a], the Petition asserts that a two-dimensional plane is “generated by interpolating the position of facial landmarks onto a single intermediate plane.” Pet. 24 (*citing* Ex. 1005, 17:12-16). In my opinion, this misunderstands Derakhshani’s discussion of the spatial metric. Derakhshani states that the locations of multiple landmarks are fit to a “closest” two-dimensional plane and the average distance is used to create the spatial metric. Ex. 1005, 17:19-22. There is no interpolation of any data to *generate* any planes; the landmarks are simply fit to an existing plane.

[redacted]

206. The Petition also argues that a POSITA would have been motivated to interpolate intermediate biometric data when modifying Derakhshani in view of Tanii. Pet., 25-26. In my opinion, this is also wrong. First, as explained above, Petitioner relies on "Derakhshani's interpolated modeling approach," which does not exist. Second, there would have been no motivation to combine Derakhshani with Tanii for the reasons that I explain further below in Section X.B.3.

ii. Claims Requiring Ears (Claims 3 and 12)

207. Claims 3 requires verifying presence of one or more features on the side of a user's head in a first image and verifying the absence or reduced visibility of those feature(s) in a second image. Claim 12 similarly requires verifying ears in a first image and verifying absence/reduced visibility in a second image. These limitations are not taught or suggested by either Derakhshani or Tanii, nor would a POSITA have been motivated to incorporate such functionality. In my opinion, Derakhshani does not teach verifying the presence, absence, or reduced visibility of any portion of the ear, nor does it suggest doing so. The reference is limited to capturing the vasculature of the eye, and any incidental capture of an ear is not used by the system to verify anything about that ear.

208. Derakhshani states that the eye images it captures could include a portion of an ear. *See*, *e.g.*, Ex. 1005, 16:51-54. But any incidental capture of the ear is as an *image* landmark used for estimating distance from a sensor to that

[redacted]

landmark. *Id.*, 16:51-17:2. In my opinion, an image including an ear does not mean *verifying* the presence, absence, or reduced visibility of an ear in any image, and nothing else in Derakhshani makes up for this deficiency. Moreover, Derakhshani's discussion using image landmarks for determining a spatial metric undercuts the idea of an ear being absent or having reduced visibility in an image. According to Derakhshani, image landmarks need to be visible for the spatial metric determination to take place. *Id.*, 16:51-17:2.

209. The Petition separately states that an ear would be blurry, and thus have "reduced visibility," if it were outside of the focal plane. Pet., 28-29. In my opinion, a blurry ear in a picture would not allow for calculation of Derakhshani's spatial metric. And regardless, as explained above, Derakhshani is merely using landmark as a method to estimate the degree of focus. In my opinion, Derakhshani does not *verify* the presence, reduced visibility, or absence of any ear.

210. The Petition suggests that Tanii teaches "the absence or presence of an ear is a natural result of changing the distance between the user and camera." Pet., 29. I do not disagree that ears can be present or absent in an image based on distance between the user and the camera. But there also is nothing in Tanii suggesting *verifying* presence, reduced visibility, or absence of ears in an image. As I discussed above, Tanii simply enlarges portions of an image proportionally to its center. The suggestion that a POSITA would have found it obvious to *verify*

[redacted]

ears lacks any support in Tanii or Derakhshani. In my opinion, the combination also would not have been obvious given that there is no teaching in Derakhshani or Tanii of identifying an ear's absence or reduced visibility.

2. '606 Grounds 2A-2C: The Proposed Zhang Combination Fails to Show All of the Claimed Elements

211. The Petition relies on Zhang as the foundation for each of its proposed Ground 2 combinations. In my opinion, this reference is insufficient. Zhang's comparison of color/intensity between a first warped image and a second image is different from the claims of the '606 patent. Regardless of what images or points are compared in Zhang, Zhang does not determine whether differences between two images have distortion expected based on a change in distance. It determines if color/intensity of distinct pixel regions as small as a single pixel ("feature points") match one another by more or less than some threshold. In my opinion, this is different from the '606's process of creating data from processing images and comparing that data to determine whether differences have the expected distortion resulting from camera or user movement between the images.

212. In my opinion, Tanii does not make up for the deficiencies in Zhang. Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. Even if it does, the mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Zhang. Indeed, Tanii's purported distortion-correction process cannot warp a close

[redacted]

image to accurately compare it to a further image as an indication of three-dimensionality. Tanii's warping at close range will fail to resemble the realities of a three-dimensional subject. And as I discuss further below in Section X.B.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Zhang Does Not Determine Expected Differences Based on Movement of Camera or User

213. The claims require comparing authenticating data from two images of a user to determine whether they exhibit expected differences, due to movement of the camera or user. Ex. 1001, 1[f], 10[g], and 19[d]. This comparison relates to authenticating the three-dimensionality and liveness of the user and relies on expected differences when the camera or user moves. Ex. 1001, 1[i], 10[h2], and 19[e2]. Zhang does not teach or suggest any such expected differences, and the Petition has not shown that it does.

214. Moreover, in my opinion, Zhang does not determine whether images exhibit expected differences or distortions consistent with the shape of a face due to movement of the camera or user. Zhang matches feature points across two images (a first image that has been warped and a second image) and compares pixel-level intensity differences around those points. Ex. 1006 ¶¶[0030]-[0034]. The comparison is based on whether the color or intensity difference exceeds a threshold. *Id.* The color/intensity difference identified in Zhang does not relate to expected differences that is based on movement of the camera or the user. In my

[redacted]

opinion, Zhang makes no prediction of how an image would change due to this movement, and no analysis of whether the observed differences conform to such a prediction.

215. Zhang's system simply compares pixel regions ("feature points") across two images and checks whether the pixel difference exceeds a numerical threshold. Ex. 1006, ¶[0033] ("If the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a face that is a live face."). In my opinion, determining pixel regions of two images differing by color/intensity does not teach the requirement 1[f], 1[i], 10[g], 10[h2], 19[d], or 19[e2] to determine "expected differences," because determining pixel differences alone does not evaluate whether observed differences are consistent with what would be expected from a *change in distance* (*i.e.*, distortion due to perspective, parallax, or other depth-related effects). *See* Ex. 1001, 46:33-35, 40-44, 47:47:50-53, 57-60, 48:59-63, 49:2-7. Indeed, Zhang's method does not relate to expected distortion or how a user should look at different distances. Zhang makes no prediction of how an image would look or whether the observed differences conform to its prediction.

216. In short, Zhang's method of comparing pixel intensity values at feature points does not teach or suggest the claimed comparison of data to determine expected distortion resulting from movement. And Petitioner does not

[redacted]

explain how Tanii would fill this gap. Pet., 54-57.

b. **Petitioner Inconsistently Treats the Claimed "First Data" as Both Feature Points and Facial Feature Locations**

217. All independent claims require comparing "biometric data" processed or generated from images, at least at 1[f], 10[g], and 19[d]. Like with its position on Derakhshani, the Petition and Dr. Daft confuse a "feature point" with a "selected location." Pet., 54-55. In my opinion, this ground must fail as well.

218. As I discussed above, feature points are used to *generate* matrix *H* while selected locations (or "facial-feature locations" as Petitioner mistakenly calls them) are used to compare images *using* matrix *H*. Ex. 1006, ¶¶[0026]-[0034], claim 3, Fig. 3.

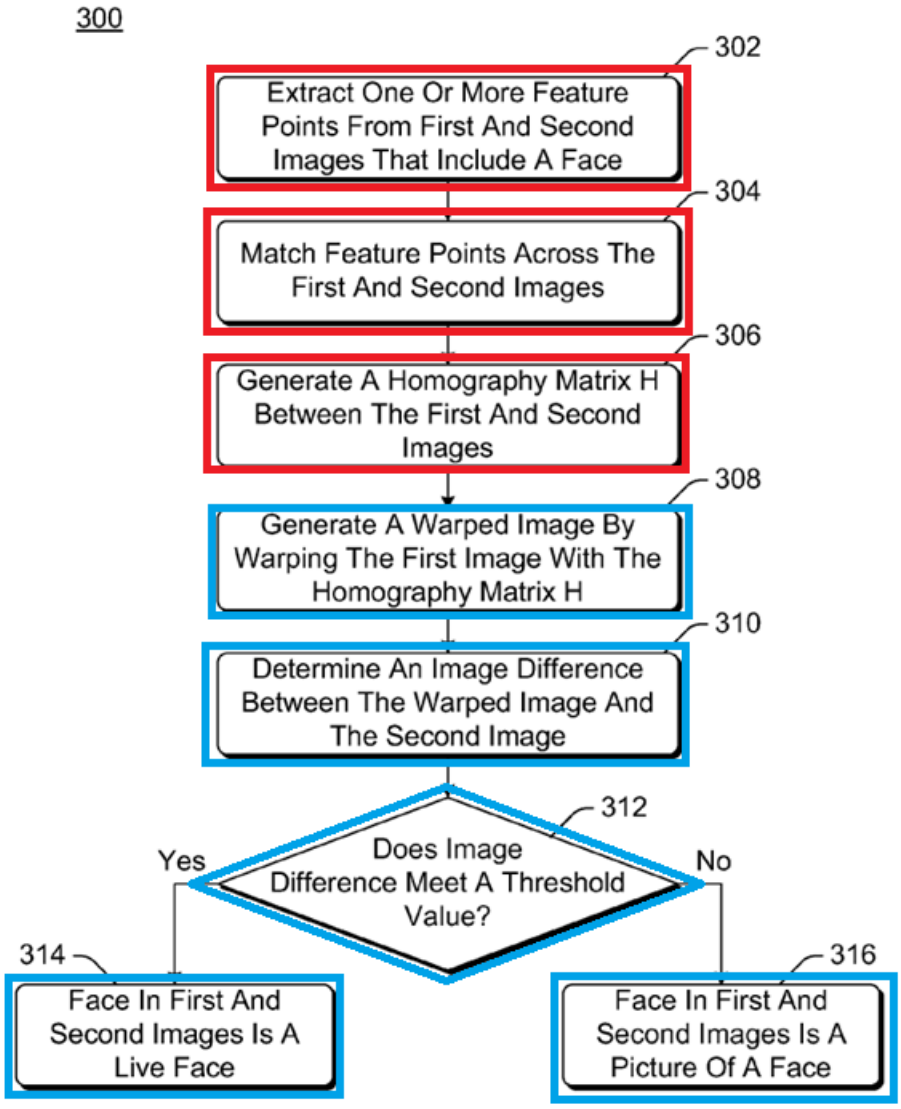


Fig. 3

219. For the "processing" (1[b], 1[d], 10[c], 10[e]) and "receiving" (19[a-b]) steps, Petitioner maps Zhang's "*feature points*" from a first image and a second image to "first data" and "second data," respectively. Pet., 51 ("Zhang discloses processing the first image to extract '*feature points*'…POSITA would have understood these *extracted feature points* to be biometric data…") (emphases

[redacted]

added), 63 ("Zhang discloses processing the second image to obtain *second feature-point data from the image*") (emphasis added); Ex. 1003, ¶¶512-14, 519-20. Petitioner admits that "feature points" are specific markers in individual images: "a corner of an eye, a corner of a mouth, [or] a tip of a nose." Pet., 51 (quoting Ex. 1006, ¶[0027]). They may be as small as a single pixel. Ex. 1006, ¶[0027].

220. But when mapping "first data" in the "comparing" elements (1[f], 10[g], 19[d]) the Petition abandons its earlier position, asserting instead that "first data" is "*selected locations*"—what it refers to without support as "facial-feature locations"—in a warped first image. Pet., 54 (referring to comparison between "*selected locations*"). Unlike "feature points" which are specific markers in individual images, "selected locations" are locations that that are compared across the warped and second images. Ex. 1006, ¶[0032].

221. Regardless of whether the Petition believes "feature points" from a first image *or* "selected locations" across the warped and second image constitute the "first data" in 1[d5], the two are not equivalent to one another and, in my opinion, the Petition's position treating them identically is fatal.[3]

[3] The Petition's citations to entirely different portions of Zhang for "first data" in 1[b] and 1[f] is further evidence that "feature points" and "selected locations" are

[redacted]

c. Zhang's "Feature Points" Are Not Biometric Data

222. The Petition incorrectly asserts Zhang's "feature points" are the claimed "first biometric data" (1[b], 10[c], 19[a]) and "second biometric data" (1[d], 10[e], 19[b]). Pet., 51 ("POSITA would have understood these extracted feature points to be biometric data") (emphases added), 53. In my opinion, this is incorrect.

223. Feature points may be as small as a single pixel. Ex. 1006, ¶¶[0026]-[0027]. And despite the suggestion that pixels at "a corner of an eye, a corner of a mouth, [or] a tip of a nose" could suffice, there is no indication that they are used for authentication or matched against stored biometrics. They are only used for generating a matrix *H* and cannot be "biometric data." Ex. 1006, ¶¶[0030]-[0034].

d. Zhang in View of Tanii Fails to Teach the Independent Claims

224. It is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." IPR2025-00106, Paper No. 17, 32-33. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072],

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not synonymous. *Compare* Pet., 51 ("feature points" in ¶[0027] for 1[b]'s "first data"), *with* 54 ("selected locations"/"facial-feature locations" in ¶¶[0031]-[0032] for 1[f]'s "first data").

[redacted]

[0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Section X.B.1.d, it is my opinion that Tanii would operate the same way whether a face or a non-face were presented. Indeed, Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Zhang.

225. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

[redacted]

e. The Petition Has Separately Failed to Show that Certain Dependent Claims Are Obvious

i. Interpolation Claims (Claims 2 and 11)

226. For reasons similar to those discussed above with respect to Derakhshani, Zhang also fails to teach dependent claims 2 and 11 which require interpolation or modeling of expected distortion between images. Zhang does not interpolate between images or model expected distortion.

227. Instead, as discussed above, Zhang compares a warped version of a first image to a second image using pixel-level intensity differences. Ex. 1006, ¶¶[0030]-[0034]. The comparison is threshold-based, such that if the difference exceeds a threshold, the face is deemed live; otherwise, it is deemed flat. *Id.* But this comparison between pixel regions means Zhang does not model expected distortion, interpolate between data sets, or predict how the image should change due to movement. Indeed, Zhang's process estimates planar motion between two images, but does not model the expected distortion that would result from movement of a nonplanar, three-dimensional face. Zhang's alleged interpolation aligns one image to another under the assumption that the feature points lie on a flat surface. It does not interpolate to generate intermediate data or predict how the image should change due to actual movement of a three-dimensional object. Thus, Zhang's interpolation is fundamentally different from the interpolation recited in claim 2, which involves modeling expected distortion patterns between images.

[redacted]

ii. Claims Requiring Ears (Claims 3 and 12)

228. As I discussed above with respect to Derakhshani, these claims require verifying the presence of a user's ears in an image and verifying the absence or reduced visibility of those ears/features in the second image. See above, Section X.B.1.e.ii. The Petition agrees that Zhang fails to teach verifying presence, absence, or reduced visibility of ears/features. Pet., 61. The Petition then asserts that Tanii makes up for the deficiencies in Zhang, making a similar case as it did with Derakhshani (discussed above in Section X.B.1.e.ii). (*Compare* Pet. 29-31 *with* 61-63.)

229. For reasons similar to those I discussed above in Section X.B.1.e.ii, it is my opinion that Tanii fails to make up for the deficiencies in Zhang. For example, Tanii simply enlarges portions of an image proportionally to its center. The suggestion that a POSITA would have found it obvious to *verify* ears lacks any support in Tanii or Zhang. In my opinion, the combination also would not have been obvious given that there is no teaching in Zhang of identifying an ear's absence or reduced visibility.

3. Tanii Cannot Cure the Deficiencies of the Other References

230. As explained, Tanii performs aesthetic image correction; it does not evaluate distortions. It is also not analogous art to the challenged patent. It purports to remove distortion, which Derakhshani and Zhang use to operate. The Petition's

[redacted]

proposed combinations would require significant distortions of Derakhshani and Zhang. And those in the field of biometric security—unlike Dr. Daft—would have had no reason to look to Tanii, which focuses on making images visually pleasing.

a. **Tanii Is Not Analogous Art**

i. Tanii Is Not from the "Same Field of Endeavor"

231. In my opinion, Tanii is not from the same field of endeavor as the '606 patent. Indeed, I understand that Dr. Daft does not argue that Tanii is from the same field of endeavor as the '606 patent. Ex. 1003, ¶110.

232. And that is correct. While I understand that the Petitioner asserted during this proceeding that Tanii is analogous because it and the '606 patent are both "concerned with identifying and accounting for distortions of [3D] faces in images captured using a camera," Pet. Reply 5, this is too simplistic of an understanding of the '606 patent. The '606 patent uses the distortion that Tanii tries to remove. In my mind, it cannot be said that the two are from the same field of endeavor.

233. Some analogies may help here. Imagine two systems: the first removes color from color images, and the second uses color from color images to segment them into meaningful regions. While both of these hypothetical systems identify color, only the second hypothetical system meaningfully "accounts" for color. The first hypothetical system acknowledges and processes color only to

[redacted]

remove it, while the second is an "accounting" of color by using it to determine the contents of images. Notably, in this analogy, the first system's removal of color prevents the second system's use of that color for segmentation, but not vice versa.

234. Another analogy is in the area of animal husbandry: one disclosure relates to milking a dairy cow while another relates to slaughtering a cow for beef. Again, while both "account" for cows on a farm, the way that they are accounted for are fundamentally different – and result in vastly different outcomes for the cow. Indeed, a dairy cow is leveraged for its milk production, whereas a beef cow is processed in a destructive way, slaughtering the cattle. Each of these analogies is instructive in evaluating Tanii's treatment of distortion because Tanii does not "account for" distortion in the sense required by the claims. Rather, Tanii assumes distortion exists and then corrects for it by warping the image to produce a natural, more user-friendly image for a viewer. "Accounting for" requires more, such as modeling, measuring, or using distortion to extract or analyze information. Tanii does not do this.

235. In my opinion, one of ordinary skill in the art would not believe that Tanii is from the same field of endeavor as the '606 patent.

ii. Tanii's Distortion Correction Shows that It Is Not "Reasonably Pertinent" to the Problems Faced in the '606 Patent

236. The Petition admits that the problem faced by the '606 patent's

[redacted]

inventor claims a system to "distinguish a three-dimensional face from a two-dimensional picture of a face." Pet., 3-4. Facial-recognition systems can be fooled (or "spoofed") by an impostor presenting a picture of an authorized face. *Id.*; *see also* Ex. 1003, ¶66 (understanding that the '606 patent described "countermeasures to prevent 'spoofing' attacks on facial-recognition systems …").

237. In my opinion, Tanii does not teach anything that would be reasonably pertinent to this problem. I understand that the Board found Tanii reasonably pertinent, stating that its "relevant teaching" is that "a three-dimensional face exhibits distortions when a cellular phone camera and a face are close together during image capture." IPR2025-00106, Paper No. 17, 47-48. In my opinion this alleged teaching would not be helpful. The inventor had already recognized this long-understood issue as a problem, and the '606 patent uses that distortion to meet its ends. *See*, *e.g.*, Ex. 1001, 29:10-43. The only teaching in Tanii relevant to distortion is removing it. Pet., 12-16.

238. The '606 patent solves the spoofing problem by "looking for" the perspective distortion that occurs because of the distance between a three-dimensional face and a camera. Pet., 4; Ex. 1003, ¶67; *see also* Ex. 1001, 30:7-23, 31:3-46 (determining that a "two-dimensional picture" is not being presented by validating an "expected pattern of distortion of [] intermediary images" at different distances).

[redacted]

239. Tanii, on the other hand, does not do anything to solve the problem faced by the '606 patent: preventing spoofing. Tanii does not even detect distortions. Tanii assumes and corrects distortion by enlarging the peripheral areas of an image, regardless of whether the image is of a distorted face.

240. In my opinion, the Board's discussion of combining Tanii with Derakhshani makes clear that Tanii does not solve this problem nor is it in any way relevant to it. The Board found that Tanii was only relied upon for "its teaching of evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." IPR2025-00106, Paper No. 17, 47-48. This single concept of evaluating distortions does not provide any solution to the spoofing problem.

241. Tanii works against the challenged claims, by removing the very thing that enabled the patent's inventor to solve the spoofing problem. The "critical feature" the Petition acknowledged (correcting image distortion, Ex. 1003, ¶113) would prevent each reference from operating as taught by the '606 patent. Thus, a POSITA would not have reasonably expected to solve the '606 patent's spoofing problem using Tanii and would not have looked to Tanii for any teaching to do so.

242. In my opinion, Tanii is also not reasonably pertinent for the additional reason that it does not have the "same purpose as the claimed invention" of the '606 patent. Tanii's purpose is to correct image distortion, rather than use it. *See*, *e.g.*, Ex. 1003, ¶¶110, 113. Whereas the claimed invention's purpose is to determine

[redacted]

three-dimensionality *using* image distortion. *See*, *e.g.*, Ex. 1001, 46:29-44 (comparing expected differences and distortions). Thus, Tanii's competing purpose would have also prevented a POSITA from considering it and would have rendered Tanii not reasonably pertinent to the '606 patent.

b. **A POSITA Would Not Have Combined the References as the Petition Suggests in Either Grounds 1 or 2**

243. Even if Tanii were analogous art here, it is my opinion that there would have been no motivation to combine it with Derakhshani or Zhang. In my opinion, either combination would destroy the basic objective of the respective primary reference, rendering it inoperable for its intended purpose.

244. The Petition admits that Derakhshani and Zhang require distortions to operate. Derakhshani allegedly determines whether a face is three-dimensional using distortions—"different amounts of blur" or "parallax"—across multiple images. Pet., 7-8; Ex. 1003, ¶¶182 ("Derakhshani's focus-distance approach *looks for expected distortions in the blurriness* or clearness of facial landmarks . . . "), 400 ("there may be other optical effects (e.g., *distance-induced distortion*) that are more apparent in the closer image than the further one"), 885 ("*more parallax*" between images helps to "verify the face as three-dimensional") (emphases added). And Zhang allegedly generates a "warped" first image of a face, matching it to a second image to determine whether the differences meet a threshold; if so, the

[redacted]

warped image is determined to represent a real (three-dimensional) face. Pet., 44-45.

245. The Board noted that

> Petitioner proposes to modify 'Derakhshani . . . to capture at least two images at different actual distances and evaluate whether they exhibit different degrees of distance-induced (barrel/fish-eye) distortion, as Tanii suggests.' Pet. 14–15 (citing Ex. 1003 ¶881). Thus, Petitioner relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. *Id.* Petitioner does not propose to modify Derakhshani by incorporating Tanii's teaching of correcting the distortion.

246. IPR2025-00106, Paper No. 17, 32-33. For reasons similar to those I discussed above, I disagree that Tanii teaches "*evaluating* distance-induced distortions in a face caused by the camera's distance from the object." Indeed, it does not identify distance-induced distortions, as the Petition contends. Pet., 46; Paper No. 17, 18. Its teachings relate to correction of images by removing the distortion Derakhshani and Zhang allegedly use. The Petition specifically asserts that Tanii's "*critical feature*" is to provide a "procedure to *correct* . . . distance-induced *distortion* . . . to produce an *undistorted image*," *i.e.*, provide a natural-appearing (undistorted) image for a viewer. Ex. 1003, ¶113 (emphases added); *see*

[redacted]

also ¶¶110-112; Pet. 10-12. And Tanii's teaching is further limited because it does not determine whether an image requires correction (Ex. 1007, ¶[0058]); it merely assumes it does.

247. In my opinion, doing so on images captured by Derakhshani and Zhang would prevent detection of three-dimensionality, rendering a system which is non-functional for its intended purpose and would destroy the principle of operation of those references.

248. In my opinion, POSITA would not have been motivated to combine Derakhshani with Tanii for additional reasons. For example, as I discussed above (Sections IX.A and X.B.1.d), any distance-induced distortions found in Derakhshani would be in pictures that are taken at very close range. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features—let alone an entire face or a head—in any image.

249. To be clear, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '606 patent

[redacted]

(August 2014). In contrast, Tanii's correction method is designed for images captured at arm's length using wide-angle lenses (Ex. 1007, ¶[0047]), making it incompatible with Derakhshani's eye-only imaging.

250. For at least these reasons, it is my opinion that a person having ordinary skill in the art would not have combined Derakhshani with Tanii.

251. As it relates to Zhang, it is also my opinion that a POSITA would not be motivated to combine. I understand that the Petition identified three different possible ways in which a person of ordinary skill in the art would have been motivated to combine Zhang and Tanii. Pet., 47-48; Paper No. 17, 17 (identifying the three ways). In my opinion, a person of ordinary skill in the art would not have been motivated to combine these references for the identified three reasons or any other reason.

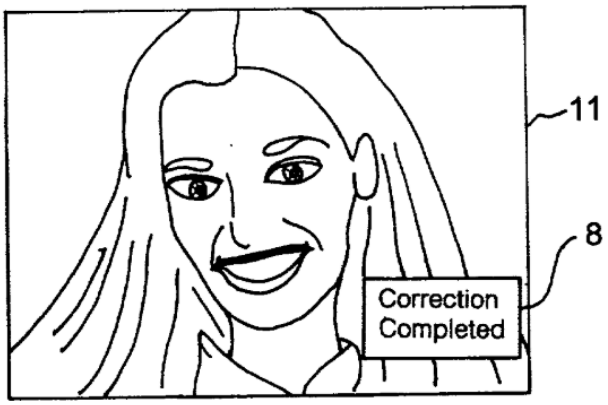
252. The first reason for allegedly combining Zhang and Tanii identified in the Petition is that

> a POSITA would have been motivated to use Zhang's existing process, but take advantage of the *distance-induced distortions identified by Tanii* by using a (wide-angle) camera that induces these distortions at different distances, and capturing two images of the face at different distances, because Zhang's procedure would identify the two images as different due to the differences in distance-induced distortion and verify three-dimensionality.

[redacted]

253. Pet., 47; Paper No. 17, 17. In my opinion, this is incorrect. As I discussed above, Tanii does not teach identifying the distance induced distortions that the Petition asserts it does. See, for example, Sections X.B.1.d and X.B.2.d. Tanii is limited to warping/correcting an image regardless of whether distortions are present or not. In my opinion, this is the motivation behind the "Correction Completed" annotation on the corrected image in Figure 9 of Tanii:

Fig.9



254. Tanii explains that this annotation enables the user to "easily recognize whether or not warp correction was performed." Tanii, ¶[0058]. In my opinion, this is because the system in Tanii cannot determine whether an image requires correction or not.

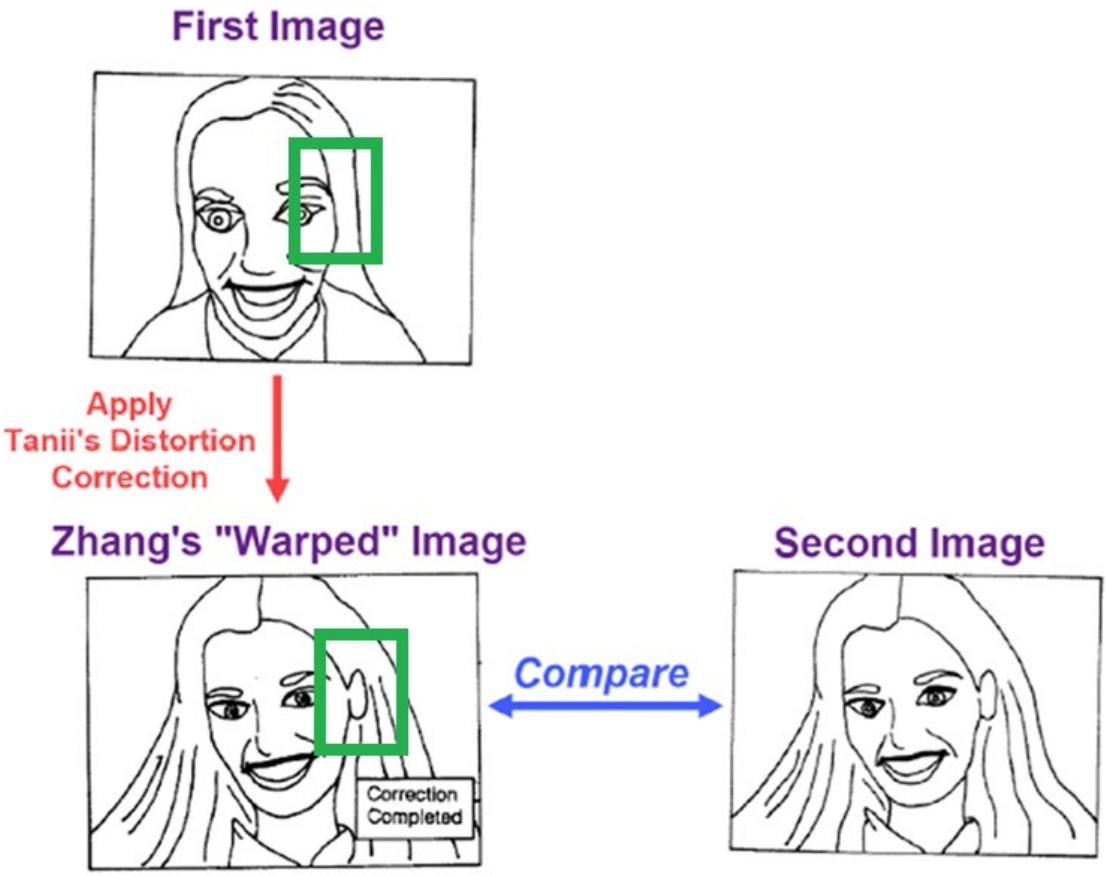
255. The second reason for allegedly combining Zhang and Tanii identified in the Petition is

> a POSITA would "warp" (i.e., correct) the "close" image using Tanii's distortion-correction procedure to compare

[redacted]

> it to the "far" image and evaluate the two for differences . . . if the "warped" (corrected) image and second image are sufficiently similar, that indicates a three-dimensional face. . . . A POSITA would have appreciated this modification would reduce spoofing of Zhang's system (which only evaluates whether a face is non-planar, which can be spoofed), and provides a simpler mathematical operation that may require less computational resources.

256. Pet., 47-48; Paper No. 17, 17. In my opinion, this is incorrect. The proposed process would not work. For example, the Petition asserts that applying Tanii's distortion correction would lead to a "warped" image that can be compared to a second image. But the Petition depicts ears that cannot be seen in the First Image appearing in the "Warped" image without explanation, as I have annotated below:



257. Pet., 48 (ear locations annotated in **green**). Ears that cannot be seen from a short-range image would not miraculously appear after Tanii's purported distortion correction. Tanii's system would merely make the warped image appear more natural. Thus, Petitioner relies on a modification that is neither taught nor suggested by the references.

258. The third reason for allegedly combining Zhang and Tanii identified in the Petition is

> when evaluating two images for different degrees of distance-induced distortion, the two images (one "close",

[redacted]

> one "far") could be compared directly to determine whether they exhibit expected differences in degree of distance-induced distortions.

259. Pet., 49; Paper No. 17, 17. In my opinion, this is incorrect. There would be no way to "eliminat[e] the need to mathematically transform an image" and directly compare two images without performing the same basic calculations. The Petition fails to explain how two images could be directly compared to one another – particularly because one of the images is distorted and merely overlaying the images as the Petition has done would not yield the result that the Petition implies.

260. Dr. Daft's declaration vaguely asserts that this third combination requires that "facial features would be mapped in each image, matched between the two images, and evaluated to determine whether differences attributable to distance-induced distortion appear." Ex. 1003, ¶1020. None of these facial-feature-matching steps even appear in Zhang or Tanii. Dr. Daft does not assert that they do, instead inventing an entire set of operations, matching, and evaluations out of whole cloth. Ex. 1003, ¶¶1020-21.

261. And while Dr. Daft asserts that a POSITA would have been motivated to combine the references with Tanii, in my opinion, an actual POSITA in the relevant field would have had no reason to look to Tanii in the first place. Tanii's teachings relate to correcting image distortion to create a more pleasing picture.

[redacted]

Making visually aesthetic images is irrelevant to the problems faced in the biometric security field, and Dr. Daft's spurious reasoning—that it allegedly teaches evaluating distortions—falls flat because Tanii does not teach evaluating distortions at all. Even if Tanii "evaluat[es]" distance induced distortions, that concept would not provide a reason for POSITA to use that reference to teach the claims. Including the concept of evaluating distortions would still leave significant gaps in the claims.

C. '938 Patent

1. '938 Grounds 1A-1C: The Proposed Derakhshani Combination Fails to Show All of the Claimed Elements

262. In my opinion, Derakhshani detects spoofing based on the visible vasculature (blood vessels) of a user's eye, not a user's face. The reference itself does not even include facial images. While the Petition includes facial images throughout its discussion of that reference, I understand that these images come from, for example, exhibits 1011 and 1012 (unrelated patents (Baldwin and Hanna)) on pages 8 and 9 of the Petition) or were created by Dr. Daft (pages 10 and 29; *see* Ex. 1003 ¶¶107-108).

263. In my opinion, any distance-induced differences found in Derakhshani would occur at very close range, as all of the images need to capture the vasculature of the eye with sufficient clarity to authenticate the user. The distance in both photos would need to be so close that there would be no way to

[redacted]

meaningfully capture other facial features (aside from the eye) in either image.

264. In my opinion, Tanii does not make up for the deficiencies in Derakhshani. I understand that the Board earlier found that the Petition relies on Tanii only for "its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object" (Paper No. 17, 18). The mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Derakhshani.

265. In my opinion, Tanii does not, in fact, "evaluat[e]" whether one or more images exhibit different degrees of distance-induced distortions as the Board found critical to Petitioner's position. Instead, Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. And as I discuss in Section X.C.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Derakhshani's "Spatial Metric" Does Not Represent the Face's Three-Dimensionality

266. The Petition contends that Derakhshani's "spatial metric" is calculated "for the entire face" and represents whether a subject's face is three-dimensional. Pet., 7. I disagree. It is not calculated for the entire face—no "entire face" is ever captured—and does not represent three-dimensionality.

267. Derakhshani's spatial metric is not a measure of any aspect of a user's face, let alone a user's "entire face", and is not indicative of the three-

[redacted]

dimensionality of a user's face or head, as required by at least 1[pre], 1[c-d], 8[pre], 8[f-g], 17[pre], 17[d-g], 20[pre], and 20[f-h2]. Derakhshani's spatial metric is based on images of the eye taken at different focus distances (Ex. 1005, 1:57-2:3), each distance needing to be close enough to capture the characteristics of the eye.

268. As I expand further below, Derakhshani is designed around capturing the vasculature (blood vessels) of a user's eye; it does not involve facial recognition or depth analysis of the user's head or face. In my opinion, this reference is unrelated to the teachings of the '938 patent, which require authenticating a user's three-dimensionality and liveness as a function of the expected distortion between two images resulting from the capture of images at two different distances (*e.g.*, Ex. 1001, claim 1).

269. Moreover, the spatial metric is "a measure of deviation of the subject from a *two-dimensional plane* . . . [or] an *expected three-dimensional shape*." Ex. 1005, 3:1-6, 17:27-36 (emphasis added). In my opinion, this expectation in Derakhshani presumes a known plane or known model of an "expected" shape, and compares captured images to that expected plane shape. The claims of the '938 patent, however, performs what I see as a different process: determining whether data from captured images have the "expected differences" resulting from the capture of images at two different distances.

[redacted]

b. **Derakhshani Captures Only the Vasculature of a User's Eyes, Not the User's Face**

270. In my opinion, Derakhshani does not teach facial liveness detection by determining a user's three-dimensionality, as required by at least 1[pre], 1[c-d], 8[pre], 8[f-g], 17[pre], 17[d-g], 20[pre], and 20[f-h2]. Derakhshani does not capture or determine anything about a user's "face," as required by all independent claims. Derakhshani is directed to biometric authentication using eye vasculature. Indeed, it is explicitly directed to "biometric authentication based on *images of the eye*." Ex. 1005, Abstract; 1:5-7 (emphasis added). Derakhshani captures images of the white of the eye (sclera) 230, iris 220, and pupil 210, and analyzes vasculature patterns 240 in the conjunctiva and episcleral. *Id.*, 5:1-40, Fig. 2:

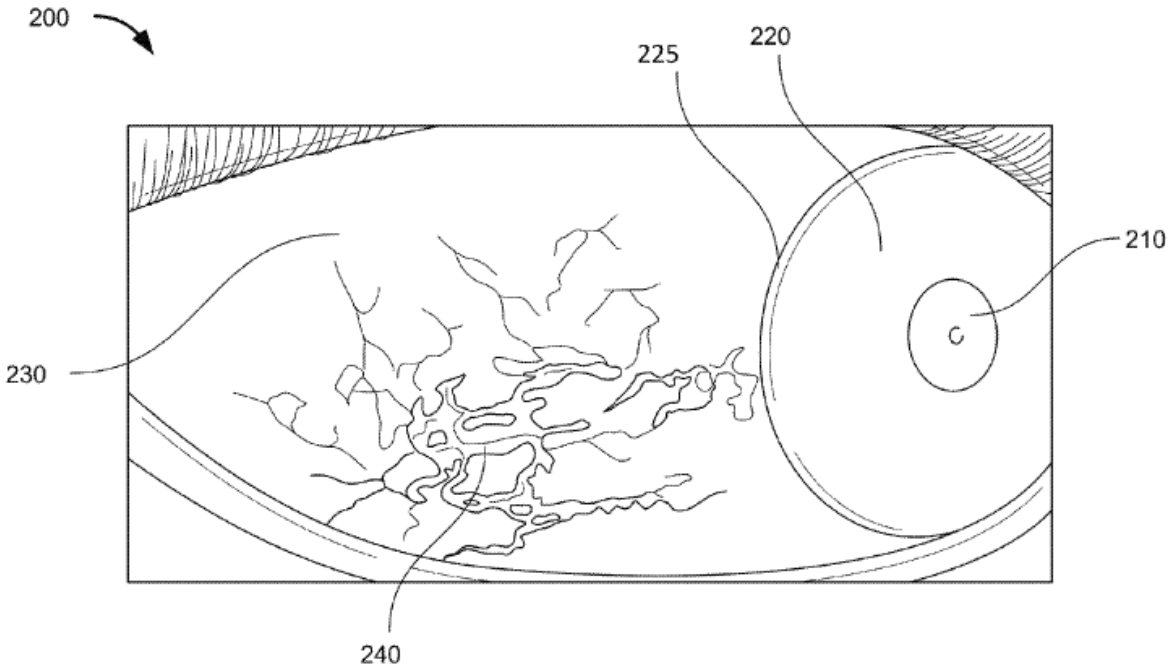


FIG. 2

[redacted]

271. Derakhshani describes three types of metrics associated with images of the eye: behavioral, spatial, and reflectance. "Behavioral" metrics are based on detected movement of the eye, such as pupil constriction or gaze transitions, and are measured by analyzing sequences of images (Ex. 1005, 2:12-17, 15:51-16:43); "spatial" metrics are derived from the apparent depth of image landmarks in an image of the eye based on different focus distances (*Id.*, 2:17-21, 16:44-18:7); and "reflectance" metrics are based on changes in glare or specular reflection patterns on the eye's surface (*Id.*, 2:21-26, 18:8-19:11). Each of these methods relies on characteristics of a user's eye. *See*, *e.g.*, *id.*, 4:19-21 (capturing "features of an individual's visible vasculature in the whites of the [individual's] eyes … to identify or authenticate the individual").

272. The focus on the eye is consistent with Derakhshani's purpose to identify and evaluate the vasculature of the user's eye for authentication – not a face. Contrary to the Petition's suggestion, Derakhshani's disclosure is silent as to capturing images of the user's face or head, and it does not suggest that the system could be adapted to capture these features. Pet., 15. Indeed, despite the assertion that faces are imaged in Derakhshani (*see, e.g.*, Pet., 16, 18), there are no images of any faces in the reference. *See, e.g.*, *id.*, Figs. 1-4 (depicting eyes and/or cross-sections of eyes):

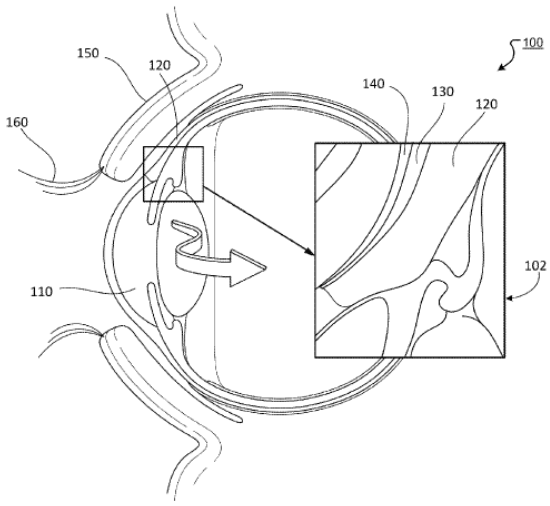


FIG. 1

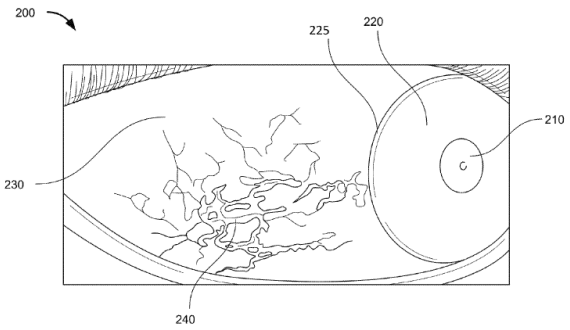
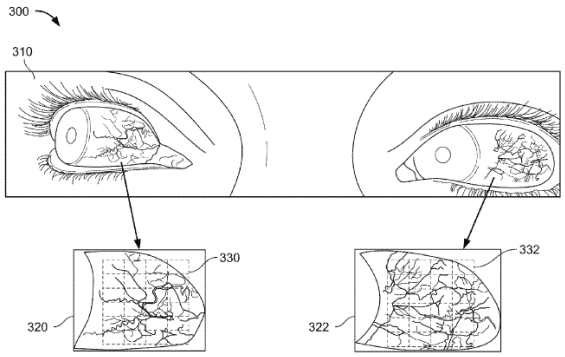
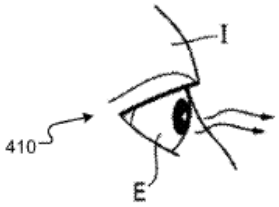
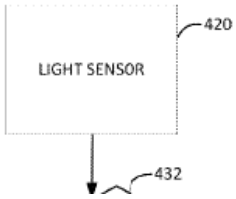


FIG. 2







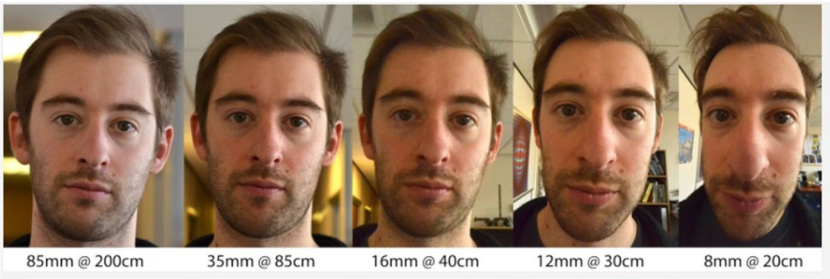
273. Each figure of the user is focused only on the user's eye. It stands to reason, in my opinion, that these figures represent images that would have to be taken from a distance that would support measuring the vasculature of that eye. Among the few references to a "face" involve presenting a picture of a face as one way to *spoof* the system rather than a legitimate presentation of the user for authentication (4:24-31) and prompting a user to "face" a sensor in order to picture the user's sclera (9:10-26).

274. Moreover, Derakhshani's focus on capturing the vasculature of the

[redacted]

eye effectively excludes the possibility of capturing the user's face or his or her three-dimensionality, and thereby authenticating the user, as claimed in the '938 patent. *See* Ex. 1001, e.g., 1[pre], 1[a-d], 8[pre], 8[a], 8[d], 8[f-g], 17[pre], 17[a], 17[c], 17[e-g], 20[pre], 20[a], 20[d], 20[f-g]. In my opinion, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '938 patent (August 2014).

275. Just as one example, the Petition provided exemplary images of a user's face at varying distances. Ex. 1022. The closest distance provided is 20 cm. 20 centimeters is about 2-3x further away than Derakhshani's envisioned distance.



276. And the type of sensors used to capture eye vasculature at the time of the invention of the '938 patent would not be able to simultaneously capture the vasculature of an eye *and* a face with enough precision to enable determination of

[redacted]

three-dimensionality or authentication. For example, the sensors capable of detecting the fine vasculature of an eye required close-range, high-resolution optics, and were designed to capture images from a very short distance. When that sensor is moved back to capture a user's face or head, the resolution becomes inadequate to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality. Thus, in my opinion, attempting to use the sensors in Derakhshani to capture a face or head as proposed by the Petition, or modifying them to do so, would prevent capture of the vasculature of the eye. In my opinion, this would also render Derakhshani's system inoperable for its original purpose.

277. In my opinion, Derakhshani is narrowly focused on ocular biometrics and analyzing vasculature patterns of the eye. For example, Derakhshani's spatial metric is based on deviations of a user from an expected three-dimensional shape. *See, e.g.*, Ex. 1005, 17:27-36. The deviation is measured based on differences between a detected location and an estimated location of an image landmark, such as an eye corner or background object. *Id.*, 16:51-54, 17:2-11. Any capture of part of a user's face or head (other than the eye) is incidental, only helps to orient the system to determine distance, and must give way to the primary purpose of capturing the eye's vasculature.

278. Thus, in my opinion, Derakhshani does not disclose or teach

[redacted]

determining a user's three-dimensionality by comparing the first data to the second data, as required by elements [1d], 8[f-g], and 17[d-g]. Nor does Derakhshani teach or suggest determining that the user does not exhibit the expected degree of three-dimensionality as claim 20. First, there is no image of a user's face. Second, the Petition's case rests on a comparison of two images to one another rather than the analyzing of respective first data and second data as required by 20[h1] and 20[h2].

279. In my opinion, for similar reasons, Derakhshani also does not disclose or teach dependent claims explicitly requiring a user's "face," including claims 9, 11, 12, 14, or 16. Derakhshani for example does not teach or suggest "additional images" of "the user's face" (claim 9), aligning a "face of the user" in on "on the screen shape" (claim 11), images being captured at a "first distance" or a "second distance" from "the user's face" (claim 12), moving a camera "toward or awa from the user's face" (claim 14), or that the "face of the user is held steady" (claim 16). Again, as I explained above, the images in Derakhshani are of the eyes. Any captured images of a face are partial, at best, and Derakhshani does not teach capturing the face along with the vasculature of the user's eye. Nor, as I discussed above, would it be possible for Derakhshani to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality.

[redacted]

280. In my opinion, with the sensors in use at the time of the invention of the '938 patent, capturing a user's face with sufficient clarity would not make possible capturing the user's eye vasculature with sufficient clarity. Thus, in my opinion, a person of ordinary skill in the art would not have found it obvious or have found any reason to modify Derakhshani to capture images of a user's face. Moreover, in my opinion, modifying Derakhshani to capture images of a user's face would render Derakhshani's system inoperable for its original purpose: measuring the vasculature of a user's eye.

c. **Derakhshani's "Landmarks" Are Not Biometric Data**

281. Independent claims 1 and 17 recite "first biometric data" (1[a], 17[d]) and "second biometric data" (1[b], 17[d]). Ex. 1001, 38:17-24. The Petition incorrectly asserts Derakhshani's "landmarks" are the claimed "first biometric data" and "second biometric data." Pet., 16 ("A POSITA would have understood Derakhshani's *facial-landmark* identification constitutes deriving "biometric *data*"") (emphases added), 17. In my opinion, this is incorrect.

282. Derakhshani's *image* landmarks do not constitute biometric data. Instead, they refer to objects (*i.e.,* an eye corner or background object) used to estimate depth and spatial metrics. Ex. 1005, 16:51-54. Even those *image* landmarks in Derakhshani that could correlate to a user's features (*i.e.*, an iris, eye corner, or ear) are not "biometric data" because they are not used to identify a user.

[redacted]

Instead, Derakhshani merely uses these "landmarks" as reference points not as identifying features of a user for authentication.

d. Tanii Fails to Make Up for the Deficiencies of Derakhshani

283. I understand that the Board found that the Petition's case relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. Paper No. 17, 18. In my opinion, this finding makes it clear that Tanii does not make up for the deficiencies of Derakhshani. As I explained above, Derakhshani does not identify a face, determine three-dimensionality, or evaluate any expected distortions based on how a live, three-dimensional face would appear from different perspectives. Tanii likewise fails to perform any analysis or evaluations. Rather, it aesthetically corrects images captured at close range by enlarging peripheral regions relative to center. Ex. 1007, ¶[0006]. But this teaching fails to make up for the deficiencies in Derakhshani, as Tanii's process of enlargement does not involve detecting a user's face, three-dimensionality, expected distortion patterns, or characteristics indicating capture at different distances. In my opinion, Tanii's purported evaluation of distance-induced distortions does not make up for Derakhshani's spatial metric not being related to the three-dimensionality of a face. In my opinion, this purported evaluation of distance induced distortions also does not make up for Derakhshani not determining three-dimensionality of a user.

[redacted]

284. Moreover, contrary to the Board's statements about Tanii, it is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 18. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Sections IX.C and X.C.1, it is my opinion that Tanii would operate the same way whether a face or a non-face was presented. Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Derakhshani.

285. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-

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dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences or distortions, or determining three-dimensionality in at least [1c-d], 8[f-g], 17[d-g], and 20[f-h2]. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

286. Additionally, Petitioner's suggestion that images of different distances from the sensor have different distortion (Pet., 12-13) is not a motivation to combine. The inventor of the '938 patent already recognized that distortion effects are "more pronounced" the closer a face is to a lens. Ex. 1001, 28:37-61. This observation does not provide a reason to combine Tanii's distortion correction with Derakhshani's eye-vasculature authentication.

e. The Petition Has Separately Failed to Show that Dependent Claims Are Obvious

i. "Comparing" First Data to Enrollment Image (Claim 5)

287. The Petition fails to demonstrate unpatentability claim 5 because it confuses biometric features used for enrollment and image landmarks used for determining a spatial metric.

288. Claim 1 requires receiving or deriving "first data" (1[a]) and "second data" (1[b]). Ex. 1001, 38:17-24.

289. The Petition asserts Derakhshani's "landmarks" are the claimed "first

[redacted]

data" and "second data." Pet., 16 ("A POSITA would have understood Derakhshani's *facial-landmark* identification constitutes deriving "biometric *data*"") (emphases added), 17. The "landmarks" in columns 16 and 17 of Derakhshani are *image* landmarks that are in multiple images like "an eye corner" or "a background object," and are used to estimate depth and spatial metrics. Ex. 1005, 16:51-54. These *image* landmarks do not constitute biometric data. Image landmarks in Derakhshani that could correlate to a user's features (such as an iris, the corner of an eye, or an ear) are not biometric data because they are not used to identify a user. They are merely used in Derakhshani as reference points.

290. Claim 5 depends on claim 1 and further requires that a user is not authenticated "when the *first data*, the *second data*, or *both* do not sufficiently correspond to the enrollment data" (5[b])). Ex. 1001, 38:63-65 (emphases added). In contrast to claim 1, where the Petition asserts that the image landmarks (in columns 16-18) teach the "first data" and "second data,", the Petition identifies biometric "features" (in column 13:9-61, among other places) used to match a user to existing enrollment data as the "first data" and "second data." Pet.,26 (emphasis added):

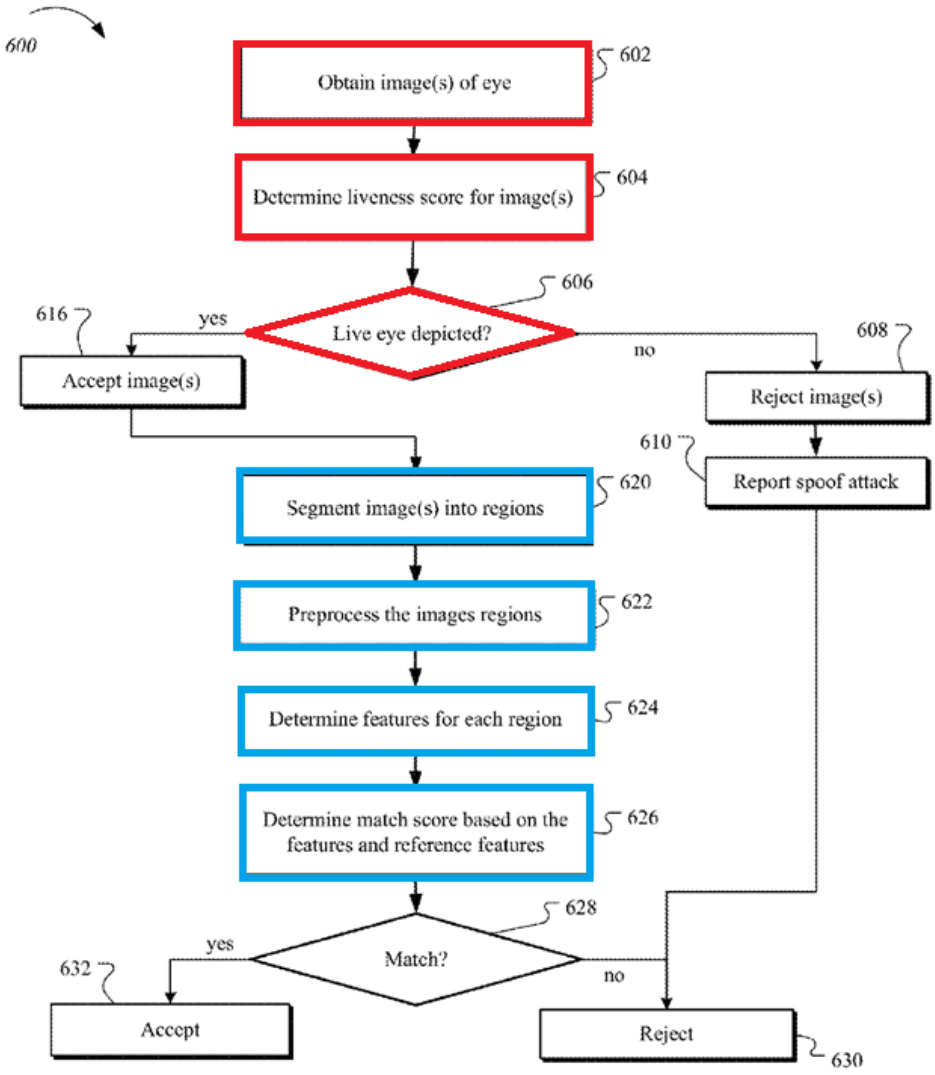
> Derakhshani calculates a match score by comparing features extracted from the <u>first and second image</u> to the <u>corresponding features</u> in a reference record.

291. In my opinion, the image "landmarks" used to generate a spatial

[redacted]

metric are *not* "features" as used in Derakhshani.

292. Derakhshani uses, among other things, three different parts of images of the user's eyes: **image landmarks**, **anatomical landmarks**, and **biometric features**. Image landmarks are used to generate a spatial metric, for example, during determination of liveness of the user's eye. Ex. 1005, 16:51-54; Fig. 6, step 604. (While Derakhshani does not refer to these as "image landmarks," I add the word "image" to distinguish them from "*anatomical* landmarks.") Anatomical landmarks are used to identify regions of interest in the vasculature (white) of an eye in order to determine regions of interest in the vasculature. Ex. 1005, 11:46-53; Fig. 6, steps 620-622. Biometric features are pulled from the identified regions and used to authenticate a user based on a stored reference record. Ex. 1005, 13:9-14:24; Fig. 6, steps 624, 626.



293. Eye liveness detection in Derakhshani uses image landmarks to determine a spatial metric. *Id.*, 10:25-11:16; 16:44-17:11; Fig. 6, steps 602-606. An image landmark may be a *non*-facial (and *non*-biometric) feature such as "a background object." Ex. 1005, 3:13-14, 16:44-54 (focus distance approach), 17:45-64 (parallax approach).

294. The authentication process, on the other hand, extracts biometric features "from each image region that reflect structure or properties of the

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vasculature visible in that region of the user's eye" (step 624), matches the extracted features against features stored in "a reference record" (step 626), and either accepts or denies authentication (steps 628-632). *Id.*, 12:23-24, 13:9-14, 62-66, 14:25-58. These "features" the Petition referenced with respect to claim 5 come from images of the *white of the eye*; the "enrollment reference record" that the Petition are compared to the extracted biometric features comprises "data derived from one or more *images of the white of an eye* for a registered [or] authorized user." *Id.*, 7:20-23; *see also* 9:18-26 (discussing authentication relating to the "white of the user's eye" and capturing it by prompting the user to "face the sensor and direct their gaze left or right to expose large portions of the white of an eye to the sensor"); 4:19-24 ("[d]istinctive features of an individual's visible vasculature in the whites of the eyes may be used to *identify or authenticate* the individual").

295. I understand that the Board found that the Petition uses "landmarks" and "features" synonymously. Paper No. 17, 33. In particular, I understand that this panel found that the Petition describes processing the images to identify "feature landmarks" and thus views the Petition's position as consistent. *Id*. I do not agree. Derakhshani distinguishes between "features," image "landmarks," and "anatomical landmarks" for the reasons I discussed above. In my opinion, the Petition's confusion of landmarks and features is fatal to the Petition's case for

[redacted]

claim 5. The Petition even seems to admit that image landmarks and features are not the same, as it discusses distinct portions of Derakhshani for claims 1 and 5. Compare Pet., 22 (citing columns 16-17 for claim 1's recitation of "first data"), with 36 (citing columns 13-14 for claim 5's recitation of "first data"). Thus, the Petition does not demonstrate that Derakhshani's purported "first data" and "second data" used for liveness detection are the same data used for authentication against enrollment records.

296. Thus, because Derakhshani's "features" are used for authentication, not for spatial metric or liveness determination, and because the Petition conflates the two, it is my opinion that the Petition has failed to demonstrate that Derakhshani teaches or suggests claim 5.

ii. Dependent Claims Requiring "First Data" and "Second Data" Comprise Biometric Data (13, 23) or Facial Features (7, 24)

297. The Petition's misunderstanding permeates its faulty analysis of claims 7-8 and 13 and 23. Claims 13 and 23 require that "first data" and "second data" comprise "biometric data." The Petition identifies image landmarks, such as the corner of an eye, as teaching these limitations. For the reasons I discussed above in Section X.C.1.e.i, it is my opinion that this is wrong.

298. Image landmarks identified to determine a spatial metric are not "biometric data" in the context of Derakhshani – they are pixel regions in multiple

[redacted]

images that have different focus depths. Ex. 1005, 16:51-54. This is, in part, because these image landmarks can be "a background object." *Id*. As explained above, even the landmarks identified that could be part of a user – including an iris, eye corner, or ear – are not "biometric data" in the context of Derakhshani because there is no discussion of how to identify a user using those landmarks.

299. In my opinion, the image landmarks do not comprise "image data of facial features" as required by claims 7 and 24. Derakhshani does not take images of faces; it captures only the user's eye from 6-12 cm away. Therefore, as I mentioned in Section X.C.1.b, because Derakhshani does not take images of faces, these close range images are not of *facial* features (because that would require an image of the user's face). *See, e.g.*, Ex 1001, 7:33-40.

2. '938 Grounds 2A-2C: The Proposed Zhang Combination Fails to Show All of the Claimed Elements

300. The Petition relies on Zhang as the foundation for each of its proposed Ground 2 combinations. In my opinion, this reference is insufficient. Zhang's comparison of color/intensity between a first warped image and a second image is different from the claims of the '938 patent. Regardless of what images or points are compared in Zhang, Zhang does not determine whether differences between two images have distortion expected based on a change in distance. It determines if color/intensity of distinct pixel regions as small as a single pixel ("feature points") match one another by more or less than some threshold. In my opinion,

[redacted]

this is different from the '938's process of creating data from processing images and comparing that data to determine whether differences have the expected distortion resulting from camera or user movement between the images.

301. With respect to claim 20, the Petition relies on similar teachings as it did for claims 1, 8, and 17. But claim 20 does not require or even envision determining "differences" between *two* images. Therefore, in my opinion, the Petition's copy-pasted reasoning fails on claim 20 for this additional reason.

302. In my opinion, Tanii does not make up for the deficiencies in Zhang. Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. Even if it does, the mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Zhang. Indeed, Tanii's purported distortion-correction process cannot warp a close image to accurately compare it to a further image as an indication of three-dimensionality. Tanii's warping at close range will fail to resemble the realities of a three-dimensional subject. And as I discuss further below in Section X.C.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Zhang Does Not Determine Expected Differences Based on Movement of Camera or User

303. The claims require comparing authenticating data from two images to determine whether they exhibit expected differences consistent with the shape of a face, due to movement of the camera or user. Ex. 1001, 1[c], 8[f], 17[d-e]. This

[redacted]

comparison relates to authenticating the three-dimensionality and liveness of the user and relies on expected differences when the camera or user moves. Ex. 1001, 1[d], 10[g], 17[f-g]. Zhang does not teach or suggest any such expected differences, and the Petition has not shown that it does.

304. Moreover, in my opinion, Zhang does not determine whether images exhibit expected differences or distortions consistent with the shape of a face due to movement of the camera or user. Zhang matches feature points across two images (a first image that has been warped and a second image) and compares pixel-level intensity differences around those points. Ex. 1006 ¶¶[0030]-[0034]. The comparison is based on whether the color or intensity difference exceeds a threshold. *Id.* The color/intensity difference identified in Zhang does not relate to expected differences that is based on movement of the camera or the user. In my opinion, Zhang makes no prediction of how an image would change due to this movement, and no analysis of whether the observed differences conform to such a prediction.

305. Zhang's system simply compares pixel regions ("feature points") across two images and checks whether the pixel difference exceeds a numerical threshold. Ex. 1006, ¶[0033] ("If the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a face that is a live face."). In my opinion, determining pixel

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regions of two images differing by color/intensity does not teach the requirement 1[f], 1[i], 10[g], 10[h2], 19[d], or 19[e2] to determine "expected differences," because determining pixel differences alone does not evaluate whether observed differences are consistent with what would be expected from a *change in distance* (*i.e.*, distortion due to perspective, parallax, or other depth-related effects). *See* Ex. 1001, 46:33-35, 40-44, 47:47:50-53, 57-60, 48:59-63, 49:2-7. Indeed, Zhang's method does not relate to expected distortion or how a user should look at different distances. Zhang makes no prediction of how an image would look or whether the observed differences conform to its prediction.

306. In short, Zhang's method of comparing pixel intensity values at feature points does not teach or suggest the claimed comparison of data to determine expected distortion resulting from movement. And Petitioner does not explain how Tanii would fill this gap. Pet., 54-57.

b. Petitioner Inconsistently Treats the Claimed "First Data" as Both Feature Points and Facial Feature Locations

307. Claims 1, 8, and 17 require receiving, deriving, or processing images to create and then compare first and second biometric data. Ex. 1001, 38:17-24, 39:16-17, 24-31, 40:19-25. Like with its position on Derakhshani, the Petition and Dr. Daft confuse a "feature point" with a "selected location." Pet., 61. In my opinion, this ground must fail as well.

[redacted]

308. As I discussed above, feature points are used to *generate* matrix *H* while selected locations (or "facial-feature locations" as Petitioner mistakenly calls them) are used to compare images *using* matrix *H*. Ex. 1006, ¶¶[0026]-[0034], claim 3, Fig. 3.

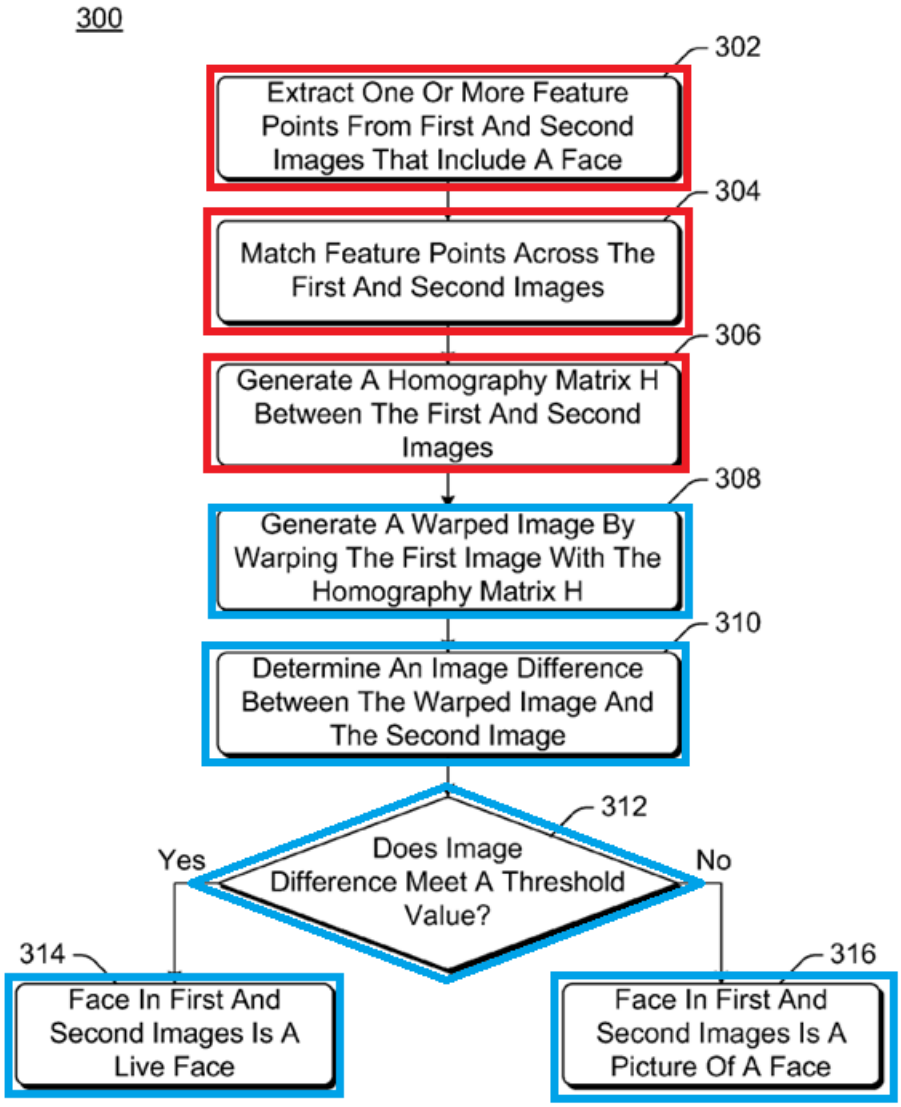


Fig. 3

309. For steps requiring processing or deriving to obtain "first" and

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"second biometric data" (including 1[a-b], 8[b], 8[e], 17[d]) Petitioner maps Zhang's "*feature points*" from a first image and a second image to "first data" and "second data," respectively. Pet., 53 ("Zhang then processes the image to derive *feature-point biometric data*") (emphasis added), 62, 63, 68; Ex. 1003, ¶¶754-62, 789, 794, 824-25. The Petition admits that these "feature points" are specific markers in individual images: "a corner of an eye, a corner of a mouth, [or] a tip of a nose." Pet., 62 (*quoting* Ex. 1006, ¶[0027]). They may be as small as a single pixel. Ex. 1006, ¶[0027].

310. But when mapping "first data" in the "comparing" "first" and "second data," Petitioner abandons its earlier position, asserting instead that "first data" is "*selected locations*"—what it refers to without textual support as "facial-feature locations"—in a warped first image. Pet., 55-56 (referring to comparison between "*selected locations*"). Unlike "feature points" which are specific markers in individual images, "selected locations" are locations that are compared across the warped and second images. Ex. 1006, ¶[0032].

311. Regardless of whether the Petition believes "feature points" from a first image *or* "selected locations" across the warped and second image constitute the "first data" in 1[d5], the two are not equivalent to one another and, in my

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opinion, the Petition's position treating them identically is fatal.[4]

312. For claim 20, the Petition incorporates the errors in its claim 1 position by reference, dooming claim 20 as well. The Petition asserts "processing" to create "first data" and "second data" is taught by deriving "feature points" used to generate a homography matrix H. Pet., 71 (20[b], referring to 1[a]), 72 (20[e], referring to 1[b]). For the "analyzing" of "first data," Petitioner changes course and now refers to the "sub-regions within a face" that are part of the "selected locations" used for image differences. Pet. 73 (20[f]). This repeated inconsistent treatment, in my opinion, demonstrates that Zhang does not teach of suggest claim 20.

c. In Contrast to Claim 20, Zhang's Process Requires Comparison of Images

313. With respect to claim 20, the Petition asserts Zhang teaches determining that a user does not exhibit non-three-dimensionality when "expected differences do not exist in the facial landmarks…of the first and second images."

[4] The Petition's citations to entirely different portions of Zhang for "first data" in 1[a] and 1[f] is further evidence that "feature points" and "selected locations" are not synonymous. *Compare* Pet., 53 ("feature-point" in ¶[0027] for 1[a]'s "first data"), *with* 56 ("selected locations"/"facial-feature locations" in ¶¶[0031]-[0032] for 1[c]'s "first data").

[redacted]

Pet., 73. The Petitioner further explains that a face is planar "if the first and second images match" after transformation of the first. Id. But claim 20 does not require—or even embrace—determining "differences" between two images.

314. Claim 20 requires analyzing each of the "first image" and "second image" separately to determine whether those images were captured at first and second distances, respectively. Ex. 1001, 41:1-11 (20[f-g]). The user's expected degree of three-dimensionality is determined based on determining that the first image was captured at the first distance and the expected degree of three-dimensionality for the *second* data is determined based on determining that the *second* image was captured at the *second* distance. *Id.*, 41:12-20 (20[h-h2]). In my opinion, there is no determination of "mismatch" between landmarks in the images because the landmarks in the images are not matched to one another.

d. Zhang Does Not Teach that "Feature Points" Are Biometric Data

315. The Petition incorrectly asserts Zhang's "feature points" are "biometric data" as recited in claims 1, 7, 13, 17, and 23. Pet., 53, 62, 66, 68-69. In my opinion, this is incorrect.

316. Feature points may be as small as a single pixel. Ex. 1006, ¶¶[0026]-[0027]. And despite the suggestion that pixels at "a corner of an eye, a corner of a mouth, [or] a tip of a nose" could suffice, there is no indication that they are used for authentication or matched against stored biometrics. They are only used for

[redacted]

generating a matrix H and cannot be "biometric data." Ex. 1006, ¶¶[0030]-[0034].

e. Zhang in View of Tanii Fails to Teach the Independent Claims

317. It is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 18. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Section X.C.1.d, it is my opinion that Tanii would operate the same way whether a face or a non-face were presented. Indeed, Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Zhang.

318. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach

[redacted]

or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

3. Tanii Cannot Cure the Deficiencies of the Other References

319. As explained, Tanii performs aesthetic image correction; it does not evaluate distortions. It is also not analogous art to the challenged patent. It purports to remove distortion, which Derakhshani and Zhang use to operate. The Petition's proposed combinations would require significant distortions of Derakhshani and Zhang. And those in the field of biometric security—unlike Dr. Daft—would have had no reason to look to Tanii, which focuses on making images visually pleasing.

a. Tanii Is Not Analogous Art

i. Tanii Is Not from the "Same Field of Endeavor"

320. In my opinion, Tanii is not from the same field of endeavor as the '938 patent. Indeed, I understand that Dr. Daft does not argue that Tanii is from the same field of endeavor as the '938 patent. Ex. 1003, ¶110.

321. And that is correct. While I understand that the Petitioner asserted during this proceeding that Tanii is analogous because it and the '938 patent are both "concerned with identifying and accounting for distortions of [3D] faces in

[redacted]

images captured using a camera," Pet. Reply 5, this is too simplistic of an understanding of the '938 patent. The '938 patent uses the distortion that Tanii tries to remove. In my mind, it cannot be said that the two are from the same field of endeavor.

322. Some analogies may help here. Imagine two systems: the first removes color from color images, and the second uses color from color images to segment them into meaningful regions. While both of these hypothetical systems identify color, only the second hypothetical system meaningfully "accounts" for color. The first hypothetical system acknowledges and processes color only to remove it, while the second is an "accounting" of color by using it to determine the contents of images. Notably, in this analogy, the first system's removal of color prevents the second system's use of that color for segmentation, but not vice versa.

323. Another analogy is in the area of animal husbandry: one disclosure relates to milking a dairy cow while another relates to slaughtering a cow for beef. Again, while both "account" for cows on a farm, the way that they are accounted for are fundamentally different—and result in vastly different outcomes for the cow. Indeed, a dairy cow is leveraged for its milk production, whereas a beef cow is processed in a destructive way, slaughtering the cattle. Each of these analogies is instructive in evaluating Tanii's treatment of distortion because Tanii does not "account for" distortion in the sense required by the claims. Rather, Tanii assumes

[redacted]

distortion exists and then corrects for it by warping the image to produce a natural, more user-friendly image for a viewer. "Accounting for" requires more, such as modeling, measuring, or using distortion to extract or analyze information. Tanii does not do this.

324. In my opinion, one of ordinary skill in the art would not believe that Tanii is from the same field of endeavor as the '938 patent.

ii. Tanii's Distortion Correction Shows that It Is Not "Reasonably Pertinent" to the Problems Faced in the '938 Patent

325. The Petition admits that the problem faced by the '938 patent's inventor claims a system to "distinguish real, three-dimensional faces from two-dimensional pictures of a face." Pet., 4. Facial-recognition systems can be fooled (or "spoofed") by an impostor presenting a picture of an authorized face. *Id.*; *see also* Ex. 1003, ¶77 (understanding that the '938 patent described "countermeasures to prevent 'spoofing' attacks on facial-recognition systems …").

326. In my opinion, Tanii does not teach anything that would be reasonably pertinent to this problem. I understand that the Board found Tanii reasonably pertinent, stating that its "relevant teaching" is that "a three-dimensional face exhibits distortions when a cellular phone camera and a face are close together during image capture." Paper No. 17, 31. In my opinion this alleged teaching would not be helpful. The inventor had already recognized this long-understood

[redacted]

issue as a problem, and the ’938 patent uses that distortion to meet its ends. *See*, *e.g.*, Ex. 1001, 28:39-47. The only teaching in Tanii relevant to distortion is removing it. Pet., 9-11.

327. The ’938 patent solves the spoofing problem by “looking for” the perspective distortion that occurs because of the distance between a three-dimensional face and a camera. Pet., 4-5; Ex. 1003, ¶78; *see also* Ex. 1001, 29:6-22, 30:1-44 (determining that a “two-dimensional picture” is not being presented by validating an “expected pattern of distortion of [] intermediary images” at different distances).

328. Tanii, on the other hand, does not do anything to solve the problem faced by the ’938 patent: preventing spoofing. Tanii does not even detect distortions. Tanii assumes and corrects distortion by enlarging the peripheral areas of an image, regardless of whether the image is of a distorted face.

329. In my opinion, the Board’s discussion of combining Tanii with Derakhshani makes clear that Tanii does not solve this problem nor is it in any way relevant to it. The Board found that Tanii was only relied upon for “its teaching of evaluating distance induced distortions in a face caused by the camera’s lens and the distance from the object.” Paper No., 17, 31. This single concept of evaluating distortions does not provide any solution to the spoofing problem.

330. Tanii works against the challenged claims, by removing the very thing

[redacted]

that enabled the patent's inventor to solve the spoofing problem. The "critical feature" the Petition acknowledged (correcting image distortion, Ex. 1003, ¶113) would prevent each reference from operating as taught by the '938 patent. Thus, a POSITA would not have reasonably expected to solve the '938 patent's spoofing problem using Tanii and would not have looked to Tanii for any teaching to do so.

331. In my opinion, Tanii is also not reasonably pertinent for the additional reason that it does not have the "same purpose as the claimed invention" of the '938 patent. Tanii's purpose is to correct image distortion, rather than use it. *See*, *e.g.*, Ex. 1003, ¶¶110, 113. Whereas the claimed invention's purpose is to determine three-dimensionality *using* image distortion. *See*, *e.g.*, Ex. 1001, 38:25-43 (comparing expected differences and distortions). Thus, Tanii's competing purpose would have also prevented a POSITA from considering it and would have rendered Tanii not reasonably pertinent to the '938 patent.

b. A POSITA Would Not Have Combined the References as the Petition Suggests in Either Grounds 1 or 2

332. Even if Tanii were analogous art here, it is my opinion that there would have been no motivation to combine it with Derakhshani or Zhang. In my opinion, either combination would destroy the basic objective of the respective primary reference, rendering it inoperable for its intended purpose.

333. The Petition admits that Derakhshani and Zhang require distortions to

[redacted]

operate. Derakhshani allegedly determines whether a face is three-dimensional using distortions—"different amounts of blur" or "parallax"—across multiple images. Pet., 7-8; Ex. 1003, ¶¶182 ("Derakhshani's focus-distance approach *looks for expected distortions in the blurriness* or clearness of facial landmarks . . . "), 400 ("there may be other optical effects (e.g., *distance-induced distortion*) that are more apparent in the closer image than the further one"), 885 ("*more parallax*" between images helps to "verify the face as three-dimensional") (emphases added). And Zhang allegedly generates a "warped" first image of a face, matching it to a second image to determine whether the differences meet a threshold; if so, the warped image is determined to represent a real (three-dimensional) face. Pet., 46-48.

334. The Board noted that

> Petitioner proposes to modify 'Derakhshani . . . to capture at least two images at different actual distances and evaluate whether they exhibit different degrees of distance-induced (barrel/fish-eye) distortion, as Tanii suggests.' Pet. 14–15 (citing Ex. 1003 ¶881). Thus, Petitioner relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. *Id.* Petitioner does not propose to modify Derakhshani by incorporating Tanii's teaching of correcting the distortion.

[redacted]

335. Paper No. 17, 18. For reasons similar to those I discussed above, I disagree that Tanii teaches "*evaluating* distance-induced distortions in a face caused by the camera's distance from the object." Indeed, it does not identify distance-induced distortions, as the Petition contends. Pet., 50. Its teachings relate to correction of images by removing the distortion Derakhshani and Zhang allegedly use. The Petition specifically asserts that Tanii's "*critical feature*" is to provide a "procedure to *correct* . . . distance-induced *distortion* . . . to produce an *undistorted image*," *i.e.*, provide a natural-appearing (undistorted) image for a viewer. Ex. 1003, ¶113 (emphases added); *see also* ¶¶110-112; Pet. 9-11. And Tanii's teaching is further limited because it does not determine whether an image requires correction (Ex. 1007, ¶[0058]); it merely assumes it does.

336. In my opinion, doing so on images captured by Derakhshani and Zhang would prevent detection of three-dimensionality, rendering a system which is non-functional for its intended purpose and would destroy the principle of operation of those references.

337. In my opinion, POSITA would not have been motivated to combine Derakhshani with Tanii for additional reasons. For example, as I discussed above (Sections IX.A and X.C.1.d), any distance-induced distortions found in Derakhshani would be in pictures that are taken at very close range. The distance in both photos would need to be so close that there would be no way to

[redacted]

meaningfully capture other facial features – let alone an entire face or a head – in any image.

338. To be clear, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '938 patent (August 2014). In contrast, Tanii's correction method is designed for images captured at arm's length using wide-angle lenses (Ex. 1007, ¶[0047]), making it incompatible with Derakhshani's eye-only imaging.

339. For at least these reasons, it is my opinion that a person having ordinary skill in the art would not have combined Derakhshani with Tanii.

340. As it relates to Zhang, it is also my opinion that a POSITA would not be motivated to combine. I understand that the Petition identified three different possible ways in which a person of ordinary skill in the art would have been motivated to combine Zhang and Tanii. Pet., 49-52; Paper No. 17, 25-26 (identifying the three ways). In my opinion, a person of ordinary skill in the art would not have been motivated to combine these references for the identified three reasons or any other reason.

[redacted]

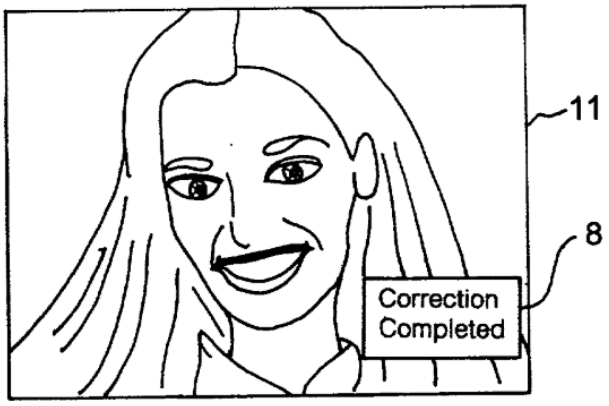
341. The first reason for allegedly combining Zhang and Tanii identified in the Petition is that

> a POSITA would have been motivated to use Zhang's existing process, but take advantage of the *distance-induced distortions identified by Tanii* by using a (wide-angle) camera that induces these distortions at different distances, and capturing two images of the face at different distances, because Zhang's procedure would identify the two images as different due to the differences in distance-induced distortion and verify three-dimensionality.

342. Pet., 50; Paper No. 17, 25. In my opinion, this is incorrect. As I discussed above, Tanii does not teach identifying the distance induced distortions that the Petition asserts it does. See, for example, Sections X.C.1.d and X.C.2.e. Tanii is limited to warping/correcting an image regardless of whether distortions are present or not. In my opinion, this is the motivation behind the "Correction Completed" annotation on the corrected image in Figure 9 of Tanii:

[redacted]

Fig.9



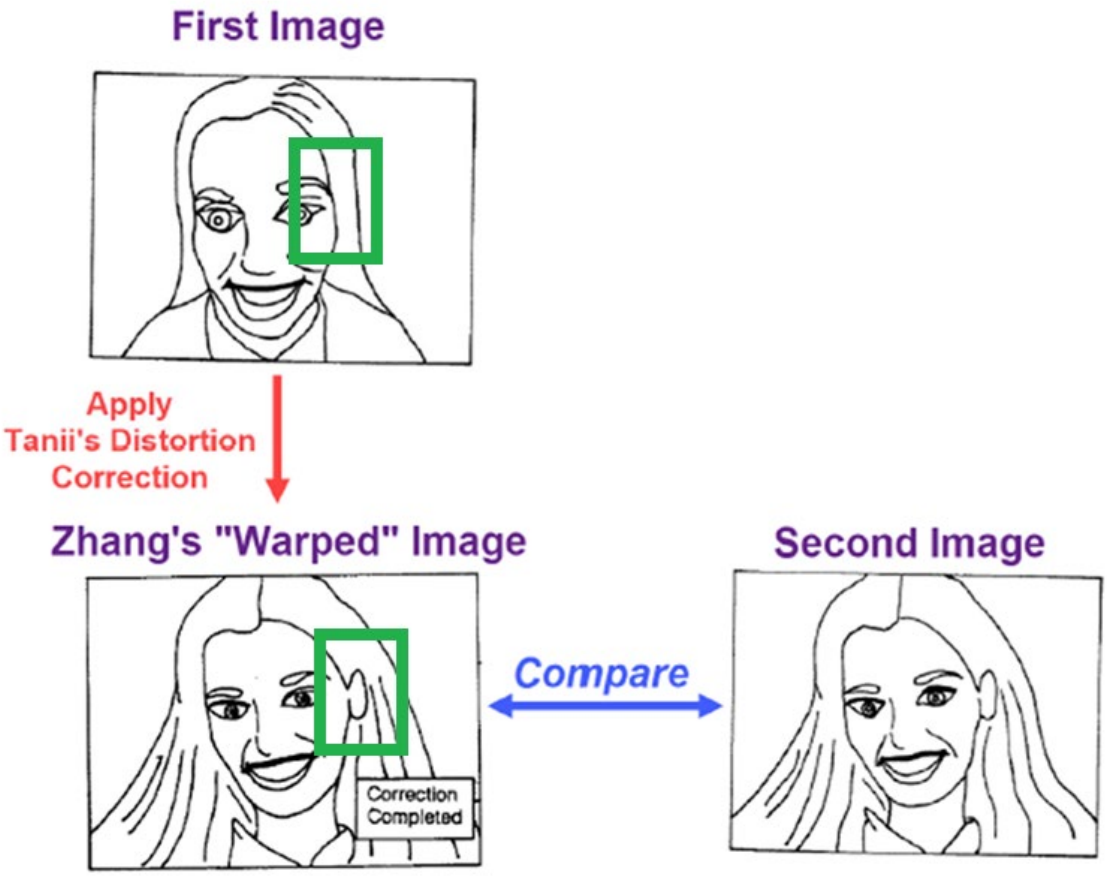
343. Tanii explains that this annotation enables the user to "easily recognize whether or not warp correction was performed." Ex. 1007, ¶[0058]. In my opinion, this is because the system in Tanii cannot determine whether an image requires correction or not.

344. The second reason for allegedly combining Zhang and Tanii identified in the Petition is

> a POSITA would "warp" (i.e., correct) the "close" image using Tanii's distortion-correction procedure to compare it to the "far" image and evaluate the two for differences . . . if the "warped" (corrected) image and second image are sufficiently similar, that indicates a three-dimensional face. . . . A POSITA would have appreciated this modification would reduce spoofing of Zhang's system (which only evaluates whether a face is non-planar, which can be spoofed), and provides a simpler mathematical operation that may require less computational resources.

[redacted]

345. Pet., 49-52; Paper No. 17, 25-26. In my opinion, this is incorrect. The proposed process would not work. For example, the Petition asserts that applying Tanii's distortion correction would lead to a "warped" image that can be compared to a second image. But the Petition depicts ears that cannot be seen in the First Image appearing in the "Warped" image without explanation, as I have annotated below:



346. Pet., 51 (ear locations annotated in **green**). Ears that cannot be seen from a short-range image would not miraculously appear after Tanii's purported distortion correction. Tanii's system would merely make the warped image appear

more natural. Thus, Petitioner relies on a modification that is neither taught nor suggested by the references.

347. The third reason for allegedly combining Zhang and Tanii identified in the Petition is

> when evaluating two images for different degrees of distance-induced distortion, the two images (one "close", one "far") could be compared directly to determine whether they exhibit expected differences in degree of distance-induced distortions.

348. Pet., 51-52; Paper No. 17, 26. In my opinion, this is incorrect. There would be no way to "eliminat[e] the need to mathematically transform an image" and directly compare two images without performing the same basic calculations. The Petition fails to explain how two images could be directly compared to one another – particularly because one of the images is distorted and merely overlaying the images as the Petition has done would not yield the result that the Petition implies.

349. Dr. Daft's declaration vaguely asserts that this third combination requires that "facial features would be mapped in each image, matched between the two images, and evaluated to determine whether differences attributable to distance-induced distortion appear." Ex. 1003, ¶748. None of these facial-feature-matching steps even appear in Zhang or Tanii. Dr. Daft does not assert that they

[redacted]

do, instead inventing an entire set of operations, matching, and evaluations out of whole cloth. Ex. 1003, ¶¶748-49.

350. And while Dr. Daft asserts that a POSITA would have been motivated to combine the references with Tanii, in my opinion, an actual POSITA in the relevant field would have had no reason to look to Tanii in the first place. Tanii's teachings relate to correcting image distortion to create a more pleasing picture. Making visually aesthetic images is irrelevant to the problems faced in the biometric security field, and Dr. Daft's spurious reasoning—that it allegedly teaches evaluating distortions—falls flat because Tanii does not teach evaluating distortions at all. Even if Tanii "evaluat[es]" distance induced distortions, that concept would not provide a reason for POSITA to use that reference to teach the claims. Including the concept of evaluating distortions would still leave significant gaps in the claims.

D. '910 Patent

1. '910 Grounds 1A-1C: The Proposed Derakhshani Combination Fails to Show All of the Claimed Elements

351. In my opinion, Derakhshani detects spoofing based on the visible vasculature (blood vessels) of a user's eye, not a user's face. The reference itself does not even include facial images. While the Petition includes facial images throughout its discussion of that reference, I understand that these images come from, for example, exhibits 1011 and 1012 (unrelated patents (Baldwin and

[redacted]

Hanna)) on pages 8 and 9 of the Petition) or were created by Dr. Daft (pages 10 and 29; *see* Ex. 1003, ¶¶107-108).

352. In my opinion, any distance-induced differences found in Derakhshani would occur at very close range, as all of the images need to capture the vasculature of the eye with sufficient clarity to authenticate the user. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features (aside from the eye) in either image, including a user's head (as required by claim 22).

353. In my opinion, Tanii does not make up for the deficiencies in Derakhshani. I understand that the Board earlier found that the Petition relies on Tanii only for "its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object" (Paper No. 17, 18). The mere concept of evaluating distance induced distortions in a face does not make up for the missing elements of Derakhshani.

354. In my opinion, Tanii does not, in fact, "evaluat[e]" whether one or more images exhibit different degrees of distance-induced distortions as the Board found critical to Petitioner's position. Instead, Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. And as I discuss in Section X.D.3, a POSITA would not have been motivated to combine Zhang and Tanii.

[redacted]

a. Derakhshani's "Spatial Metric" Does Not Represent the Face's Three-Dimensionality

355. The Petition contends that Derakhshani's "spatial metric" is calculated "for the entire face" and represents whether a subject's face is three-dimensional. Pet., 16. I disagree. It is not calculated for the entire face—no "entire face" is ever captured—and does not represent three-dimensionality.

356. Derakhshani's spatial metric is not a measure of any aspect of a user's face, let alone a user's "entire face", and is not indicative of the three-dimensionality of a face, as required by at least 1[pre], 1[d5-6], 10[pre], 10[f-g], 22[pre], and 22[d-e]. Derakhshani's spatial metric is based on images of the eye taken at different focus distances (Ex. 1005, 1:57-2:3), each distance needing to be close enough to capture the characteristics of the eye.

357. As I expand further below, Derakhshani is designed around capturing the vasculature (blood vessels) of a user's eye; it does not involve facial recognition or depth analysis of the user's head or face. In my opinion, this reference is unrelated to the teachings of the '910 patent, which require authenticating a user's three-dimensionality and liveness as a function of the expected distortion between two images of the user's face resulting from the movement of a camera or a user to a second distance (Ex. 1001, claim 1).

358. Moreover, the spatial metric is "a measure of deviation of the subject from a *two-dimensional plane* . . . [or] an *expected three-dimensional shape*." Ex.

[redacted]

1005, 3:1-6, 17:27-36 (emphasis added). In my opinion, this expectation in Derakhshani presumes a known plane or known model of an "expected" shape, and compares captured images to that expected plane shape. The claims of the '910 patent, however, performs what I see as a different process: detecting if differences between data based on captured images have the "expected differences" resulting from the movement of a camera in between taking the images.

b. **Derakhshani Captures Only the Vasculature of a User's Eyes, Not the User's Face**

359. In my opinion, Derakhshani does not teach facial liveness detection by determining a user's three-dimensionality, as required by at least 1[pre], 1[d5-6], 10[pre], 10[f-g], 22[pre], and 22[d-e]. Derakhshani is directed to biometric authentication using eye vasculature. Indeed, it is explicitly directed to "biometric authentication based on *images of the eye*." Ex. 1005, Abstract; 1:5-7 (emphasis added). The system captures images of the white of the eye (sclera) 230, iris 220, and pupil 210, and analyzes vasculature patterns 240 in the conjunctiva and episcleral. *Id.*, 5:1-40, Fig. 2:

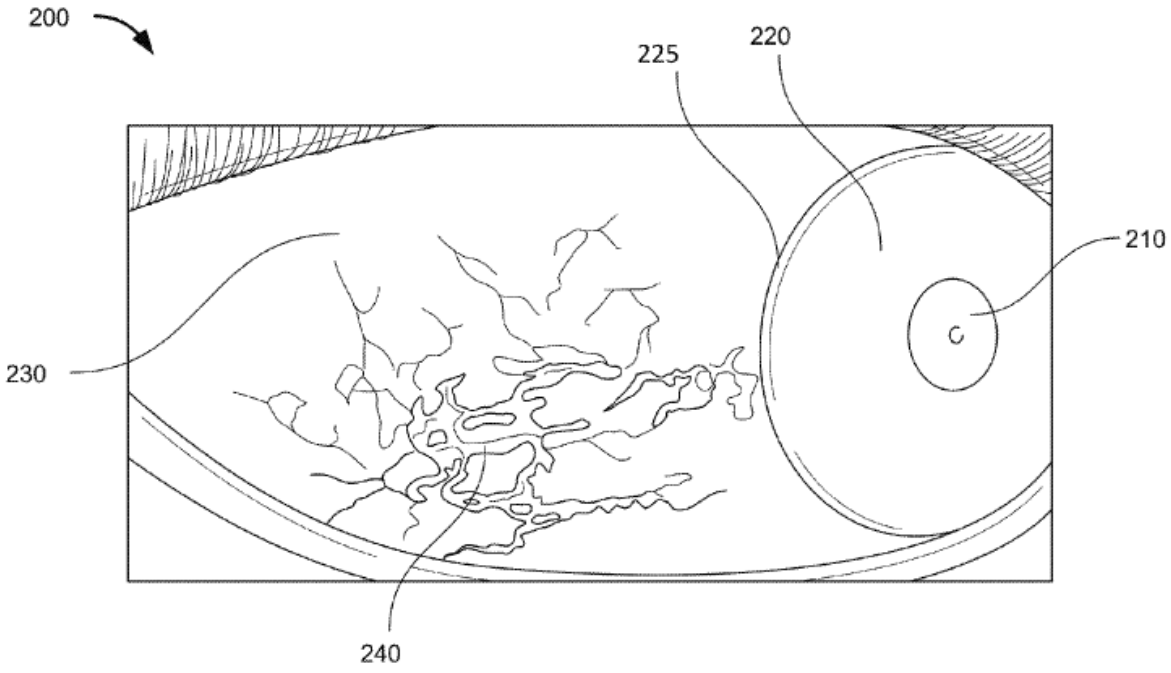


FIG. 2

360. Derakhshani describes three types of metrics associated with images of the eye: behavioral, spatial, and reflectance. "Behavioral" metrics are based on detected movement of the eye, such as pupil constriction or gaze transitions, and are measured by analyzing sequences of images (Ex. 1005, 2:12-17, 15:51-16:43); "spatial" metrics are derived from the apparent depth of image landmarks in an image of the eye based on different focus distances (*Id.*, 2:17-21, 16:44-18:7); and "reflectance" metrics are based on changes in glare or specular reflection patterns on the eye's surface (*Id.*, 2:21-26, 18:8-19:11). Each of these methods relies on characteristics of a user's eye. *See*, *e.g.*, *id.*, 4:19-21 (capturing "features of an individual's visible vasculature in the whites of the [individual's] eyes … to identify or authenticate the individual").

[redacted]

361. The focus on the eye is consistent with Derakhshani's purpose to identify and evaluate the vasculature of the user's eye for authentication – not a face. Contrary to the Petition's suggestion, Derakhshani's disclosure is silent as to capturing images of the user's face or head, and it does not suggest that the system could be adapted to capture these features. Indeed, despite the assertion that faces are imaged in Derakhshani, there are no images of any faces in the reference. See, e.g., *id.*, Figs. 1-4 (depicting eyes and/or cross-sections of eyes):

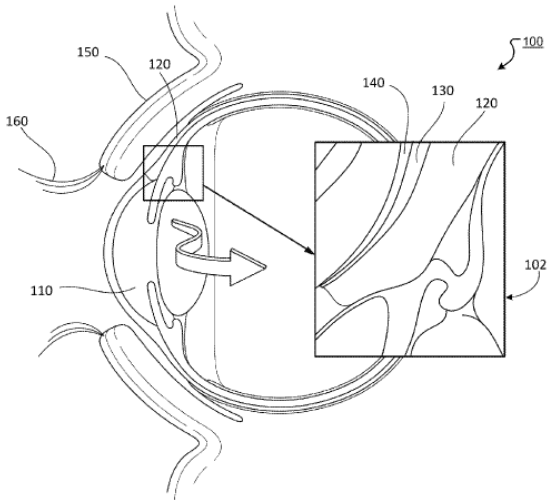


FIG. 1

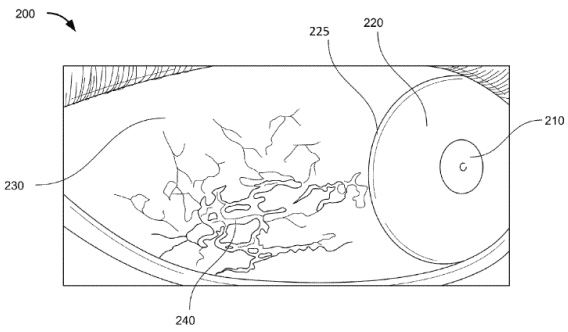
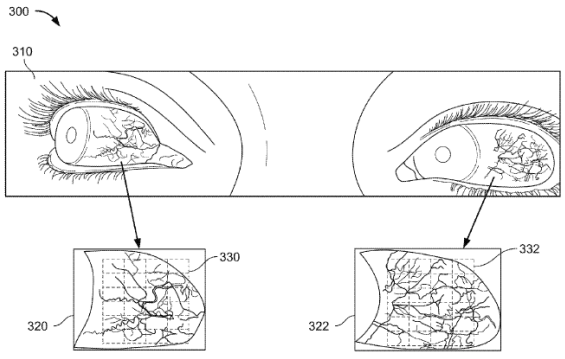
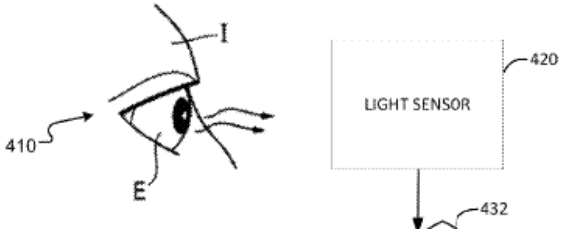


FIG. 2





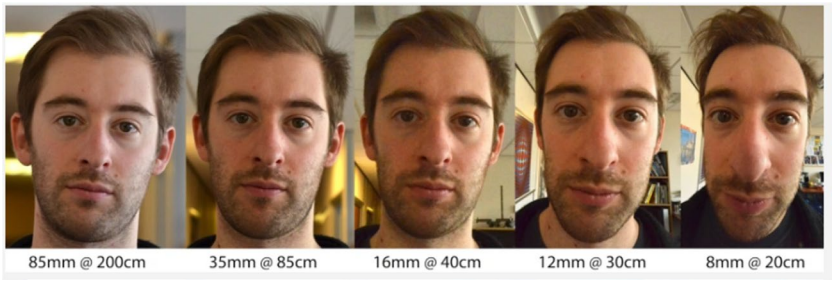
362. Each figure of the user is focused only on the user's eye. It stands to

[redacted]

reason, in my opinion, that these figures represent images that would have to be taken from a distance that would support measuring the vasculature of that eye. Among the few references to a "face" involve presenting a picture of a face as one way to *spoof* the system rather than a legitimate presentation of the user for authentication (4:24-31) and prompting a user to "face" a sensor in order to picture the user's sclera (9:10-26).

363. Moreover, Derakhshani's focus on capturing the vasculature of the eye effectively excludes the possibility of capturing the user's face or his or her three-dimensionality, and thereby authenticating the user, as claimed in the '910 patent. In my opinion, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '910 patent (August 2014).

364. Just as one example, the Petition provided exemplary images of a user's face at varying distances. Ex. 1022. The closest distance provided is 20 cm. 20 centimeters is about 2-3x further away than Derakhshani's envisioned distance.



365. And the type of sensors used to capture eye vasculature at the time of the invention of the ’910 patent would not be able to simultaneously capture the vasculature of an eye *and* a face with enough precision to enable determination of three-dimensionality or authentication. For example, the sensors capable of detecting the fine vasculature of an eye required close-range, high-resolution optics, and were designed to capture images from a very short distance. When that sensor is moved back to capture a user’s face or head, the resolution becomes inadequate to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality. Thus, in my opinion, attempting to use the sensors in Derakhshani to capture a face or head as proposed by the Petition, or modifying them to do so, would prevent capture of the vasculature of the eye. In my opinion, this would also render Derakhshani’s system inoperable for its original purpose.

366. In my opinion, Derakhshani is narrowly focused on ocular biometrics and analyzing vasculature patterns of the eye. For example, Derakhshani’s spatial metric is based on deviations of a user from an expected three-dimensional shape.

[redacted]

See, e.g., Ex. 1005, 17:27-36. The deviation is measured based on differences between a detected location and an estimated location of an image landmark, such as an eye corner or background object. *Id.*, 16:51-54, 17:2-11. Any capture of part of a user's face (other than the eye) is incidental, only helps to orient the system to determine distance, and must give way to the primary purpose of capturing the eye's vasculature.

367. Thus, in my opinion, Derakhshani does not disclose or teach determining a user's three-dimensionality by comparing the first data to the second data, as required by elements [1pre], 1[d5], 10[pre], 10[f], 22[pre], and 22[d].

368. In my opinion, for similar reasons, Derakhshani also does not disclose or teach claims explicitly requiring a user's "face," including claims 9, 14, 18, or 19. Derakhshani for example does not teach or suggest that either of the "first image" or "second image" are "of the user's face" (as required by claim 9), that a "face of the user is placed" into an oval during capture (as required by claim 14), detecting a "reflection of [] illumination from a face of the user" (as required by claim 18), that a "face of the user is held steady" (as required by claim 19), or that a "user's head is the user's face" (as required by claim 24). Again, as I explained above, the images in Derakhshani are of the eyes. Any captured images of a face are partial, at best, and Derakhshani does not teach capturing the face along with the vasculature of the user's eye. Nor, as I discussed above, would it be possible

[redacted]

for Derakhshani to capture both the vasculature of the eye and the broader facial features with sufficient accuracy to support biometric authentication or to determine three-dimensionality.

369. In my opinion, with the sensors in use at the time of the invention of the '910 patent, capturing a user's face with sufficient clarity would not make possible capturing the user's eye vasculature with sufficient clarity. Thus, in my opinion, a person of ordinary skill in the art would not have found it obvious or have found any reason to modify Derakhshani to capture images of a user's face. Moreover, in my opinion, modifying Derakhshani to capture images of a user's face would render Derakhshani's system inoperable for its original purpose: measuring the vasculature of a user's eye.

370. Indeed, capturing an eye would become more unrealistic when trying to capture a user's head. For this additional reason, Derakhshani fails to teach capturing an "image of the user's *head*" as required by independent claim 22. Derakhshani also does not disclose or teach "features on a side of a user's head" (as required by claim 3), that a "head . . . [is] held steady" (as required by claim 9), "aspects of the user's head from the first image" (as required by claim 23), or that a "user's head is the user's face" (as required by claim 24).

c. Tanii Fails to Make Up for the Deficiencies of Derakhshani

371. I understand that the Board found that the Petition's case relies on

[redacted]

Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. Paper No. 17, 17-18. In my opinion, this finding makes it clear that Tanii does not make up for the deficiencies of Derakhshani. As I explained above, Derakhshani does not identify a face, determine three-dimensionality, or evaluate any expected distortions based on how a live, three-dimensional face would appear from different perspectives. Tanii likewise fails to perform any analysis or evaluations. Rather, it aesthetically corrects images captured at close range by enlarging peripheral regions relative to center. Ex. 1007, ¶[0006]. But this teaching fails to make up for the deficiencies in Derakhshani, as Tanii's process of enlargement does not involve detecting a user's face, three-dimensionality, or expected differences. In my opinion, Tanii's purported evaluation of distance-induced distortions does not make up for Derakhshani's spatial metric not being related to the three-dimensionality of a face. In my opinion, this purported evaluation of distance induced distortions also does not make up for Derakhshani not determining three-dimensionality of a user.

372. Moreover, contrary to the Board's statements about Tanii, it is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 32-33. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077],

[redacted]

[0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Sections IX.C and X.D.1, it is my opinion that Tanii would operate the same way whether a face or a non-face was presented. Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Derakhshani.

373. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality in [1pre], 1[d5], 10[pre], 10[f], 22[pre], and 22[d]. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

[redacted]

374. Additionally, Petitioner's suggestion that images of different distances from the sensor have different distortion (Pet., 14) is not a motivation to combine. The inventor of the '910 patent already recognized that distortion effects are "more pronounced" the closer a face is to a lens. Ex. 1001, 28:53-29:20. This observation does not provide a reason to combine Tanii's distortion correction with Derakhshani's eye-vasculature authentication.

d. The Petition Has Separately Failed to Show that Dependent Claims Are Obvious

i. Interpolation Claims (Claims 2, 11)

375. Claims 2 and 11 of the '910 patent require interpolating the first data and second data to obtain "estimated intermediate data," capturing a third image of a user at a "third distance from the user" that is between the first and second distances, processing the third image to obtain third data, and comparing the estimated intermediate data to the third data. In my opinion, the Petition fails to demonstrate that these claims are unpatentable.

376. For claim element 2[a], the Petition asserts that a two-dimensional plane is "generated by interpolating the position of facial landmarks onto a single intermediate plane." Pet. 29 (*citing* Ex. 1005, 17:12-16). In my opinion, this misunderstands Derakhshani's discussion of the spatial metric. Derakhshani states that the locations of multiple landmarks are fit to a "closest" two-dimensional plane and the average distance is used to create the spatial metric. Ex. 1005,

[redacted]

17:19-22. There is no interpolation of any data to *generate* any planes; the landmarks are simply fit to an existing plane.

377. The Petition also argues that a POSITA would have been motivated to interpolate intermediate biometric data when modifying Derakhshani in view of Tanii. Pet., 30-31. In my opinion, this is also wrong. First, as explained above, Petitioner relies on "Derakhshani's interpolated modeling approach," which does not exist. Second, there would have been no motivation to combine Derakhshani with Tanii for the reasons that I explain further below in Section X.D.3.

ii. Claims Requiring Ears/Features (Claims 3 and 12)

378. Claims 3 required verifying presence of one or more features on the side of a user's head in a first image and verifying the absence or reduced visibility of those feature(s) in a second image. Claim 12 similarly requires verifying ears in a first image and verifying absence/reduced visibility in a second image. These limitations are not taught or suggested by either Derakhshani or Tanii, nor would a POSITA have been motivated to incorporate such functionality. In my opinion, Derakhshani does not teach verifying the presence, absence, or reduced visibility of any portion of the ear, nor does it suggest doing so. The reference is limited to capturing the vasculature of the eye, and any incidental capture of an ear is not used by the system to verify anything about that ear.

379. Derakhshani states that the eye images it captures could include a

[redacted]

portion of an ear. *See*, *e.g.*, Ex. 1005, 16:51-54. But any incidental capture of the ear is as an *image* landmark used for estimating distance from a sensor to that landmark. *Id.*, 16:51-17:2. In my opinion, an image including an ear does not mean *verifying* the presence, absence, or reduced visibility of an ear in any image, and nothing else in Derakhshani makes up for this deficiency. Moreover, Derakhshani's discussion using image landmarks for determining a spatial metric undercuts the idea of an ear being absent or having reduced visibility in an image. According to Derakhshani, image landmarks need to be visible for the spatial metric determination to take place. *Id.*, 16:51-17:2.

380. The Petition separately states that an ear would be blurry, and thus have "reduced visibility," if it were outside of the focal plane. Pet. 34. In my opinion, a blurry ear in a picture would not allow for calculation of Derakhshani's spatial metric. And regardless, as explained above, Derakhshani is merely using landmark as a method to estimate the degree of focus. In my opinion, Derakhshani does not *verify* the presence, reduced visibility, or absence of any ear.

381. The Petition suggests that Tanii teaches "the absence or presence of an ear is a natural result of changing the distance between the user and camera." Pet., 34-35. I do not disagree that ears can be present or absent in an image based on distance between the user and the camera. But there also is nothing in Tanii suggesting *verifying* presence, reduced visibility, or absence of ears in an image.

[redacted]

As I discussed above, Tanii simply enlarges portions of an image proportionally to its center. The suggestion that a POSITA would have found it obvious to *verify* ears lacks any support in Tanii or Derakhshani. In my opinion, the combination also would not have been obvious given that there is no teaching in Derakhshani or Tanii of identifying an ear's absence or reduced visibility.

iii. "Comparing" First Data to Enrollment Image (Claim 5)

382. The Petition fails to demonstrate unpatentability of claim 1 and claim 5 because it confuses biometric features used for enrollment and image landmarks used for determining a spatial metric.

383. Claim 1 requires, in part, "processing the at least one first image or a portion thereof to create first data" (1[d2]) and "processing the at least one second image or a portion thereof to create second data" (1[d4]). Ex. 1001, 46:4-5, 14-15.

384. The Petition asserts Derakhshani's "landmarks" are the claimed "first data" and "second data." Pet., 23 ("A POSITA would have understood Derakhshani's identification of facial landmarks constitutes creating data (specifically, biometric data)") (emphases added), 26 ("identify data 'landmarks' in the face ('second [biometric] data')") (emphases added), citing column 16, lines 44-54 and column 17, lines 45-64. The "landmarks" in columns 16 and 17 of Derakhshani are *image* landmarks that are in multiple images like "an eye corner" or "a background object," and are used to estimate depth and spatial metrics. Ex.

[redacted]

1005, 16:51-54. These *image* landmarks do not constitute biometric data. Image landmarks in Derakhshani that could correlate to a user's features (such as an iris, the corner of an eye, or an ear) are not biometric data because they are not used to identify a user. They are merely used in Derakhshani as reference points.

385. Claim 5 depends on claim 1 and further requires "only authenticating the user when the first data, the second data, or both match the enrollment data within a predetermined threshold" (element 5[b])). Ex. 1001, 46:55-57 (emphases added). In contrast to claim 1, where the Petition asserts that the image landmarks (in columns 16-18) teach the "first data" and "second data,", the Petition identifies biometric "features" (in column 13:9-61, among other places) used to match a user to existing enrollment data as the "first data" and "second data." Pet., 37-38 (emphasis added):

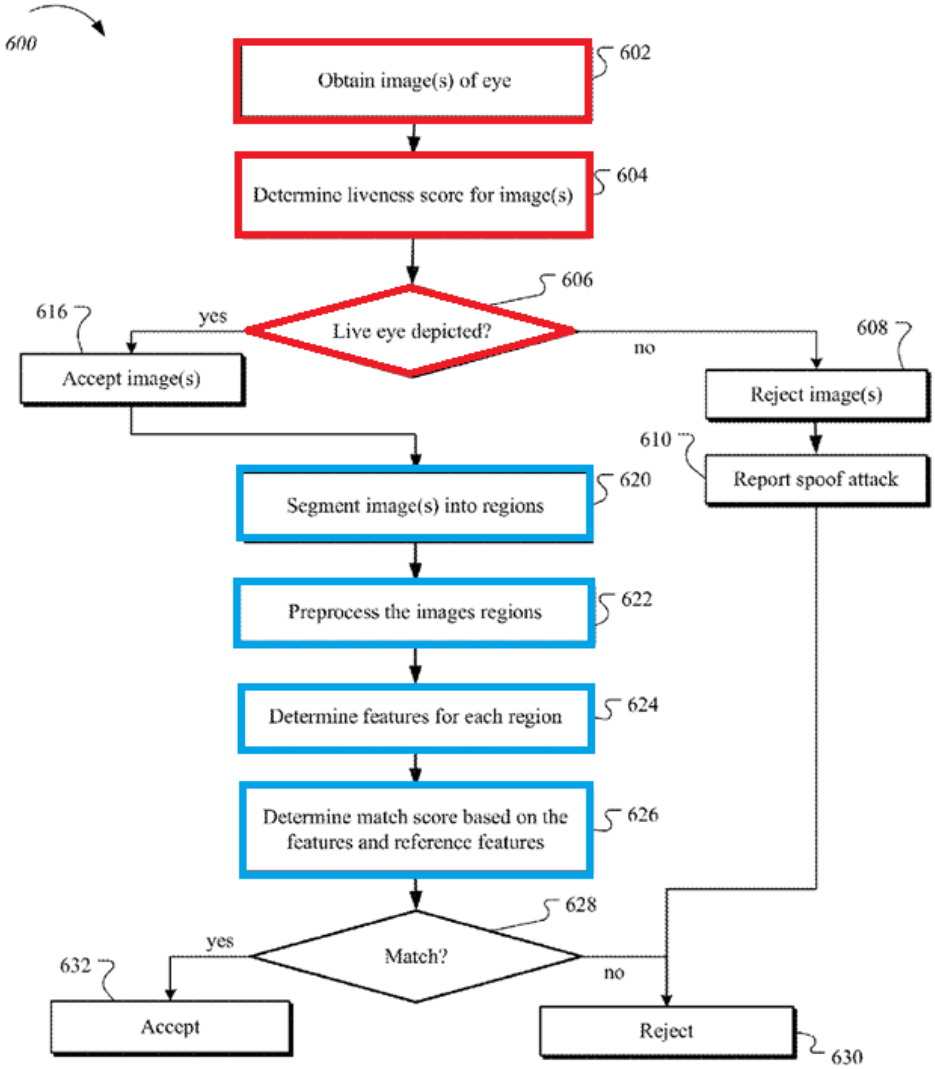
> Derakhshani calculates a match score based on the comparison of features extracted from the first and second image to the corresponding features in an enrollment reference record.

386. In my opinion, the image "landmarks" used to generate a spatial metric are *not* "features" as used in Derakhshani.

387. Derakhshani uses, among other things, three different parts of images of the user's eyes: **image landmarks**, **anatomical landmarks**, and **biometric features**. Image landmarks are used to generate a spatial metric, for example, during determination of liveness of the user's eye. Ex.1005, 16:51-54; Fig. 6, step

[redacted]

604. (While Derakhshani does not refer to these as "image landmarks," I add the word "image" to distinguish them from "*anatomical* landmarks.") Anatomical landmarks are used to identify regions of interest in the vasculature (white) of an eye in order to determine regions of interest in the vasculature. Ex. 1005, 11:46-53; Fig. 6, steps 620-622. Biometric features are pulled from the identified regions and used to authenticate a user based on a stored reference record. Ex. 1005, 13:9-14:24; Fig. 6, steps 624, 626.



[redacted]

388. Eye liveness detection in Derakhshani uses image landmarks to determine a spatial metric. *Id.*, 10:25-11:16; 16:44-17:11; Fig. 6, steps 602-606. An image landmark may be a *non*-facial (and *non*-biometric) feature such as "a background object." Ex. 1005, 3:13-14, 16:44-54 (focus distance approach), 17:45-64 (parallax approach).

389. The authentication process, on the other hand, extracts biometric features "from each image region that reflect structure or properties of the vasculature visible in that region of the user's eye" (step 624), matches the extracted features against features stored in "a reference record" (step 626), and either accepts or denies authentication (steps 628-632). *Id.*, 12:23-24, 13:9-14, 62-66, 14:25-58. These "features" the Petition referenced with respect to claim 5 come from images of the *white of the eye*; the "enrollment reference record" that the Petition are compared to the extracted biometric features comprises "data derived from one or more *images of the white of an eye* for a registered [or] authorized user." *Id.*, 7:20-23; *see also* 9:18-26 (discussing authentication relating to the "white of the user's eye" and capturing it by prompting the user to "face the sensor and direct their gaze left or right to expose large portions of the white of an eye to the sensor"); 4:19-24 ("[d]istinctive features of an individual's visible vasculature in the whites of the eyes may be used to *identify or authenticate* the individual").

[redacted]

390. I understand that the Board found that the Petition uses "landmarks" and "features" synonymously. Paper No. 17, 27. In particular, I understand that this panel found that the Petition describes processing the images to identify "feature landmarks" and thus views the Petition's position as consistent. *Id*. I do not agree. Derakhshani distinguishes between "features," image "landmarks," and "anatomical landmarks" for the reasons I discussed above. In my opinion, the Petition's confusion of landmarks and features is fatal to the Petition's case for claim 5. The Petition even seems to admit that image landmarks and features are not the same, as it discusses distinct portions of Derakhshani for claims 1 and 5. Compare Pet., 23 (citing columns 16-17 for claim 1's recitation of "first data"), with 37-38 (citing columns 13-14 for claim 5's recitation of "first data"). Thus, the Petition does not demonstrate that Derakhshani's purported "first data" and "second data" used for liveness detection are the same data used for authentication against enrollment records.

391. Thus, because Derakhshani's "features" are used for authentication, not for spatial metric or liveness determination, and because the Petition conflates the two, it is my opinion that the Petition has failed to demonstrate that Derakhshani teaches or suggests claim 5.

[redacted]

iv. Claims Requiring "First Data" and "Second Data" Comprise Biometric Data (7, 16) or Facial Features (8, 17)

392. The Petition's misunderstanding permeates its faulty analysis of claims 7-8 and 16-17.

393. Claims 7 and 16 require that "the first data and the second data comprise biometric data." Ex. 1001, claims 7, 16.

394. The Petition identifies image landmarks, such as the corner of an eye, as teaching that "the first data and the second data comprise biometric data" as required by claims 7 and 16. For the reasons I discussed above in Section X.D.1.d.iii, it is my opinion that this is wrong.

395. Image landmarks identified to determine a spatial metric are not "biometric data" in the context of Derakhshani – they are pixel regions in multiple images that have different focus depths. Ex. 1005, 16:51-54. This is, in part, because these image landmarks can be "a background object." *Id*.

396. As explained above, even the landmarks identified that could be part of a user – including an iris, eye corner, or ear – are not "biometric data" in the context of Derakhshani because there is no discussion of how to identify a user using those landmarks.

397. In my opinion, the image landmarks used to determine a spatial metric are also not a "mapping" or "map of facial features" as required by claims 8 and 17

[redacted]

(respectively). Derakhshani does not take images of faces; it captures only the user's eye from 6-12 cm away.

398. Therefore, as I mentioned in Section X.D.1.b, because Derakhshani does not take images of faces, a mapping of image landmarks would not be a "mapping" or "map" of *facial* features. *See, e.g.*, Ex 1001, 7:31-38.

2. '910 Grounds 2A-2C: The Proposed Zhang Combination Fails to Show All of the Claimed Elements

399. The Petition relies on Zhang as the foundation for each of its proposed Ground 2 combinations. In my opinion, this reference is insufficient. Zhang's comparison of color/intensity between a first warped image and a second image is different from the claims of the '910 patent. Regardless of what images or points are compared in Zhang, Zhang does not determine whether differences between two images have distortion expected based on a change in distance. It determines if color/intensity of distinct pixel regions as small as a single pixel ("feature points") match one another by more or less than some threshold. In my opinion, this is different from the '910's process of creating data from processing images and comparing that data to determine whether differences have the expected distortion resulting from camera or user movement between the images.

400. In my opinion, Tanii does not make up for the deficiencies in Zhang. Tanii warps distortions that are due to non-planarity without detecting or evaluating degree of distortion. Even if it does, the mere concept of evaluating

[redacted]

distance induced distortions in a face does not make up for the missing elements of Zhang. Indeed, Tanii's purported distortion-correction process cannot warp a close image to accurately compare it to a further image as an indication of three-dimensionality. Tanii's warping at close range will fail to resemble the realities of a three-dimensional subject. And as I discuss further below in Section X.D.3, a POSITA would not have been motivated to combine Zhang and Tanii.

a. Zhang Does Not Determine Expected Differences Based on Movement of Camera or User

401. The claims require comparing authenticating data from two images to determine whether they exhibit expected differences consistent with the shape of a face, due to movement of the camera or user. Ex. 1001, 1[d5], 10[f], 22[d]. This comparison relates to authenticating the three-dimensionality and liveness of the user and relies on expected differences when the camera or user moves. Ex. 1001, 1[d6], 10[g], 22[e].

402. I understand that the Board found that the Petition had shown a reasonable likelihood of prevailing on claim 1. I further understand that it did so without identifying any disclosure in Zhang of "expected distortion" as required by the independent claims. *See* Paper No. 17, 23. In summarizing the Petition's argument that Zhang compared images to determine whether expected differences exist, the Board noted that Zhang "looks for distortions in a homography transform." Paper No. 17, 23. In my opinion, this is, at best, a mere detection of

[redacted]

differences, not a determination of expected distortion resulting from movement of the camera or user.

403. Moreover, in my opinion, Zhang does not determine whether images exhibit expected differences or distortions consistent with the shape of a face due to movement of the camera or user. Zhang matches feature points across two images (a first image that has been warped and a second image) and compares pixel-level intensity differences around those points. Ex. 1006, ¶¶[0030]-[0034]. The comparison is based on whether the color or intensity difference exceeds a threshold. *Id.* The color/intensity difference identified in Zhang does not relate to expected differences that is based on movement of the camera or the user. In my opinion, Zhang makes no prediction of how an image would change due to this movement, and no analysis of whether the observed differences conform to such a prediction.

404. Zhang's system simply compares pixel regions ("feature points") across two images and checks whether the pixel difference exceeds a numerical threshold. Ex. 1006, ¶[0033] ("If the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a face that is a live face."). In my opinion, determining pixel regions of two images differing by color/intensity does not teach the requirement 1[d5]-[d6], 10[f]-[g], or 22[d]-[e] to determine "expected differences," because

[redacted]

determining pixel differences alone does not evaluate whether observed differences are consistent with what would be expected from a *change in distance* (*i.e.*, distortion due to perspective, parallax, or other depth-related effects). *See* Ex. 1001, 38:24-30.

b. Petitioner Inconsistently Treats the Claimed "First Data" as Both Feature Points and Facial Feature Locations

405. Claims 1 and 10 require processing images to create and then compare first and second data. Ex. 1001, 46:1-19, 47:6-10, 16-25. Like with its position on Derakhshani, the Petition and Dr. Daft confuse a "feature point" with a "selected location." Pet., 60, 64. In my opinion, this ground must fail as well.

406. As I discussed above, feature points are used to *generate* matrix *H* while selected locations (or "facial-feature locations" as Petitioner mistakenly calls them) are used to compare images *using* matrix *H*. Ex. 1006, ¶¶[0026]-[0034], claim 3, Fig. 3.

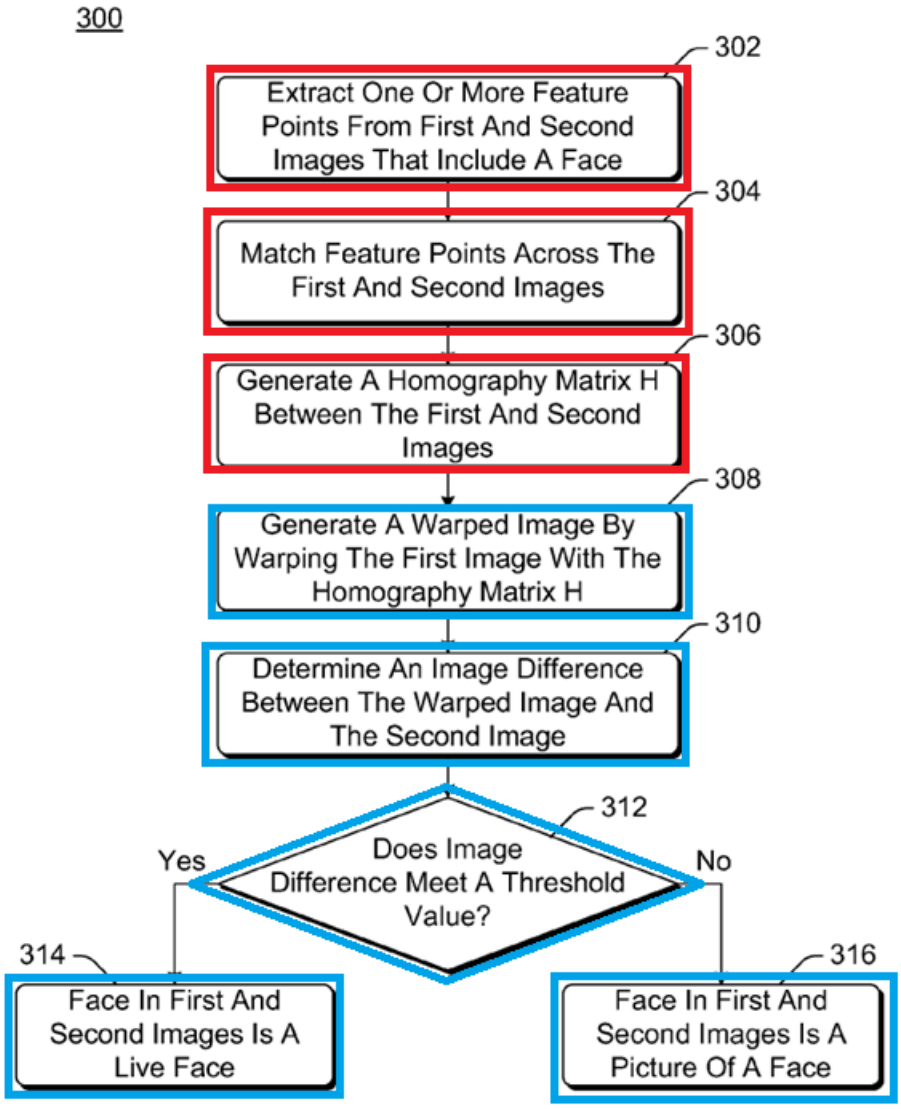


Fig. 3

407. For steps requiring processing to obtain "first" and "second data" (including 1[d2], 1[d4], 10[b], 10[e]) Petitioner maps Zhang's "*feature points*" from a first image and a second image to "first data" and "second data," respectively. Pet., 60 ("Zhang discloses processing the first image to extract '*feature points*' of the face from the image") (emphasis added), 63; Ex. 1003,

[redacted]

¶¶1040-42, 1049-50. The Petition admits that these "feature points" are specific markers in individual images: "a corner of an eye, a corner of a mouth, [or] a tip of a nose." Pet., 61-62 (*quoting* Ex. 1006, ¶[0027]). They may be as small as a single pixel. Ex. 1006, ¶[0027].

408. But when mapping "first data" in the "comparing" step, "first" and "second data," Petitioner abandons its earlier position, asserting instead that "first data" is "*selected locations*"—what it refers to without textual support as "facial-feature locations"—in a warped first image. Pet., 64 (referring to comparison between "*selected locations*"). Unlike "feature points" which are specific markers in individual images, "selected locations" are locations that that are compared across the warped and second images. Ex. 1006, ¶[0032].

409. Regardless of whether the Petition believes "feature points" from a first image *or* "selected locations" across the warped and second image constitute the "first data" in 1[d5], the two are not equivalent to one another and, in my opinion, the Petition's position treating them identically is fatal.[5]

[5] The Petition's citations to entirely different portions of Zhang for "first data" in 1[d2] and 1[d5] is further evidence that "feature points" and "selected locations" are not synonymous. *Compare* Pet., 60-61 ("feature points" in ¶[0027] for 1[d2]'s

[redacted]

c. Zhang in View of Tanii Fails to Teach the Independent Claims

410. It is my opinion that Tanii does not teach or suggest "evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 18. Tanii detects the size of an "object" in the frame and a "distance" to the object. *See, e.g.*, Ex. 1007, ¶¶[0072], [0074], [0076]-[0077], [0079], [0097]-[0098] (size); [0096]-[0098], [0100]-[0102] (distance). Tanii does not evaluate distortions. Indeed, it just corrects warp that is due to non-planarity based on the size of the object and the distance between the lens and the object. There is no "evaluation" of any distortion. Indeed, as I mention above in Section X.D.1.c, it is my opinion that Tanii would operate the same way whether a face or a non-face were presented. Indeed, Tanii does not detect faces in an image nor does it detect what is in the image at all. Tanii teaches enlarging peripheral areas of an image relative to the center of the image. That mere teaching of enlargement fails to make up for the deficiencies in Zhang.

411. Furthermore, Tanii does not measure, assess, or undo *actual* three-dimensional distortion. At best, Tanii performs a two-dimensional warp without evaluating the actual three-dimensional geometry of a human face and its expected

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"first data"), *with* 64 ("selected locations"/"facial-feature locations" in ¶¶[0031]-[0032] for 1[d5]'s "first data").

[redacted]

distortion at different perspectives. Thus, even if Tanii were considered solely for its purported teaching of "evaluating" distance-induced distortion, it does not teach or suggest any method for determining whether an image represents a live, three-dimensional face. Accordingly, Tanii cannot supply the missing claim limitations, analyzing expected differences and distortions or determining three-dimensionality. Moreover, its mere aesthetic teachings are incompatible with the claimed biometric authentication objections and, therefore, do not support a motivation to combine.

d. The Petition Has Separately Failed to Show that Certain Dependent Claims Are Obvious

i. Interpolation Claims (Claims 2 and 11)

412. For reasons similar to those discussed above with respect to Derakhshani, Zhang also fails to teach dependent claims 2 and 11 which require interpolation or modeling of expected distortion between images. Zhang does not interpolate between images or model expected distortion.

413. Instead, as discussed above, Zhang compares a warped version of a first image to a second image using pixel-level intensity differences. Ex. 1006, ¶¶[0030]-[0034]. The comparison is threshold-based, such that if the difference exceeds a threshold, the face is deemed live; otherwise, it is deemed flat. *Id.* But this comparison between pixel regions means Zhang does not model expected distortion, interpolate between data sets, or predict how the image should change

[redacted]

due to movement. Indeed, Zhang's process estimates planar motion between two images, but does not model the expected distortion that would result from movement of a nonplanar, three-dimensional face. Zhang's alleged interpolation aligns one image to another under the assumption that the feature points lie on a flat surface. It does not interpolate to generate intermediate data or predict how the image should change due to actual movement of a three-dimensional object. Thus, Zhang's interpolation is fundamentally different from the interpolation recited in claim 2, which involves modeling expected distortion patterns between images.

ii. Claims Requiring Ears/Features (Claims 3 and 12)

414. As I discussed above with respect to Derakhshani, these claims require verifying the presence of a user's ears in an image and verifying the absence or reduced visibility of those ears/features in the second image. See above, Section X.D.1.d.ii. The Petition agrees that Zhang fails to teach verifying presence, absence, or reduced visibility of ears/features. Pet., 70. The Petition then asserts that Tanii makes up for the deficiencies in Zhang, making a similar case as it did with Derakhshani (discussed above in Section X.D.1.d.ii). (*Compare* Pet. 34-36 with 70-72.)

415. For reasons similar to those I discussed above in Section X.D.1.d.ii, it is my opinion that Tanii fails to make up for the deficiencies in Zhang. For example, Tanii simply enlarges portions of an image proportionally to its center.

[redacted]

The suggestion that a POSITA would have found it obvious to *verify* ears lacks any support in Tanii or Zhang. In my opinion, the combination also would not have been obvious given that there is no teaching in Zhang of identifying an ear's absence or reduced visibility.

iii. Zhang Does Not Capture "Biometric Data" as Required by Claim 7 and 16

416. Claims 7 and 16 explicitly require "biometric data." The Petition relies on Zhang's disclosure of "feature points" as satisfying the biometric data limitation. *See* Pet. 60-61, 74 (*citing* Ex. 1006, ¶¶[0026]-[0027]). As I explained above, Zhang's feature points may be as small as a single pixel. Ex. 1006, ¶[0027]. These points are merely "a single pixel or a region of multiple pixels" that identify "a corner of an eye, a corner of a mouth, a tip of a nose, and so forth." Ex. 1006, ¶¶[0026]-[0027]. There is no indication that these pixels are used, for example, for authentication or matched against stored biometric templates. They are only used for generating a matrix H. Zhang's system is designed to detect spoofing by comparing pixel-level differences from a warped image to a second image and concludes whether a face is live or flat. Ex. 1006, ¶¶[0030]-[0034].

417. I understand that the Board described Zhang's process as one that "looks for distortions in a homography transform." Paper No. 17, 23. But in my opinion, at best, this describes a geometric comparison, not a facial liveness detection or a biometric authentication.

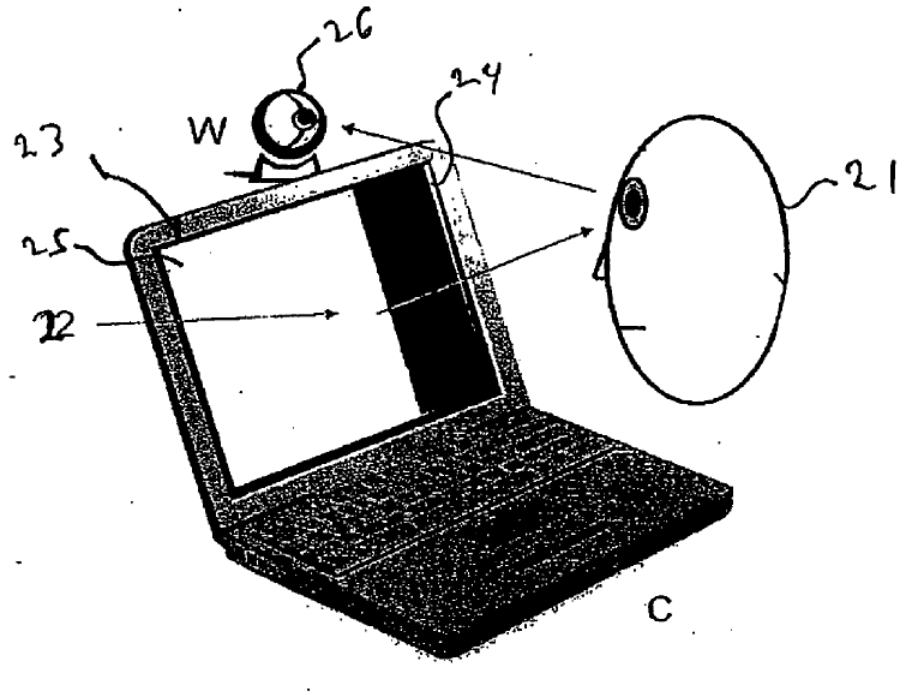
[redacted]

418. Accordingly, in my opinion, Zhang cannot satisfy the biometric data requirements of claims 7 and 16.

iv. Reflections from Illuminations of Face (Claim 18)

419. Claim 18 of the '910 patent require analysis of a reflection "from a face of the user." Ex. 1001, 48:10-13. The Petition admits that Zhang does not teach claim 18 and relies on Hoyos as teaching claim 18. Pet., 84. In my opinion, Hoyos does not teach claim 18.

420. Hoyos presents a first image on a screen, capturing a first reflection, presenting a second image, capturing a second reflection, and comparing the first and second reflections to determine if they were formed by a "curved surface *consistent with a human eye*." Ex. 1010, ¶[0019], Fig. 2:



421. Hoyos detects reflections from human eyes, not a *face*, as required by the explicit language of claim 18. Capturing reflections from an eye is materially different from analyzing reflections from the face. The human eye is a smooth, curved, and highly reflective surface that behaves similarly to a mirror or calm water. For example, the eye exhibits specular reflection that preserves the shape and pattern of the light source. In contrast, facial skin is a complex, textured surface that acts as a diffuse reflector. This fundamental difference in surface properties means that the techniques used to process reflections from the eye are not transferable to facial reflection analysis. Moreover, the face includes heterogeneous regions (such as hair, nostrils, and blemishes) that reflect light differently or not at all. Additionally, the eye occupies a relatively small area of

[redacted]

the face, requiring close-range optics and high resolution for reflectance analysis. Eyes can also reflect things like QR codes while it would be more difficult to read a QR code reflected off of a face. Ex. 1001 ('910 patent), 3:24-30 (discussing reflecting a QR code off of a user's eye).

422. Moreover, Hoyos' only use of a face is to calculate the probability of a biometric match (Pm). Ex. 1010, ¶¶[0033], [0038]. Because Hoyos does not "detect a reflection of [any] displayed image off of the user's *face*," it is my opinion that Hoyos fails to teach claim 18.

3. Tanii Cannot Cure the Deficiencies of the Other References

423. As explained, Tanii performs aesthetic image correction; it does not evaluate distortions. It is also not analogous art to the challenged patent. It purports to remove distortion, which Derakhshani and Zhang use to operate. The Petition's proposed combinations would require significant distortions of Derakhshani and Zhang. And those in the field of biometric security—unlike Dr. Daft—would have had no reason to look to Tanii, which focuses on making images visually pleasing.

a. **Tanii Is Not Analogous Art**

i. Tanii Is Not from the "Same Field of Endeavor"

424. In my opinion, Tanii is not from the same field of endeavor as the '910 patent. Indeed, I understand that Dr. Daft does not argue that Tanii is from the same field of endeavor as the '910 patent. Ex. 1003, ¶110.

425. And that is correct. While I understand that the Petitioner asserted

during this proceeding that Tanii is analogous because it and the '910 patent are both "concerned with identifying and accounting for distortions of [3D] faces in images captured using a camera," Pet. Reply 5, this is too simplistic of an understanding of the '910 patent. The '910 patent uses the distortion that Tanii tries to remove. In my mind, it cannot be said that the two are from the same field of endeavor.

426. Some analogies may help here. Imagine two systems: the first removes color from color images, and the second uses color from color images to segment them into meaningful regions. While both of these hypothetical systems identify color, only the second hypothetical system meaningfully "accounts" for color. The first hypothetical system acknowledges and processes color only to remove it, while the second is an "accounting" of color by using it to determine the contents of images. Notably, in this analogy, the first system's removal of color prevents the second system's use of that color for segmentation, but not vice versa.

427. Another analogy is in the area of animal husbandry: one disclosure relates to milking a dairy cow while another relates to slaughtering a cow for beef. Again, while both "account" for cows on a farm, the way that they are accounted for are fundamentally different—and result in vastly different outcomes for the cow. Indeed, a dairy cow is leveraged for its milk production, whereas a beef cow is processed in a destructive way, slaughtering the cattle. Each of these analogies

[redacted]

is instructive in evaluating Tanii's treatment of distortion because Tanii does not "account for" distortion in the sense required by the claims. Rather, Tanii assumes distortion exists and then corrects for it by warping the image to produce a natural, more user-friendly image for a viewer. "Accounting for" requires more, such as modeling, measuring, or using distortion to extract or analyze information. Tanii does not do this.

428. In my opinion, one of ordinary skill in the art would not believe that Tanii is from the same field of endeavor as the '910 patent.

ii. Tanii's Distortion Correction Shows that It Is Not "Reasonably Pertinent" to the Problems Faced in the '910 patent

429. The Petition admits that the problem faced by the '910 patent's inventor claims a system to "distinguish a three-dimensional face from a two-dimensional picture of a face." Pet., 4. Facial-recognition systems can be fooled (or "spoofed") by an impostor presenting a picture of an authorized face. *Id.*; *see also* Ex. 1003, ¶88 ("the '910 Patent describes countermeasures to prevent 'spoofing' attacks on facial-recognition systems …").

430. In my opinion, Tanii does not teach anything that would be reasonably pertinent to this problem. I understand that the Board found Tanii reasonably pertinent, stating that its "relevant teaching" is that "a three-dimensional face exhibits distortions when a cellular phone camera and a face are close together

during image capture." Paper No. 17, 26. In my opinion this alleged teaching would not be helpful. The inventor had already recognized this long-understood issue as a problem, and the '910 patent uses that distortion to meet its ends. *See*, *e.g.*, Ex. 1001, 28:53-29:20. The only teaching in Tanii relevant to distortion is removing it. Pet., 12-16.

431. The '910 patent solves the spoofing problem by "looking for" the perspective distortion that occurs because of the distance between a three-dimensional face and a camera. Pet., 4; Ex. 1003, ¶89; *see also* Ex. 1001, 29:51-67, 30:47-31:23 (determining that a "two-dimensional picture" is not being presented by validating an "expected pattern of distortion of [] intermediary images" at different distances).

432. Tanii, on the other hand, does not do anything to solve the problem faced by the '910 patent: preventing spoofing. Tanii does not even detect distortions. Tanii assumes and corrects distortion by enlarging the peripheral areas of an image, regardless of whether the image is of a distorted face.

433. In my opinion, the Board's discussion of combining Tanii with Derakhshani makes clear that Tanii does not solve this problem nor is it in any way relevant to it. The Board found that Tanii was only relied upon for "its teaching of evaluating distance induced distortions in a face caused by the camera's lens and the distance from the object." Paper No. 17, 18. This single concept of evaluating

[redacted]

distortions does not provide any solution to the spoofing problem.

434. Tanii works against the challenged claims, by removing the very thing that enabled the patent's inventor to solve the spoofing problem. The "critical feature" the Petition acknowledged (correcting image distortion, Ex. 1003, ¶113) would prevent each reference from operating as taught by the '910 patent. Thus, a POSITA would not have reasonably expected to solve the '910 patent's spoofing problem using Tanii and would not have looked to Tanii for any teaching to do so.

435. In my opinion, Tanii is also not reasonably pertinent for the additional reason that it does not have the "same purpose as the claimed invention" of the '910 patent. Tanii's purpose is to correct image distortion, rather than use it. *See*, *e.g.*, Ex. 1003, ¶¶110, 113. Whereas the claimed invention's purpose is to determine three-dimensionality *using* image distortion. *See*, *e.g.*, Ex. 1001, 46:16-25 (comparing expected differences and distortions). Thus, Tanii's competing purpose would have also prevented a POSITA from considering it and would have rendered Tanii not reasonably pertinent to the '910 patent.

b. A POSITA Would Not Have Combined the References as the Petition Suggests in Either Grounds 1 or 2

436. Even if Tanii were analogous art here, it is my opinion that there would have been no motivation to combine it with Derakhshani or Zhang. In my opinion, either combination would destroy the basic objective of the respective

[redacted]

primary reference, rendering it inoperable for its intended purpose.

437. The Petition admits that Derakhshani and Zhang require distortions to operate. Derakhshani allegedly determines whether a face is three-dimensional using distortions—"different amounts of blur" or "parallax"—across multiple images. Pet., 7-8; Ex. 1003, ¶¶182 ("Derakhshani's focus-distance approach *looks for expected distortions in the blurriness* or clearness of facial landmarks . . . "), 400 ("there may be other optical effects (e.g., *distance-induced distortion*) that are more apparent in the closer image than the further one"), 885 ("*more parallax*" between images helps to "verify the face as three-dimensional") (emphases added). And Zhang allegedly generates a "warped" first image of a face, matching it to a second image to determine whether the differences meet a threshold; if so, the warped image is determined to represent a real (three-dimensional) face. *Id.*, 50-52.

438. The Board noted that

> Petitioner proposes to modify 'Derakhshani . . . to capture at least two images at different actual distances and evaluate whether they exhibit different degrees of distance-induced (barrel/fish-eye) distortion, as Tanii suggests.' Pet. 14–15 (citing Ex. 1003 ¶881). Thus, Petitioner relies on Tanii for its teaching of evaluating distance-induced distortions in a face caused by the camera's lens and the distance from the object. *Id.*

[redacted]

> Petitioner does not propose to modify Derakhshani by incorporating Tanii's teaching of correcting the distortion.

439. Paper No. 17, 17-18. For reasons similar to those I discussed above, I disagree that Tanii teaches "*evaluating* distance-induced distortions in a face caused by the camera's distance from the object." Indeed, it does not identify distance-induced distortions, as the Petition contends. Pet., 53-54; Paper No. 17, 18. Its teachings relate to correction of images by removing the distortion Derakhshani and Zhang allegedly use. The Petition specifically asserts that Tanii's "*critical feature*" is to provide a "procedure to *correct* . . . distance-induced *distortion* . . . to produce an *undistorted image*," *i.e.*, provide a natural-appearing (undistorted) image for a viewer. Ex. 1003, ¶113 (emphases added); *see also* ¶¶110-112; Pet., 12-13. And Tanii's teaching is further limited because it does not determine whether an image requires correction (Ex. 1007, ¶[0058]); it merely assumes it does.

440. In my opinion, doing so on images captured by Derakhshani and Zhang would prevent detection of three-dimensionality, rendering a system which is non-functional for its intended purpose and would destroy the principle of operation of those references.

441. In my opinion, POSITA would not have been motivated to combine Derakhshani with Tanii for additional reasons. For example, as I discussed above

[redacted]

(Sections IX.A and X.D.1.c), any distance-induced distortions found in Derakhshani would be in pictures that are taken at very close range. The distance in both photos would need to be so close that there would be no way to meaningfully capture other facial features – let alone an entire face or a head – in any image.

442. To be clear, capturing an eye with sufficient clarity of the vasculature of the eye means the sensor or camera needs to be placed a short distance from the user's eye. Ex. 1005, 13:35-40 (suggesting a capture distance between 6-12 centimeters from the eye). This necessarily eliminates the ability to capture the user's entire face, head, or three-dimensionality for authentication – particularly using sensors that were available at the time of the invention of the '910 patent (August 2014). In contrast, Tanii's correction method is designed for images captured at arm's length using wide-angle lenses (Ex. 1007, ¶[0047]), making it incompatible with Derakhshani's eye-only imaging.

443. For at least these reasons, it is my opinion that a person having ordinary skill in the art would not have combined Derakhshani with Tanii.

444. As it relates to Zhang, it is also my opinion that a POSITA would not be motivated to combine. I understand that the Petition identified three different possible ways in which a person of ordinary skill in the art would have been motivated to combine Zhang and Tanii. Pet., 54-56; Paper No. 17, 23-24

[redacted]

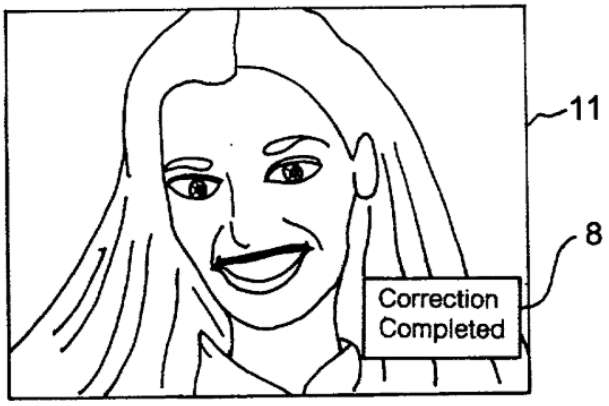
(identifying the three ways). In my opinion, a person of ordinary skill in the art would not have been motivated to combine these references for the identified three reasons or any other reason.

445. The first reason for allegedly combining Zhang and Tanii identified in the Petition is that

> a POSITA would have been motivated to use Zhang's existing process, but take advantage of the *distance-induced distortions identified by Tanii* by using a (wide-angle) camera that induces these distortions at different distances, and capturing two images of the face at different distances, because Zhang's procedure would identify the two images as different due to the differences in distance-induced distortion and verify three-dimensionality.

446. Pet., 54; Paper No. 17, 23. In my opinion, this is incorrect. As I discussed above, Tanii does not teach identifying the distance induced distortions that the Petition asserts it does. See, for example, Sections X.D.1.c and X.D.2.c. Tanii is limited to warping/correcting an image regardless of whether distortions are present or not. In my opinion, this is the motivation behind the "Correction Completed" annotation on the corrected image in Figure 9 of Tanii:

Fig.9



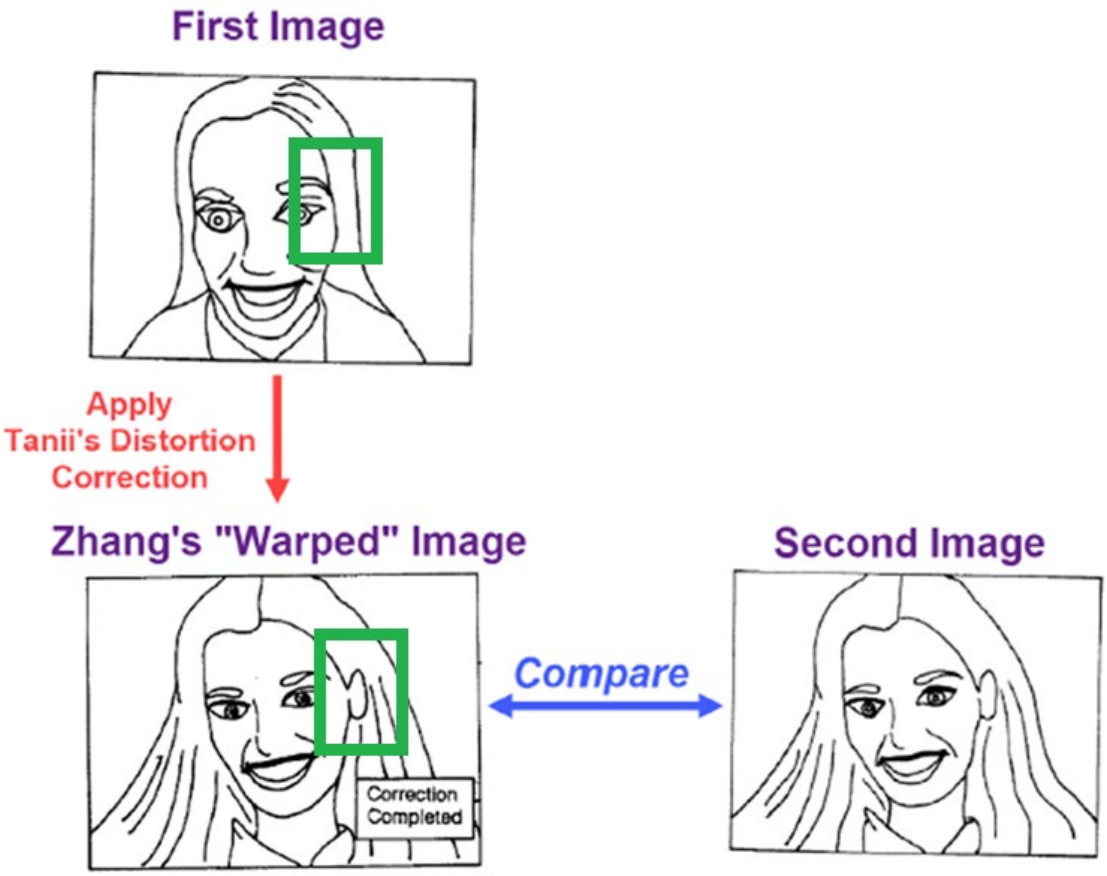
447. Tanii explains that this annotation enables the user to "easily recognize whether or not warp correction was performed." Ex. 1007, ¶[0058]. In my opinion, this is because the system in Tanii cannot determine whether an image requires correction or not.

448. The second reason for allegedly combining Zhang and Tanii identified in the Petition is

> a POSITA would "warp" (i.e., correct) the "close" image using Tanii's distortion-correction procedure to compare it to the "far" image and evaluate the two for differences . . . if the "warped" (corrected) image and second image are sufficiently similar, that indicates a three-dimensional face. . . . A POSITA would have appreciated this modification would reduce spoofing of Zhang's system (which only evaluates whether a face is non-planar, which can be spoofed), and provides a simpler mathematical operation that may require less computational resources.

[redacted]

449. Pet., 54-55; Paper No. 17, 23-24. In my opinion, this is incorrect. The proposed process would not work. For example, the Petition asserts that applying Tanii's distortion correction would lead to a "warped" image that can be compared to a second image. But the Petition depicts ears that cannot be seen in the First Image appearing in the "Warped" image without explanation, as I have annotated below:



450. Pet., 55 (ear locations annotated in **green**). Ears that cannot be seen from a short-range image would not miraculously appear after Tanii's purported distortion correction. Tanii's system would merely make the warped image appear

more natural. Thus, Petitioner relies on a modification that is neither taught nor suggested by the references.

451. The third reason for allegedly combining Zhang and Tanii identified in the Petition is

> when evaluating two images for different degrees of distance-induced distortion, the two images (one "close", one "far") could be compared directly to determine whether they exhibit expected differences in degree of distance-induced distortions.

452. Pet., 56; Paper No. 17, 24. In my opinion, this is incorrect. There would be no way to "eliminat[e] the need to mathematically transform an image" and directly compare two images without performing the same basic calculations. The Petition fails to explain how two images could be directly compared to one another – particularly because one of the images is distorted and merely overlaying the images as the Petition has done would not yield the result that the Petition implies.

453. Dr. Daft's declaration vaguely asserts that this third combination requires that "facial features would be mapped in each image, matched between the two images, and evaluated to determine whether differences attributable to distance-induced distortion appear." Ex. 1003, ¶1020. None of these facial-feature-matching steps even appear in Zhang or Tanii. Dr. Daft does not assert that

they do, instead inventing an entire set of operations, matching, and evaluations out of whole cloth. Ex. 1003, ¶¶1020-21.

454. And while Dr. Daft asserts that a POSITA would have been motivated to combine the references with Tanii, in my opinion, an actual POSITA in the relevant field would have had no reason to look to Tanii in the first place. Tanii's teachings relate to correcting image distortion to create a more pleasing picture. Making visually aesthetic images is irrelevant to the problems faced in the biometric security field, and Dr. Daft's spurious reasoning—that it allegedly teaches evaluating distortions—falls flat because Tanii does not teach evaluating distortions at all. Even if Tanii "evaluat[es]" distance induced distortions, that concept would not provide a reason for POSITA to use that reference to teach the claims. Including the concept of evaluating distortions would still leave significant gaps in the claims.

XI. Objective Evidence of Nonobviousness Further Supports the Patentability of the Challenged Claims

A. The Challenged Patent Claims Encompass FaceTec's Software

455. I understand that objective evidence of nonobviousness must have a nexus to the merits of the claimed invention and that nexus may be presumed when the objective evidence of nonobviousness is tied to a specific product and that product embodies and is coextensive with the claimed features.

456. As set forth in the claim charts in Appendices A-H, FaceTec's

software embodies and is coextensive with the challenged claims. Indeed, the core functionality of FaceTec's software—3D liveness detection—is achieved by using a camera-equipped computing device having a camera, screen, processor, and memory to capture facial images of a user at two distinct and fairly consistent distances, process the images, and analyze data from images for expected differences in, e.g., perspective distortion. *See* Ex. 2059, ¶¶9–24; Ex. 2063 at 3. Specifically, FaceTec's software captures at least one facial image of the user at a first distance from the camera, captures at least one facial image of the user at a second distance from the camera, compares data from the images for expected differences, and authenticates the user as live when expected differences are present. *See* Ex. 2059, ¶¶9–24; Ex. 2063 at 3. The expected differences may be expected distortion resulting from the movement of the camera and/or user from the first distance to the second distance. Ex. 2059, ¶19.

457. [redacted]. Ex. 2059 ¶16. And to guide the user to capture the first and second image(s), the computing device displays one or more

[redacted]

prompts in the form of ovals within which the user aligns or places their face during the capture of the first and second image(s). Ex. 2059, ¶14; Ex. 2067 at No. 2.

458. As such, it is my opinion that nexus should be presumed because FaceTec's software embodies and is coextensive with the challenged claims. Ex. 2059, ¶¶6-28.

B. FaceTec's Software Has Received Industry Praise

459. I understand that industry recognition—including awards and certifications—is evidence of nonobviousness.

460. FaceTec's software has garnered substantial industry recognition, including from Petitioner, and in my opinion, this industry recognition evidences the nonobviousness of the challenged claims. FaceTec was the first, for example, to achieve Level 1 and Level 2 certifications in iBeta's PAD evaluations under ISO/IEC 30107-3. *See* Ex. 2036; Ex. 2037; Ex. 2059, ¶47; Ex. 2078. Additional certifications FaceTec has received include BixeLab's Level 2 PAD and 3D:2D Face Matching Tests, and Praetorian's penetration testing. *See* Exs. 2038–2041. Industry commentary has described FaceTec as "stand[ing] head and shoulders above the rest." Ex. 2064 at 2.

461. Additionally, Petitioner itself repeatedly endorsed FaceTec's 3D liveness detection technology, calling it a "genius solution," "spoof proof," and

[redacted]

"the most accurate and secure solution." Ex. 2057; Ex. 2079. Petitioner's executives praised the software's intuitive interface and robust AI, crediting it with delivering a "significant competitive advantage." Ex. 2079. Petitioner further emphasized the importance of certified methods and highlighted FaceTec's unique achievement of Level 1 and Level 2 certifications in iBeta's PAD evaluations. *See* Exs. 2042–2043.

462. Further, Petitioner's marketing materials prominently featured FaceTec's patented 3D liveness detection technology, including the claimed two-distance image capture involving near and far oval-shaped prompts. *See* Exs. 2044–2045; Ex. 2073. This direct alignment with the claimed invention underscores that the praise was for the patented technology itself.

463. Taken together, it is my opinion that the industry recognition, certifications, and Petitioner's own endorsements constitute compelling evidence of nonobviousness of the challenged claims.

C. iProov and Jumio Copied FaceTec's Software

464. I understand that evidence of copying is indicative of nonobviousness. To establish copying, I understand that there must be evidence of deliberate replication of a specific product that embodies the claimed invention and that such evidence may include access to the patented product and substantial similarity in the accused product.

[redacted]

465. Here, both iProov and Petitioner had access to FaceTec's patented software and subsequently released software that closely mirrors FaceTec's claimed technology. In my opinion, this supports a finding of copying and reinforces the nonobviousness of the challenged claims.

1. iProov

466. [redacted] *See* Ex. 2059, ¶¶34–46. In my opinion, iProov's software replicates key features of FaceTec's technology, including the use of facial images captured at varying distances to verify three-dimensionality, further supporting a finding of copying and reinforcing the nonobviousness of the claimed inventions.

467. I understand that FaceTec's Spoof Bounty Program, which launched in 2019, granted participants controlled access to FaceTec's software for the sole purpose of attempting spoof attacks under strict confidentiality and non-reverse engineering terms. *See* Ex. 2059, ¶¶30–32; Ex. 2046. [redacted]

[redacted]

468. Following this extensive access, I understand that iProov released its "Liveness Assurance" software in late 2020. According to iProov's own materials, the software verifies that a user is a live human and not a spoof artifact. *See* Ex. 2059, ¶45; Ex. 2060. In my opinion, the software mimics FaceTec's patented approach by manipulating the interface to prompt user movement and capturing user images at different distances—resulting in substantially similar functionality. *See* Ex. 2059. Appendices A-D set forth a comparative analysis based on materials describing iProov's software service and FaceTec's patented software service.

469. In my opinion, this pattern of access, replication, and product release constitutes compelling evidence of copying.

2. Petitioner

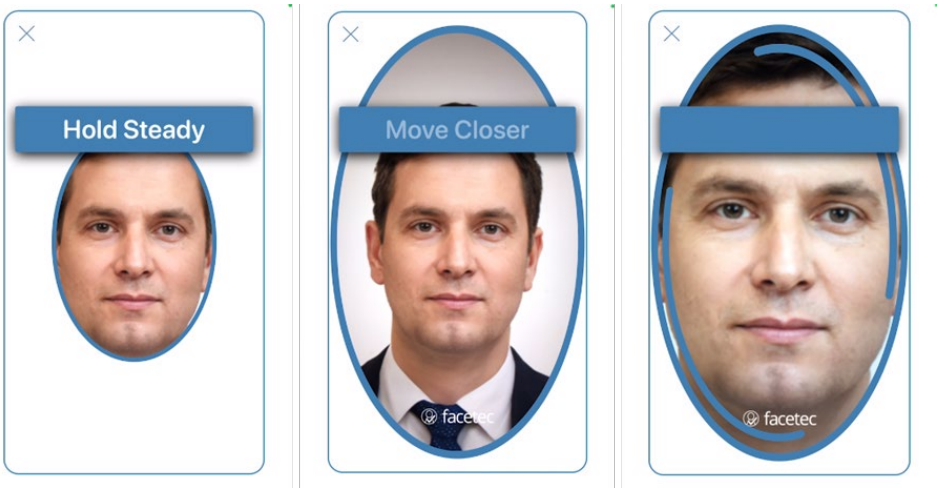
470. I understand that from [redacted], Petitioner licensed FaceTec's software and had developer support and unrestricted access to FaceTec's software and documentation. *See* Ex. 2073; Ex. 2059, ¶50. I understand that during this period, Petitioner executed over [redacted] 3D liveness checks using FaceTec's technology. *Id*.

471. I understand that in 2021, Petitioner launched its own liveness detection software. *See* Ex. 2077. The operation of Petitioner's product closely

[redacted]

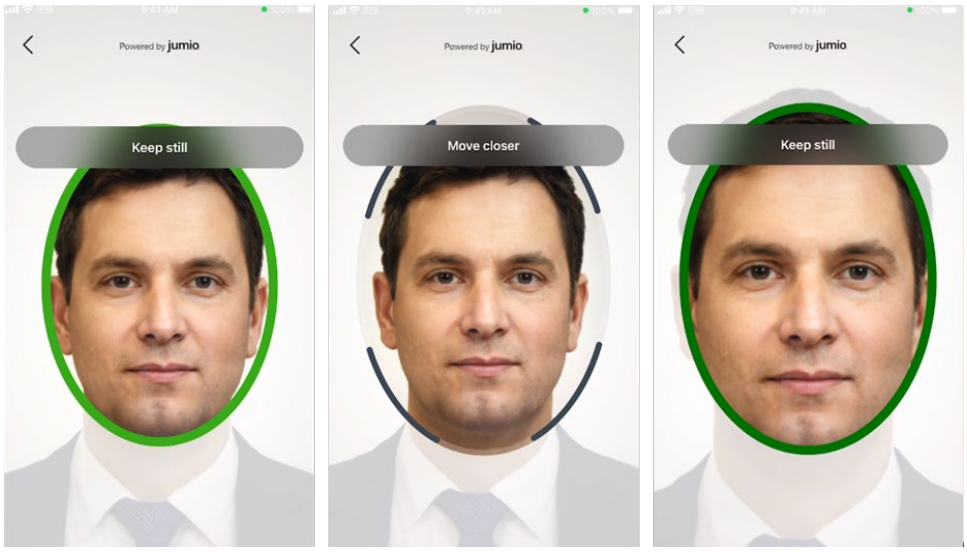
mirrors FaceTec's patented approach. Like FaceTec's system, Petitioner's software captures a facial image at a first distance, prompts the user to "move closer," and captures a second image at a different distance.

472. Appendices E-H set forth a comparative analysis based on materials describing Petitioner's software service and FaceTec's patented software service. Visual comparisons of the user interfaces confirm the similarity:



FaceTec's Software

[redacted]



Petitioner's Software

Ex. 2072.

473. In my opinion, Petitioner's replication of the core functionality of FaceTec's software—following extensive access to FaceTec's technology—constitutes further evidence of copying and demonstrates the nonobviousness of the challenged claims.

D. FaceTec Satisfied a Long-Felt Need for a Secure Software-Based 3D Liveness Detection Technology that Others Tried but Failed to Meet and Instead Licensed FaceTec's Software

474. I understand that evidence that a long-standing need existed for the claimed invention—and that others attempted but failed to meet that need—is evidence of nonobviousness. I understand that the relevant timeframe for assessing unmet need is the patent's filing date but that failures occurring after patent issuance may be even more persuasive.

[redacted]

475. In my opinion, FaceTec's patented 3D liveness detection technology addressed a long-felt but unmet need for a secure, software-based anti-spoofing solution. As biometric systems became widespread in the 2000s, vulnerabilities to presentation attacks became a critical concern. By the 2014 priority date, the biometric industry had acknowledged the challenge and called for robust countermeasures. *See* Ex. 2047 at Abstract, 1531, 1548.

476. Three anti-spoofing approaches emerged—hardware-based, software-based, and score-level techniques—each with tradeoffs. Software-based methods were preferred for their cost-efficiency, non-invasiveness, and user-friendliness, but achieving high performance remained elusive. *See* Ex. 2047 at 1532–35.

477. FaceTec was the first to meet these demands, earning both Level 1 and Level 2 certifications under iBeta's PAD evaluation (ISO/IEC 30107-3). *See* Ex. 2078, Ex. 2037, Ex. 2059, ¶47. No prior company had achieved this benchmark. Ex. 2059, ¶47. FaceTec's solution met all key criteria: it was secure, fast, non-invasive, low-cost, and compatible with standard camera-enabled devices.

478. Others in the industry, including Petitioner, attempted but failed to develop effective 3D liveness detection. Petitioner's early implementations—such as facial movement monitoring, eye-tracking dots, and handwritten note verification—were quickly abandoned. *See* Exs. 2048–2049. Ultimately, Petitioner

[redacted]

licensed FaceTec's software, describing it as an "upgraded liveness detection functionality." See Ex. 2079 at 2; Ex. 2059, ¶50. Petitioner repeatedly praised FaceTec's technology for its speed, accuracy, anti-spoofing capabilities, and user experience. *See* supra § XI.B. Petitioner also acknowledged that the software was patented. *See* Ex. 2045, Ex. 2073.

479. I understand that today, FaceTec's technology is deployed globally by over 250 customers and partners, with more than [redacted] uses in 2024. *See* Ex. 2059, ¶53.

480. The existence of a long-felt need, repeated failures by others, and widespread adoption of FaceTec's patented solution provide compelling evidence of nonobviousness.

E. The Industry Was Skeptical of FaceTec's Software

481. I understand that skepticism among those of ordinary skill in the art regarding the feasibility or effectiveness of a claimed solution supports nonobviousness.

482. The biometric industry expressed skepticism that a software-only approach to 3D liveness detection could deliver secure and reliable results. In October 2017, shortly after FaceTec launched its 3D liveness detection technology, MIT Technology Review published an article questioning whether such a solution could succeed. *See* Ex. 2050. The article contrasted FaceTec's software-based

[redacted]

method with hardware-dependent approaches like Apple's infrared sensor-based Face ID, noting that FaceTec's system relied on analyzing perspective distortion from facial images captured at different distances. *Id.* at 1-2.

483. Experts cited in the article voiced doubts. *Id.* at 2. Marios Savvides, Director of the CyLab Biometrics Center at Carnegie Mellon, questioned whether FaceTec's technology could prevent spoofing with masks. *Id.* at 2. Rich Mogull, CEO of Securosis, stated that a purely software-based solution would require additional hardware protections to match the security of Apple's system. *Id.* at 3. He acknowledged that FaceTec's approach was more secure than 2D facial recognition but expressed skepticism about its usability and robustness compared to emerging alternatives. *Id.*

484. In my opinion, this documented skepticism from industry experts—particularly in light of FaceTec's subsequent success—further supports the nonobviousness of the claimed invention.

XII. Conclusion

485. For the reasons set forth above, in my opinion, each of the Challenged Claims of each Challenged Patent is not unpatentable.

486. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be

[redacted]

subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

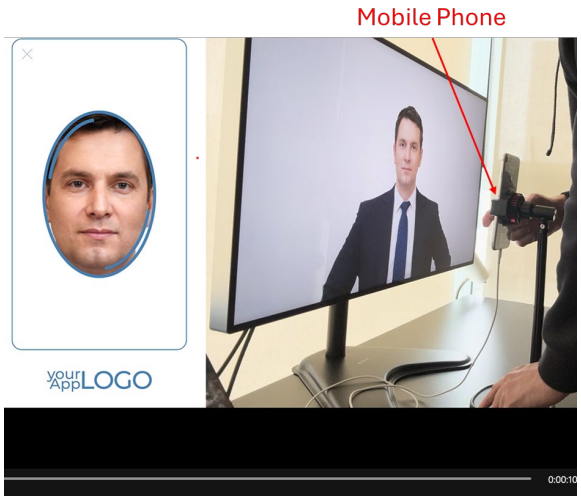
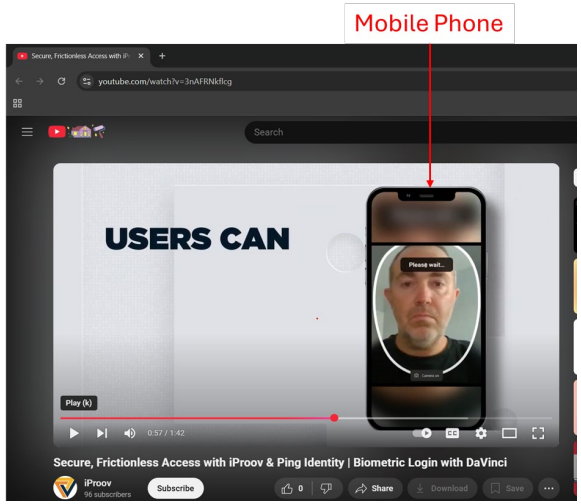
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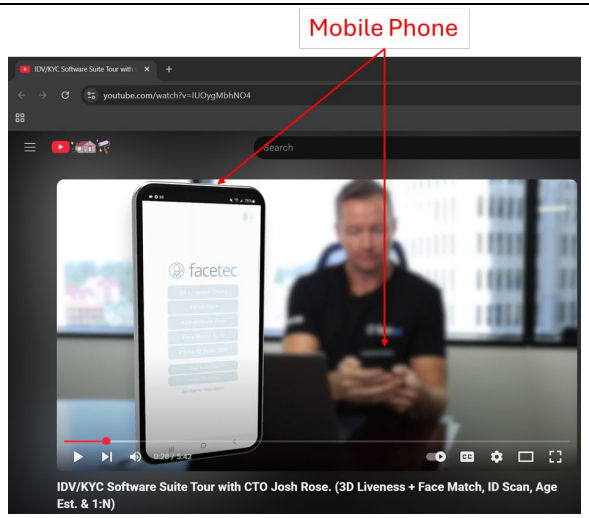
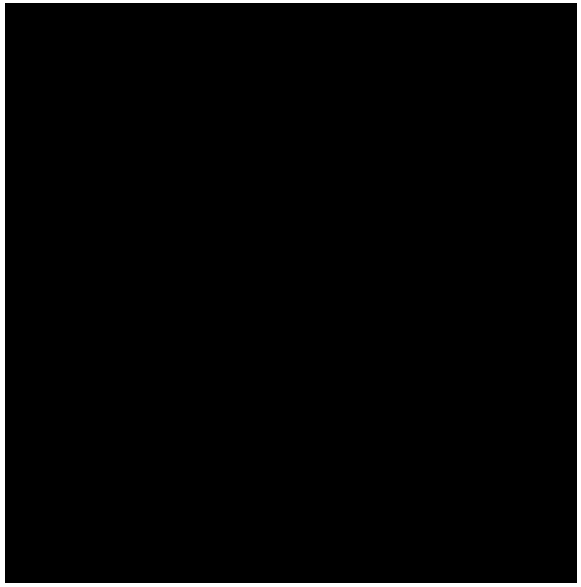
487. I declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Executed on: October 16, 2025 By: _____
Matthew Turk, Ph.D.

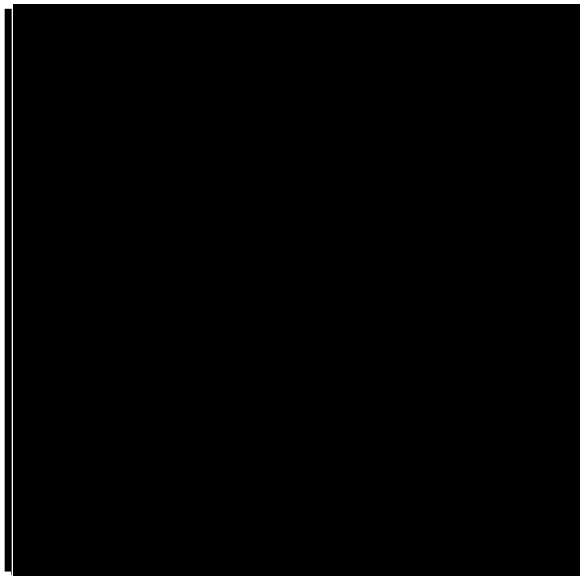
Appendix A: Comparison of FaceTec's and iProov's 3D Liveness Detection Technology

U.S. Patent No. 10,776,471		FaceTec	iProov
Claim 1			
1[pre]	A system for authenticating three-dimensionality of a user via a user's camera equipped computing device, the computing device comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first distance to the	iProov's system practices this element.

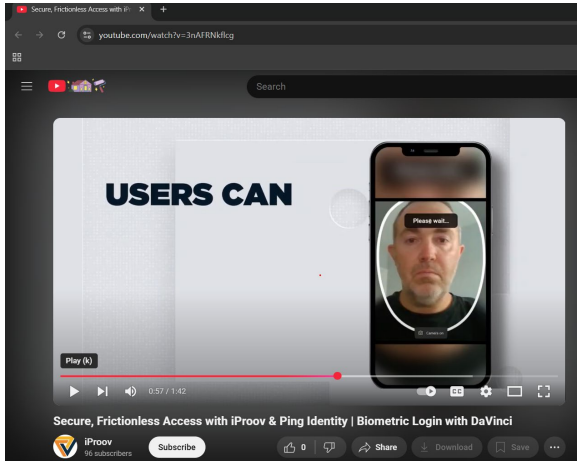
U.S. Patent No. 10,776,471		FaceTec	iProov
		second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone.  Excerpt from Ex. 2072.	For example, the computing device in iProov's system may be a mobile phone.  Excerpt from Ex. 2071.

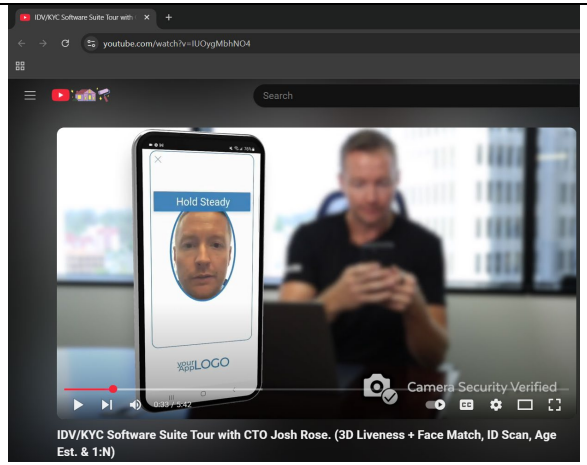
U.S. Patent No. 10,776,471		FaceTec	iProov
		 Excerpt from Ex. 2069. 	

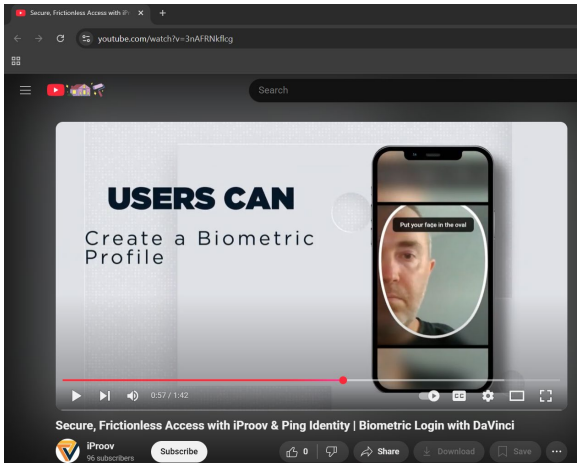
U.S. Patent No. 10,776,471		FaceTec	iProov
		Ex. 2067.	
1[a]	a processor configured to execute machine executable code;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code. Ex. 2059 (Rose) ¶ 10.	iProov's system practices this element. A computing device like a mobile phone includes a processor configured to execute machine executable code. *See* Ex. 2059 (Rose) ¶ 10.
1[b]	a screen configured to provide a user interface to the user;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a screen configured with a user interface. Ex. 2059 (Rose) ¶ 10.	iProov's system practices this element. For example, a computing device like a mobile phone includes a screen configured with a user interface. *See* Ex. 2059 (Rose) ¶ 10.
1[c]	a camera configured to capture images;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a	iProov's system practices this element. For example, a computing device like a mobile phone includes a camera

U.S. Patent No. 10,776,471		FaceTec	iProov
		camera configured to capture images. Ex. 2059 (Rose) ¶ 10.	configured to capture images. *See* Ex. 2059 (Rose) ¶ 10.
1[d]	one or more memories configured to store machine readable instructions that are stored on the memory of the authentication server which when executed by the processor, cause the computing device to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. 	iProov's system practices this element. For example, a computing device like a mobile phone includes one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10.

U.S. Patent No. 10,776,471		FaceTec	iProov
		Ex. 2067.   Ex. 2067.	
1[d1]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a first	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken	iProov's system practices this element.

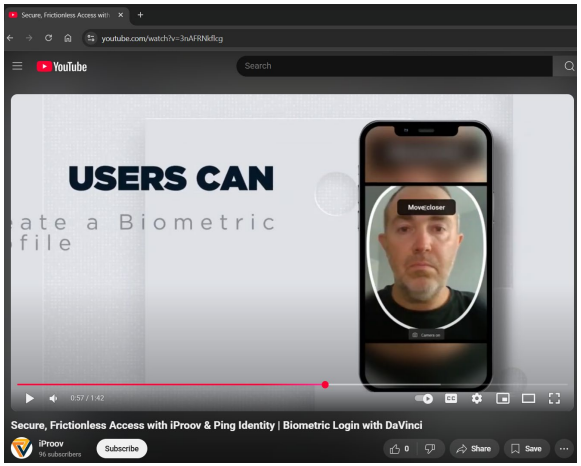
U.S. Patent No. 10,776,471		FaceTec	iProov
	distance from the user;	with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The image below shows first image captured by a mobile phone at a first distance using iProov's system.  Excerpt from Ex. 2071.

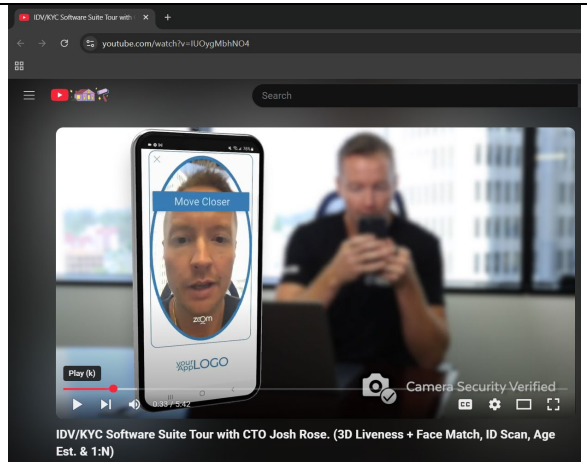
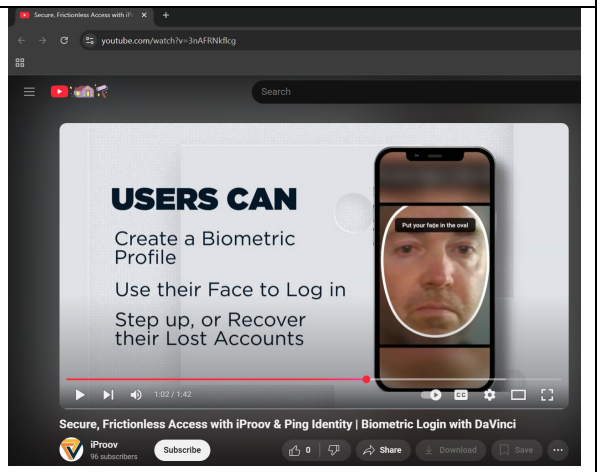
U.S. Patent No. 10,776,471		FaceTec	iProov
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]").	

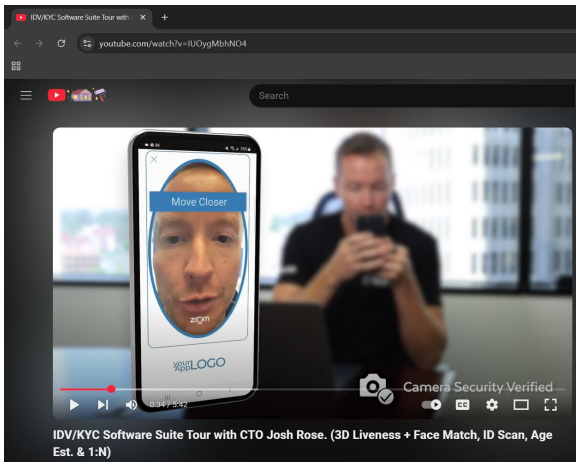
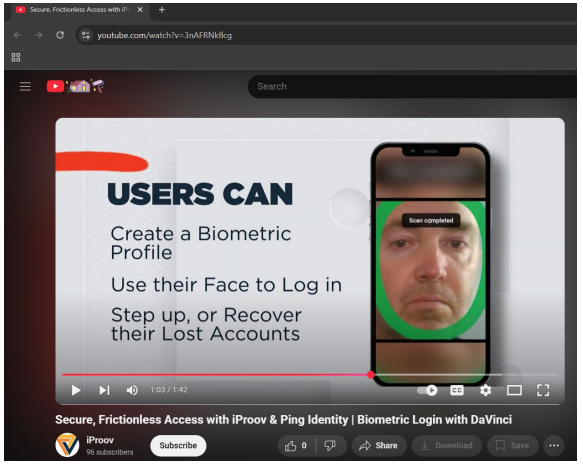
U.S. Patent No. 10,776,471		FaceTec	iProov
1[d2]	processing the at least one first image or a portion to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. [redacted] Ex. 2067 ("[redacted]	iProov's system practices this element. The image below shows iProov creating a biometric profile, which is obtained by processing the first image.  Excerpt from Ex. 2071.

U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted].”).	
1[d3]	moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving from the first location to the second location to change the distance between the user and the camera from the first distance to a second distance;	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology the user’s computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec’s 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec’s 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose)	iProov’s system practices this element.

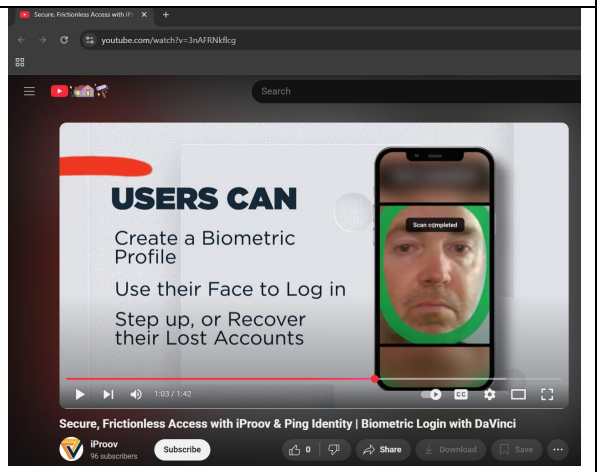
U.S. Patent No. 10,776,471		FaceTec	iProov
		¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. [redacted] Ex. 2067 ("[redacted]."). Because the distance is	

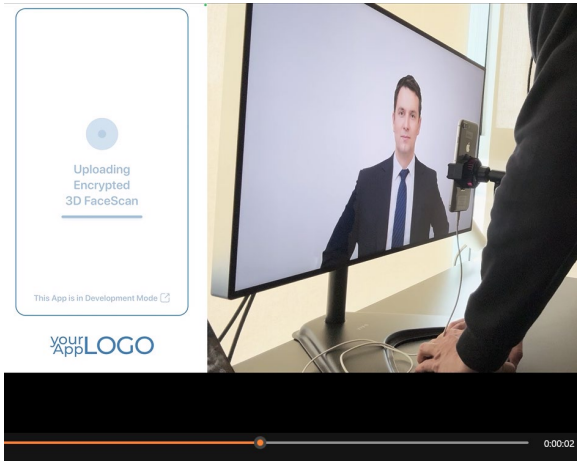
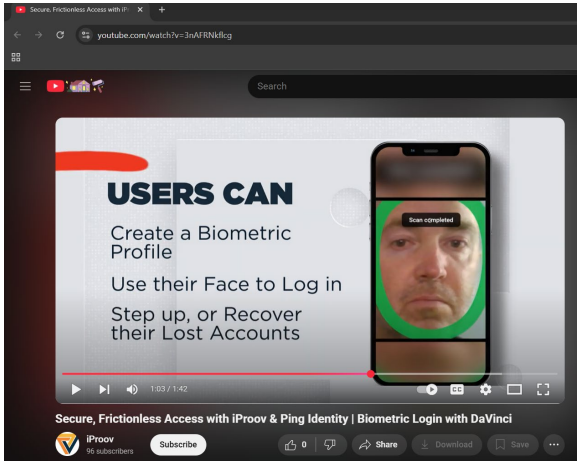
U.S. Patent No. 10,776,471		FaceTec	iProov
		decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.  Excerpt from Ex. 2072.	The images below show a prompt on the screen asking the user to move to put their face within the oval, requiring either movement of the camera or movement of the user.  Excerpt from Ex. 2071.

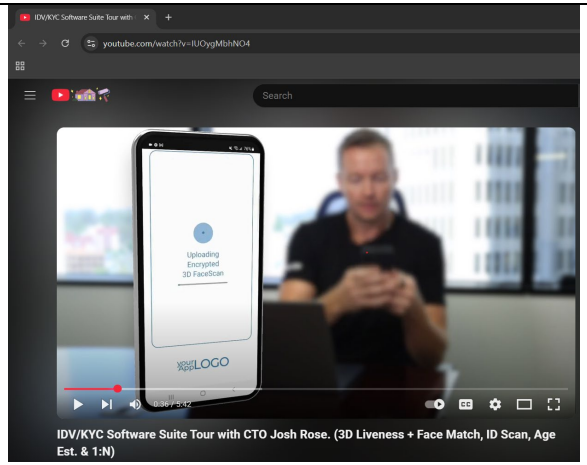
U.S. Patent No. 10,776,471		FaceTec	iProov
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2071.
1[d4]	capturing at least one second image of the user taken with the camera of the computing device at the second distance from the user, the second distance being different than the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The images below show second image captured by a mobile phone at	iProov's system practices this element. The image below shows a second image captured by a mobile phone at

U.S. Patent No. 10,776,471		FaceTec	iProov
		a second distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.  Excerpt from Ex. 2069.	a second distance using iProov's system.  Excerpt from Ex. 2071.

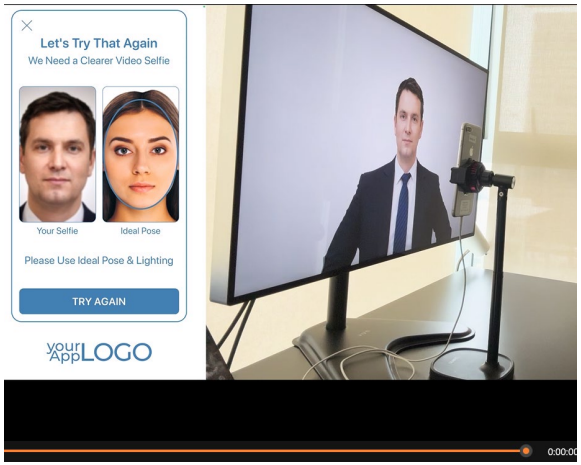
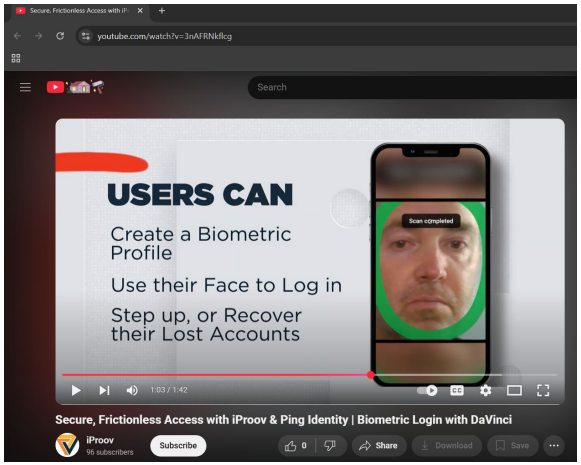
U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted].").	
1[d5]	processing the at least one second image or a portion thereof to create second data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12.	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the second image.

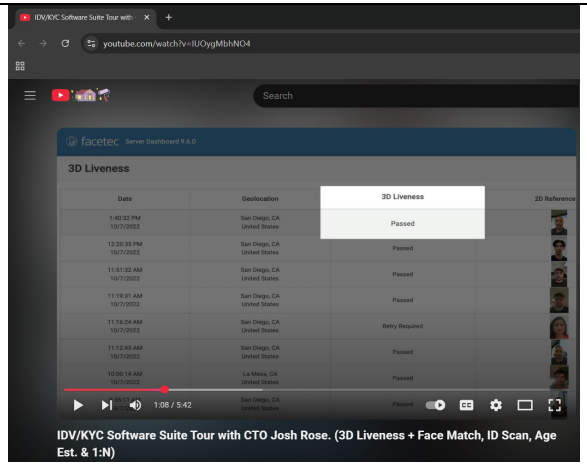
U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted].").	 Excerpt from Ex. 2071.
1[d6]	comparing the first data to the second data to determine whether expected differences exist between the first data and the second data which indicated three-dimensionality of the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the	iProov's system practices this element.

U.S. Patent No. 10,776,471		FaceTec	iProov
		second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov compares the biometric data obtained by processing the second image.  Excerpt from Ex. 2071.

U.S. Patent No. 10,776,471		FaceTec	iProov
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]	

U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted].”).	
1[d7]	authenticating the user when differences between the first data and the second data have expected distortion resulting from movement of the camera from the first location to the second location or movement of the user from the first location to the second location, which causes the change in distance between the user and the camera.	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device determines that the user’s face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18.	iProov’s system practices this element.

U.S. Patent No. 10,776,471		FaceTec	iProov
		The images below show FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing user to log in based on the biometric profile, which indicates that iProov authenticates using the biometric data obtained by processing the second image.  Excerpt from Ex. 2071.

U.S. Patent No. 10,776,471		FaceTec	iProov
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]	

U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted].”). Ex. 2067 (“[redacted]”).	
Claim 10			
10[pre]	A method for authenticating three-dimensionality of a user via a user’s camera equipped computing device,	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].

U.S. Patent No. 10,776,471		FaceTec	iProov
	the method, during an authentication session comprising:		
10[a]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a first distance from the user;	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].
10[b]	processing the at least one first image or a portion to create first data;	*See, e.g.*, claim 1[d2].	*See, e.g.*, claim 1[d2].
10[c]	moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving from	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].

U.S. Patent No. 10,776,471		FaceTec	iProov
	the first location to the second location to change the distance between the user and the camera from the first distance to a second distance;		
10[d]	capturing at least one second image of the user taken with the camera of the computing device at the second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[d4].	*See, e.g.*, claim 1[d4].
10[e]	processing the at least one second image or a portion thereof to create second data;	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].

U.S. Patent No. 10,776,471		FaceTec	iProov
10[f]	comparing the first data to the second data to determine whether expected distortion exist between the first data and the second data which indicated three-dimensionality of the user;	*See, e.g.*, claim 1[d6]. For example, "[a]mong other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. FaceTec's technology can detect this perspective distortion and other expected differences by examining at least two images taken at different distances." Ex. 2059 (Rose) ¶ 25. [redacted] Ex. 2067 ([redacted]	*See, e.g.*, claim 1[d6].

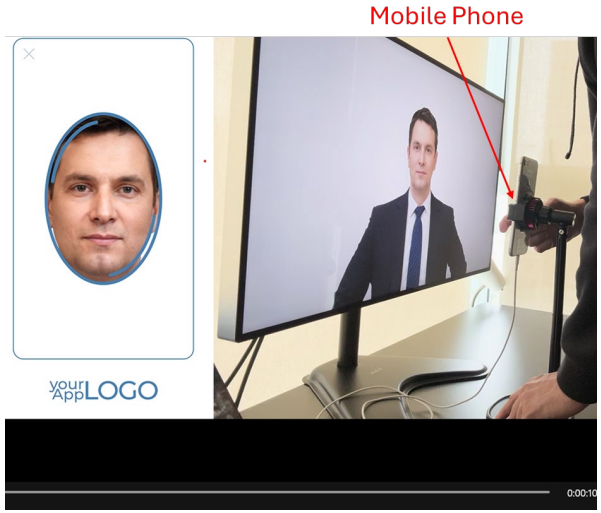
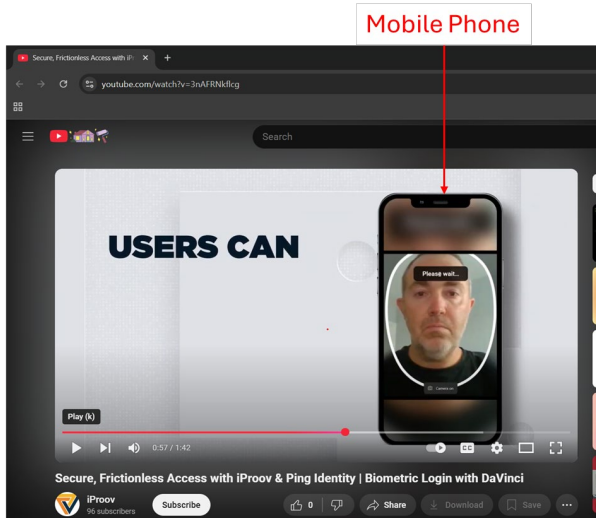
U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted].”).	
10[g]	authenticating the user when the differences between the first data and the second data have expected distortion resulting from movement of the camera from the first location to the second location or movement of the user from the first location to the second location, which causes the change in distance between the user and the camera.	*See, e.g.*, claim 1[d7]. For example, “[a]mong other subtle but detectable distortions, perspective distortion causes the user’s nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. FaceTec’s technology can detect this perspective distortion and other expected differences by examining at least two images taken at different distances.” Ex. 2059 (Rose) ¶ 25. FaceTec’s 3D liveness detection technology collects one or more facial images at a first distance from the camera, collects one or more facial images at a second distance from the camera, and then compares the images to confirm the presence of	*See, e.g.*, claim 1[d7].

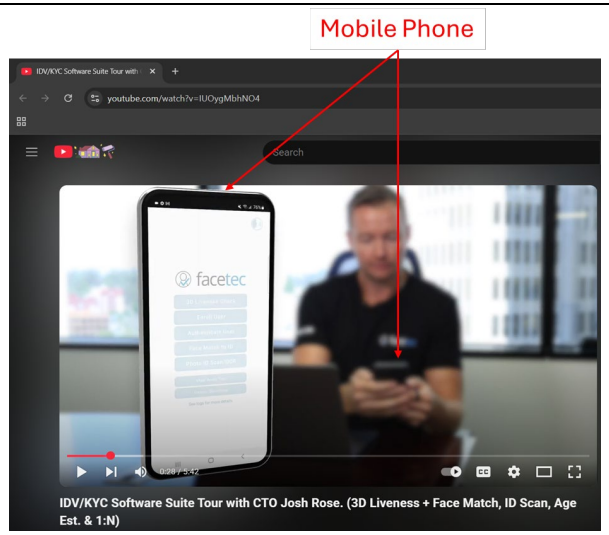
U.S. Patent No. 10,776,471		FaceTec	iProov
		appropriate perspective distortion. Ex. 2059 (Rose) ¶ 9. The FaceTec software determines that the user's face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19.	

U.S. Patent No. 10,776,471		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted].").	

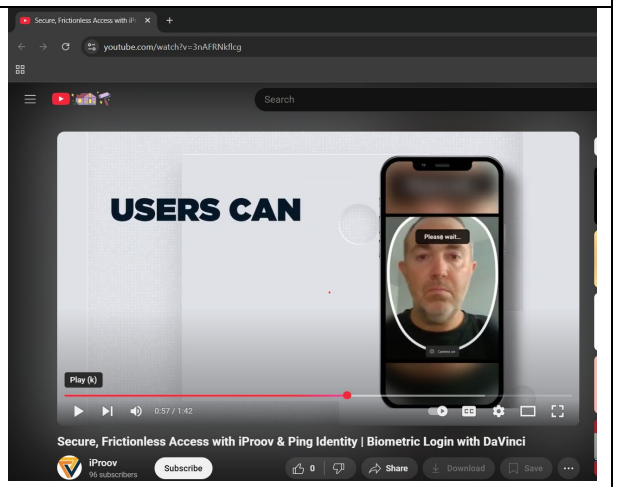
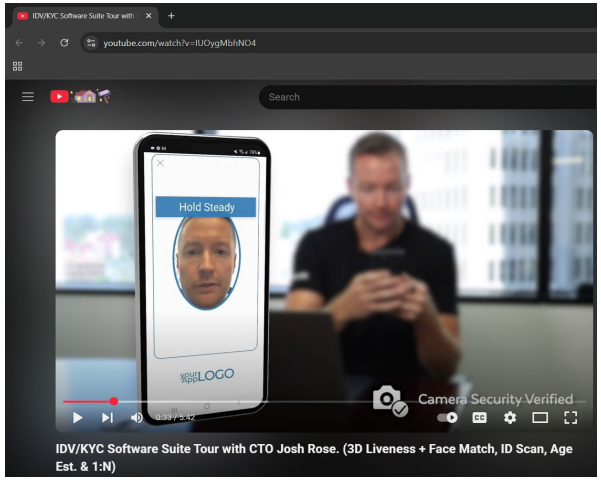
Appendix B: Comparison of FaceTec's and iProov's 3D Liveness Detection Technology

U.S. Patent No. 11,157,606		FaceTec	iProov
Claim 1			
1[pre]	A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first distance to the second distance to capture the first	iProov's system practices this element.

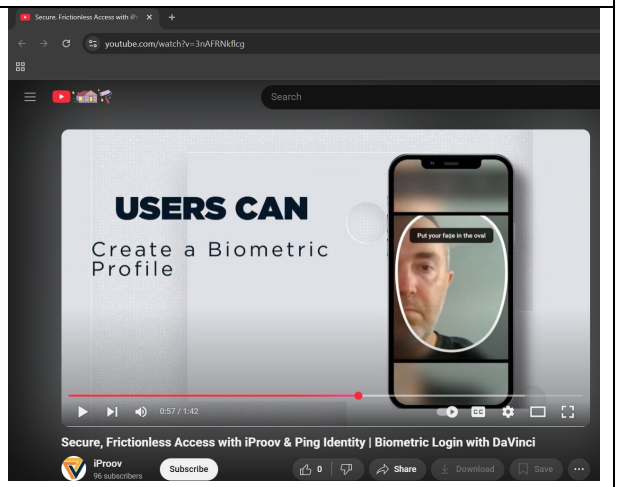
U.S. Patent No. 11,157,606		FaceTec	iProov
		image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone.  Excerpt from Ex. 2072.	For example, the computing device in iProov's system may be a mobile phone.  Excerpt from Ex. 2071.

U.S. Patent No. 11,157,606		FaceTec	iProov
		 Excerpt from Ex. 2069. [redacted]	

U.S. Patent No. 11,157,606		FaceTec	iProov
		Ex. 2067.	
1[a]	capturing at least one first image of the user taken with the camera of the computing device at a first distance from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.	iProov's system practices this element. The image below shows a first image captured by a mobile phone at a first distance using iProov's system.

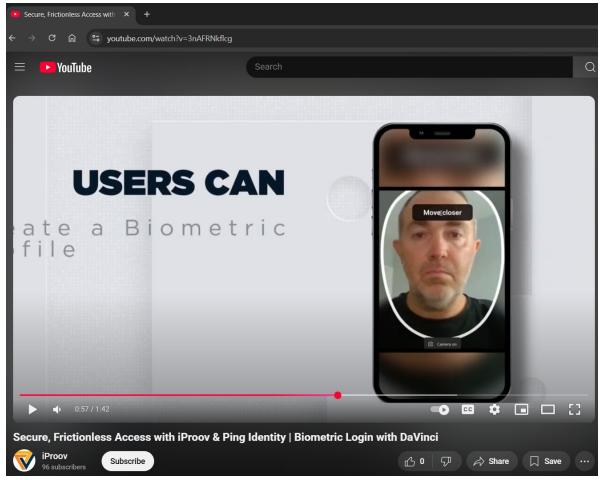
U.S. Patent No. 11,157,606		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

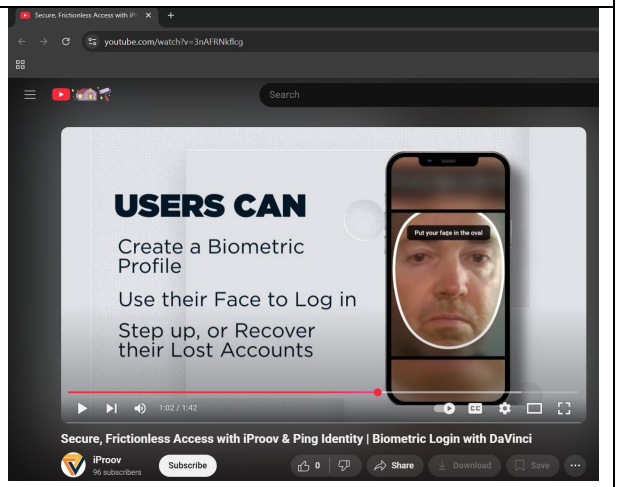
U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
1[b]	processing the at least one first image to obtain first biometric data from the at least one first image;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The first data and the second data include biometric data and	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the first image.

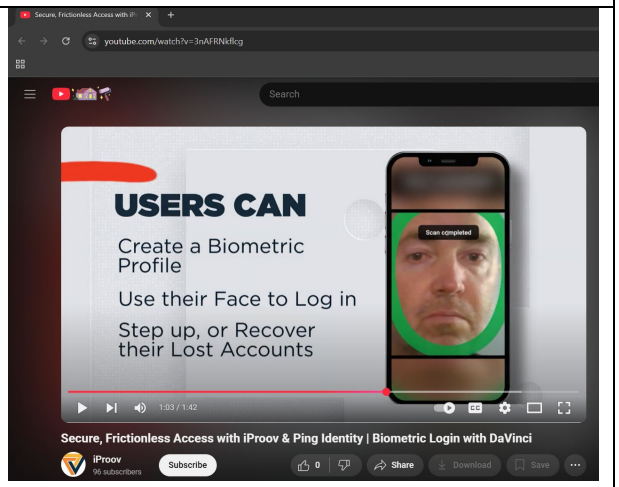
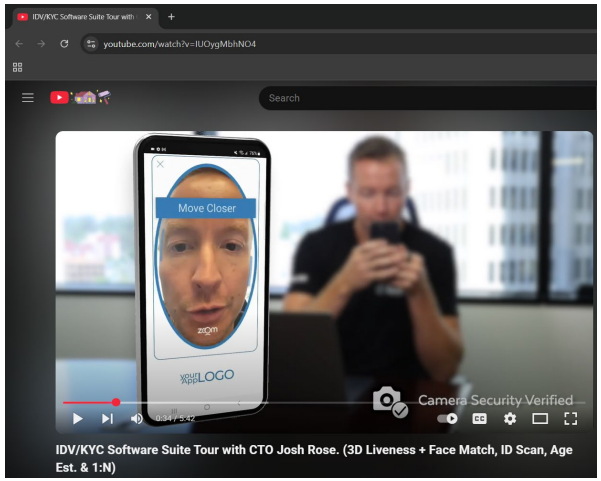
U.S. Patent No. 11,157,606		FaceTec	iProov
		a mapping of facial features. Ex. 2059 (Rose) ¶ 21. [redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2071.
1[c]	capturing at least one second image of the user taken with the camera of the computing device at a second distance from the user, the second	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from	iProov's system practices this element.

U.S. Patent No. 11,157,606		FaceTec	iProov
	distance being different than the first distance;	the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.	

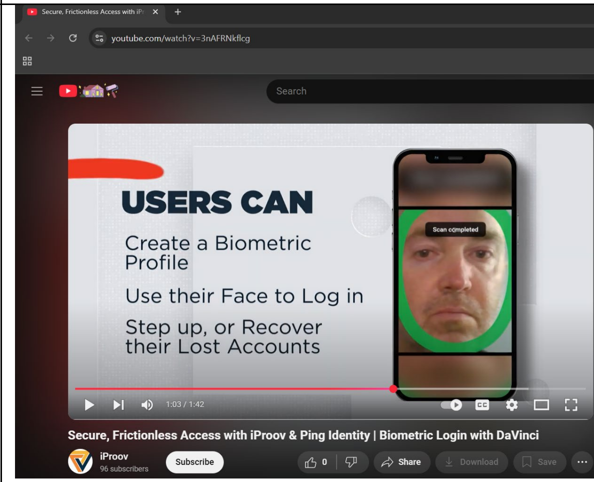
U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]"). Because the distance is decreased, the first distance is greater than the second distance. In FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the	

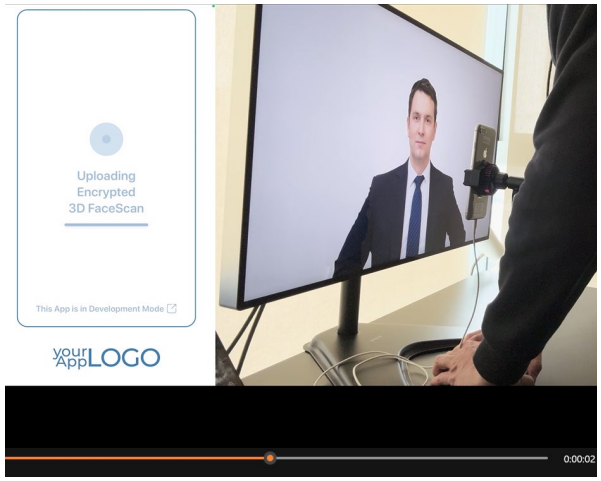
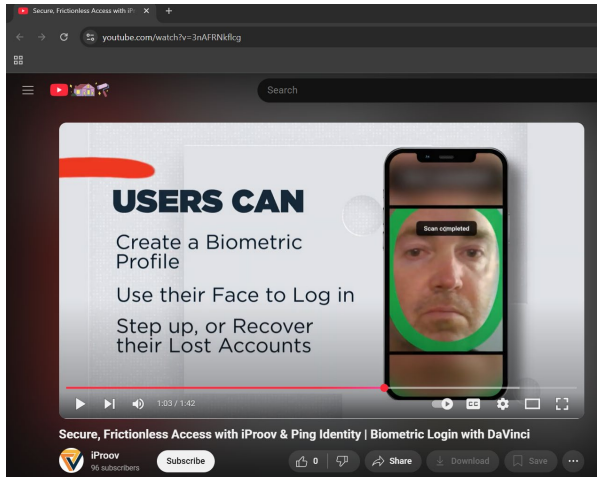
U.S. Patent No. 11,157,606		FaceTec	iProov
		camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.  Excerpt from Ex. 2072.	The images below show a prompt on the screen asking the user to move to put their face within the oval, requiring either movement of the camera, movement of the user, or both.  Excerpt from Ex. 2071.

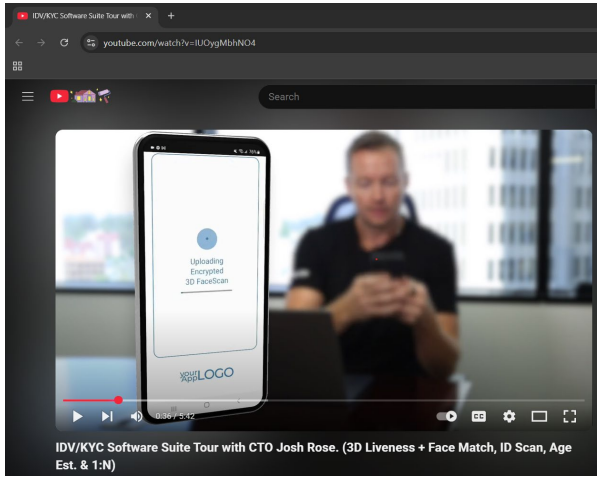
U.S. Patent No. 11,157,606		FaceTec	iProov
		The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.	 Excerpt from Ex. 2071. The image below shows a second image captured by a mobile phone at a second distance using iProov's system.

U.S. Patent No. 11,157,606		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted].").	
1[d]	processing the at least one second image to obtain second biometric data based on the at least one second image;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12. The first data and the second data include biometric data and a mapping of facial features. Ex. 2059 (Rose) ¶ 21.	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the second image.

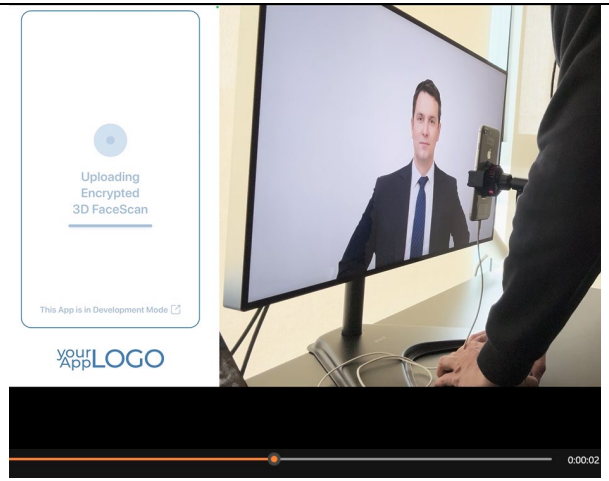
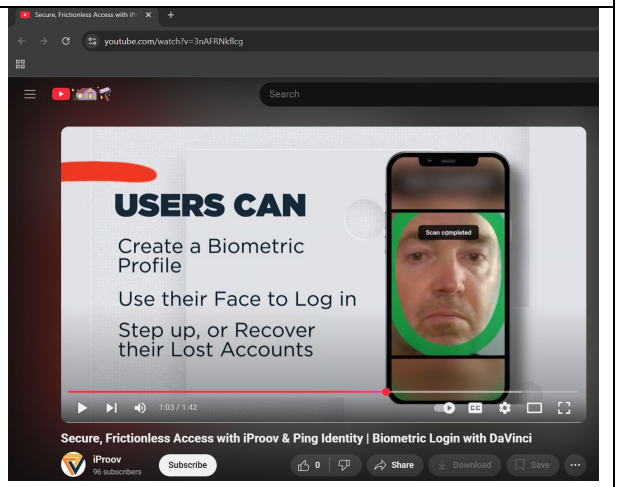
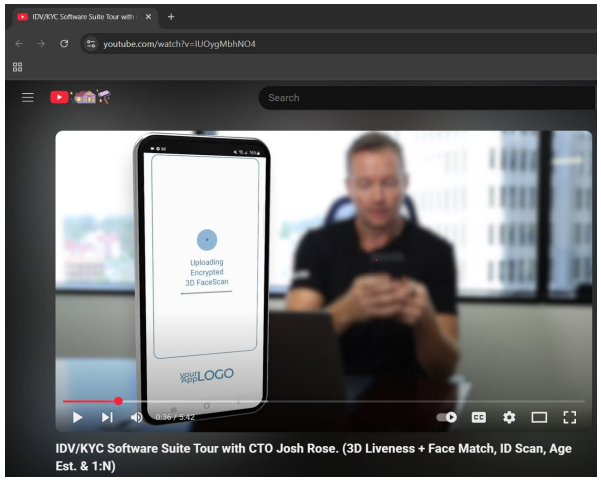
U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 (“[redacted]).	 Excerpt from Ex. 2071.
1[e]	comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the second biometric data;	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology the user’s computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between	iProov’s system practices this element.

U.S. Patent No. 11,157,606		FaceTec	iProov
		the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data. 	The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov's system compares the biometric data obtained by processing the second image. 

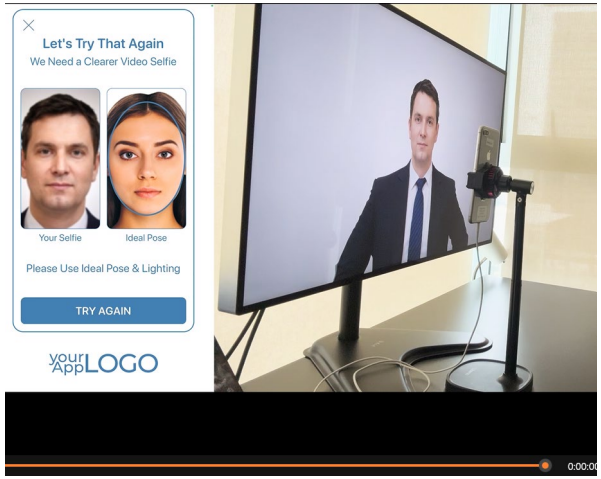
U.S. Patent No. 11,157,606		FaceTec	iProov
		Excerpt from Ex. 2072.  Excerpt from Ex. 2069.	Excerpt from Ex. 2071.

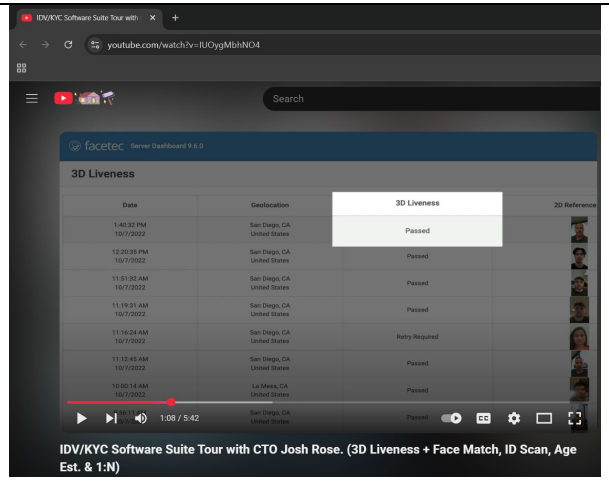
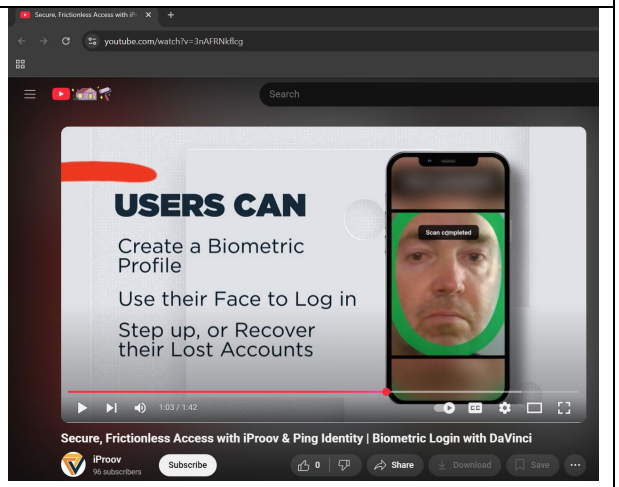
U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
1[f]	comparing the first biometric data to second biometric data to determine whether differences between the at	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to	iProov's system practices this element.

U.S. Patent No. 11,157,606		FaceTec	iProov
	least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance;	determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov's system compares the biometric data obtained by processing the second image.

U.S. Patent No. 11,157,606		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,157,606		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
1[g]	determining that the user's face is three-dimensional when:	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device determines that the user's face is three-dimensional when	iProov's system practices this element.

U.S. Patent No. 11,157,606		FaceTec	iProov
		the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18. The images below show FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing a user to log in based on the biometric profile, which indicates that iProov's system authenticates using the biometric data obtained by processing the second image.

U.S. Patent No. 11,157,606		FaceTec	iProov
		 Excerpt from Exhibit Ex. 2069.	 Excerpt from Ex. 2071.
		[redacted]	

U.S. Patent No. 11,157,606		FaceTec	iProov
		Ex. 2067 (“[redacted]”). Ex. 2067 (“[redacted]”).	
1[h]	the first biometric data does not match the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
1[i]	the second biometric data has	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

U.S. Patent No. 11,157,606		FaceTec	iProov
	the expected differences as compared to the first biometric data resulting from the change in distance between the user and the camera when capturing the at least one first image and the at least one second image.		
Claim 10			
10[pre]	A system for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device,	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].

U.S. Patent No. 11,157,606		FaceTec	iProov
	the system comprising:		
10[a]	a computing device having a camera, screen, processor, and memory configured with non-transitory machine readable code that is executable by the processor, the machine readable code configured to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10.	iProov's system practices this element. For example, iProov uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10.
10[b]	capture at least one first image of the user taken with the camera of the computing device when the camera is located a first distance from the user;	*See, e.g.*, claim 1[a].	*See, e.g.*, claim 1[a].

U.S. Patent No. 11,157,606		FaceTec	iProov
10[c]	process the at least one first image to obtain first biometric data from the at least one first image;	*See, e.g.*, claim 1[b].	*See, e.g.*, claim 1[b].
10[d]	capture at least one second image of the user taken with the camera of the computing device when the camera is located a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[c].	*See, e.g.*, claim 1[c].
10[e]	process the at least one second image to obtain second biometric data based on the at	*See, e.g.*, claim 1[d].	*See, e.g.*, claim 1[d].

U.S. Patent No. 11,157,606		FaceTec	iProov
	least one second image;		
10[f]	compare the first biometric data to the second biometric data to determine whether the first biometric data matches the second biometric data;	*See, e.g.*, claim 1[e].	*See, e.g.*, claim 1[e].
10[g]	compare the first biometric data to second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences	*See, e.g.*, claim 1[f].	*See, e.g.*, claim 1[f].

U.S. Patent No. 11,157,606		FaceTec	iProov
	resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance;		
10[h]	determine that the user's face is three-dimensional when:	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
10[h1]	the first biometric data does not match the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
10[h2]	the second biometric data has the expected differences as compared to the first biometric data resulting from the change in distance	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

U.S. Patent No. 11,157,606		FaceTec	iProov
	between the user and the camera.		
Claim 19			
19[pre]	A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:	*See, e.g.*, claim 1[pre]	*See, e.g.*, claim 1[pre]
19[a]	receiving first biometric data generated from at least one first image of the user taken with the camera of the computing device located at a first	*See, e.g.*, claim 1[a] and 1[b].	*See, e.g.*, claim 1[a] and 1[b].

U.S. Patent No. 11,157,606		FaceTec	iProov
	distance from the user;		
19[b]	receiving second biometric data generated from at least one second image of the user taken with the camera of the computing device located at a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[c] and 1[d].	*See, e.g.*, claim 1[c] and 1[d].
19[c]	comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the	*See, e.g.*, claim 1[e].	*See, e.g.*, claim 1[e].

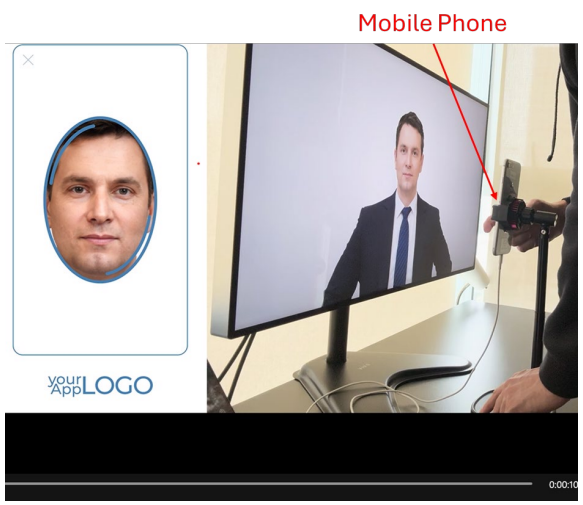
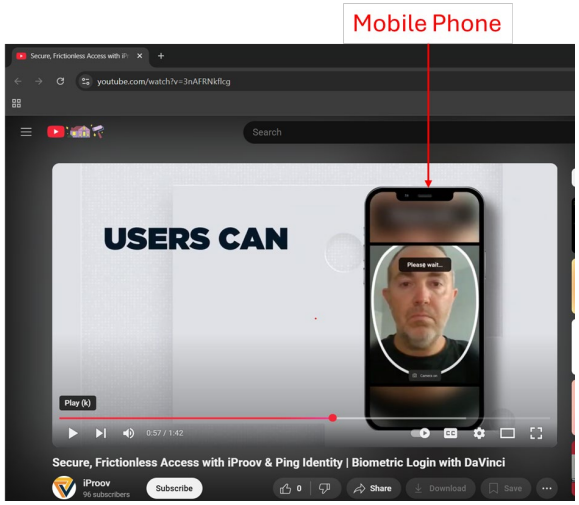
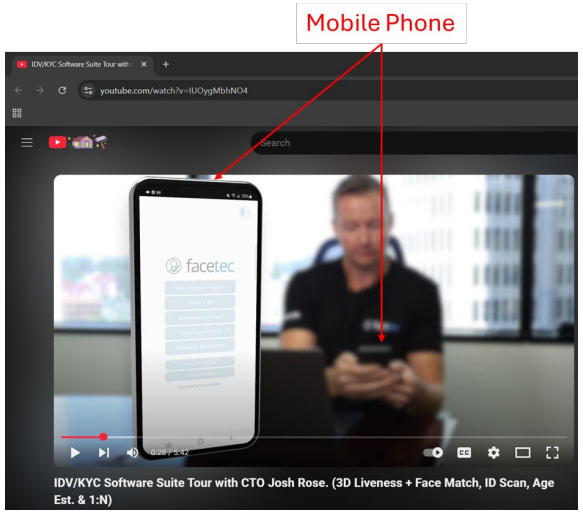
U.S. Patent No. 11,157,606		FaceTec	iProov
	second biometric data;		
19[d]	comparing the first biometric data with second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changes the distance between the user and camera for capture of the one or more first images at the	*See, e.g.*, claim 1[f].	*See, e.g.*, claim 1[f].

U.S. Patent No. 11,157,606		FaceTec	iProov
	first distance and capture of the one or more second images at the second distance;		
19[e]	determining that the user's face is three-dimensional when:	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
19[e1]	the first biometric data is not identical to the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
19[e2]	the second biometric data has expected differences as compared to the first biometric data, the expected differences resulting from the change in distance between the user	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

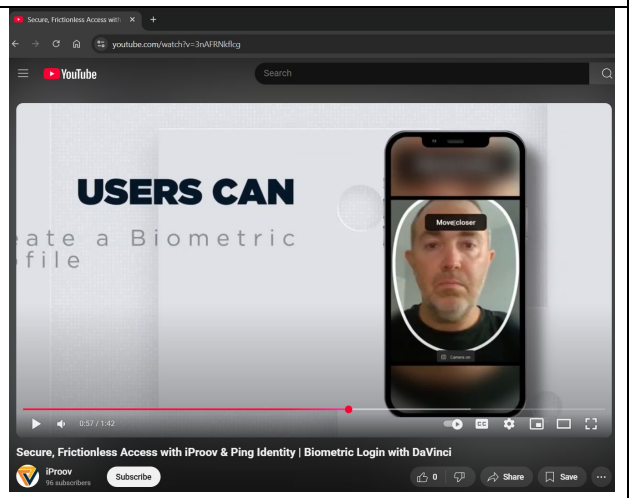
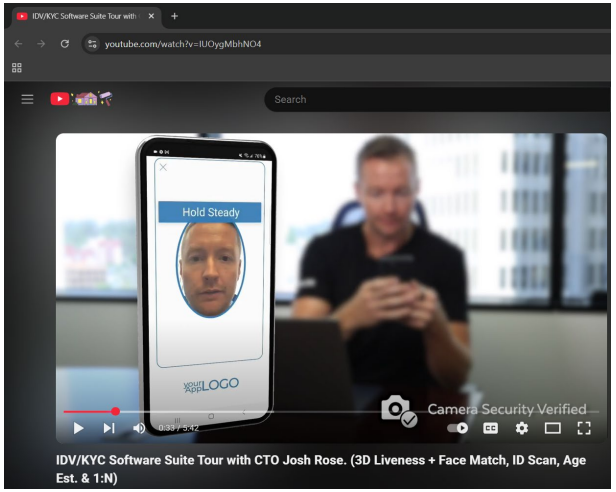
U.S. Patent No. 11,157,606		FaceTec	iProov
	and the camera when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance.		

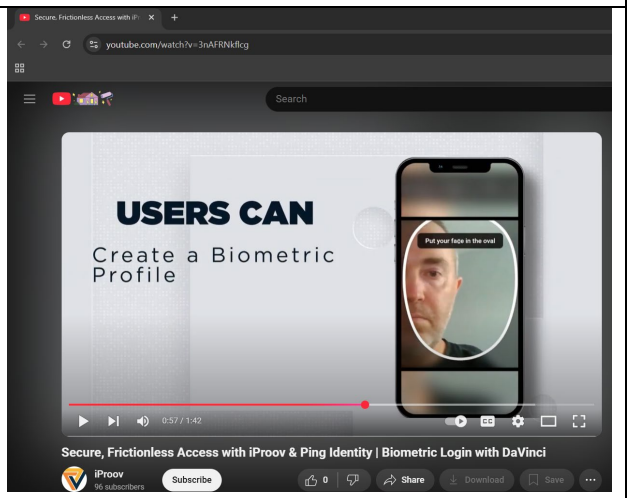
Appendix C: Comparison of FaceTec's and iProov's 3D Liveness Detection Technology

U.S. Patent No. 11,693,938		FaceTec	iProov
Claim 1			
1[pre]	A non-transient computer readable medium containing non-transitory machine executable code configured to determine if the three-dimensional shape is consistent with that of a human face, the non-transitory machine executable code configured to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. For example, the computing device may be a mobile phone.	iProov's system practices this element. For example, iProov's system uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10. For example, the computing device in iProov's system may be a mobile phone.

U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

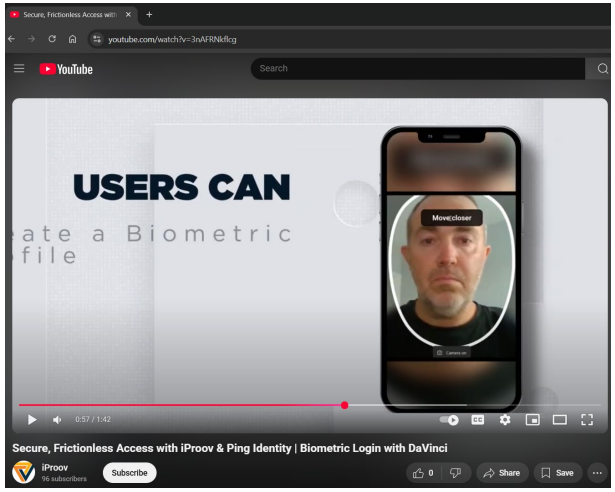
U.S. Patent No. 11,693,938		FaceTec	iProov
1[a]	receive or derive first biometric data from at least one first image of a user taken with a computing device camera located at a first distance from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The user's computing device processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The first data and the second data include biometric data and a mapping of facial features. Ex. 2059 (Rose) ¶ 21. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.	iProov's system practices this element. The image below shows a first image captured by a mobile phone at a first distance using iProov's system.

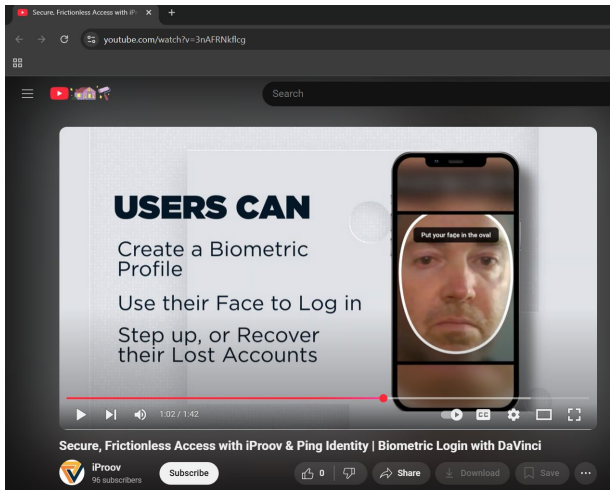
U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	The image below shows iProov's system creating a biometric profile, which is obtained by processing the first image.

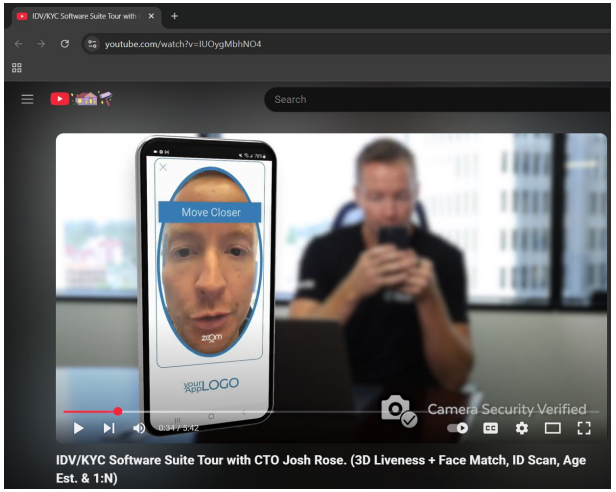
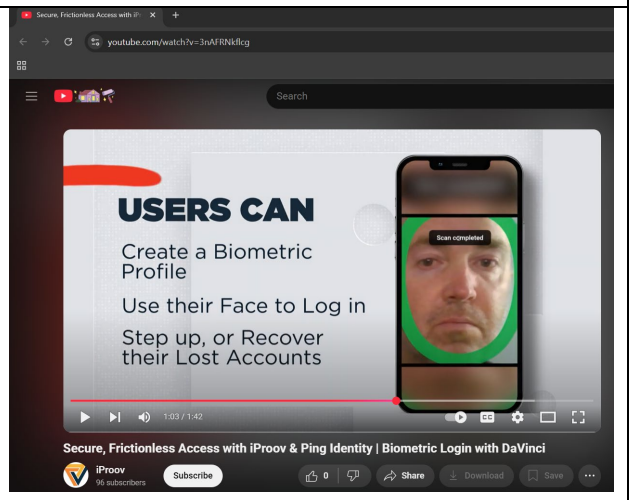
U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 (“[redacted]”). Ex. 2067 (“[redacted]”).	 Excerpt from Ex. 2071.
1[b]	receive or derive second biometric data from at least one second image of the user taken with the	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology the user’s computing device captures at least one	iProov practices this element.

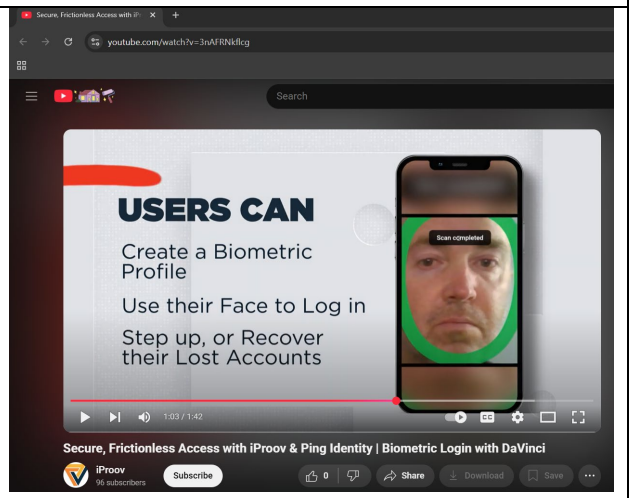
U.S. Patent No. 11,693,938		FaceTec	iProov
	computing device camera located at a second distance from the user, the second distance being different than the first distance;	second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.	

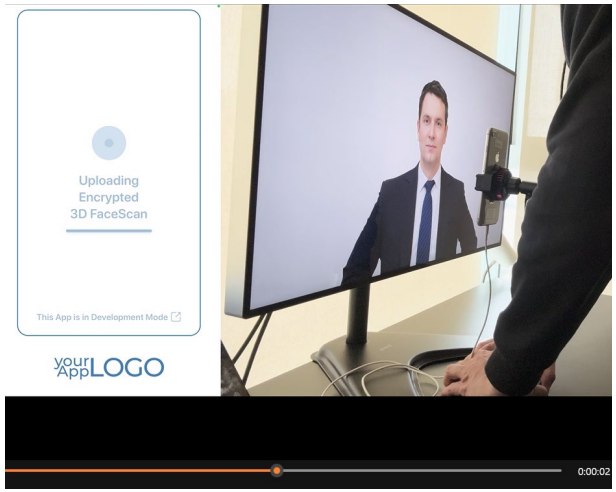
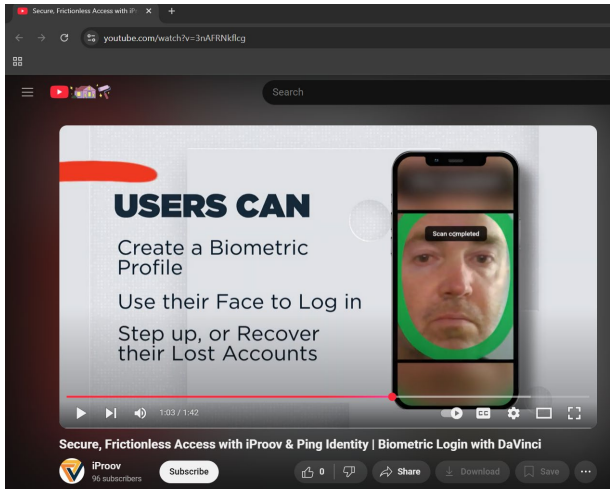
U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]."). Because the distance is decreased, the first distance is greater than the second distance. Ex. 2067 ("[redacted]")	

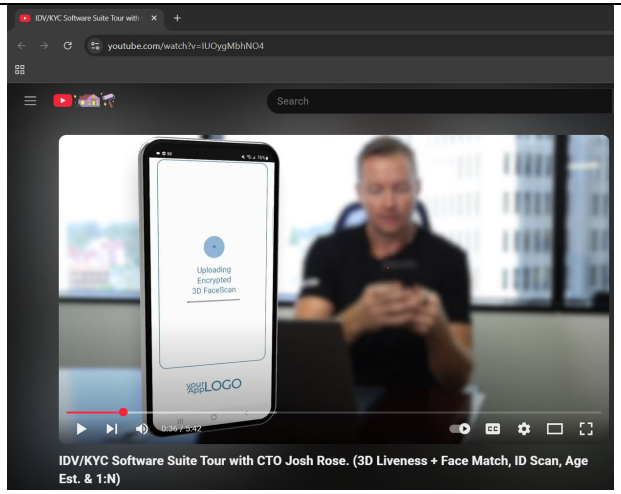
U.S. Patent No. 11,693,938		FaceTec	iProov
		In FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The image below shows a prompt on the screen asking the user to move closer indicating either movement of the camera or movement of the user.  Excerpt from Ex. 2072.	The image below shows a prompt on the screen asking the user to move to put their face within the oval, requiring either movement of the camera or movement of the user.  Excerpt from Ex. 2071.

U.S. Patent No. 11,693,938		FaceTec	iProov
		The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.	 Excerpt from Ex. 2071. The image below shows a second image captured by a mobile phone at a second distance using iProov's system.

U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.  Excerpt from Ex. 2069.	 Excerpt from Ex. 2071. The image below shows iProov's system creating a biometric profile, which is obtained by processing the second image.

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2071.
1[c]	compare the first biometric data with second biometric data for expected differences that result from characteristics of a human face and the at least one first image and the at least one second	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of	iProov's system practices this element.

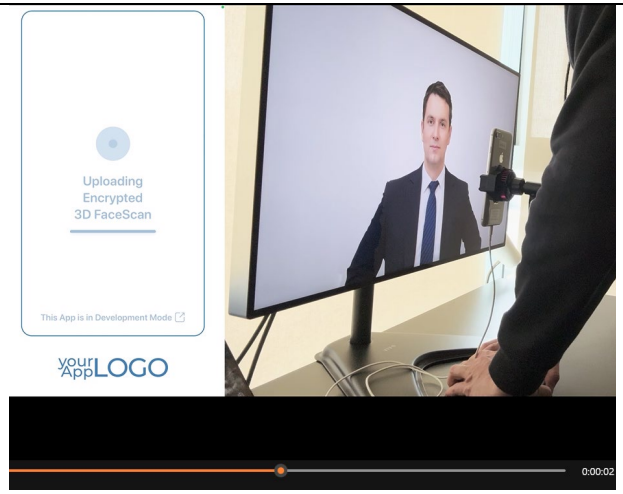
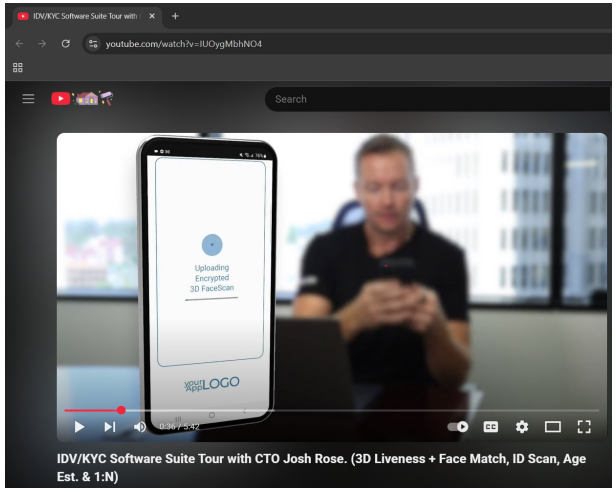
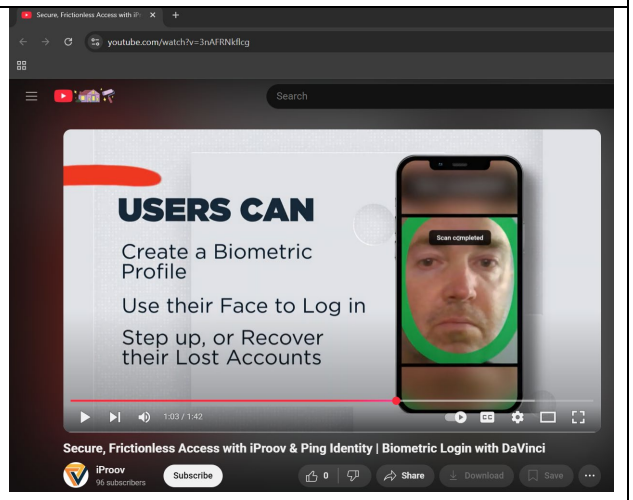
U.S. Patent No. 11,693,938		FaceTec	iProov
	image being captured at different distances from the user;	the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov's system compares the biometric data obtained by processing the second image to identify expected differences between the first and second images.  Excerpt from Ex. 2071.

U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2069. 	

U.S. Patent No. 11,693,938		FaceTec	iProov
		Ex. 2067 ("[redacted]."). Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among	

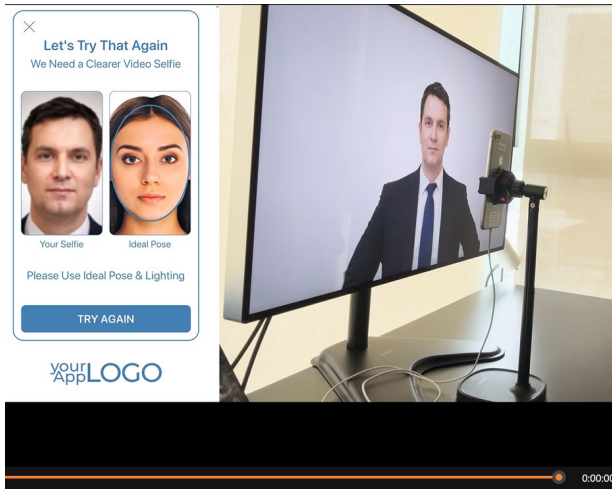
U.S. Patent No. 11,693,938		FaceTec	iProov
		other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25.	
1[d]	determine that the three-dimensional shape is not exhibited when the second biometric data does not have expected differences compared to the first biometric data, the expected differences comprising at least differences due to the change in the relative distance between the user's facial features and	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. In FaceTec's 3D liveness detection technology, the user's computing device	iProov's system practices this element.

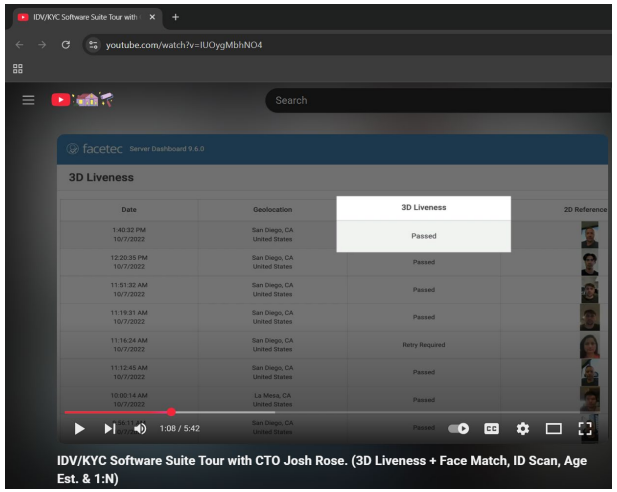
U.S. Patent No. 11,693,938		FaceTec	iProov
	the camera when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance, wherein the expected differences result from fish-eye type distortion in at least one of the at least one first image and the at least one second image and due to the three-dimensional nature of the human face and the change in distance between	determines that the user's face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	The image below shows iProov's system allowing user to log in based on the biometric profile, which indicates that iProov authenticates using the biometric data obtained by processing the second image.

U.S. Patent No. 11,693,938		FaceTec	iProov
	the camera and the user.	 Excerpt from Ex. 2072.  Excerpt from Ex. 2069.	 Excerpt from Ex. 2071.

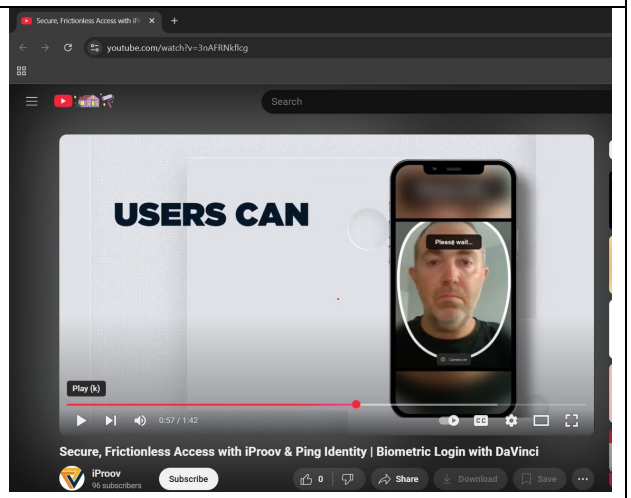
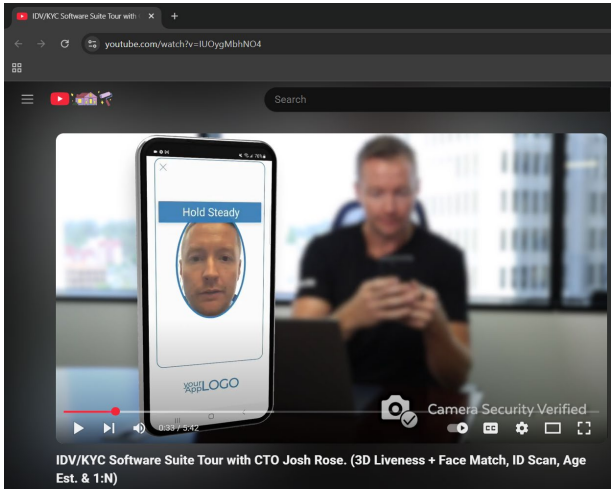
U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]")	

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted]"). Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among other subtle but detectable distortions,	

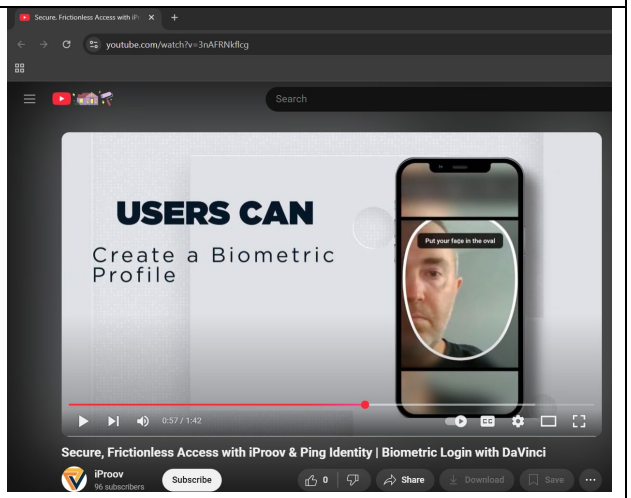
U.S. Patent No. 11,693,938		FaceTec	iProov
		perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25. The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does not have the expected differences.  Excerpt from Ex. 2072	

U.S. Patent No. 11,693,938		FaceTec	iProov
		The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does have the expected differences.  Excerpt from Ex. 2069.	
Claim 8			
8[pre]	A method for determining when a user, based on images of the user's face, does not exhibit three-dimensionality, the	*See, e.g.*, 1[pre].	*See, e.g.*, 1[pre].

U.S. Patent No. 11,693,938		FaceTec	iProov
	method comprising:		
8[a]	capturing at least one first image of the user's face taken with a camera located at a first distance from the user's face, the camera associated with a computing device;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.	iProov's system practices this element. The image below shows first image captured by a mobile phone at a first distance using iProov.

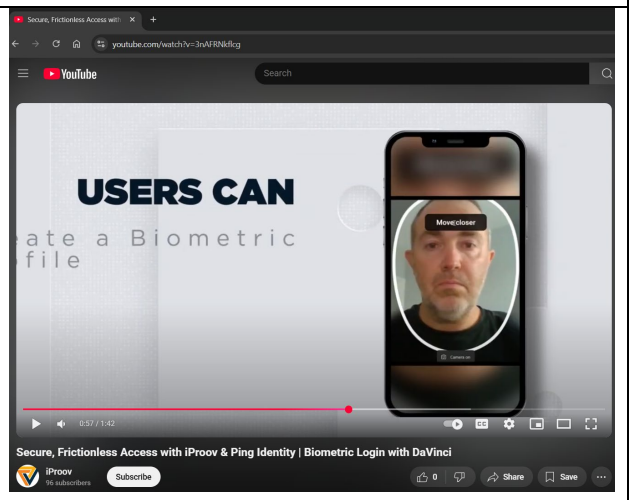
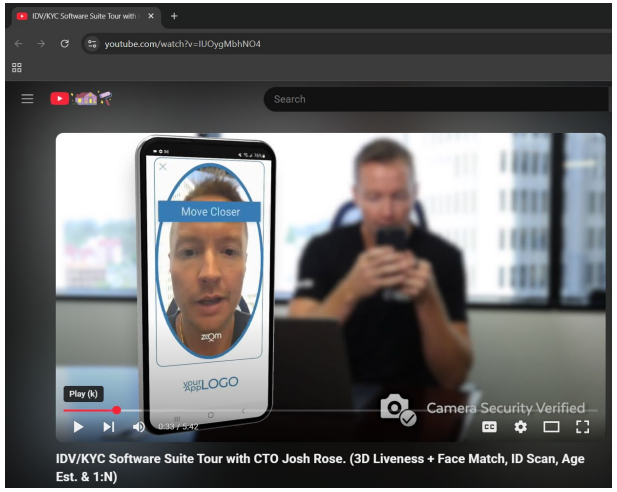
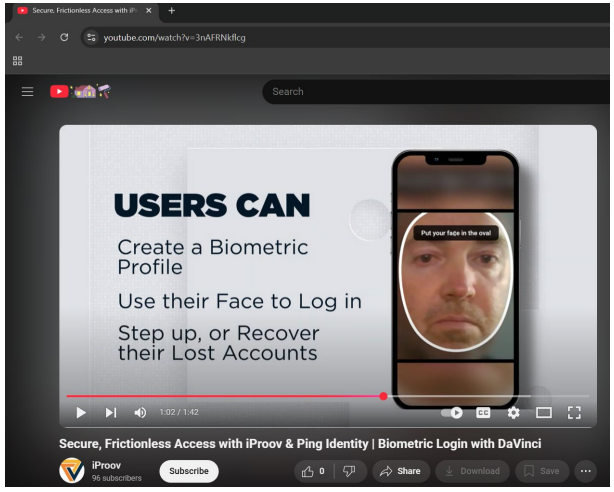
U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

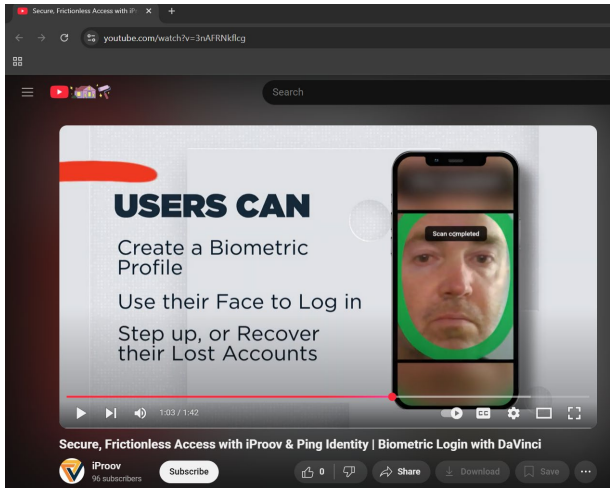
U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
8[b]	processing the at least one first image or a portion thereof to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11.	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the first image.

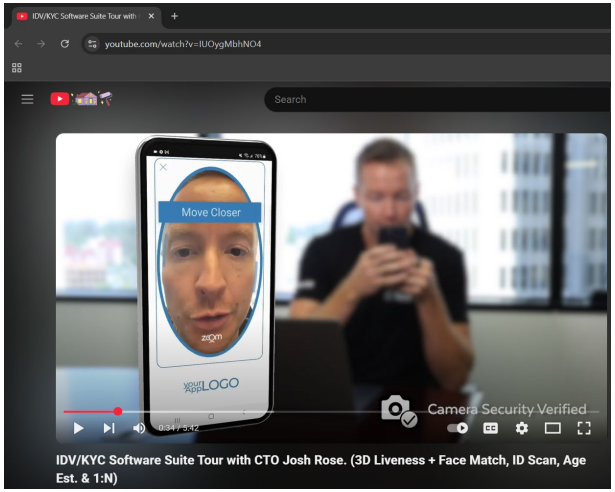
U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2071.
8[c]	moving the camera to a second distance from the user's face, where the second distance is different from the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the	iProov's system practices this element.

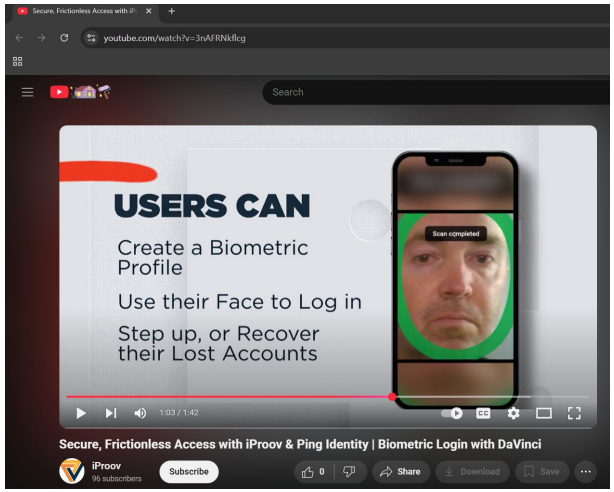
U.S. Patent No. 11,693,938		FaceTec	iProov
		user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. 	

U.S. Patent No. 11,693,938		FaceTec	iProov
		Ex. 2067 ("[redacted]."). Because the distance is decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.	The image below shows a prompt on the screen asking the user to move to put their face within the oval, requiring movement of the camera, movement of the user, or both.

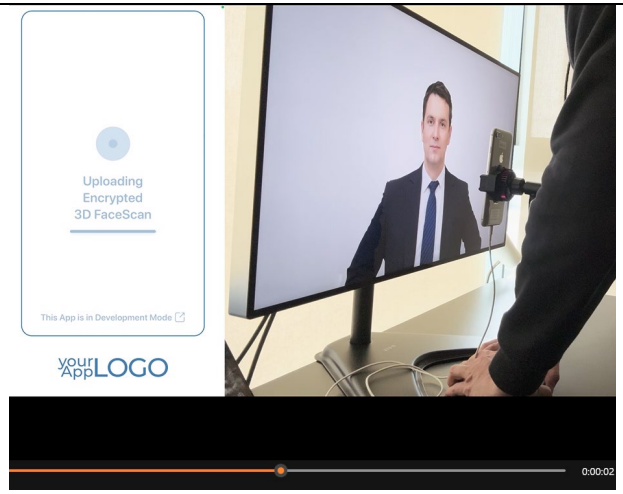
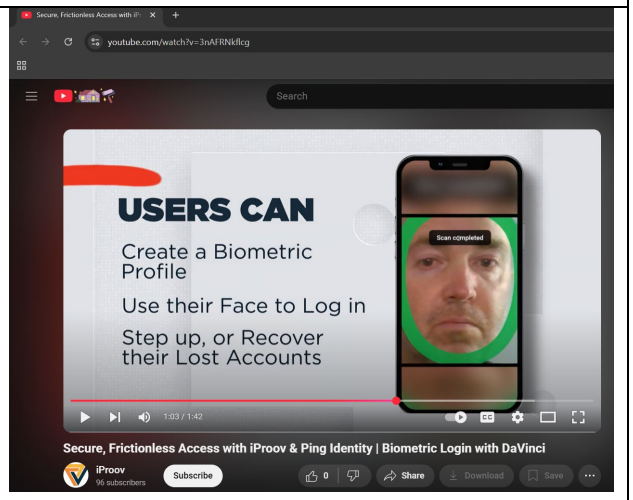
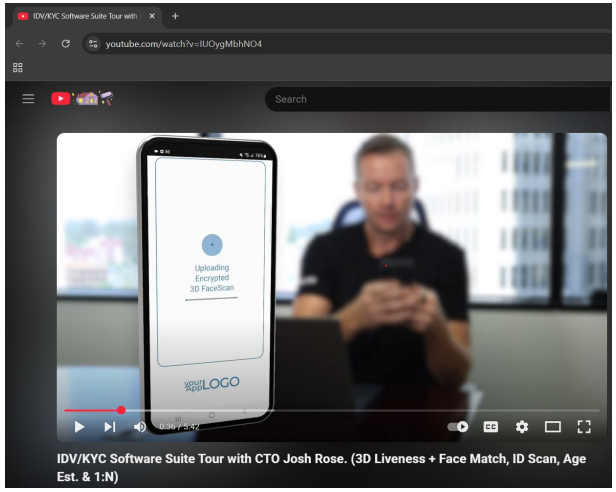
U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2071.

U.S. Patent No. 11,693,938		FaceTec	iProov
8[d]	capturing, at the second distance, at least one second image of the user's face taken with the camera associated with the computing device;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology. 	iProov's system practices this element. The image below shows a second image captured by a mobile phone at a second distance using iProov's system. 

U.S. Patent No. 11,693,938		FaceTec	iProov
		Excerpt from Ex. 2072.  Excerpt from Ex. 2069. [redacted] Ex. 2067 (“[redacted]	Excerpt from Ex. 2071.

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted]").	
8[e]	processing the at least one second image or a portion thereof to create second data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12. [redacted] Ex. 2067 ("[redacted].").	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the second image.  Excerpt from Ex. 2071.

U.S. Patent No. 11,693,938		FaceTec	iProov
8[f]	examining the first data and the second data to determine whether differences between the first data and the second data indicate an expected type of distorting change in at least one image that is consistent with a real person being imaged and which is indicative of three-dimensionality;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	iProov's system practices this element. The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov's system compares the biometric data obtained by processing the second image.

U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
		Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high	

U.S. Patent No. 11,693,938		FaceTec	iProov
		degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25.	
8[g]	determining the user's face is not three-dimensional when the first data and the second data do not have expected	*See, e.g.*, claim 1[d].	iProov's system practices this element. For example, iProov's system performs authentication by comparing biometric data generated by capturing new images of the face of a person with an encrypted biometric template generated

U.S. Patent No. 11,693,938		FaceTec	iProov
	differences indicating the user exhibits three-dimensionality.		during enrollment. Ex. 2080. The biometric data includes expected differences between images. *See, e.g.*, claim 1[c]. Thus, iProov's system determines whether the user's face is three-dimensional or not based on whether the biometric data based on the new images includes or excludes the expected differences as compared to the biometric data obtained during enrollment.
Claim 17			
17[pre]	A method, performed using a computing device, for providing authentication of a person during an authentication session, the method comprising:	*See, e.g.*, claim 8[pre].	*See, e.g.*, claim 8[pre].
17[a]	capturing a first image of a head of	*See, e.g.*, claim 8[a].	*See, e.g.*, claim 8[a].

U.S. Patent No. 11,693,938		FaceTec	iProov
	the person with a camera at a first distance from the person, the camera associated with the computing device;		
17[b]	changing a distance between the person and the camera to a second distance, which is different from the first distance;	*See, e.g.*, claim 8[c].	*See, e.g.*, claim 8[c].
17[c]	capturing a second image of the head of the person with the camera at the second distance from the person;	*See, e.g.*, claim 8[d].	*See, e.g.*, claim 8[d].
17[d]	comparing one or more aspects of the head from the first image or first biometric data	*See, e.g.*, claims 1[d], 8[b], 8[e], and 8[f].	*See, e.g.*, claims 1[d], 8[b], 8[e], and 8[f].

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	derived from the first image to one or more aspects of the head from the second image or second biometric data derived from the second image to determine whether expected differences are not present, wherein the expected differences:		
17[e]	would be present when the first image and second images of the head of the person being captured at different distances has three-dimensional characteristics but	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].

U.S. Patent No. 11,693,938		FaceTec	iProov
	not if the head did not have three-dimensional characteristics; and		
17[f]	the expected differences result from differences in relative dimensions of a person's face appearing different when capturing images is done close to the person's face and far from the persons face; and	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].
17[g]	if the expected differences are not present, denying authentication of the person and providing notice thereof to one or	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].

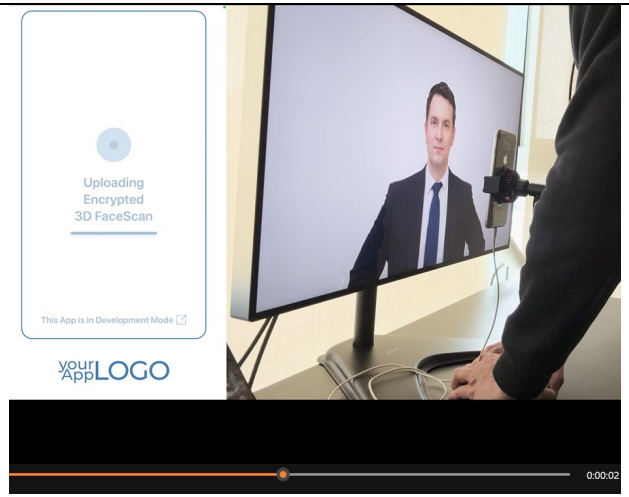
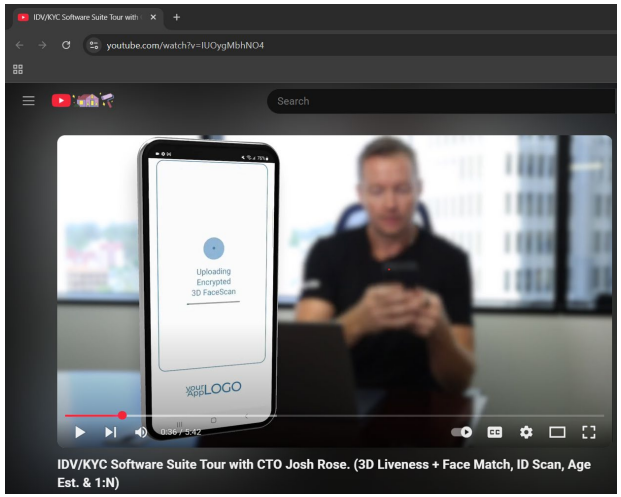
U.S. Patent No. 11,693,938		FaceTec	iProov
	more of the person, a third party, or a software application, wherein the authentication is authentication of liveness, three-dimensionality, or both.		
Claim 20			
20[pre]	A method for determining whether a user exhibits three-dimensionality, the method comprising:	*See, e.g.*, claim 8[pre].	*See, e.g.*, claim 8[pre].
20[a]	capturing at least one first image of a user's face taken with a camera located a first distance from the	*See, e.g.*, claim 8[a].	*See, e.g.*, claim 8[a].

U.S. Patent No. 11,693,938		FaceTec	iProov
	user, the camera associated with a computing device;		
20[b]	processing the at least one first image or a portion thereof to create first data, the first data derived from the user's face;	*See, e.g.*, claim 8[b].	*See, e.g.*, claim 8[b].
20[c]	intentionally moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving to change a distance between the user and the camera from the	*See, e.g.*, claim 8[c].	*See, e.g.*, claim 8[c].

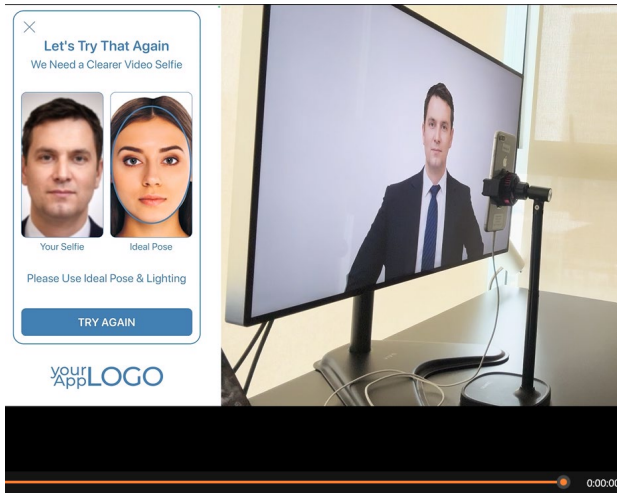
U.S. Patent No. 11,693,938		FaceTec	iProov
	first distance to the second distance;		
20[d]	capturing at least one second image of the user's face taken with the camera located a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 8[d].	*See, e.g.*, claim 8[d].
20[e]	processing the at least one second image or a portion thereof to create second data, the second data derived from the user's face;	*See, e.g.*, claim 8[e].	*See, e.g.*, claim 8[e].
20[f]	analyzing the first data to determine at least if the first	FaceTec's 3D liveness detection technology practices this element.	*See, e.g.*, claim 1[c].

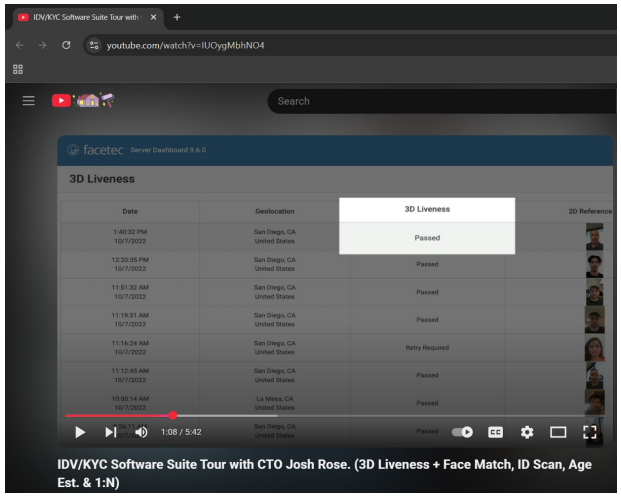
U.S. Patent No. 11,693,938		FaceTec	iProov
	data exhibits first characteristics that indicate the first data was derived from an image of the user captured at the first distance;	Ex. 2067 (“[redacted]”).	
20[g]	analyzing the second data to determine at least if the second data exhibits second characteristics that indicate the second data was derived from an image the user captured at the second distance, wherein the first	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first	*See, e.g.*, claim 1[c].

U.S. Patent No. 11,693,938		FaceTec	iProov
	characteristics or the second characteristics include at least distortion within the at least one first image or the at least one second image;	distance to the second distance. Ex. 2059 (Rose) ¶ 17. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	

U.S. Patent No. 11,693,938		FaceTec	iProov
		 Excerpt from Ex. 2072.	
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
		Ex. 2067 ("[redacted]"	

U.S. Patent No. 11,693,938		FaceTec	iProov
		[redacted]"). The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does not have the expected differences.  Excerpt from Ex. 2072.	

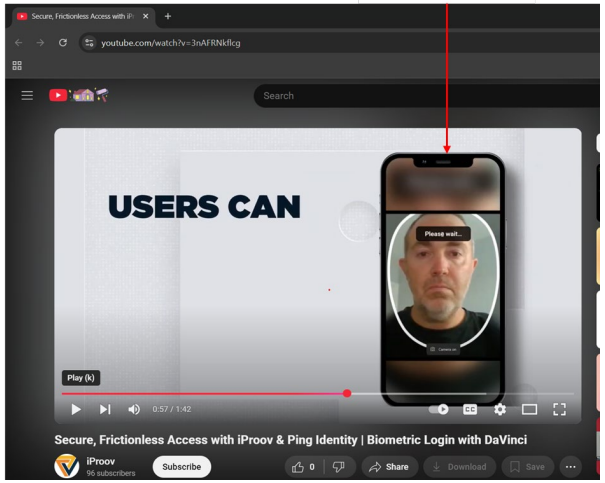
U.S. Patent No. 11,693,938		FaceTec	iProov
		The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does have expected differences.  Excerpt from Ex. 2069	
20[h]	determining the user does not exhibit the expected degree of three-dimensionality when either or both of the following occur:	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].

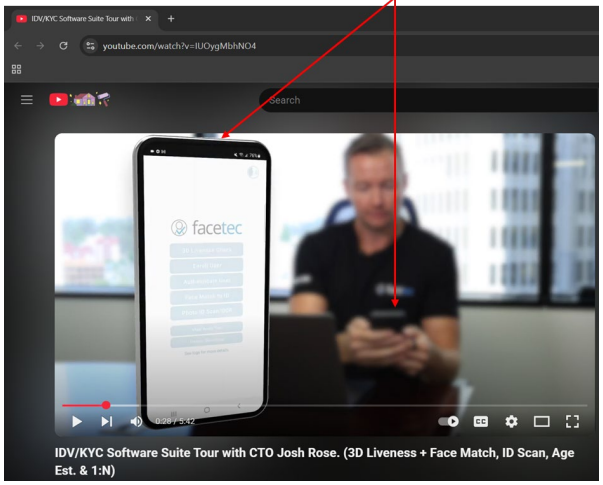
U.S. Patent No. 11,693,938		FaceTec	iProov
20[h1]	the step of analyzing the first data determines the first data does not exhibit first characteristics that indicate the first data was derived from an image of the user captured at the first distance; or	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].
20[h2]	the step of analyzing the second data determines the second data does not exhibit second characteristics that indicate the second data was derived from an image of the user captured	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].

U.S. Patent No. 11,693,938		FaceTec	iProov
	at the second distance.		

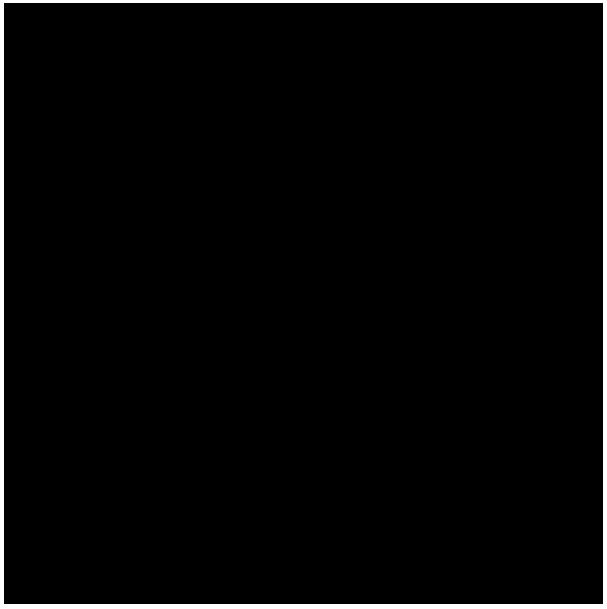
Appendix D: Comparison of FaceTec's and iProov's 3D Liveness Detection Technology

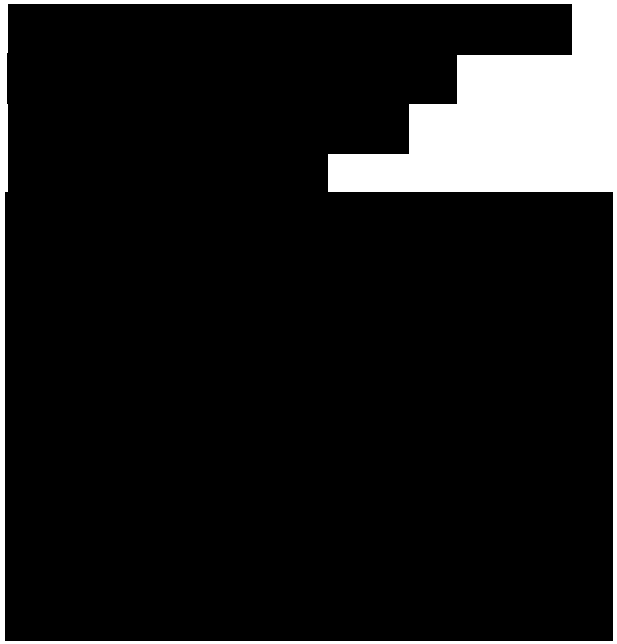
U.S. Patent No. 11,874,910		FaceTec	iProov
Claim 1			
1[pre]	A computing device for verifying three-dimensionality of a user via a user's camera equipped computing device, the computing device comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first distance to the second distance to capture the first	iProov's system practices this element.

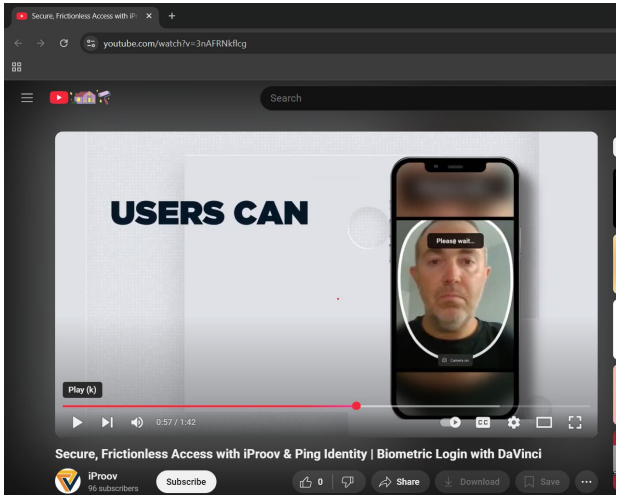
U.S. Patent No. 11,874,910		FaceTec	iProov
		image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone. Mobile Phone  Excerpt from Ex. 2072.	For example, the computing device in iProov's system may be a mobile phone. Mobile Phone  Excerpt from Ex. 2071.

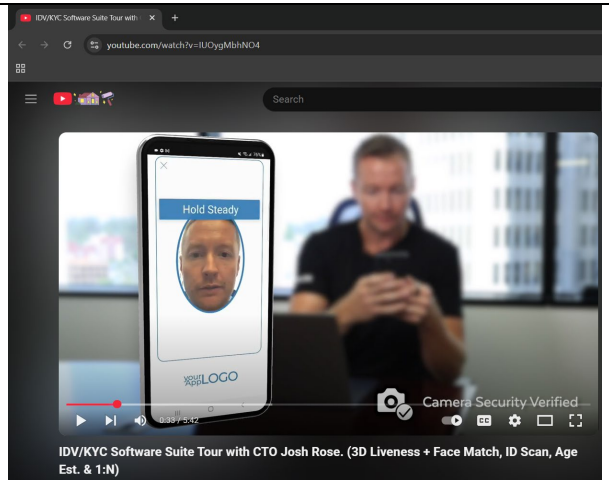
U.S. Patent No. 11,874,910		FaceTec	iProov
		Mobile Phone  Excerpt from Ex. 2069. 	

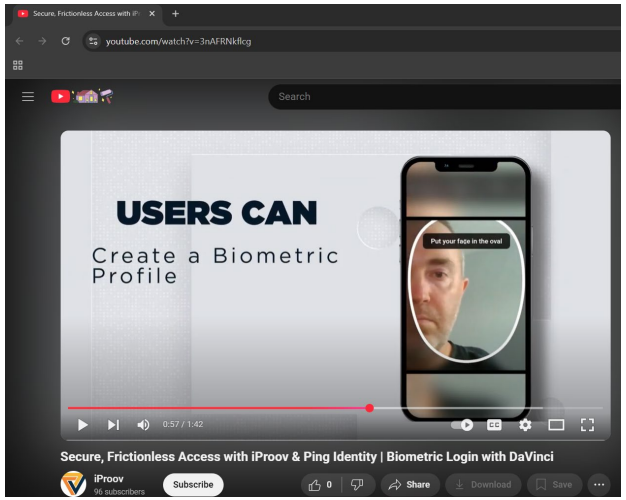
U.S. Patent No. 11,874,910		FaceTec	iProov
		Ex. 2067.	
1[a]	a processor configured to execute machine executable code;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code. Ex. 2059 (Rose) ¶ 10.	iProov's system practices this element. A computing device like a mobile phone includes a processor configured to execute machine executable code. *See* Ex. 2059 (Rose) ¶ 10.
1[b]	a screen configured to provide a user interface to the user;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a screen configured with a user interface. Ex. 2059 (Rose) ¶ 10.	iProov's system practices this element. For example, a computing device like a mobile phone includes a screen configured with a user interface. *See* Ex. 2059 (Rose) ¶ 10.
1[c]	a camera configured to capture images;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a	iProov's system practices this element. For example, a computing device like a mobile phone includes a camera

U.S. Patent No. 11,874,910		FaceTec	iProov
		camera configured to capture images. Ex. 2059 (Rose) ¶ 10.	configured to capture images. *See* Ex. 2059 (Rose) ¶ 10.
1[d]	one or more memories configured to store machine readable instructions that are stored on the memory of the authentication server which when executed by the processor, cause the computing device to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. 	iProov's system practices this element. For example, a computing device like a mobile phone includes one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10.

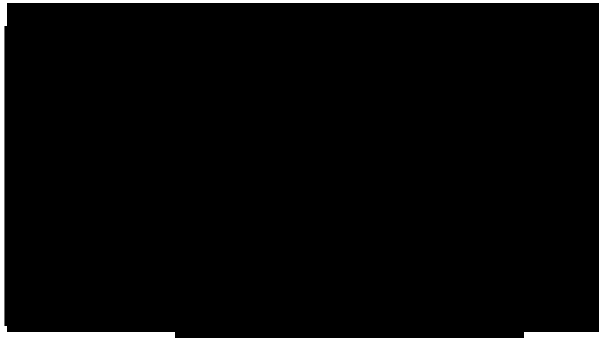
U.S. Patent No. 11,874,910		FaceTec	iProov
		Ex. 2067.  Ex. 2067.	
1[d1]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a first	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user	iProov's system practices this element.

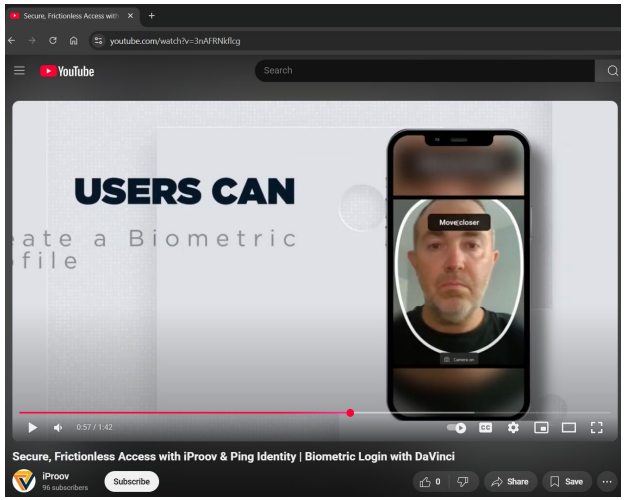
U.S. Patent No. 11,874,910		FaceTec	iProov
	distance from the user;	and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The image below shows a first image captured by a mobile phone at a first distance using iProov.  Excerpt from Ex. 2071.

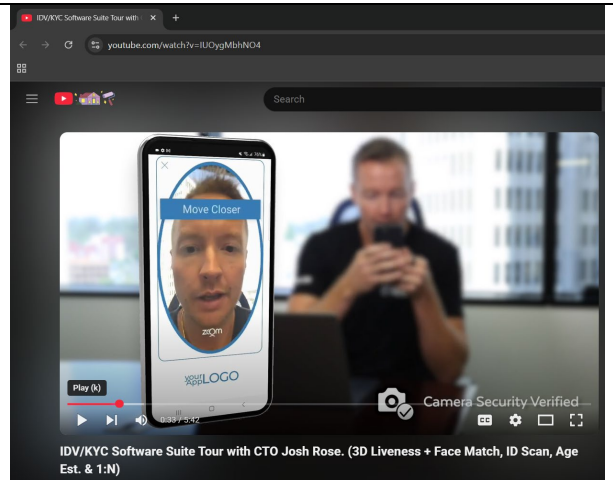
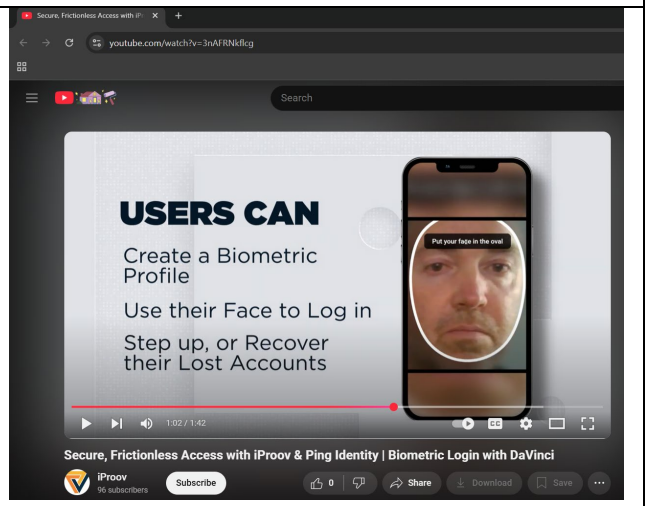
U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]).	

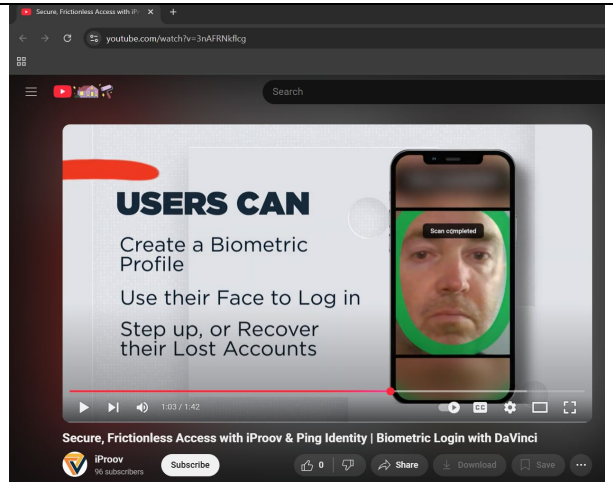
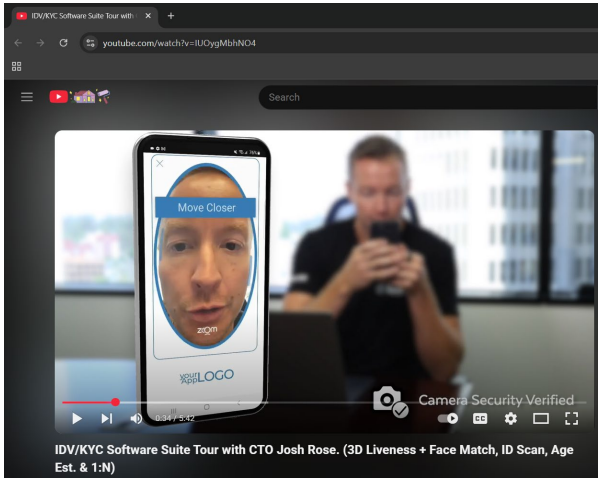
U.S. Patent No. 11,874,910		FaceTec	iProov
1[d2]	processing the at least one first image or a portion thereof to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. [redacted] Ex. 2067 ("[redacted]	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the first image.  Excerpt from Ex. 2071.

U.S. Patent No. 11,874,910		FaceTec	iProov
		[redacted].”).	
1[d3]	capturing at least one second image of the user taken with the camera of the computing device is at a second distance from the user, the second distance being different than the first distance, the capturing at least one second image of the user occurring after movement of the camera or the user to establish the camera at the second distance from the user;	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec’s 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec’s 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the	iProov practices this element.

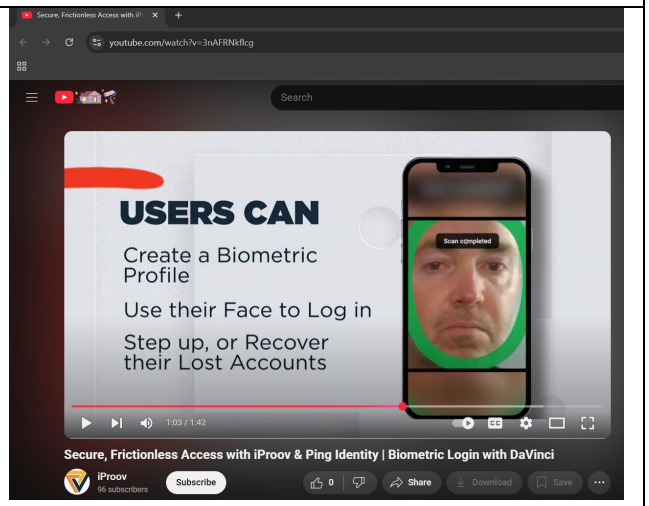
U.S. Patent No. 11,874,910		FaceTec	iProov
		computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.  Ex. 2067 (“ ”). Because the distance is decreased, the	

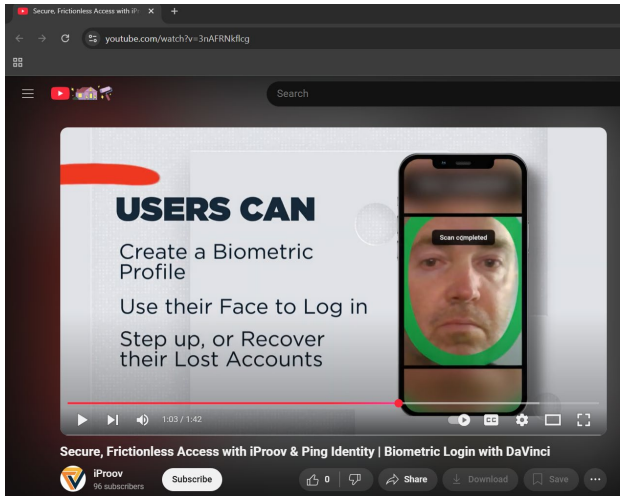
U.S. Patent No. 11,874,910		FaceTec	iProov
		first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.  Excerpt from Ex. 2072.	The image below shows a prompt on the screen asking the user to move to put their face within the oval, requiring movement of the camera, movement of the user, or both.  Excerpt from Ex. 2071.

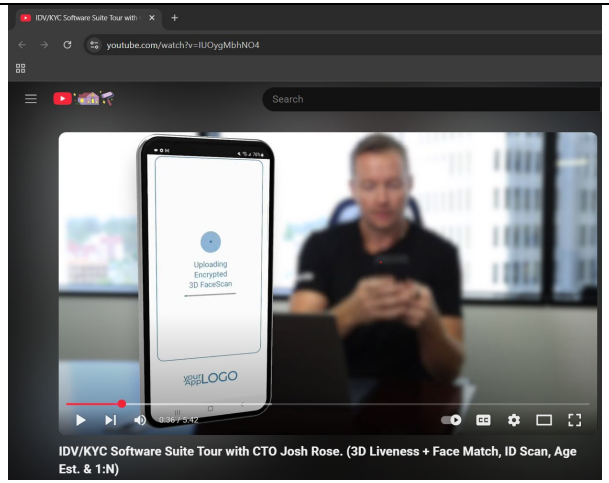
U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2069. The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.	 Excerpt from Ex. 2071. The image below shows a second image captured by a mobile phone at a second distance using iProov's system.

U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

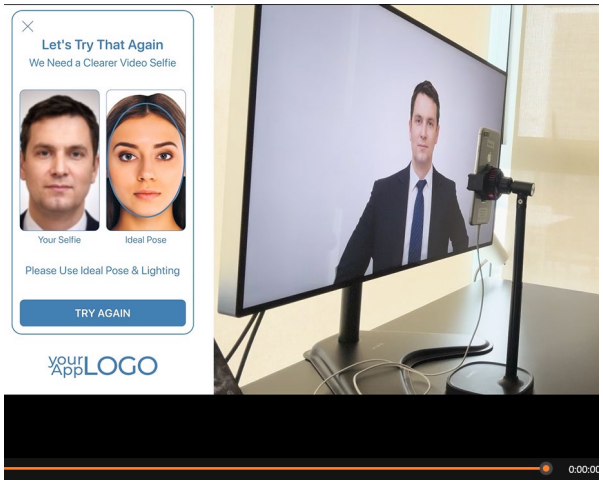
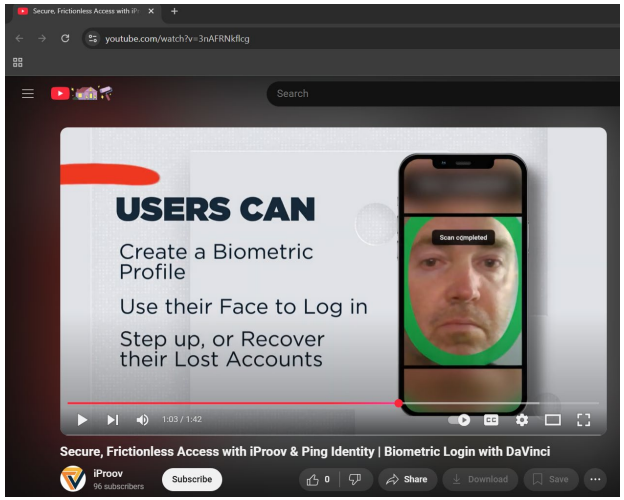
U.S. Patent No. 11,874,910		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	
1[d4]	processing the at least one second image or a portion thereof to create second data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12.	iProov's system practices this element. The image below shows iProov's system creating a biometric profile, which is obtained by processing the second image.

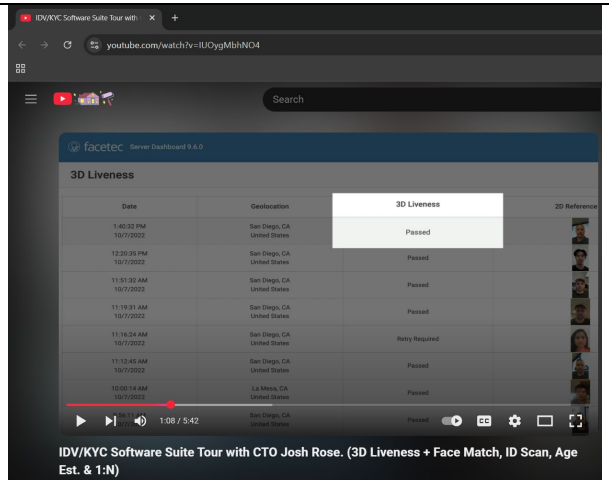
U.S. Patent No. 11,874,910		FaceTec	iProov
		[redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2071.
1[d5]	comparing the first data to the second data to determine whether expected differences exist between the first data and the second data which indicates three-	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second	iProov's system practices this element.

U.S. Patent No. 11,874,910		FaceTec	iProov
	dimensionality of the user;	image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing log in based on the biometric profile, which indicates that iProov's system compares the biometric data obtained by processing the second image.  Excerpt from Ex. 2071.

U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2069. 	

U.S. Patent No. 11,874,910		FaceTec	iProov
		Ex. 2067 (“[redacted]”).	
1[d6]	verifying the images of the user exhibit three dimensional traits when the expected differences exist between the first data and the second data as a result of capturing the at least one first image and the at least one second image at different distances from the user.	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device determines that the user’s face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18.	iProov’s system practices this element.

U.S. Patent No. 11,874,910		FaceTec	iProov
		The images below show FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072.	The image below shows iProov's system allowing user to log in based on the biometric profile, which indicates that iProov's system authenticates using the biometric data obtained by processing the second image.  Excerpt from Ex. 2071.

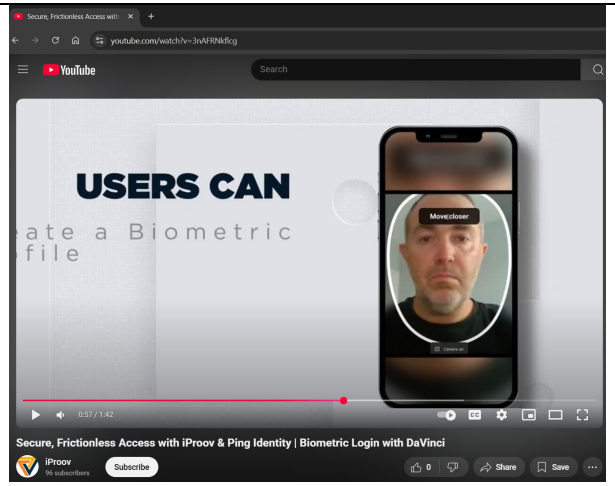
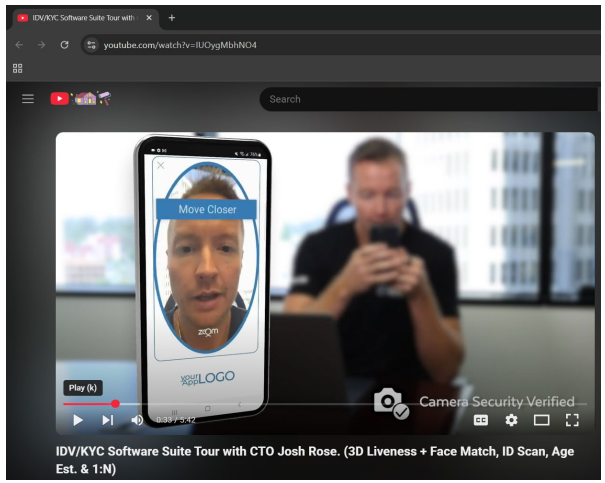
U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2069. 	

U.S. Patent No. 11,874,910		FaceTec	iProov
		Ex. 2067 (“[redacted]”). Ex. 2067 (“[redacted]”).	
Claim 10			
10[pre]	A method for evaluating three-dimensionality of a user, the method comprising:	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].

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10[a]	capturing at least one first image of the user taken with a camera at a first location which is a first distance from the user;	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].
10[b]	processing the at least one first image or a portion thereof to create first data;	*See, e.g.*, claim 1[d2].	*See, e.g.*, claim 1[d2].
10[c]	moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving to change the distance between the user and the	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the	iProov's system practices this element.

U.S. Patent No. 11,874,910		FaceTec	iProov
	camera from the first distance to the second distance;	user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. 	

U.S. Patent No. 11,874,910		FaceTec	iProov
		Ex. 2067 ("[redacted]."). Because the distance is decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.	The image below shows a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.

U.S. Patent No. 11,874,910		FaceTec	iProov
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2071.
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,874,910		FaceTec	iProov
10[d]	capturing at least one second image of the user taken with the camera when the camera is the second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].
10[e]	processing the at least one second image or a portion thereof to create second data;	*See, e.g.*, claim 1[d4].	*See, e.g.*, claim 1[d4].
10[f]	comparing the first data to the second data to determine whether expected differences exist between the first data and the	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].

U.S. Patent No. 11,874,910		FaceTec	iProov
	second data which indicate three-dimensionality of the user;		
10[g]	verifying the images of the user exhibit three-dimensional traits when the first data and the second data have expected differences resulting from the at least one first image being captured with the camera at a different distance from the user than when the at least one second image is captured.	*See, e.g.*, claim 1[d6].	*See, e.g.*, claim 1[d6].
Claim 22			

U.S. Patent No. 11,874,910		FaceTec	iProov
22[pre]	A method, performed by a user using a user's computer device, for verifying three-dimensionality of the user, the method comprising:	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].
22[a]	capturing a first image of the user's head with a camera at a first distance from the user, the camera associated with the user's computing device;	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].
22[b]	changing a distance between the user and the camera to a second distance by	*See, e.g.*, claims 10[e].	*See, e.g.*, claims 10[e].

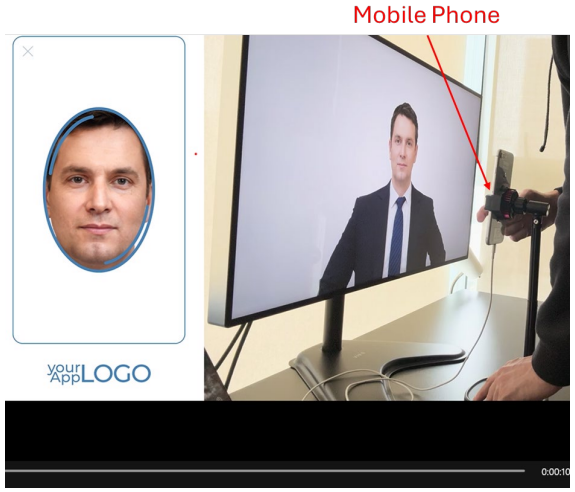
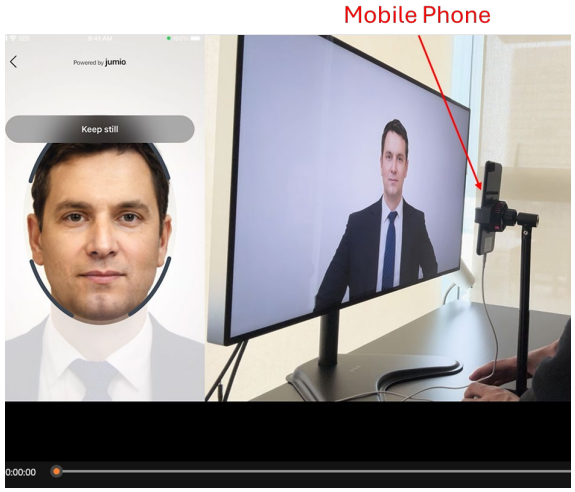
U.S. Patent No. 11,874,910		FaceTec	iProov
	the user moving the camera, or the user moving relative to the camera, or both;		
22[c]	capturing a second image of the user's head with the camera when the camera is at the second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].
22[d]	comparing one or more aspects of the user's head from the first image to one or more aspects of the user's head from the second	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].

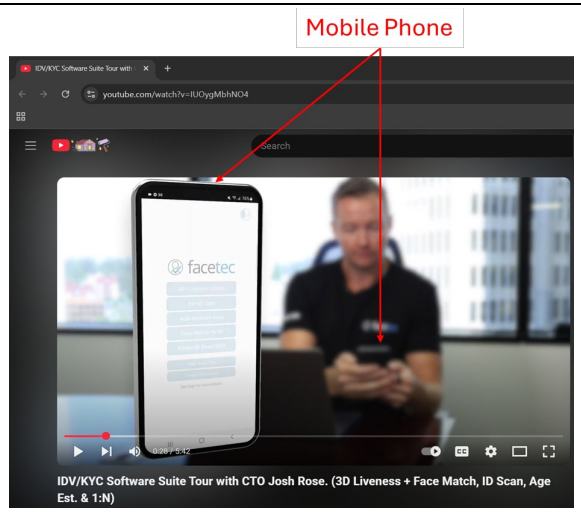
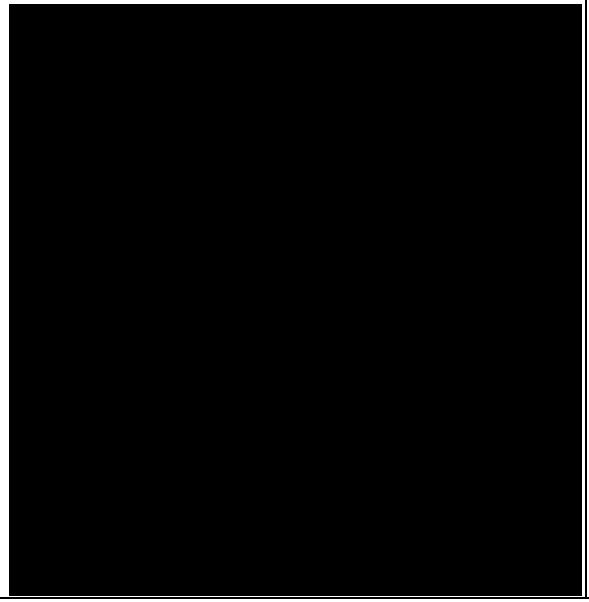
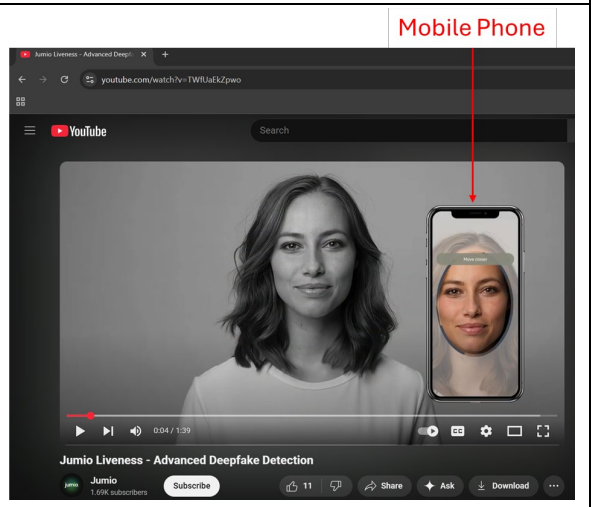
U.S. Patent No. 11,874,910		FaceTec	iProov
	image to determine whether expected differences, between the first image and the second image, exist which indicates three-dimensionality of the user, such that the expected differences between the first image and the second image result from the first image being captured when the camera is at a different distance from the user than when the second		

U.S. Patent No. 11,874,910		FaceTec	iProov
	image is captured; and		
22[e]	responsive to the comparing determining that expected differences between the first image and the second image exist, providing notice to the user, a third party, or both that the three-dimensionality of the user is verified.	*See, e.g.*, claim 1[d6].	*See, e.g.*, claim 1[d6].

Appendix E: Comparison of FaceTec's and Jumio's 3D Liveness Detection Technology

U.S. Patent No. 10,776,471		FaceTec	Jumio
Claim 1			
1[pre]	A system for authenticating three-dimensionality of a user via a user's camera equipped computing device, the computing device comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first	Jumio's system practices this element.

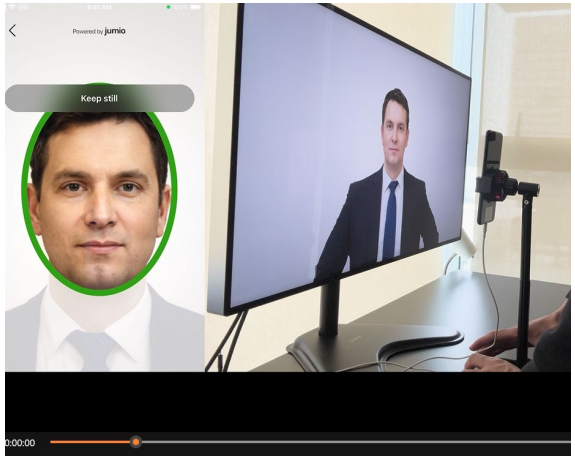
U.S. Patent No. 10,776,471		FaceTec	Jumio
		distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone.  Excerpt from Ex. 2072.	For example, the computing device in Jumio's system may be a mobile phone.  Excerpt from Ex. 2072.

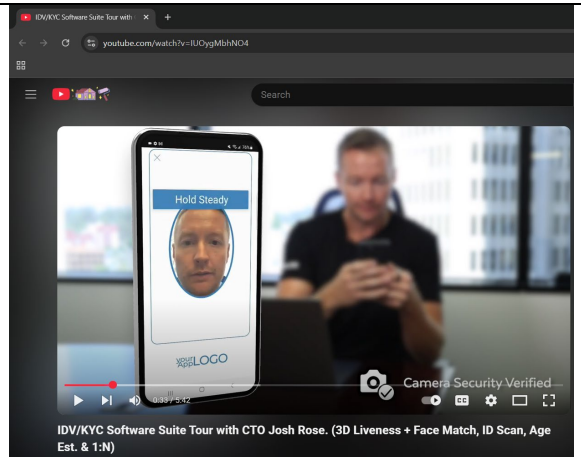
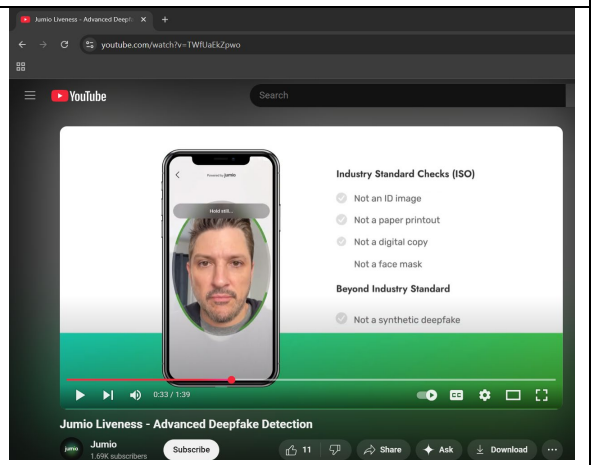
U.S. Patent No. 10,776,471		FaceTec	Jumio
		 Excerpt from Ex. 2069. 	 Excerpt from Ex. 2070.

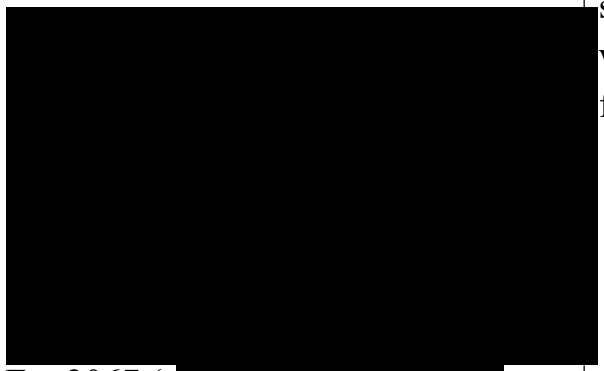
U.S. Patent No. 10,776,471		FaceTec	Jumio
		Ex. 2067.	
1[a]	a processor configured to execute machine executable code;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code. Ex. 2059 (Rose) ¶ 10.	Jumio's system practices this element. A computing device like a mobile phone includes a processor configured to execute machine executable code. *See* Ex. 2059 (Rose) ¶ 10.
1[b]	a screen configured to provide a user interface to the user;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a screen configured with a user interface. Ex. 2059 (Rose) ¶ 10.	Jumio's system practices this element. For example, a computing device like a mobile phone includes a screen configured with a user interface. *See* Ex. 2059 (Rose) ¶ 10.
1[c]	a camera configured to capture images;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a	Jumio's system practices this element. For example, a computing device like a mobile phone includes a camera

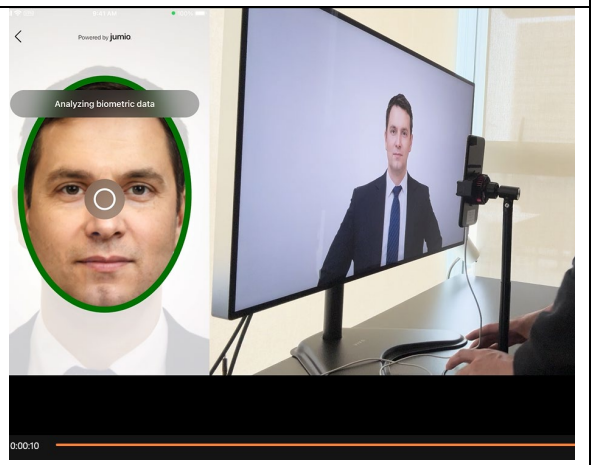
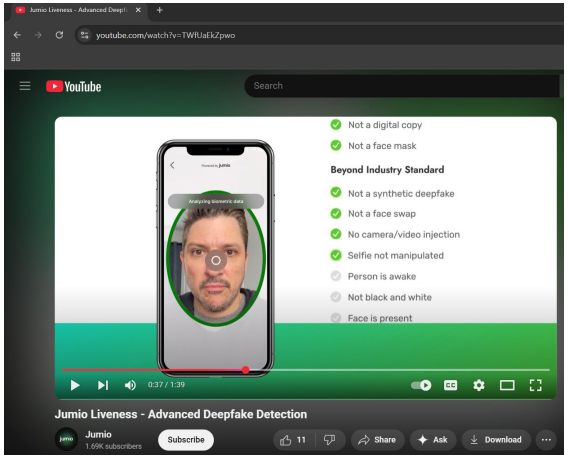
U.S. Patent No. 10,776,471		FaceTec	Jumio
		camera configured to capture images. Ex. 2059 (Rose) ¶ 10.	configured to capture images. *See* Ex. 2059 (Rose) ¶ 10.
1[d]	one or more memories configured to store machine readable instructions that are stored on the memory of the authentication server which when executed by the processor, cause the computing device to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. [redacted]	Jumio's system practices this element. For example, a computing device like a mobile phone includes one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		Ex. 2067.   Ex. 2067.	
1[d1]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken	Jumio's system practices this element.

U.S. Patent No. 10,776,471		FaceTec	Jumio
	first distance from the user;	with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The image below shows first image captured by a mobile phone at a first distance using Jumio's system.  Excerpt from Ex. 2072.

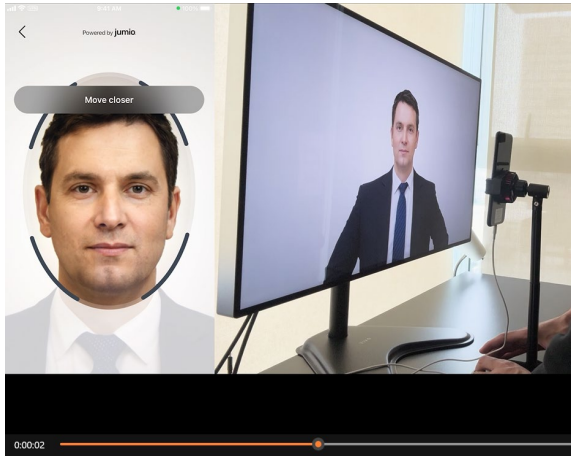
U.S. Patent No. 10,776,471		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]).	 Excerpt from Ex. 2070.

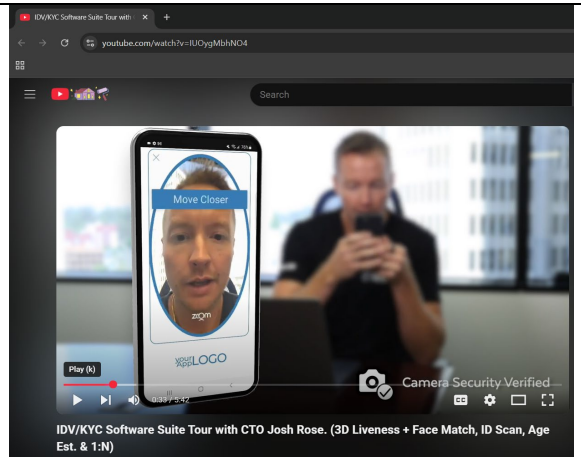
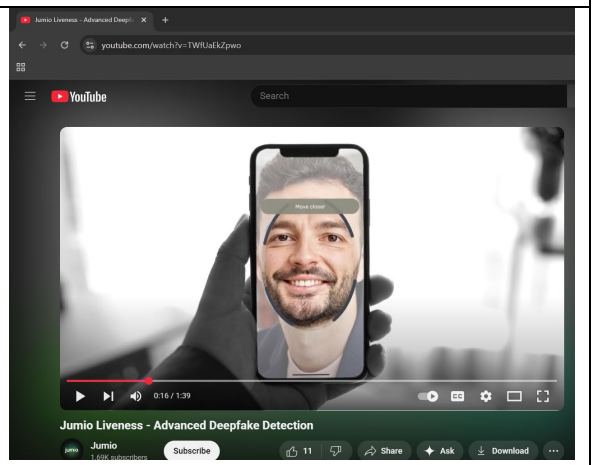
U.S. Patent No. 10,776,471		FaceTec	Jumio
1[d2]	processing the at least one first image or a portion to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11.  Ex. 2067 (	Jumio's system practices this element. For example, Jumio discloses that "users take a selfie with their smartphones or other devices to create a biometric template for our facial recognition system." Ex. 2076 at 2. The selfie is the first image. The images below show Jumio's system analyzing biometric data, which is obtained by processing the first image.

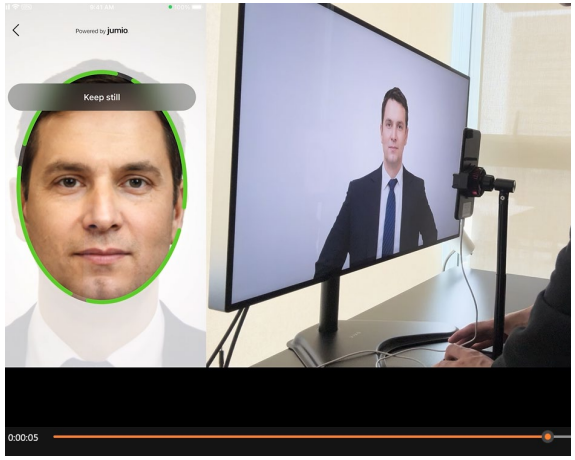
U.S. Patent No. 10,776,471		FaceTec	Jumio
		[redacted]").	 Excerpt from Ex. 2072.  Excerpt from Ex. 2070.
1[d3]	moving the camera from the first location	FaceTec's 3D liveness detection technology practices this element.	Jumio's system practices this element.

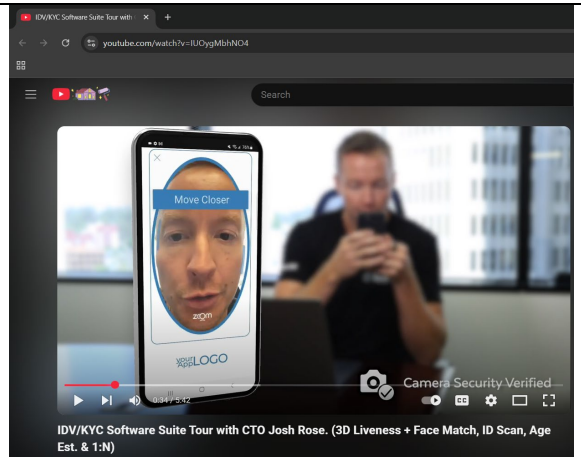
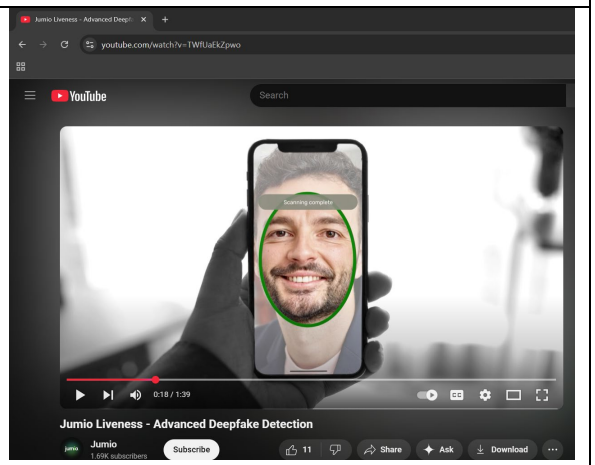
U.S. Patent No. 10,776,471		FaceTec	Jumio
	to a second location, the second location being a second distance from the user, or the user moving from the first location to the second location to change the distance between the user and the camera from the first distance to a second distance;	For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second	

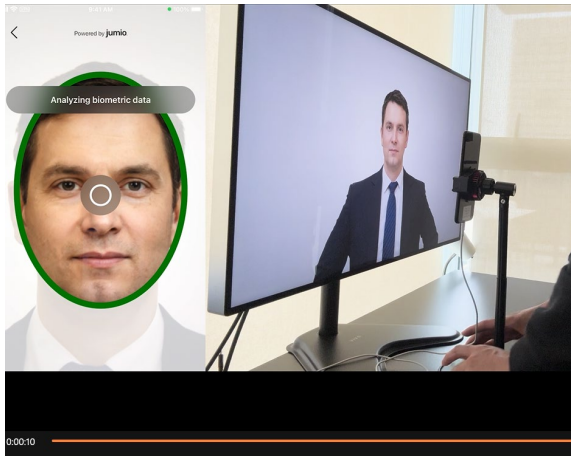
U.S. Patent No. 10,776,471		FaceTec	Jumio
		distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.  Ex. 2067 (“[redacted]”). Because the distance is decreased, the first distance is greater than the second distance.	

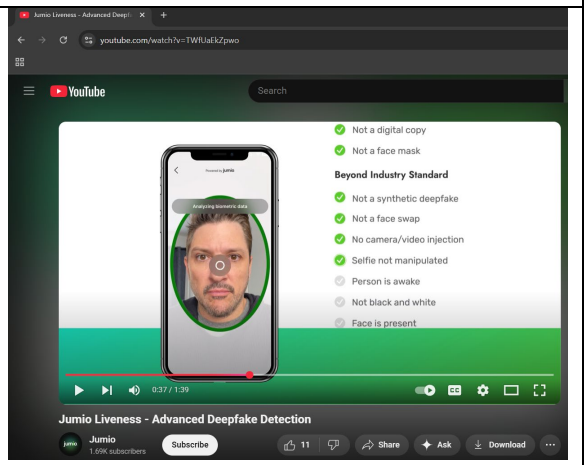
U.S. Patent No. 10,776,471		FaceTec	Jumio
		The images below shows a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.  Excerpt from Ex. 2072.	The images below show prompts on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.  Excerpt from Ex. 2072.

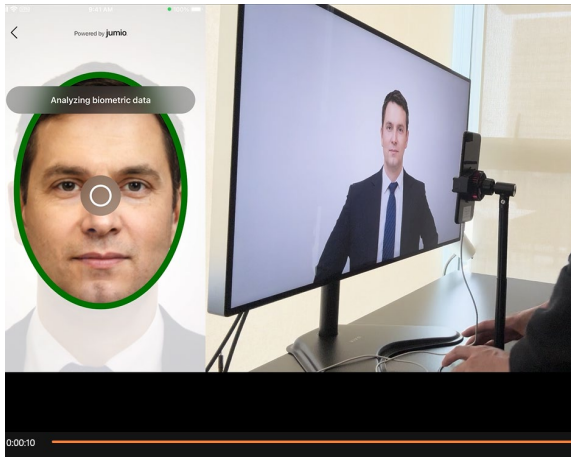
U.S. Patent No. 10,776,471		FaceTec	Jumio
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.
1[d4]	capturing at least one second image of the user taken with the camera of the computing device at the second distance from the user, the second distance being different than the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12.	Jumio's system practices this element.

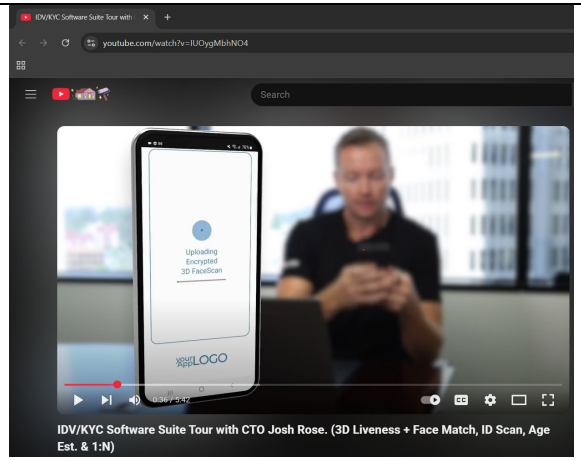
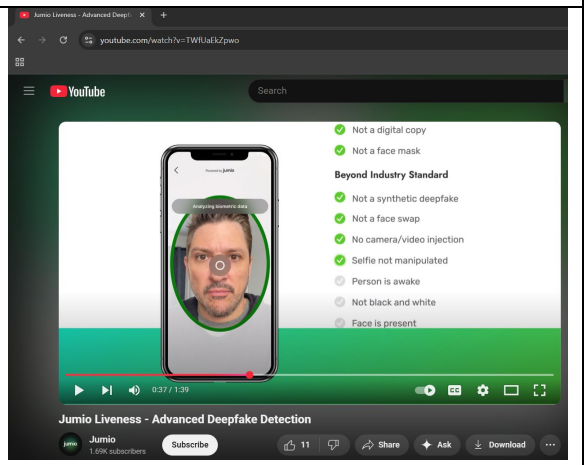
U.S. Patent No. 10,776,471		FaceTec	Jumio
		The image below shows second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The images below show second images captured by a mobile phone at a second distance using Jumio's system.  Excerpt from Ex. 2072.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ("[redacted]")	 Excerpt from Ex. 2070.

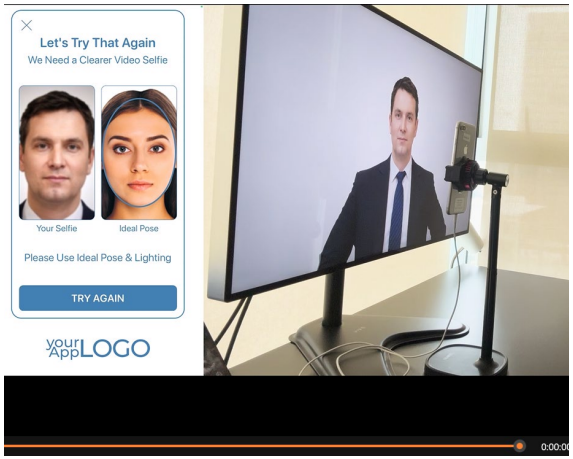
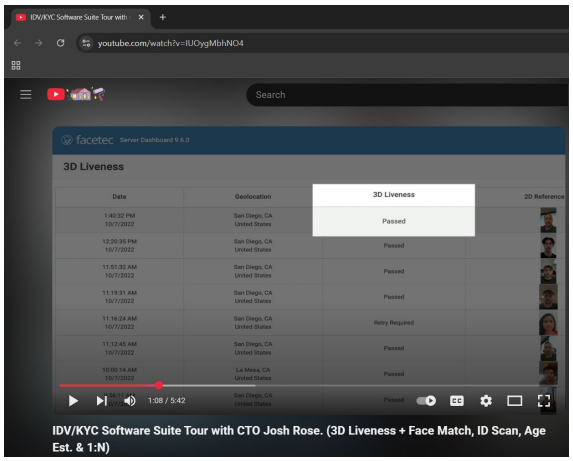
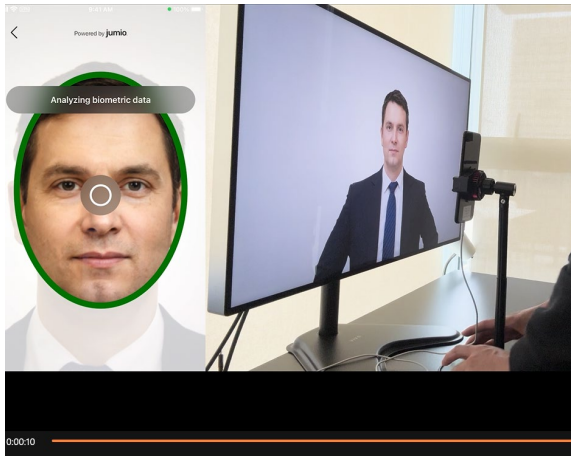
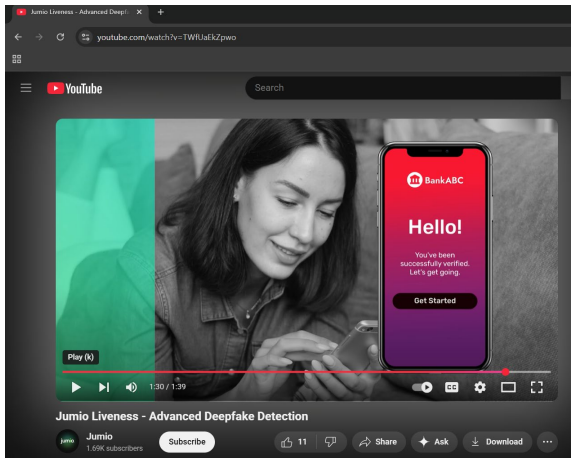
U.S. Patent No. 10,776,471		FaceTec	Jumio
1[d5]	processing the at least one second image or a portion thereof to create second data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12. [redacted] Ex. 2067 ("[redacted]")	Jumio's system practices this element. For example, Jumio uses a selfie (e.g., second image) to create a biometric template. Ex. 2076 at 2. The images below show Jumio's system analyzing biometric data, which is obtained by processing the second image.  Excerpt from Ex. 2072.

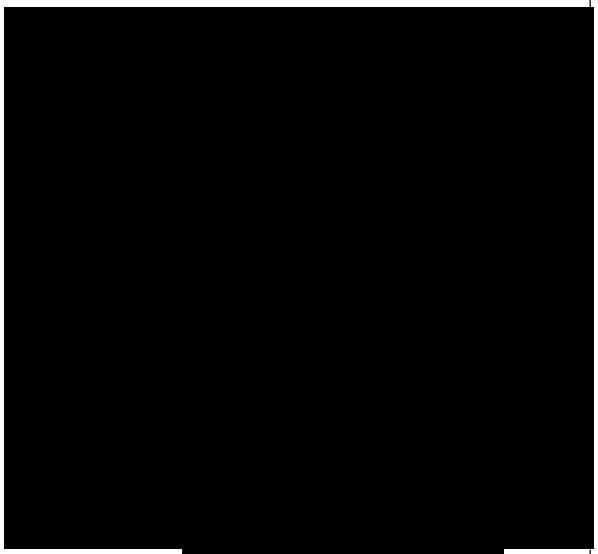
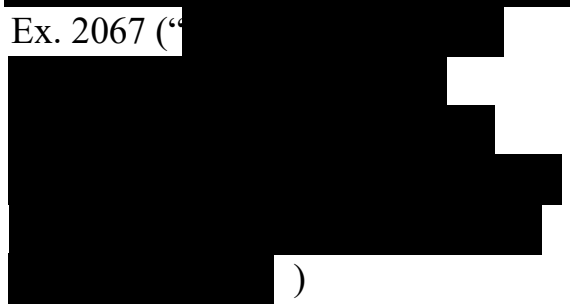
U.S. Patent No. 10,776,471		FaceTec	Jumio
			 Excerpt from Ex. 2070.
1[d6]	comparing the first data to the second data to determine whether expected differences exist between the first data and the second data which indicated three-dimensionality of the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement	Jumio's system practices this element. For example, Jumio uses a selfie (e.g., first image) to create a biometric template. Ex. 2076 at 2. A validity check determines whether the selfie is a valid, live selfie by comparing the biometric data from the first image with the second image. Ex. 2076.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The image below shows FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The images below show Jumio's system analyzing biometric data.  Excerpt from Ex. 2072.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.
		[redacted] Ex. 2067 (“[redacted]	

U.S. Patent No. 10,776,471		FaceTec	Jumio
		[redacted]).	
1[d7]	authenticating the user when differences between the first data and the second data have expected distortion resulting from movement of the camera from the first location to the second location or movement of the user from the first location to the second location, which causes the change in distance between the user and the camera.	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device determines that the user's face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18.	Jumio's system practices this element.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		The image below shows FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072. 	The images below show Jumio authenticating the user.  Excerpt from Ex. 2072. 

U.S. Patent No. 10,776,471		FaceTec	Jumio
		Excerpt from Ex. 2069.  Ex. 2067 (“ ) Ex. 2067 (“ 	Excerpt from Ex. 2070.

U.S. Patent No. 10,776,471		FaceTec	Jumio
		[redacted]").	
Claim 10			
10[pre]	A method for authenticating three-dimensionality of a user via a user's camera equipped computing device, the method, during an authentication session comprising:	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].
10[a]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].

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	first distance from the user;		
10[b]	processing the at least one first image or a portion to create first data;	*See, e.g.*, claim 1[d2].	*See, e.g.*, claim 1[d2].
10[c]	moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving from the first location to the second location to change the distance between the user and the camera from the first distance to a second distance;	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].
10[d]	capturing at least one second image of the user taken with the camera of the	*See, e.g.*, claim 1[d4].	*See, e.g.*, claim 1[d4].

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	computing device at the second distance from the user, the second distance being different than the first distance;		
10[e]	processing the at least one second image or a portion thereof to create second data;	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].
10[f]	comparing the first data to the second data to determine whether expected distortion exist between the first data and the second data which indicated three-dimensionality of the user;	*See, e.g.*, claim 1[d6]. For example, "[a]mong other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. FaceTec's technology can detect this perspective distortion and other expected differences by examining at least two images taken at different distances." Ex. 2059 (Rose) ¶ 25.	*See, e.g.*, claim 1[d6].

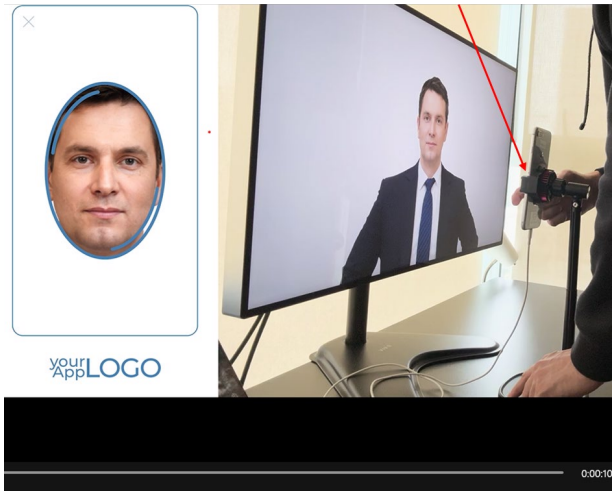
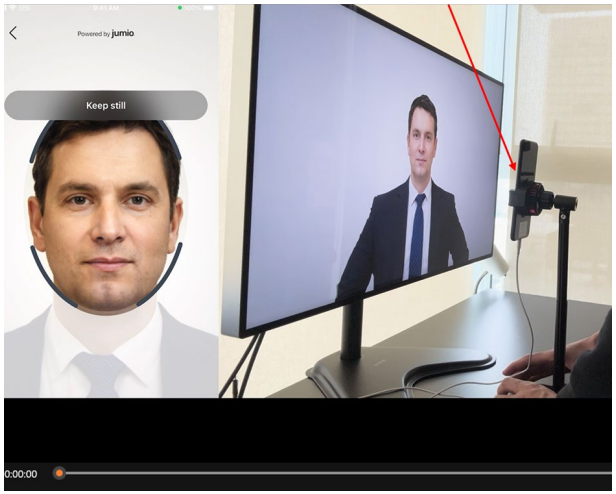
U.S. Patent No. 10,776,471		FaceTec	Jumio
		[redacted] Ex. 2067 ("[redacted]).	
10[g]	authenticating the user when the differences between the first data and the second data have expected distortion resulting from movement of the camera from the first location to the second	*See, e.g.*, claim 1[d7]. For example, "[a]mong other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. FaceTec's technology can detect this perspective distortion and other	*See, e.g.*, claim 1[d7].

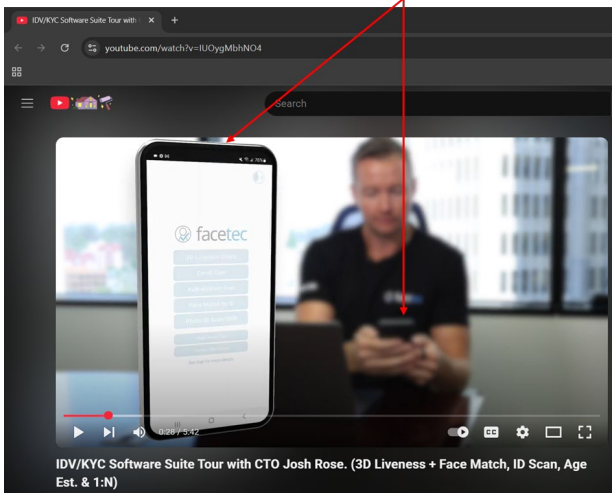
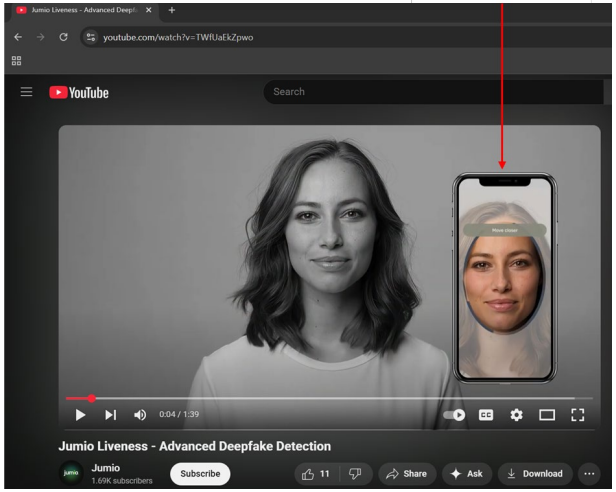
U.S. Patent No. 10,776,471		FaceTec	Jumio
	location or movement of the user from the first location to the second location, which causes the change in distance between the user and the camera.	expected differences by examining at least two images taken at different distances." Ex. 2059 (Rose) ¶ 25. FaceTec's 3D liveness detection technology collects one or more facial images at a first distance from the camera, collects one or more facial images at a second distance from the camera, and then compares the images to confirm the presence of appropriate perspective distortion. Ex. 2059 (Rose) ¶ 9. The FaceTec software determines that the user's face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18. The expected differences include expected distortions,	

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		including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. [redacted] Ex. 2067 ("[redacted]).	

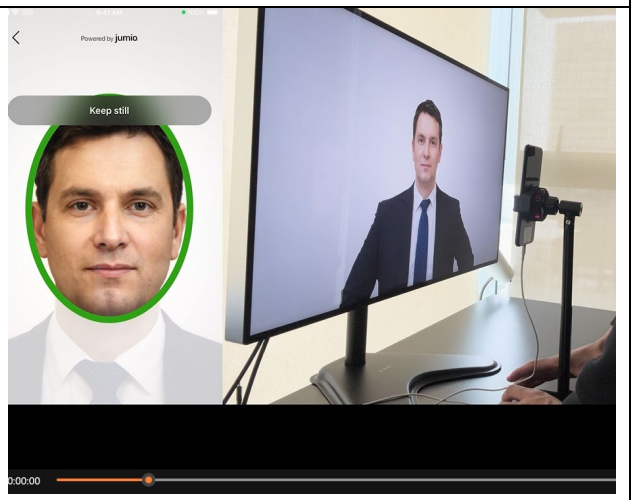
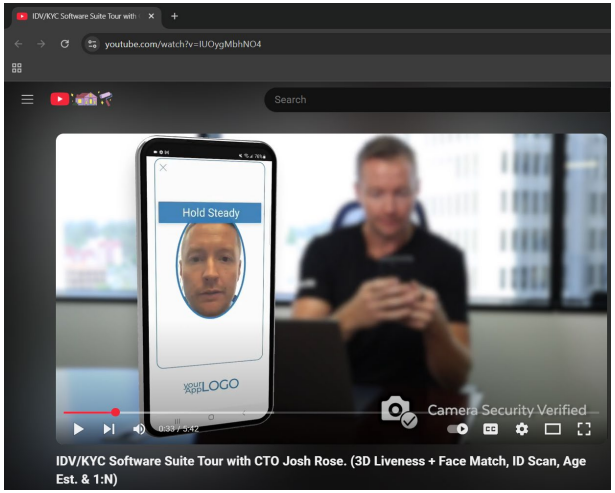
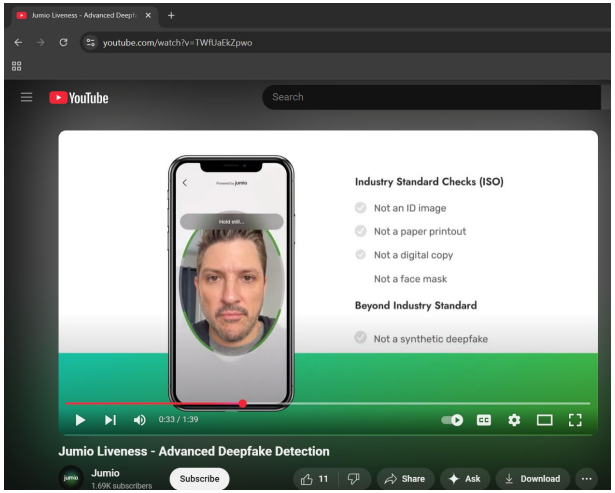
Appendix F: Comparison of FaceTec's and Jumio's 3D Liveness Detection Technology

U.S. Patent No. 11,157,606		FaceTec	Jumio
Claim 1			
1[pre]	A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device and using images of the user's face captured using a camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at a first distance and a second distance to capture first image(s) and second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer,	Jumio's system practices this element.

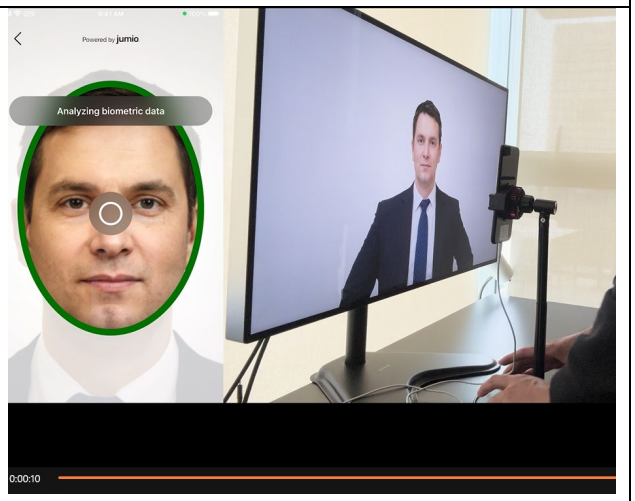
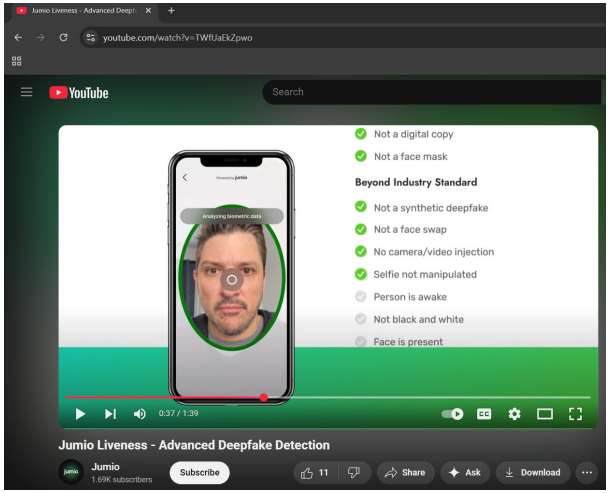
U.S. Patent No. 11,157,606		FaceTec	Jumio
		and the user may move from the first distance to the second distance to capture first image(s) the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone. Mobile Phone  Excerpt from Ex. 2072.	For example, the computing device in Jumio's system may be a mobile phone. Mobile Phone  Excerpt from Ex. 2072.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		Mobile Phone  Excerpt from Ex. 2069. [redacted]	Mobile Phone  Excerpt from Ex. 2070. Jumio's "system compares the images [captured using the camera equipped computing device] and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		Ex. 2067.	
1[a]	capturing at least one first image of the user taken with the camera of the computing device at a first distance from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.	Jumio's system practices this element. The images below show a first image captured by a mobile phone at a first distance using Jumio's system.

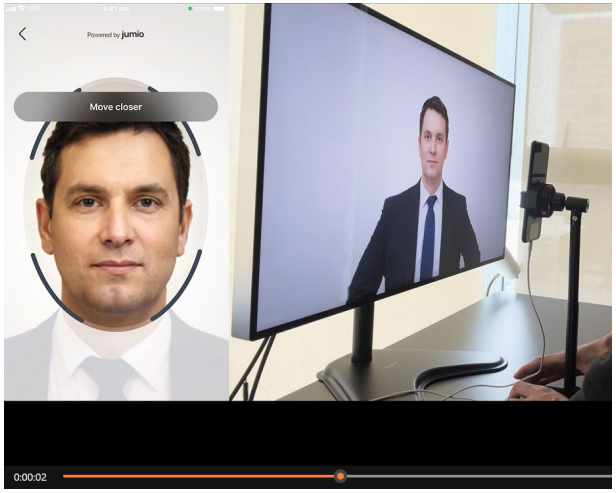
U.S. Patent No. 11,157,606		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

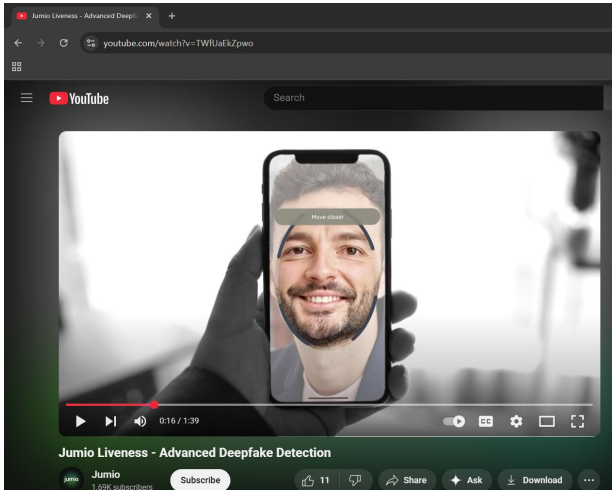
U.S. Patent No. 11,157,606		FaceTec	Jumio
		[redacted] Ex. 2067 ("[redacted]).	
1[b]	processing the at least one first image to obtain first biometric data from the at least one first image;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The first data and the second data include biometric data and	Jumio's system practices this element. The images below show Jumio's system analyzing biometric data, which is obtained by processing the first image.

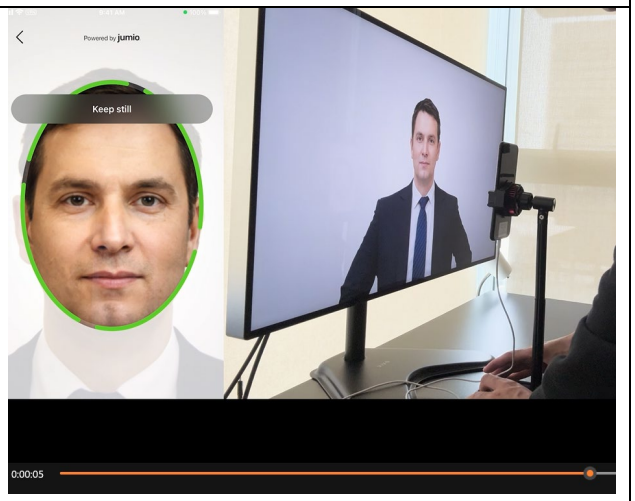
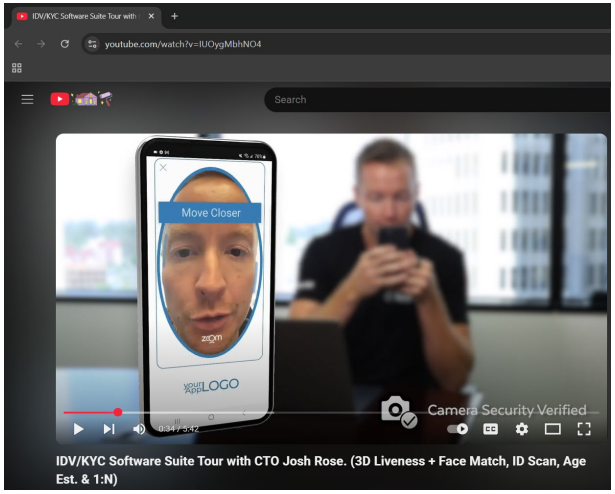
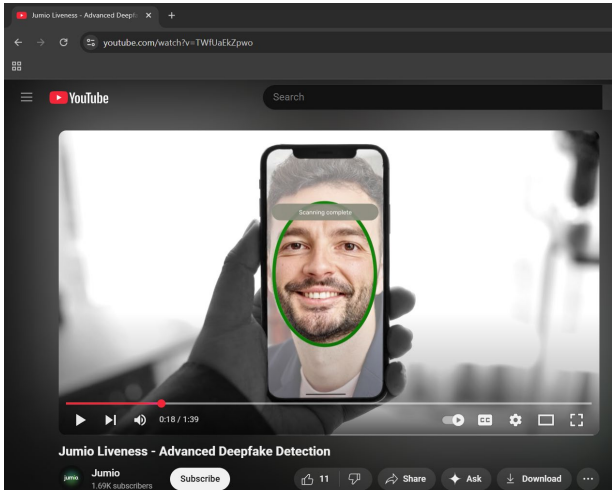
U.S. Patent No. 11,157,606		FaceTec	Jumio
		a mapping of facial features. Ex. 2059 (Rose) ¶ 21. [redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data). 

U.S. Patent No. 11,157,606		FaceTec	Jumio
			Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data).
1[c]	capturing at least one second image of the user taken with the camera of the computing device at a second distance from the user, the second distance being different than the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the	Jumio's system practices this element.

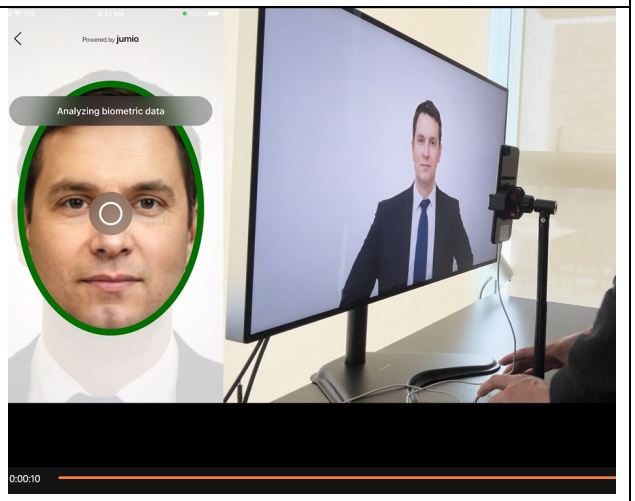
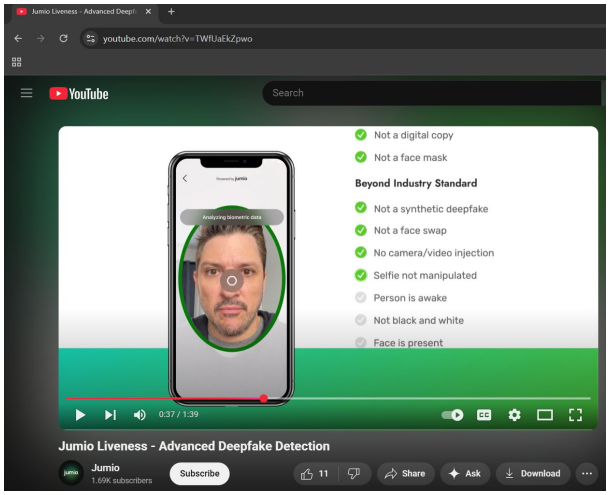
U.S. Patent No. 11,157,606		FaceTec	Jumio
		computing device may be a laptop or desktop computer, and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.  Ex. 2067 (“[redacted]”). Because the distance is decreased, the first	

U.S. Patent No. 11,157,606		FaceTec	Jumio
		distance is greater than the second distance. In FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The image below shows a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both. 	The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both. 

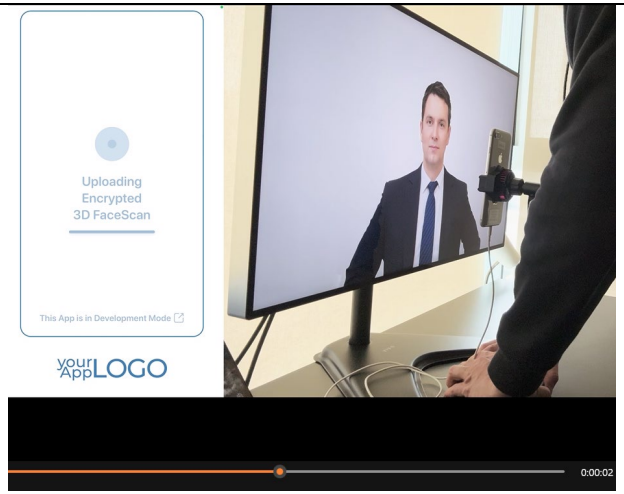
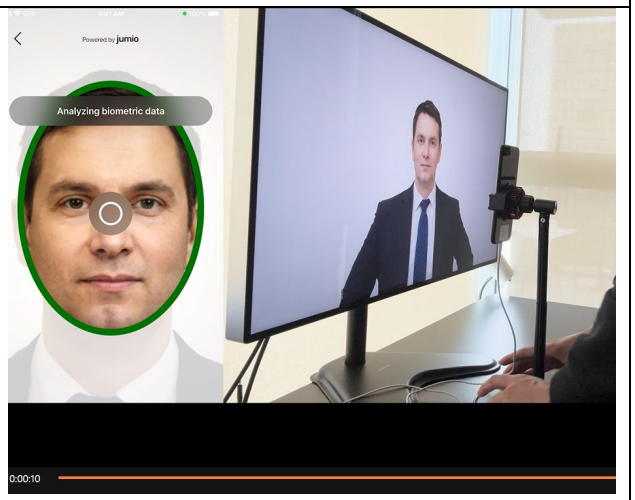
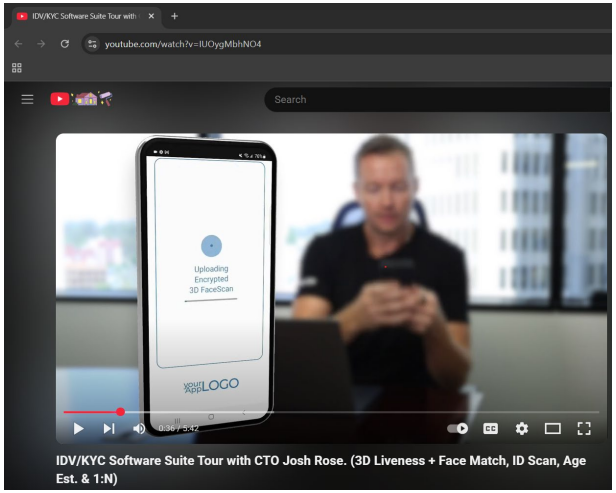
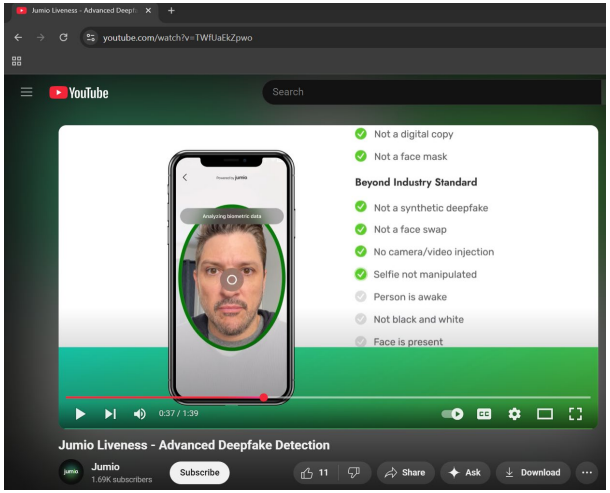
U.S. Patent No. 11,157,606		FaceTec	Jumio
		Excerpt from Ex. 2072. The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.	Excerpt from Ex. 2072.  Excerpt from Ex. 2070. The images below show a second image captured by a mobile phone at a second distance using Jumio's system.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		[redacted] Ex. 2067 ("[redacted]").	
1[d]	processing the at least one second image to obtain second biometric data based on the at least one second image;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12. The first data and the second data include biometric data and a mapping of facial features. Ex. 2059 (Rose) ¶ 21.	Jumio's system practices this element. For example, Jumio discloses that "users take a selfie with their smartphones or other devices to create a biometric template for our facial recognition system." Ex. 2076 at 2. The images below show Jumio's system analyzing biometric data, which is obtained by processing the second image.

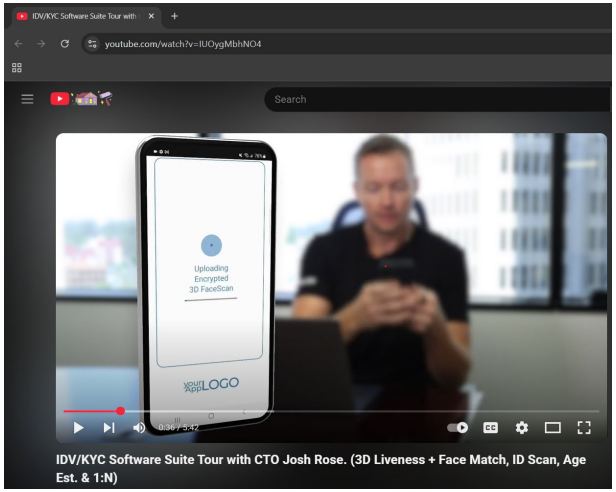
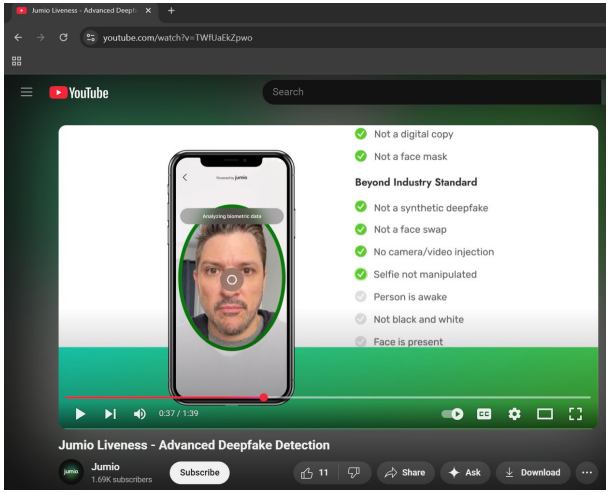
U.S. Patent No. 11,157,606		FaceTec	Jumio
		[redacted] Ex. 2067 ("[redacted]").	 Excerpt from Ex. 2072.  Excerpt from Ex. 2070.

U.S. Patent No. 11,157,606		FaceTec	Jumio
1[e]	comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the second biometric data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	Jumio's system practices this element. For example, Jumio uses a selfie (e.g., first image) to create a biometric template. Ex. 2076 at 2. A validity check determines whether the selfie is a valid, live selfie by comparing the biometric data from the first image with the second image. Ex. 2076 at 2. The images below show Jumio's system analyzing biometric data.

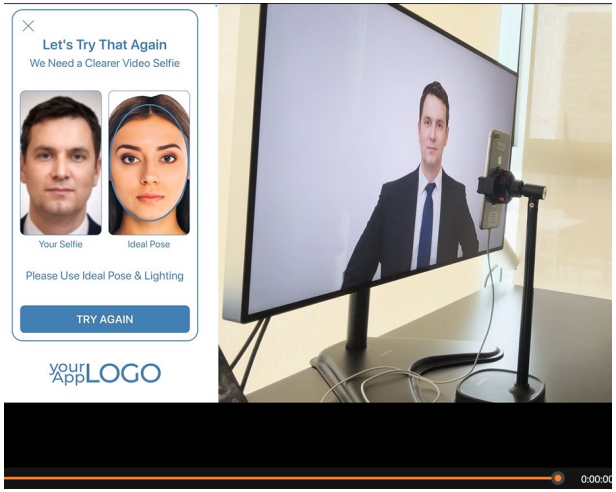
U.S. Patent No. 11,157,606		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

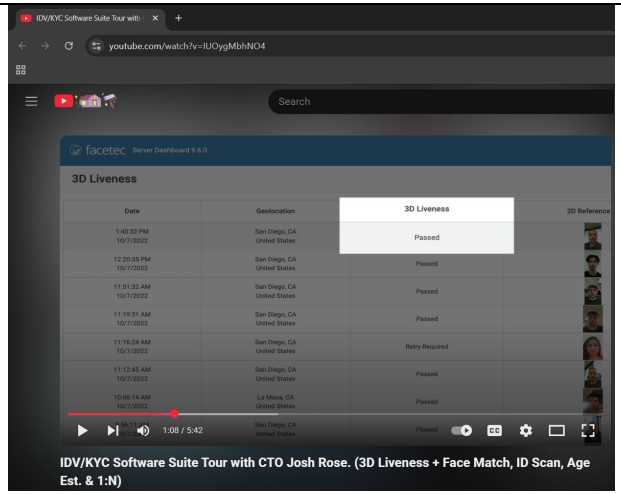
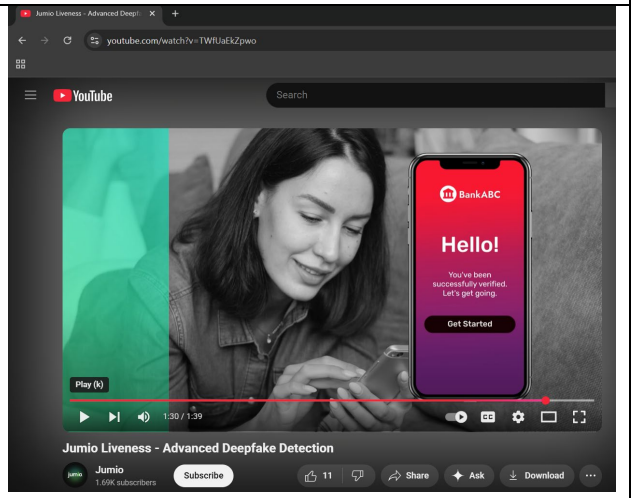
U.S. Patent No. 11,157,606		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]).	
1[f]	comparing the first biometric data to second biometric data to determine whether differences between the at	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device the compares the first data with the second data to determine	Jumio's system practices this element.

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	least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance;	whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The images below show Jumio's system analyzing biometric data.  Excerpt from Ex. 2072.

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		 Excerpt from Ex. 2069. 	 Excerpt from Ex. 2070.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		Ex. 2067 (“[redacted]”).	
1[g]	determining that the user’s face is three-dimensional when:	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device determines that the user’s face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18.	Jumio’s system practices this element.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		The images below show FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072.	The images below show Jumio's system authenticating the user.  Excerpt from Ex. 2072.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted]	 Excerpt from Ex. 2070.

U.S. Patent No. 11,157,606		FaceTec	Jumio
		Ex. 2067 (“[redacted].”). Ex. 2067 (“[redacted]”).	
1[h]	the first biometric data does not match the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

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1[i]	the second biometric data has the expected differences as compared to the first biometric data resulting from the change in distance between the user and the camera when capturing the at least one first image and the at least one second image.	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
Claim 10			
10[pre]	A system for verifying three-dimensionality of a user's face using images of the user's face captured using a	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].

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	camera equipped computing device, the system comprising:		
10[a]	a computing device having a camera, screen, processor, and memory configured with non-transitory machine readable code that is executable by the processor, the machine readable code configured to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10.	Jumio's system practices this element. For example, Jumio uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10.
10[b]	capture at least one first image of the user taken with the camera of the computing device when the camera	*See, e.g.*, claim 1[a].	*See, e.g.*, claim 1[a].

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	is located a first distance from the user;		
10[c]	process the at least one first image to obtain first biometric data from the at least one first image;	*See, e.g.*, claim 1[b].	*See, e.g.*, claim 1[b].
10[d]	capture at least one second image of the user taken with the camera of the computing device when the camera is located a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[c].	*See, e.g.*, claim 1[c].
10[e]	process the at least one second image	*See, e.g.*, claim 1[d].	*See, e.g.*, claim 1[d].

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	to obtain second biometric data based on the at least one second image;		
10[f]	compare the first biometric data to the second biometric data to determine whether the first biometric data matches the second biometric data;	*See, e.g.*, claim 1[e].	*See, e.g.*, claim 1[e].
10[g]	compare the first biometric data to second biometric data to determine whether differences between the at least one first image and the at least one second	*See, e.g.*, claim 1[f].	*See, e.g.*, claim 1[f].

U.S. Patent No. 11,157,606		FaceTec	Jumio
	image match expected differences resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance;		
10[h]	determine that the user's face is three-dimensional when:	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
10[h1]	the first biometric data does not match the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
10[h2]	the second biometric data has	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

U.S. Patent No. 11,157,606		FaceTec	Jumio
	the expected differences as compared to the first biometric data resulting from the change in distance between the user and the camera.		
Claim 19			
19[pre]	A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:	*See, e.g.*, claim 1[pre]	*See, e.g.*, claim 1[pre]
19[a]	receiving first biometric data generated from at	*See, e.g.*, claim 1[a] and 1[b].	*See, e.g.*, claim 1[a] and 1[b].

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	least one first image of the user taken with the camera of the computing device located at a first distance from the user;		
19[b]	receiving second biometric data generated from at least one second image of the user taken with the camera of the computing device located at a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[c] and 1[d].	*See, e.g.*, claim 1[c] and 1[d].
19[c]	comparing the first biometric	*See, e.g.*, claim 1[e].	*See, e.g.*, claim 1[e].

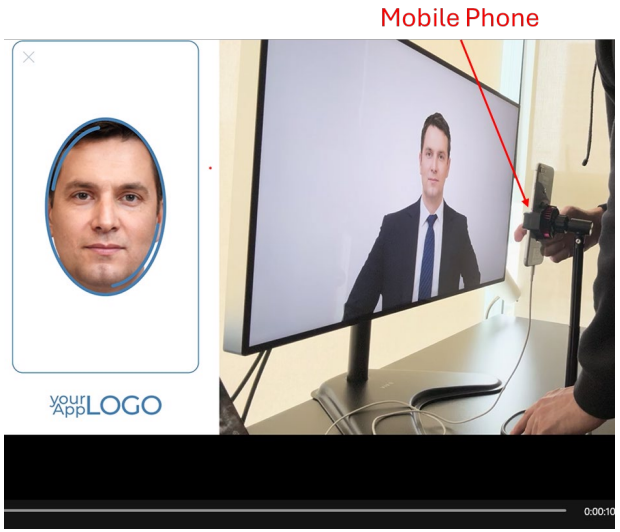
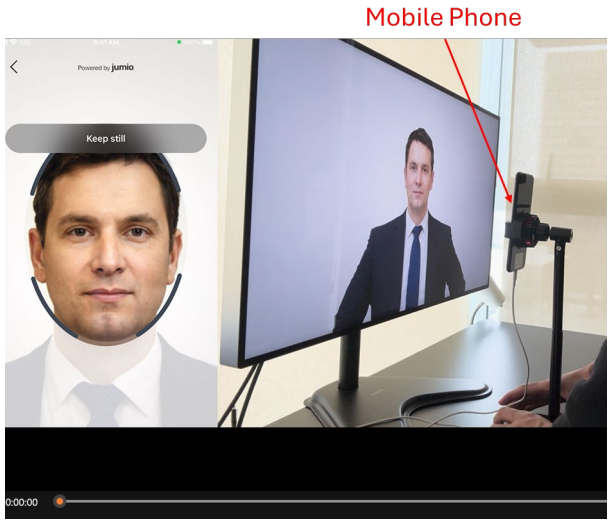
U.S. Patent No. 11,157,606		FaceTec	Jumio
	data with the second biometric data to determine whether the first biometric data matches the second biometric data;		
19[d]	comparing the first biometric data with second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences resulting from movement of the camera or the user	*See, e.g.*, claim 1[f].	*See, e.g.*, claim 1[f].

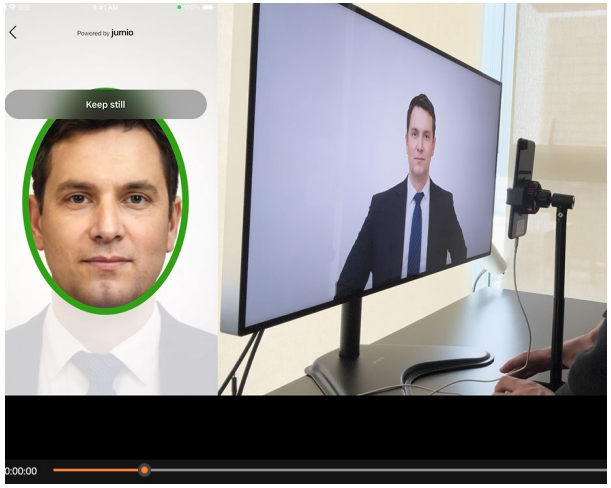
U.S. Patent No. 11,157,606		FaceTec	Jumio
	which changes the distance between the user and camera for capture of the one or more first images at the first distance and capture of the one or more second images at the second distance;		
19[e]	determining that the user's face is three-dimensional when:	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
19[e1]	the first biometric data is not identical to the second biometric data; and	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].
19[e2]	the second biometric data has expected differences as	*See, e.g.*, claim 1[g].	*See, e.g.*, claim 1[g].

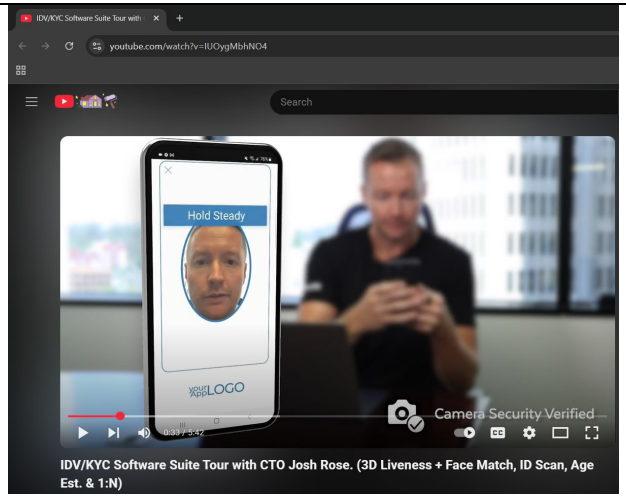
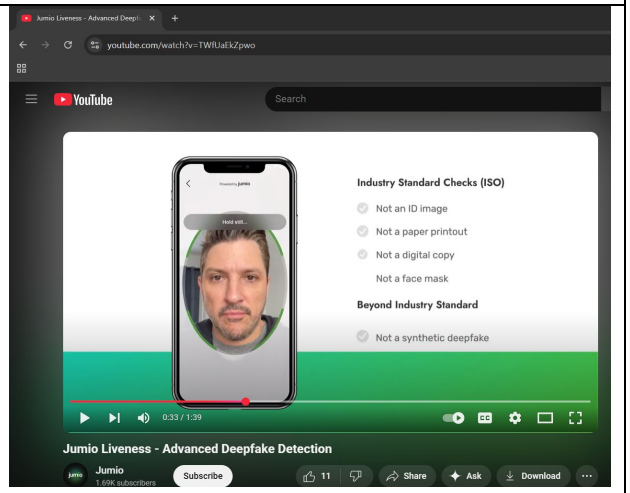
U.S. Patent No. 11,157,606		FaceTec	Jumio
	compared to the first biometric data, the expected differences resulting from the change in distance between the user and the camera when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance.		

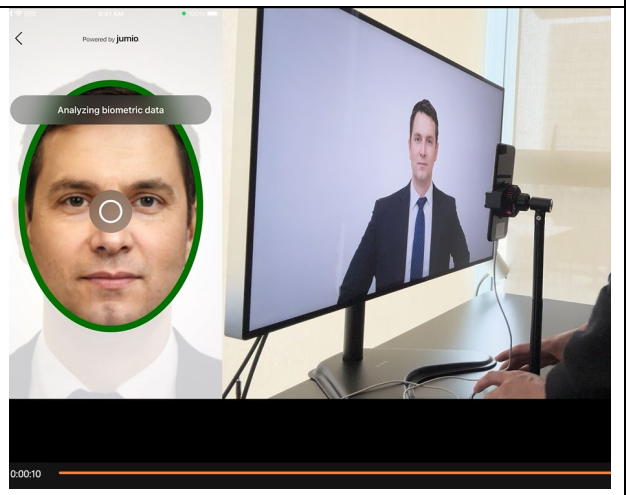
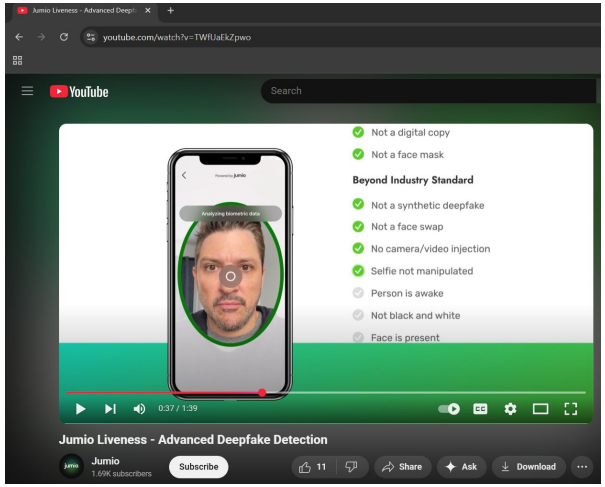
Appendix G: Comparison of FaceTec's and Jumio's 3D Liveness Detection Technology

U.S. Patent No. 11,693,938		FaceTec	Jumio
Claim 1			
1[pre]	A non-transient computer readable medium containing non-transitory machine executable code configured to determine if the three-dimensional shape is consistent with that of a human face, the non-transitory machine executable code configured to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. For example, the computing device may be a mobile phone.	Jumio's system practices this element. For example, Jumio's system uses a user's computing device that includes a processor configured to execute machine executable code, a screen with a user interface, a camera, and one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10. For example, the computing device in Jumio's system may be a mobile phone.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
1[a]	receive or derive first biometric data from at least one first image of a user taken with a computing device camera located at a first distance from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The user's computing device processes the first image(s) to	Jumio's system practices this element.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The first data includes biometric data and a mapping of facial features. Ex. 2059 (Rose) ¶ 21. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The images below show a first image captured by a mobile phone at a first distance using Jumio's system.  Excerpt from Ex. 2072.

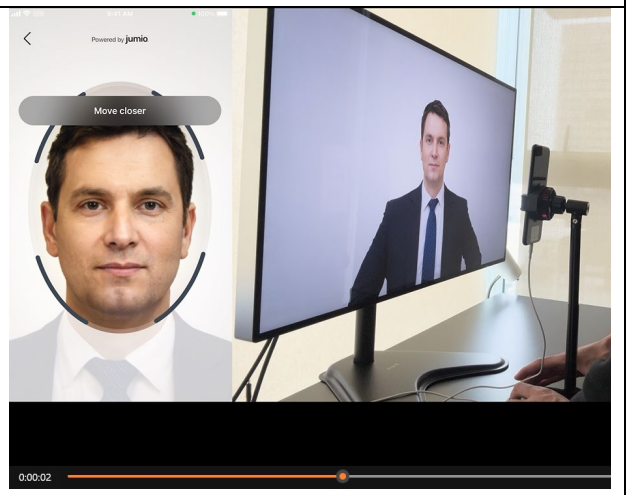
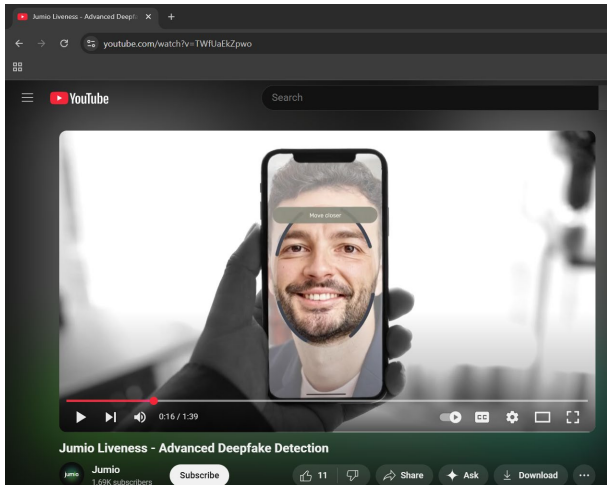
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]").	 Excerpt from Ex. 2070. The images below show Jumio's system analyzing biometric data, which is obtained by processing the first image.

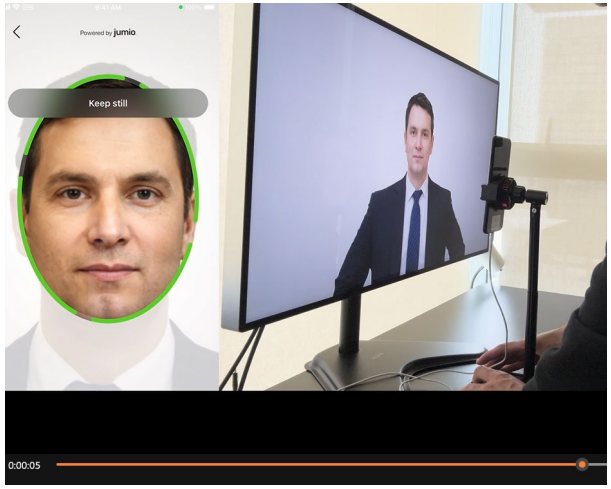
U.S. Patent No. 11,693,938		FaceTec	Jumio
		Ex. 2067 ([redacted]”).	 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data). 

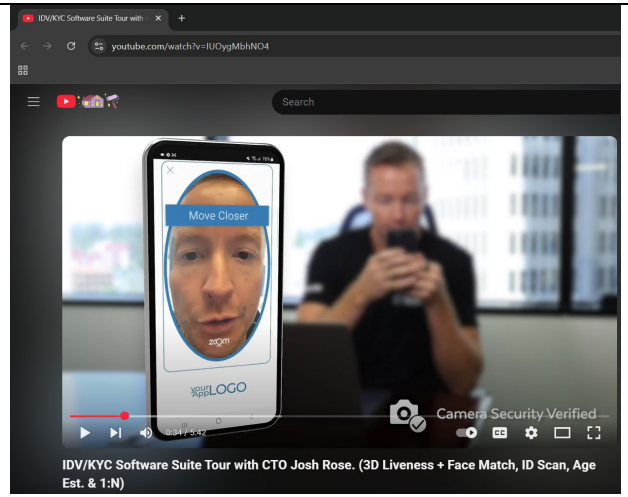
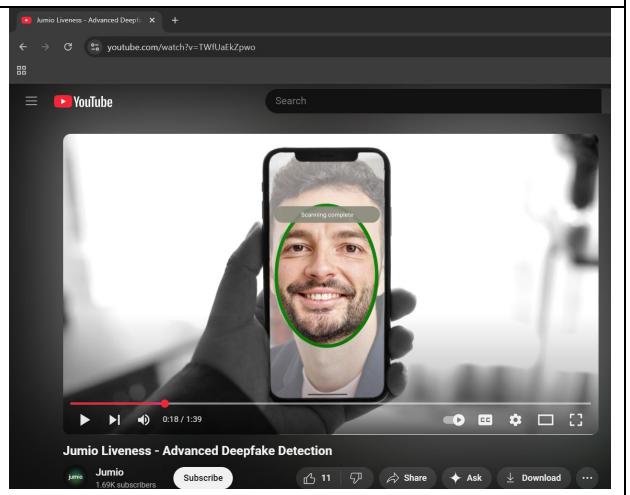
U.S. Patent No. 11,693,938		FaceTec	Jumio
			Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data).
1[b]	receive or derive second biometric data from at least one second image of the user taken with the computing device camera located at a second distance from the user, the second distance being different than the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing	Jumio's system practices this element.

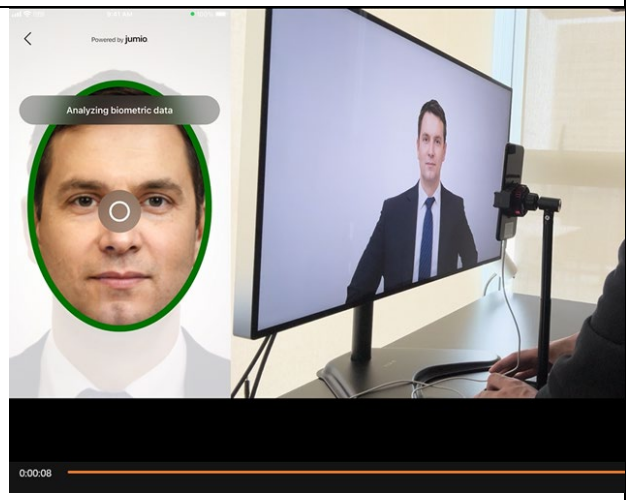
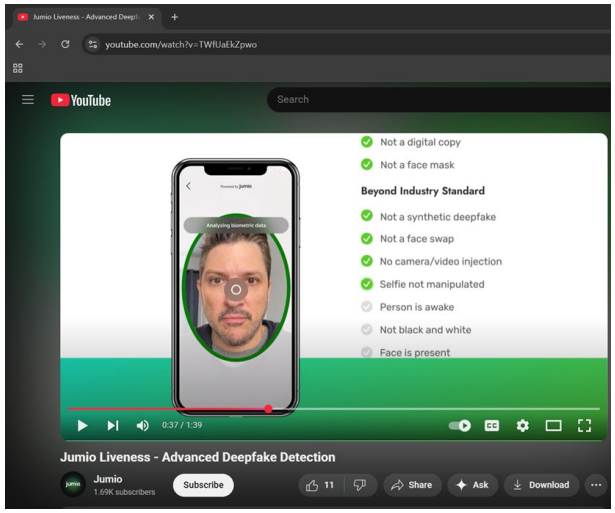
U.S. Patent No. 11,693,938		FaceTec	Jumio
		device may be a laptop or desktop computer, and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.  Ex. 2067 ([redacted]). Because the distance is decreased, the first distance is greater than the second distance.	

U.S. Patent No. 11,693,938		FaceTec	Jumio
		Ex. 2067 ([redacted].”). In FaceTec’s 3D liveness detection technology, the user’s computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The image below shows a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.	The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.

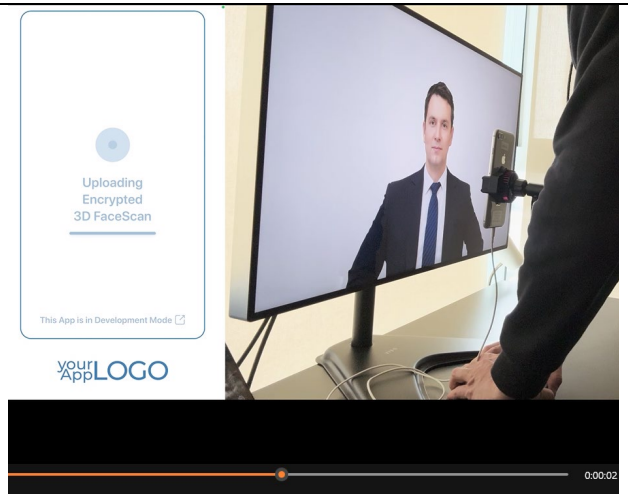
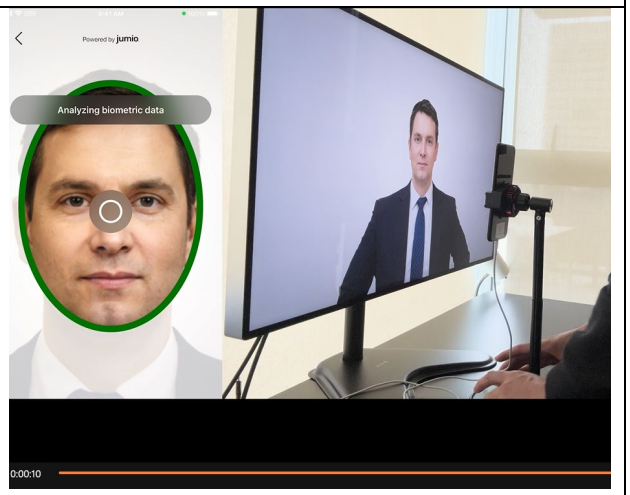
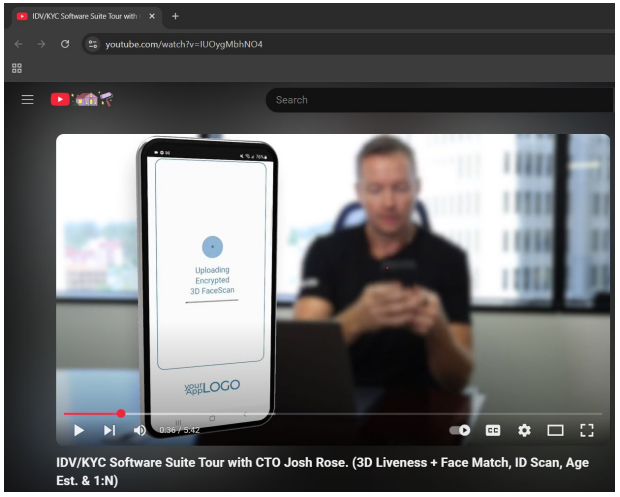
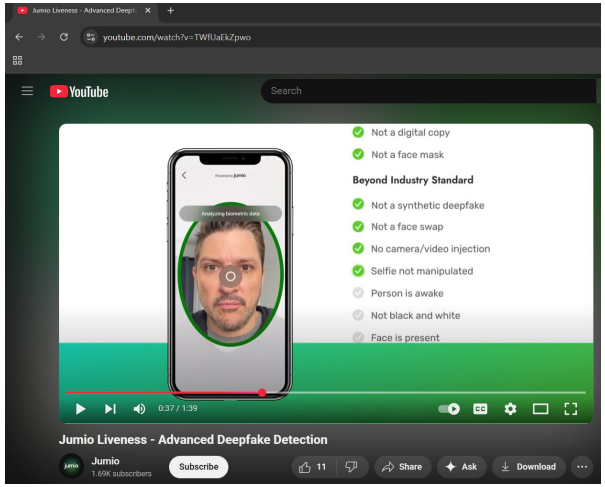
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.  Excerpt from Ex. 2070.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The images below show s second image captured by a mobile phone at a second distance using Jumio's system.  Excerpt from Ex. 2072.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]).	 Excerpt from Ex. 2070. The images below show Jumio analyzing biometric data, which is obtained by processing the second image.

U.S. Patent No. 11,693,938		FaceTec	Jumio
			 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data). 

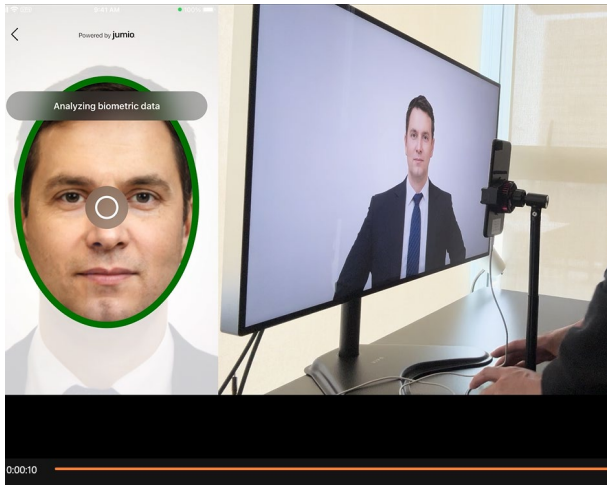
U.S. Patent No. 11,693,938		FaceTec	Jumio
			Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data).
1[c]	compare the first biometric data with second biometric data for expected differences that result from characteristics of a human face and the at least one first image and the at least one second image being captured at different distances from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	Jumio's system practices this element. The images below show Jumio's system analyzing biometric data.

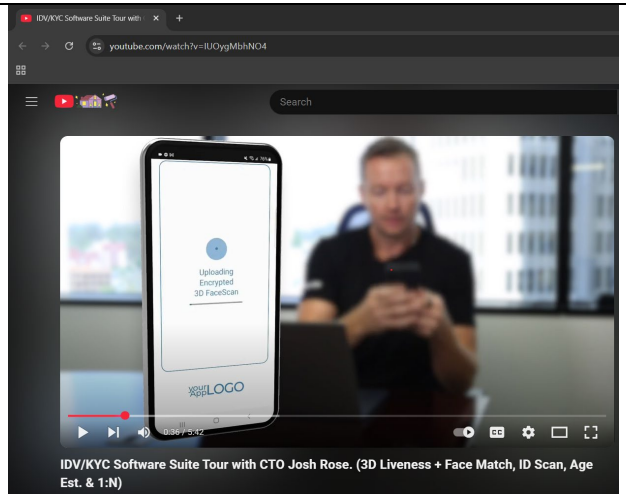
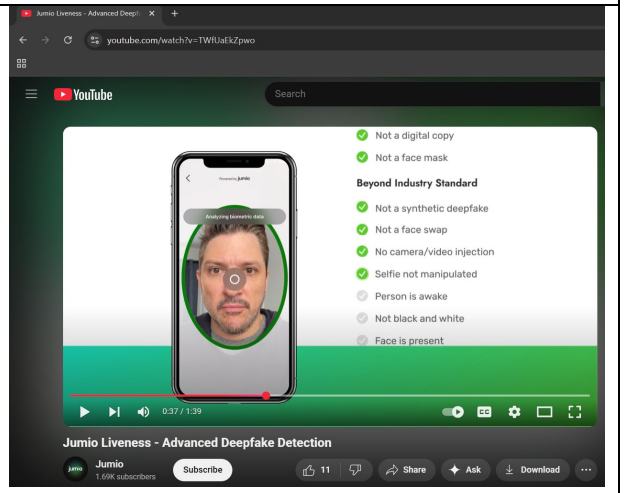
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072 Ex.2074 (discussing the use of biometric data).
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,693,938		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]). Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high	Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data). Jumio's "system compares the images and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25.	
1[d]	determine that the three-dimensional shape is not exhibited when the second biometric data does not have expected	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device the compares the first data with the second data to determine	Jumio's system practices this element.

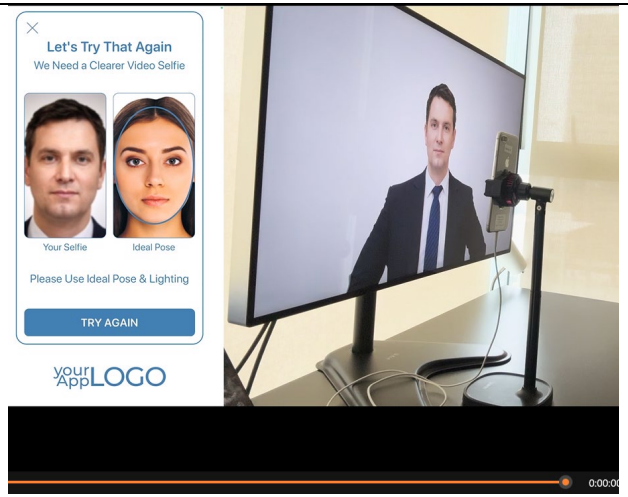
U.S. Patent No. 11,693,938		FaceTec	Jumio
	differences compared to the first biometric data, the expected differences comprising at least differences due to the change in the relative distance between the user's facial features and the camera when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance, wherein the expected differences result from fish-eye type	whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. In FaceTec's 3D liveness detection technology, the user's computing device determines that the user's face is three-dimensional when the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18.	

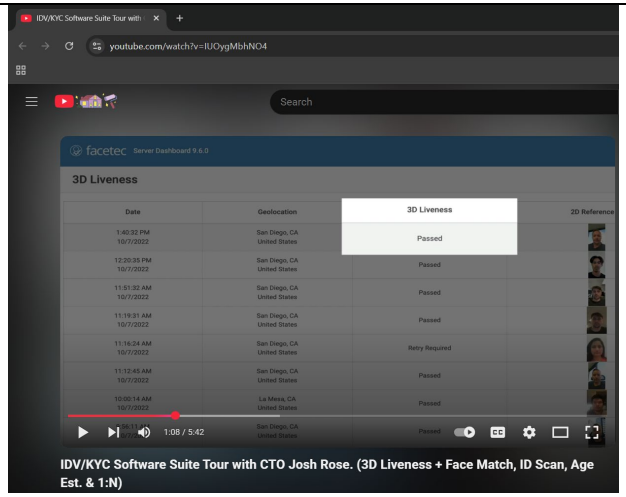
U.S. Patent No. 11,693,938		FaceTec	Jumio
	distortion in at least one of the at least one first image and the at least one second image and due to the three-dimensional nature of the human face and the change in distance between the camera and the user.	The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The images below show Jumio's system analyzing the biometric data to determine presence or absence of the expected differences to in turn determine whether a three-dimensional shape is exhibited in the images.  Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data).

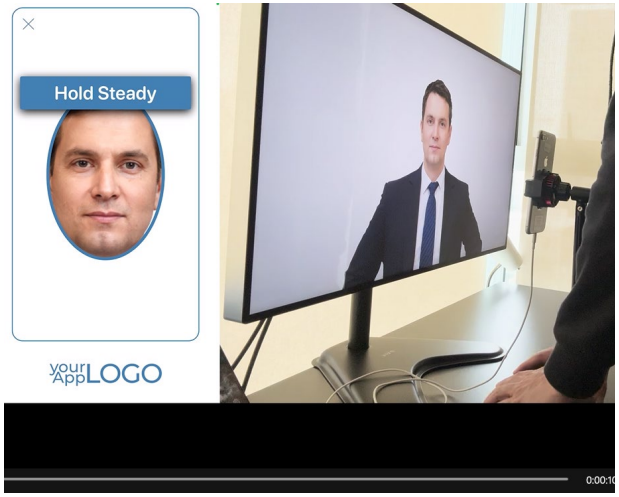
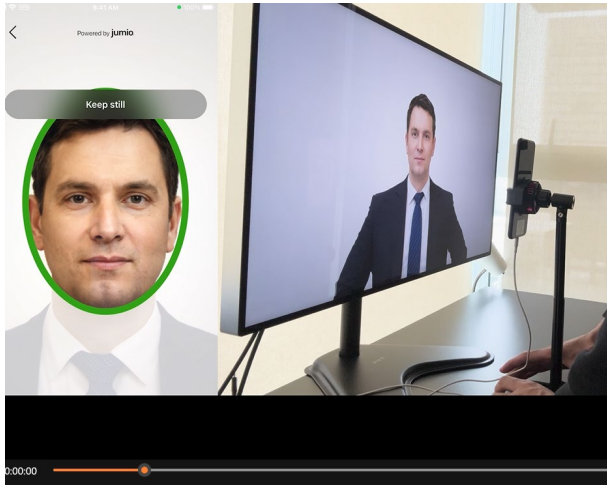
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069. 	 Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data). Jumio's "system compares the images and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.

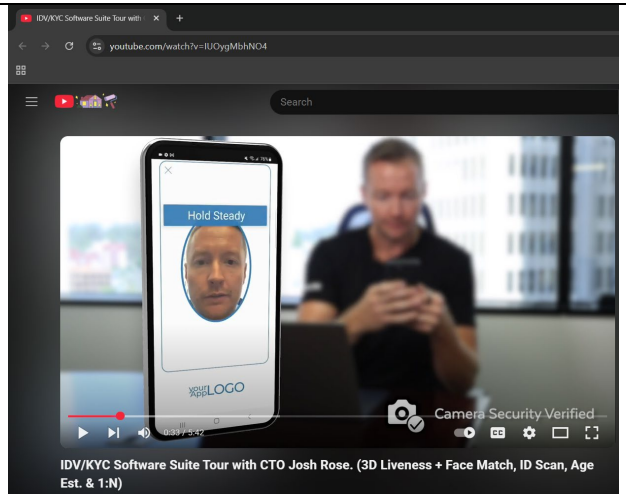
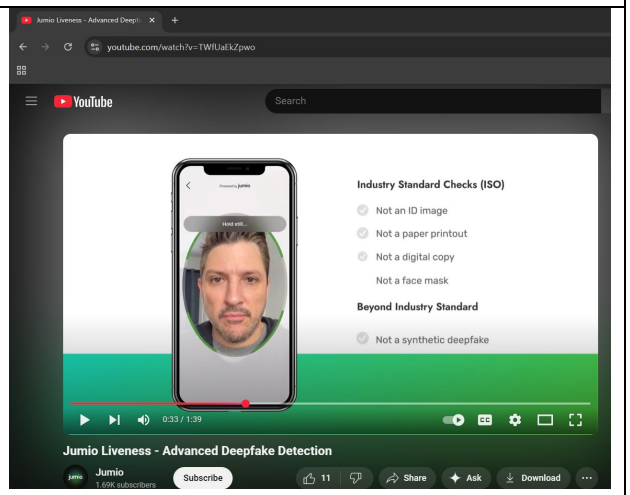
U.S. Patent No. 11,693,938		FaceTec	Jumio
		Ex. 2067 ([redacted]). Ex. 2067 ([redacted]). Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high	

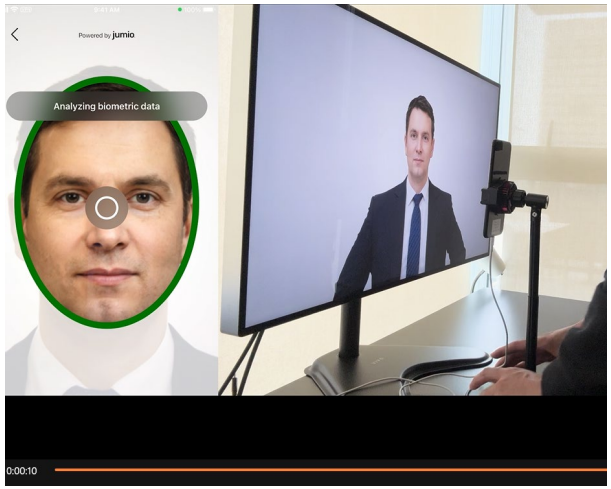
U.S. Patent No. 11,693,938		FaceTec	Jumio
		degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among other subtle but detectable distortions, perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25. The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does not have the expected differences.	

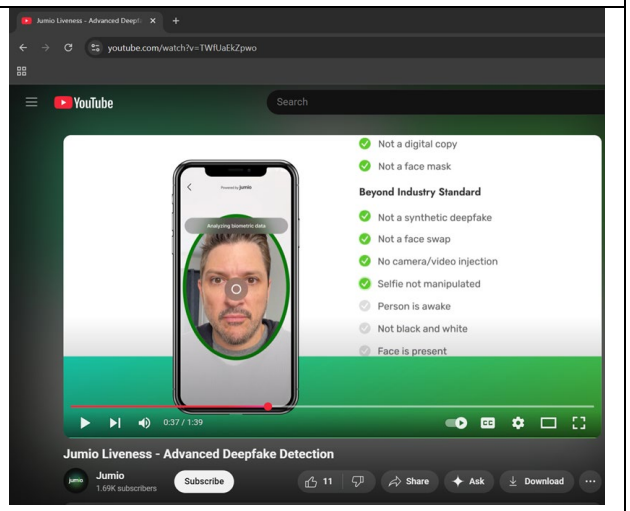
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072. The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does have expected differences.	

U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069.	
Claim 8			
8[pre]	A method for determining when a user, based on images of the user's face, does not exhibit three-dimensionality, the method comprising:	*See, e.g.*, 1[pre].	*See, e.g.*, 1[pre].
8[a]	capturing at least one first image of the user's face	FaceTec's 3D liveness detection technology practices this element.	Jumio's system practices this element.

U.S. Patent No. 11,693,938		FaceTec	Jumio
	taken with a camera located at a first distance from the user's face, the camera associated with a computing device;	For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The images below show a first image captured by a mobile phone at a first distance using Jumio's system.  Excerpt from Ex. 2072.

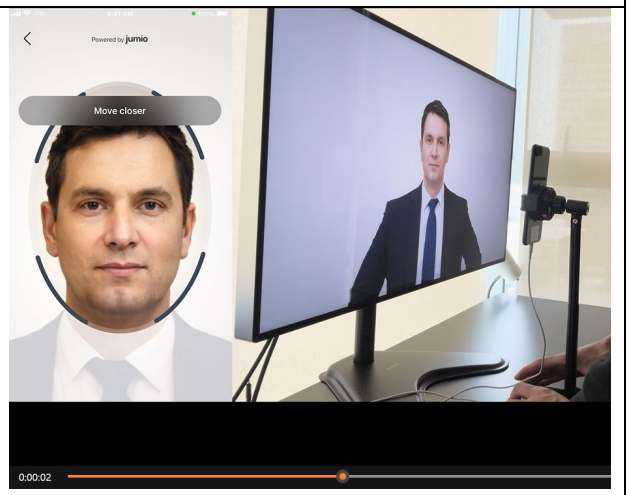
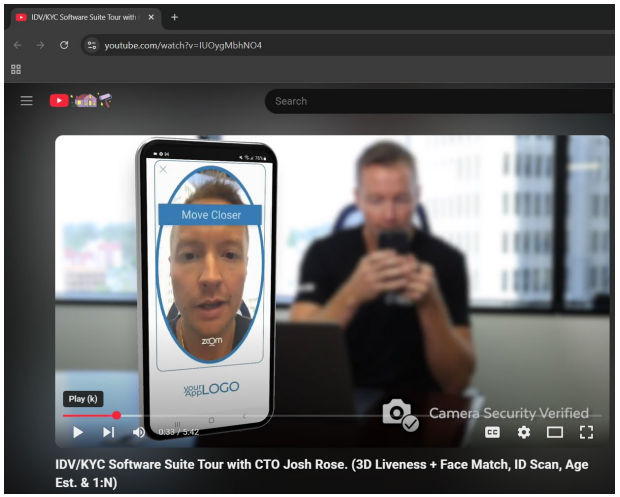
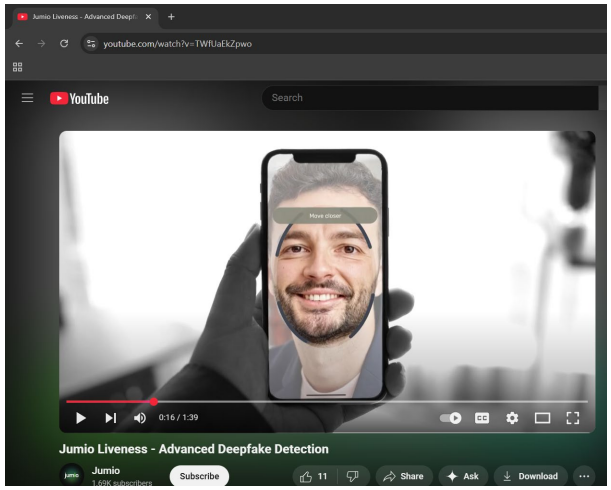
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]”).	 Excerpt from Ex. 2070.

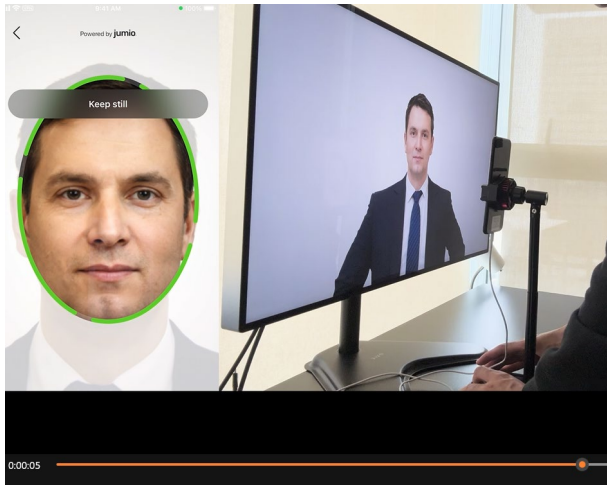
U.S. Patent No. 11,693,938		FaceTec	Jumio
8[b]	processing the at least one first image or a portion thereof to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. [redacted] Ex. 2067 ([redacted]").	Jumio's system practices this element. The images below show Jumio analyzing biometric data, which is obtained by processing the first image.  Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data).

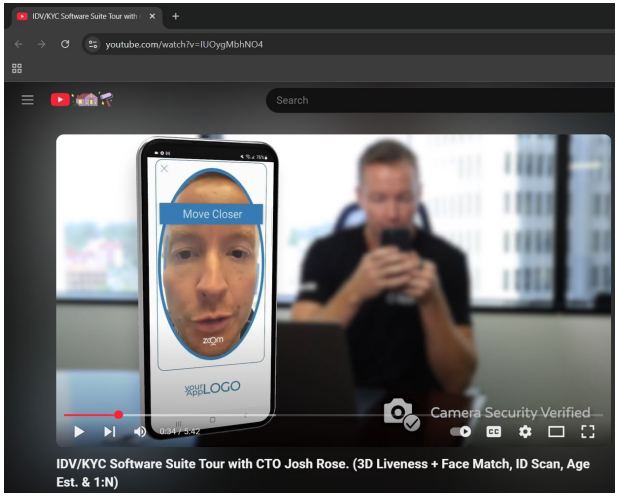
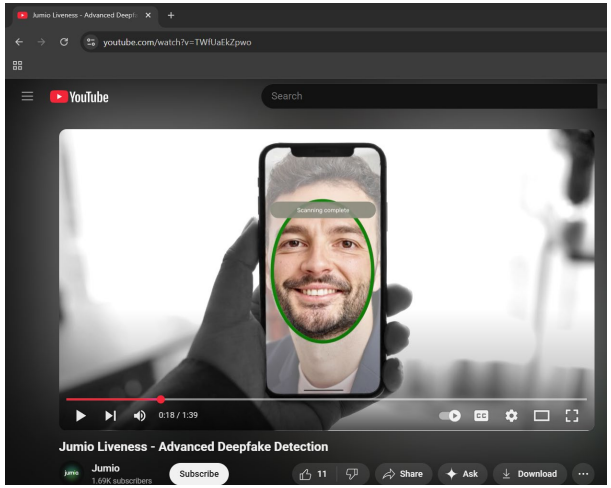
U.S. Patent No. 11,693,938		FaceTec	Jumio
			 Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data).
8[c]	moving the camera to a second distance from the user's face, where the second distance is different from the first distance;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance	Jumio's system practices this element.

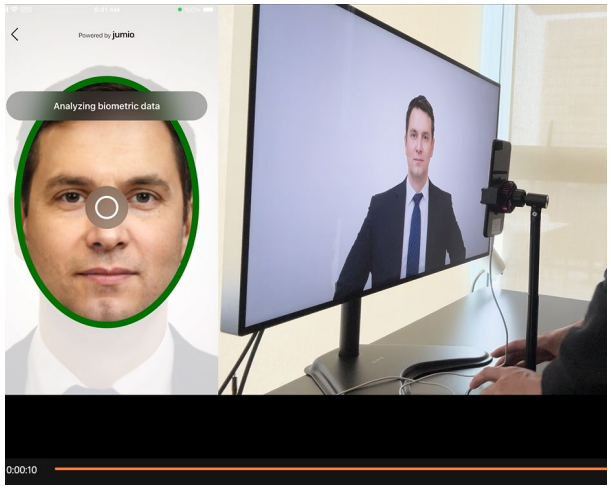
U.S. Patent No. 11,693,938		FaceTec	Jumio
		between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. 	

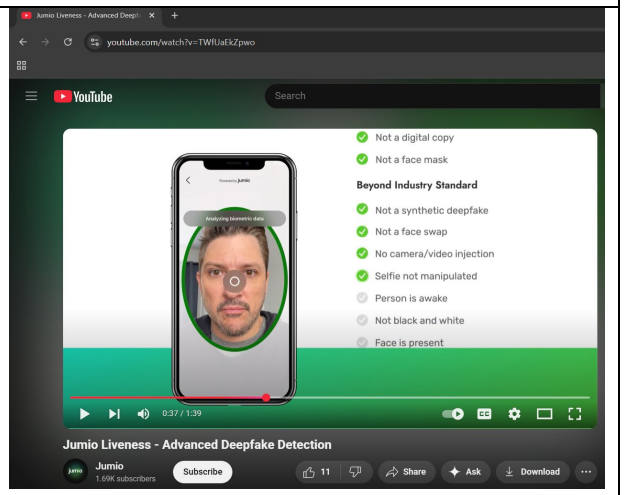
U.S. Patent No. 11,693,938		FaceTec	Jumio
		Ex. 2067 ([redacted]"). Because the distance is decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.	The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.

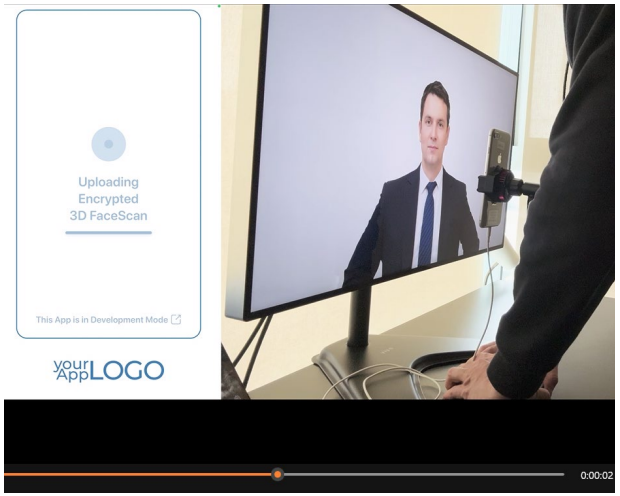
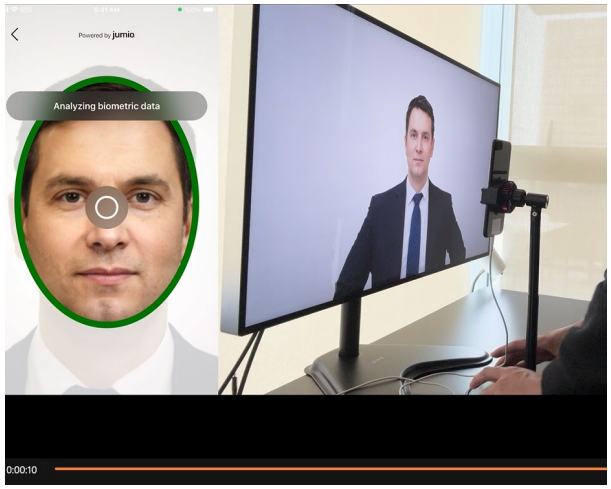
U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

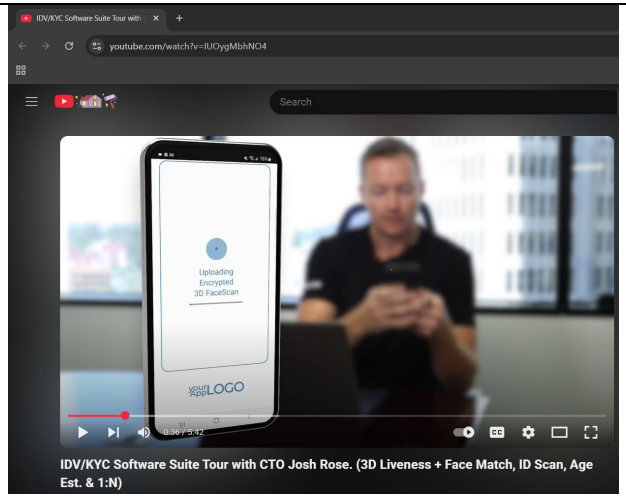
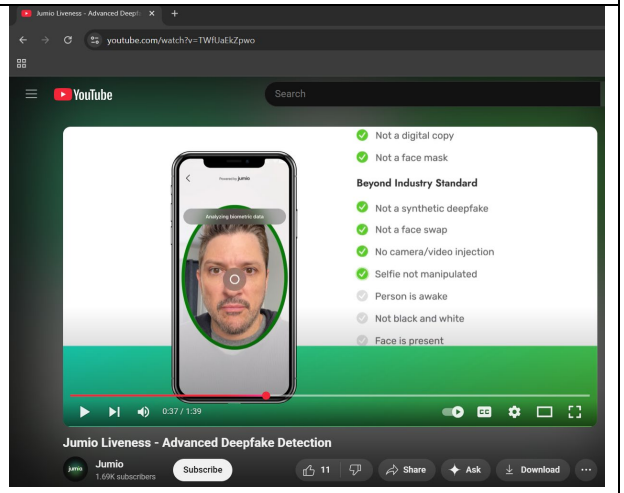
U.S. Patent No. 11,693,938		FaceTec	Jumio
8[d]	capturing, at the second distance, at least one second image of the user's face taken with the camera associated with the computing device;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology. 	Jumio's system practices this element. The images below show a second image captured by a mobile phone at a second distance using Jumio's system. 

U.S. Patent No. 11,693,938		FaceTec	Jumio
		Excerpt from Ex. 2072.  Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]	Excerpt from Ex. 2072.  Excerpt from Ex. 2070.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		[redacted]”).	
8[e]	processing the at least one second image or a portion thereof to create second data;	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12. [redacted] Ex. 2067 ([redacted]”).	Jumio’s system practices this element. The images below show Jumio analyzing biometric data, which is obtained by processing the second image.  Excerpt from Ex. 2072.

U.S. Patent No. 11,693,938		FaceTec	Jumio
			 Excerpt from Ex. 2070.
8[f]	examining the first data and the second data to determine whether differences between the first data and the second data indicate an expected type of distorting change in at least one image that is	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first	Jumio's system practices this element.

U.S. Patent No. 11,693,938		FaceTec	Jumio
	consistent with a real person being imaged and which is indicative of three-dimensionality;	distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.  Excerpt from Ex. 2072.	The images below show Jumio's system analyzing biometric data.  Excerpt from Ex. 2072.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2069. 	 Excerpt from Ex. 2070.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		Ex. 2067 ([redacted]). Perspective distortion refers to the apparent change in the shape or size of an object (e.g., the face) in an image due to the camera's relative position and angle. When appropriately present, perspective distortion verifies to a high degree of confidence that the face captured in the photos in 3D and not a 2D photo or video. Ex. 2059 (Rose) ¶ 7. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. Among other subtle but detectable distortions,	

U.S. Patent No. 11,693,938		FaceTec	Jumio
		perspective distortion causes the user's nose to appear larger in proportion to the rest of the face in the second image as compared to the first image. Ex. 2059 (Rose) ¶ 25.	
8[g]	determining the user's face is not three-dimensional when the first data and the second data do not have expected differences indicating the user exhibits three-dimensionality.	*See, e.g.*, claim 1[d].	*See, e.g.*, claim 1[d].
Claim 17			
17[pre]	A method, performed using a computing device, for providing authentication of a person during an authentication	*See, e.g.*, claim 8[pre].	*See, e.g.*, claim 8[pre].

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	session, the method comprising:		
17[a]	capturing a first image of a head of the person with a camera at a first distance from the person, the camera associated with the computing device;	*See, e.g.*, claim 8[a].	*See, e.g.*, claim 8[a].
17[b]	changing a distance between the person and the camera to a second distance, which is different from the first distance;	*See, e.g.*, claim 8[c].	*See, e.g.*, claim 8[c].
17[c]	capturing a second image of the head of the person with the camera at the second distance from the person;	*See, e.g.*, claim 8[d].	*See, e.g.*, claim 8[d].

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17[d]	comparing one or more aspects of the head from the first image or first biometric data derived from the first image to one or more aspects of the head from the second image or second biometric data derived from the second image to determine whether expected differences are not present, wherein the expected differences:	*See, e.g.*, claims 1[d], 8[b], 8[e], and 8[f].	*See, e.g.*, claims 1[d], 8[b], 8[e], and 8[f].
17[e]	would be present when the first image and second images of the head of the person being	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].

U.S. Patent No. 11,693,938		FaceTec	Jumio
	captured at different distances has three-dimensional characteristics but not if the head did not have three-dimensional characteristics; and		
17[f]	the expected differences result from differences in relative dimensions of a person's face appearing different when capturing images is done close to the person's face and far from the persons face; and	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].
17[g]	if the expected differences are not	*See, e.g.*, claim 17[d].	*See, e.g.*, claim 17[d].

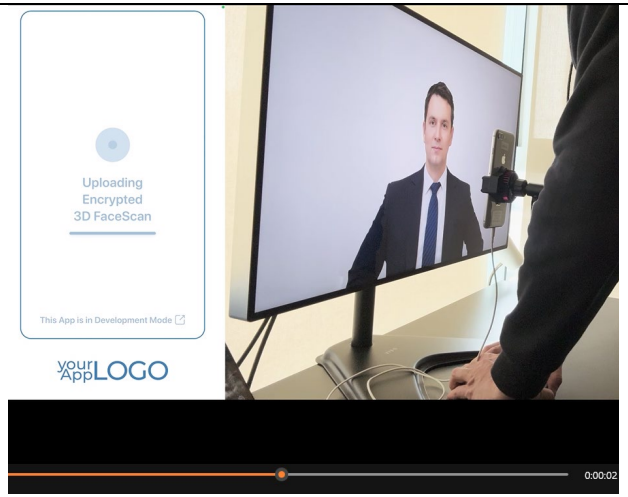
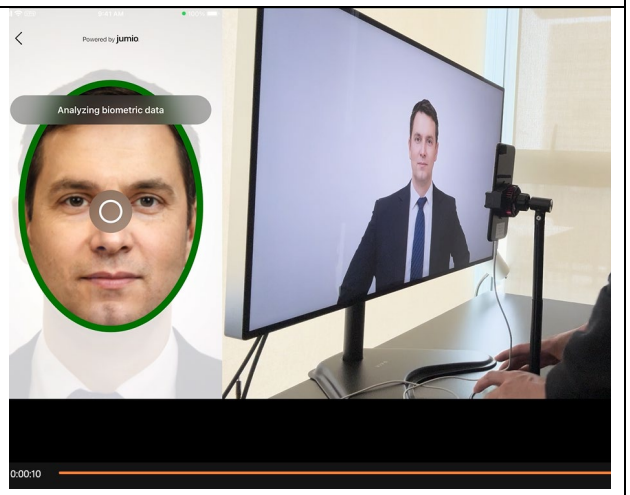
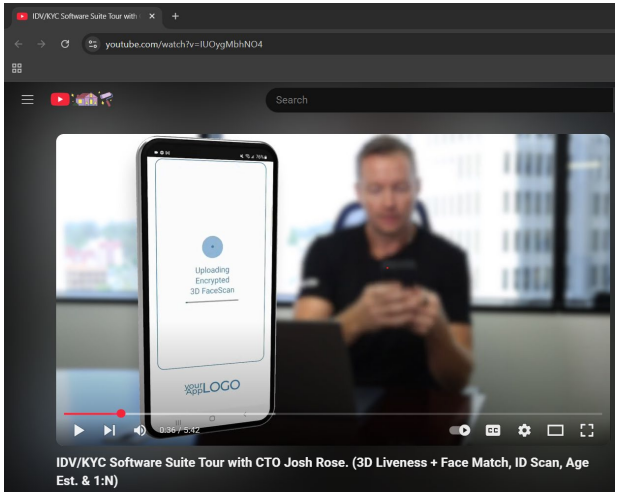
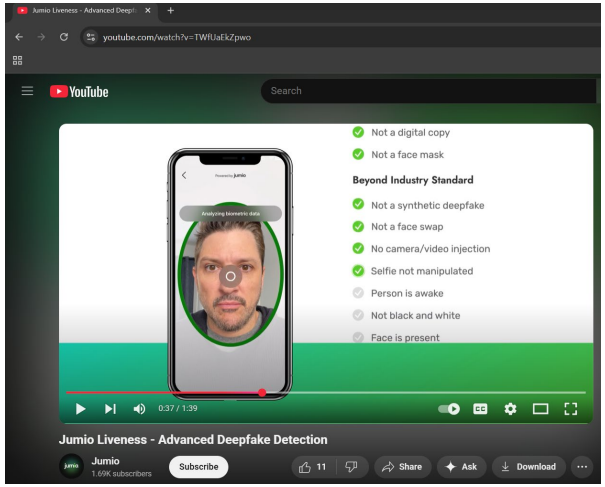
U.S. Patent No. 11,693,938		FaceTec	Jumio
	present, denying authentication of the person and providing notice thereof to one or more of the person, a third party, or a software application, wherein the authentication is authentication of liveness, three-dimensionality, or both.		
Claim 20			
20[pre]	A method for determining whether a user exhibits three-dimensionality, the method comprising:	*See, e.g.*, claim 8[pre].	*See, e.g.*, claim 8[pre].

U.S. Patent No. 11,693,938		FaceTec	Jumio
20[a]	capturing at least one first image of a user's face taken with a camera located a first distance from the user, the camera associated with a computing device;	*See, e.g.*, claim 8[a].	*See, e.g.*, claim 8[a].
20[b]	processing the at least one first image or a portion thereof to create first data, the first data derived from the user's face;	*See, e.g.*, claim 8[b].	*See, e.g.*, claim 8[b].
20[c]	intentionally moving the camera from the first location to a second location, the second location being a second distance from the	*See, e.g.*, claim 8[c].	*See, e.g.*, claim 8[c].

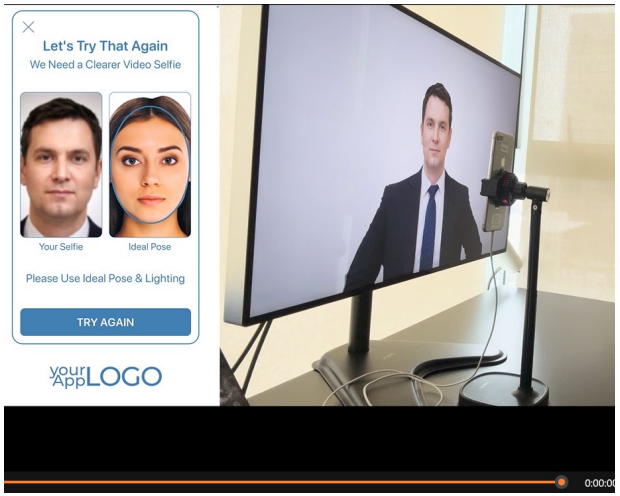
U.S. Patent No. 11,693,938		FaceTec	Jumio
	user, or the user moving to change a distance between the user and the camera from the first distance to the second distance;		
20[d]	capturing at least one second image of the user's face taken with the camera located a second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 8[d].	*See, e.g.*, claim 8[d].
20[e]	processing the at least one second image or a portion thereof to create second data, the second data	*See, e.g.*, claim 8[e].	*See, e.g.*, claim 8[e].

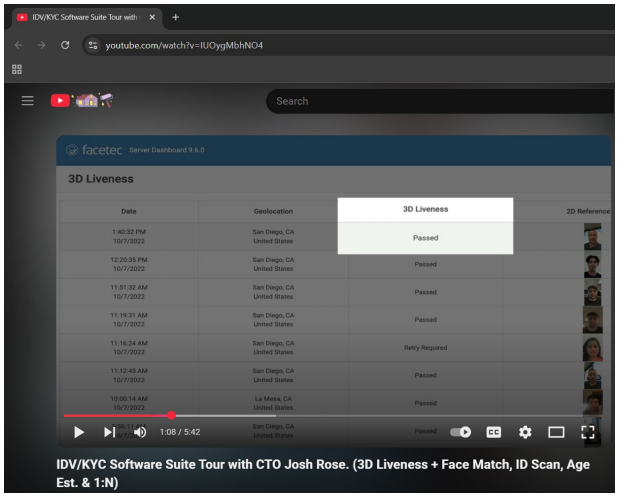
U.S. Patent No. 11,693,938		FaceTec	Jumio
	derived from the user's face;		
20[f]	analyzing the first data to determine at least if the first data exhibits first characteristics that indicate the first data was derived from an image of the user captured at the first distance;	FaceTec's 3D liveness detection technology practices this element. Ex. 2067 ("[redacted]").	Jumio's system practices this element. Jumio's "system compares the images and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.
20[g]	analyzing the second data to determine at least if the second data exhibits second characteristics that indicate the second data was derived	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device the compares the first data with the second data to determine whether the first data matches the	Jumio's system practices this element.

U.S. Patent No. 11,693,938		FaceTec	Jumio
	from an image the user captured at the second distance, wherein the first characteristics or the second characteristics include at least distortion within the at least one first image or the at least one second image;	second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The expected differences include expected distortions, including fish-eye type distortions in at least one of the first image(s) or the second image(s) due to the three-dimensional nature of the human face and the change in distance between the camera and the user. Ex. 2059 (Rose) ¶ 19. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	The images below show Jumio's system analyzing the biometric data to determine presence or absence of the expected differences to in turn determine whether a three-dimensional shape is exhibited in the images.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data).
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,693,938		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]). Ex. 2067 (“ [redacted]	Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data). Jumio’s “system compares the images and automatically provides scores on validity/liveness and similarity.” Ex. 2076 at 2.

U.S. Patent No. 11,693,938		FaceTec	Jumio
		[redacted]). The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does not have the expected differences.  Excerpt from Ex. 2072.	

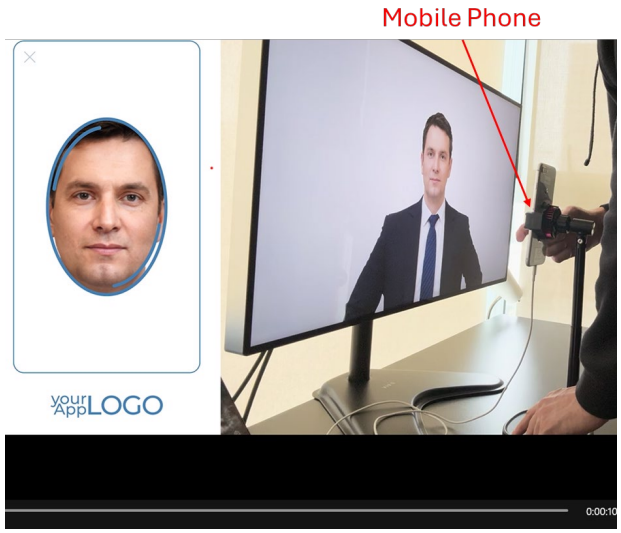
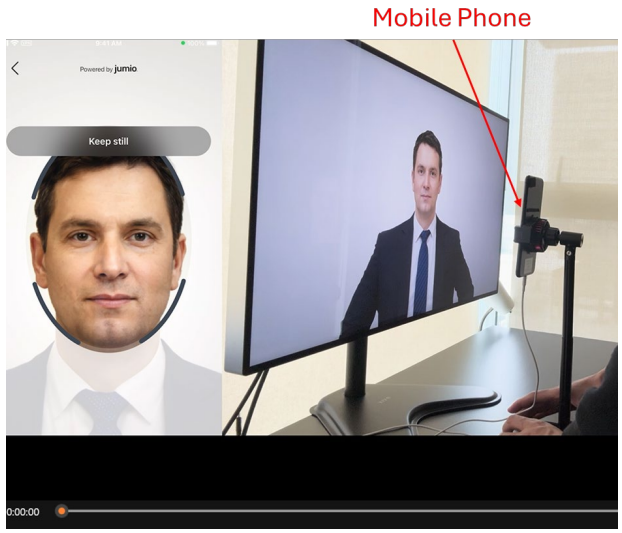
U.S. Patent No. 11,693,938		FaceTec	Jumio
		The image below shows FaceTec's 3D liveness detection technology determining that the second biometric data does have expected differences.  Excerpt from Ex. 2069	
20[h]	determining the user does not exhibit the expected degree of three-dimensionality when either or both of the following occur:	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].

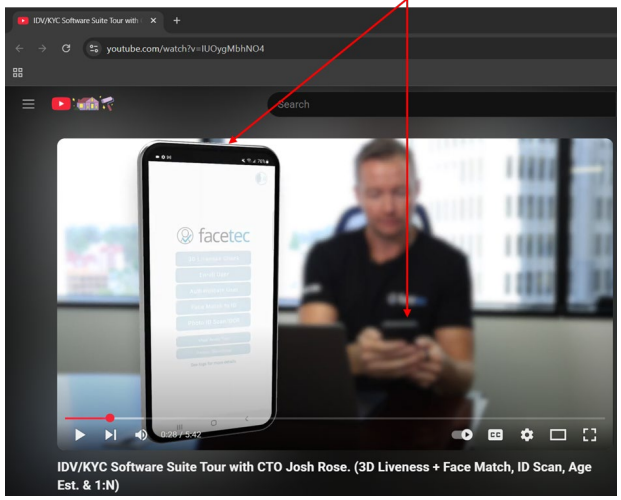
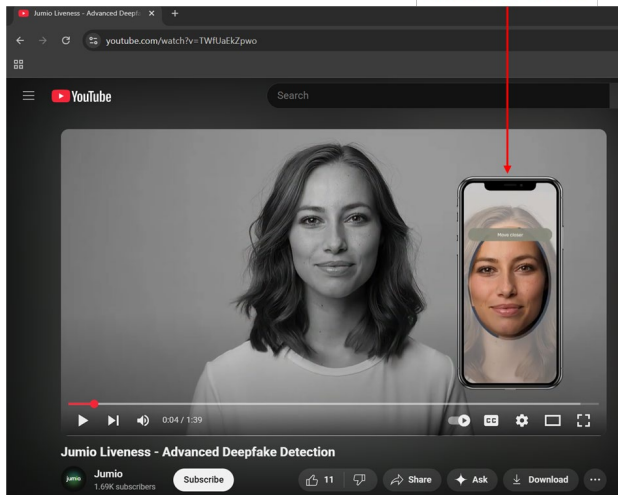
U.S. Patent No. 11,693,938		FaceTec	Jumio
20[h1]	the step of analyzing the first data determines the first data does not exhibit first characteristics that indicate the first data was derived from an image of the user captured at the first distance; or	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].
20[h2]	the step of analyzing the second data determines the second data does not exhibit second characteristics that indicate the second data was derived from an image of the user captured	*See, e.g.*, claim 20[f]-[g].	*See, e.g.*, claim 20[f]-[g].

U.S. Patent No. 11,693,938		FaceTec	Jumio
	at the second distance.		

Appendix H: Comparison of FaceTec's and Jumio's 3D Liveness Detection Technology

U.S. Patent No. 11,874,910		FaceTec	Jumio
Claim 1			
1[pre]	A computing device for verifying three-dimensionality of a user via a user's camera equipped computing device, the computing device comprising:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology authenticates three-dimensionality of a user via a user's camera equipped computing device. Ex. 2059 (Rose) ¶¶ 1-9, 17-19. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first distance to the second distance	Jumio's system practices this element.

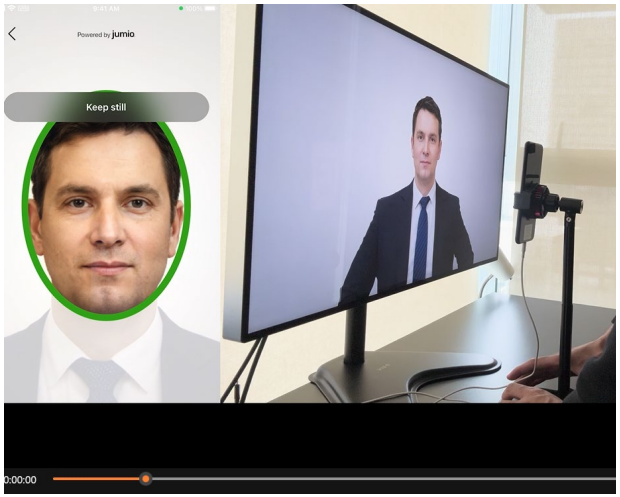
U.S. Patent No. 11,874,910		FaceTec	Jumio
		to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. For example, the computing device may be a mobile phone.  Excerpt from Ex. 2072.	For example, the computing device in Jumio's system may be a mobile phone.  Excerpt from Ex. 2072.

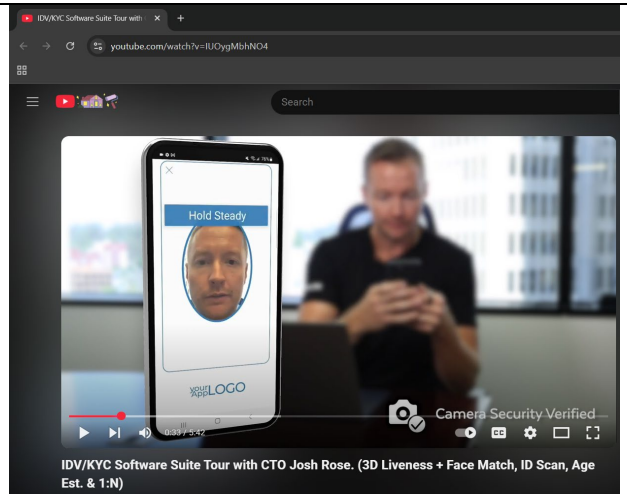
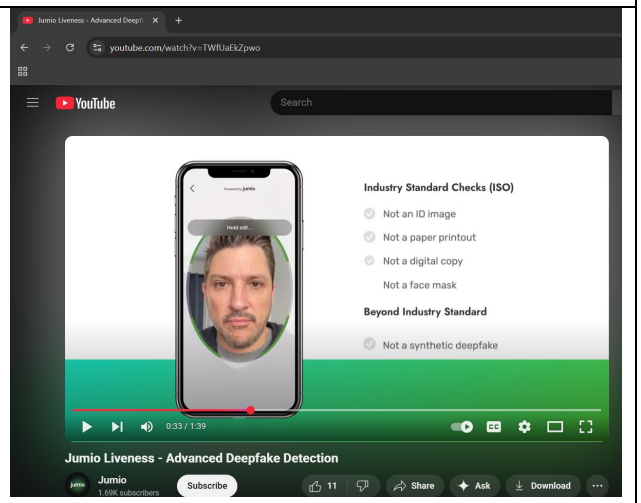
U.S. Patent No. 11,874,910		FaceTec	Jumio
		Mobile Phone  Excerpt from Ex. 2069. [redacted]	Mobile Phone  Excerpt from Ex. 2070.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		Ex. 2067.	
1[a]	a processor configured to execute machine executable code;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a processor configured to execute machine executable code. Ex. 2059 (Rose) ¶ 10.	Jumio's system practices this element. A computing device like a mobile phone includes a processor configured to execute machine executable code. *See* Ex. 2059 (Rose) ¶ 10.
1[b]	a screen configured to provide a user interface to the user;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a screen configured with a user interface. Ex. 2059 (Rose) ¶ 10.	Jumio's system practices this element. For example, a computing device like a mobile phone includes a screen configured with a user interface. *See* Ex. 2059 (Rose) ¶ 10.
1[c]	a camera configured to capture images;	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes a camera	Jumio's system practices this element. For example, a computing device like a mobile phone includes a camera

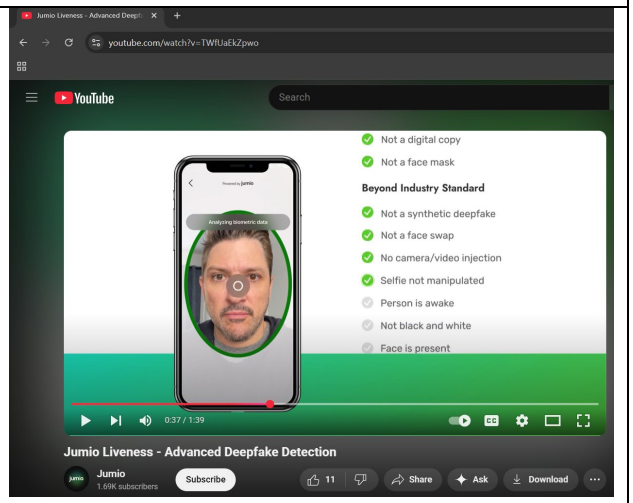
U.S. Patent No. 11,874,910		FaceTec	Jumio
		configured to capture images. Ex. 2059 (Rose) ¶ 10.	configured to capture images. *See* Ex. 2059 (Rose) ¶ 10.
1[d]	one or more memories configured to store machine readable instructions that are stored on the memory of the authentication server which when executed by the processor, cause the computing device to:	FaceTec's 3D liveness detection technology practices this element. For example, FaceTec's 3D liveness detection technology uses a user's computing device that includes one or more memories configured to store machine readable instructions. Ex. 2059 (Rose) ¶ 10. 	Jumio's system practices this element. For example, a computing device like a mobile phone includes one or more memories configured to store machine readable instructions. *See* Ex. 2059 (Rose) ¶ 10.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		Ex. 2067.  Ex. 2067.	
1[d1]	capturing at least one first image of the user taken with the camera of the computing device at a first location which is a first distance from the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to	Jumio's system practices this element.

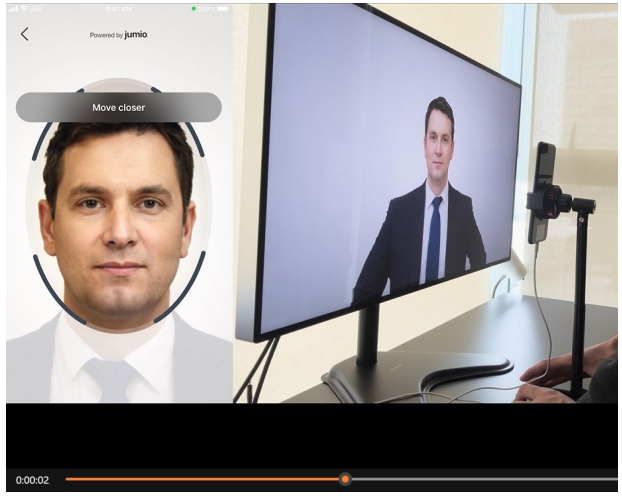
U.S. Patent No. 11,874,910		FaceTec	Jumio
		obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. The images below show a first image captured by a mobile phone at a first distance using FaceTec's 3D liveness detection technology.  Excerpt from Ex. 2072.	The images below show a first image captured by a mobile phone at a first distance using Jumio's system.  Excerpt from Ex. 2072.

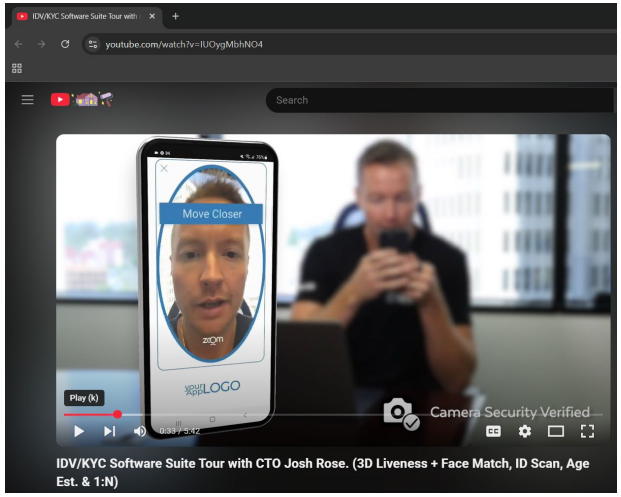
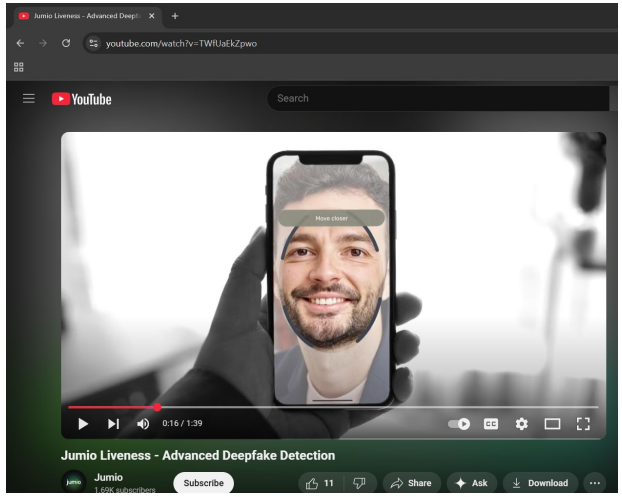
U.S. Patent No. 11,874,910		FaceTec	Jumio
		 Excerpt from Ex. 2069. [redacted] Ex. 2067 ([redacted]").	 Excerpt from Ex. 2070.

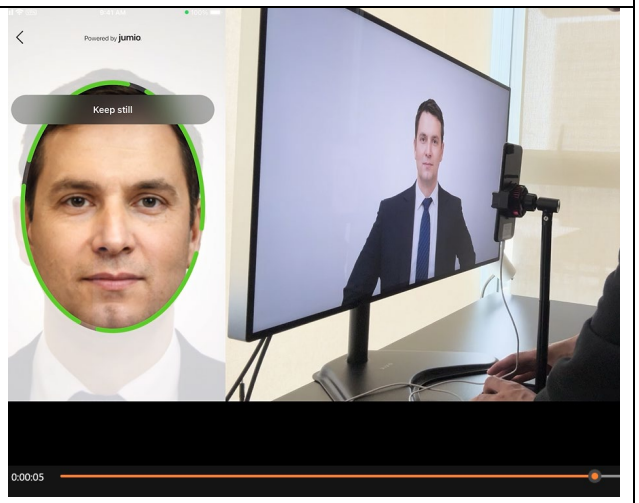
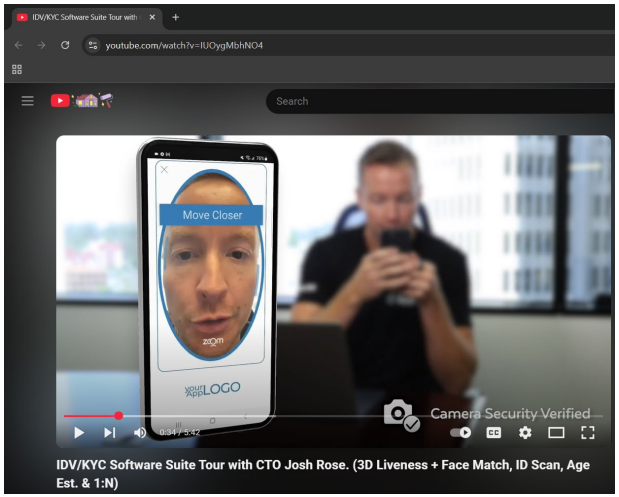
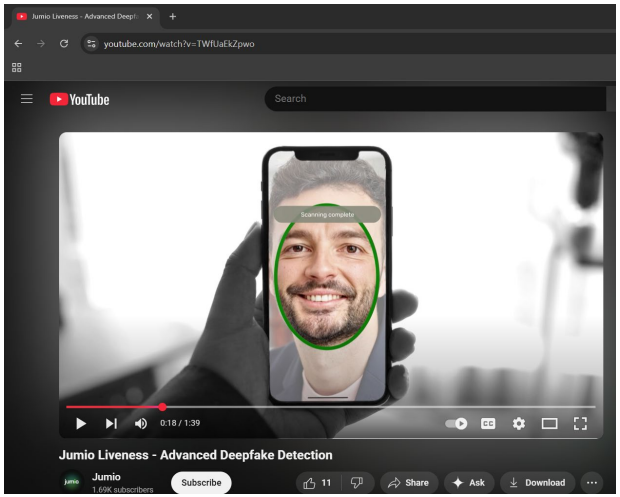
U.S. Patent No. 11,874,910		FaceTec	Jumio
1[d2]	processing the at least one first image or a portion thereof to create first data;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one first image of the user taken with the camera at a first distance from the user and processes the first image(s) to obtain first data from the image(s). Ex. 2059 (Rose) ¶ 11. [redacted] Ex. 2067 ([redacted]).	Jumio's system practices this element. The images below show Jumio analyzing biometric data, which is obtained by processing the first image.  Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data).

U.S. Patent No. 11,874,910		FaceTec	Jumio
			 Excerpt from Ex. 2070.
1[d3]	capturing at least one second image of the user taken with the camera of the computing device is at a second distance from the user, the second distance being different than the first distance, the capturing at least	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance between the user and the camera, the user may move the camera, the user may	Jumio's system practices this element.

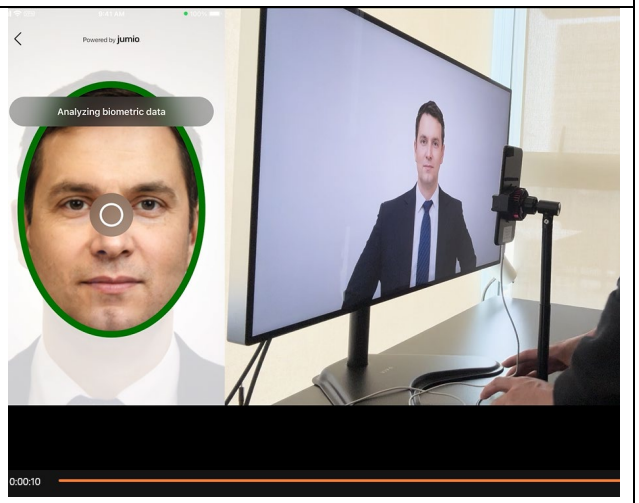
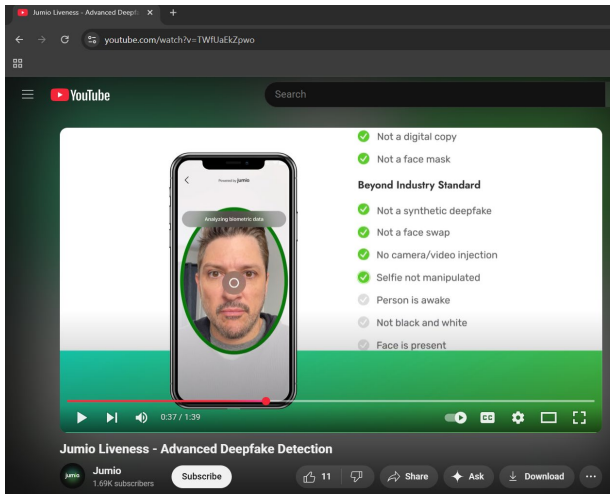
U.S. Patent No. 11,874,910		FaceTec	Jumio
	one second image of the user occurring after movement of the camera or the user to establish the camera at the second distance from the user;	move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer, and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24.  Ex. 2067 ("[redacted]	

U.S. Patent No. 11,874,910		FaceTec	Jumio
		[redacted]"). Because the distance is decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both. 	The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both. 

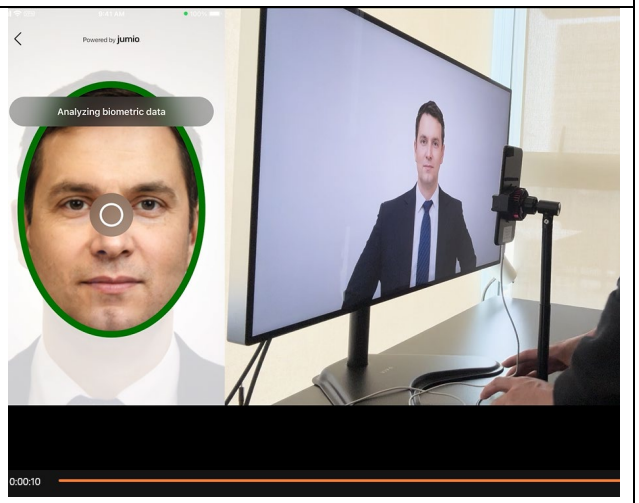
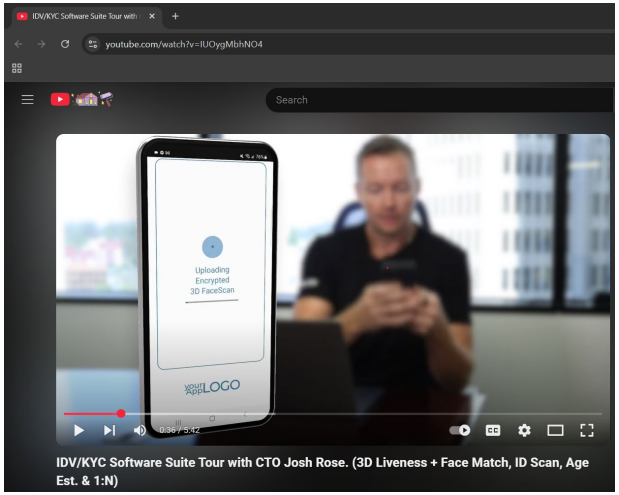
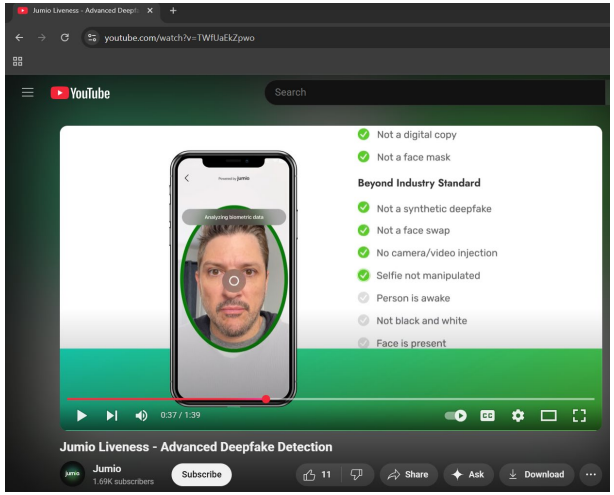
U.S. Patent No. 11,874,910		FaceTec	Jumio
		Excerpt from Ex. 2072.  Excerpt from Ex. 2069. The images below show a second image captured by a mobile phone at a second distance using FaceTec's 3D liveness detection technology.	Excerpt from Ex. 2072.  Excerpt from Ex. 2070 The image below shows a second image captured by a mobile phone at a second distance using Jumio's system.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

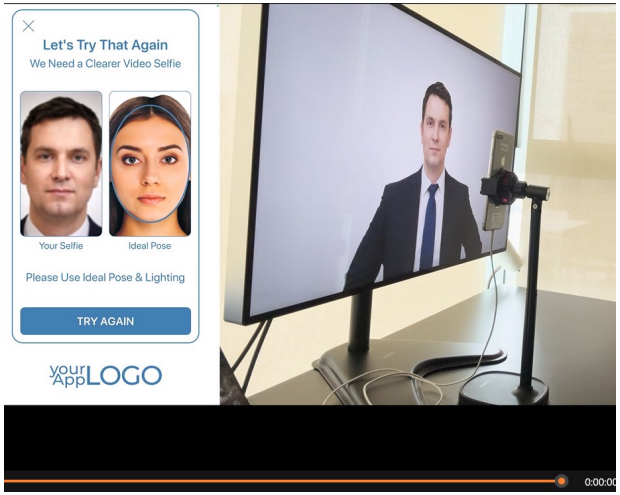
U.S. Patent No. 11,874,910		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]”).	
1[d4]	processing the at least one second image or a portion thereof to create second data;	FaceTec’s 3D liveness detection technology practices this element. For example, in FaceTec’s 3D liveness detection technology, the user’s computing device processes the second image(s) to obtain (e.g., receive or derive) second data from the image(s). Ex. 2059 (Rose) ¶ 12.	Jumio’s system practices this element. The images below show Jumio’s system analyzing biometric data, which is obtained by processing the second image.

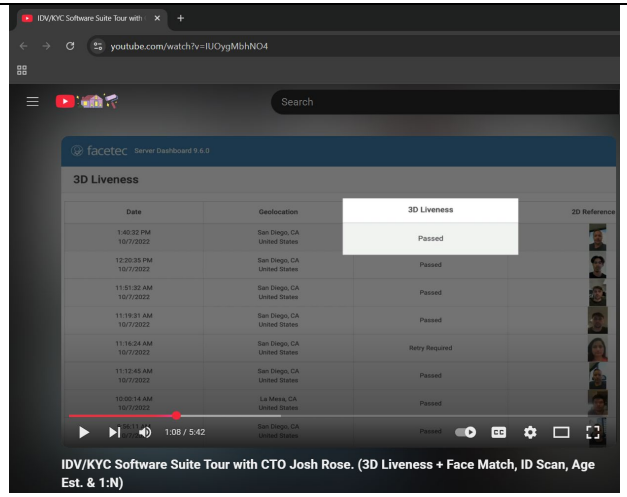
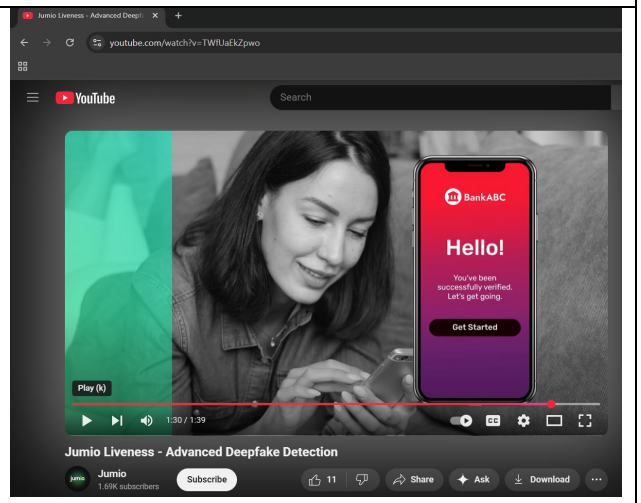
U.S. Patent No. 11,874,910		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]).	 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data). 

U.S. Patent No. 11,874,910		FaceTec	Jumio
			Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data).
1[d5]	comparing the first data to the second data to determine whether expected differences exist between the first data and the second data which indicates three-dimensionality of the user;	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device the compares the first data with the second data to determine whether the first data matches the second data and to determine whether differences between the first image(s) and the second image(s) match expected differences resulting from movement of the camera or the user from the first distance to the second distance. Ex. 2059 (Rose) ¶ 17. The images below show FaceTec's 3D liveness detection technology comparing the first data to the second data.	Jumio's system practices this element. The images below show Jumio analyzing biometric data.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072; Ex.2074 (discussing the use of biometric data).
		 Excerpt from Ex. 2069.	

U.S. Patent No. 11,874,910		FaceTec	Jumio
		[redacted] Ex. 2067 ([redacted]).	Excerpt from Ex. 2070; Ex.2074 (discussing the use of biometric data). Jumio's "system compares the images and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.
1[d6]	verifying the images of the user exhibit three dimensional traits when the expected differences exist between the first	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device determines that the user's face is three-dimensional when	Jumio's system practices this element.

U.S. Patent No. 11,874,910		FaceTec	Jumio
	data and the second data as a result of capturing the at least one first image and the at least one second image at different distances from the user.	the first data does not match the second data and the second data has the expected differences as compared to the first data that should be present as the result of the change in distance between the user and the camera when capturing the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 18. The images below show FaceTec's 3D liveness detection technology authenticating the user.  Excerpt from Ex. 2072.	The images below show Jumio's system authenticating the user.  Excerpt from Ex. 2072.

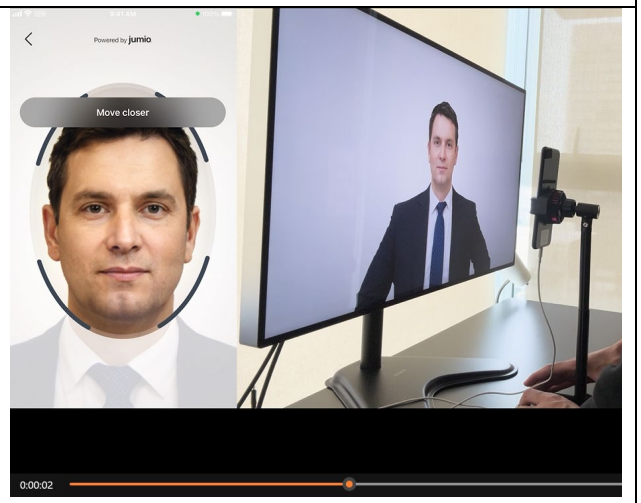
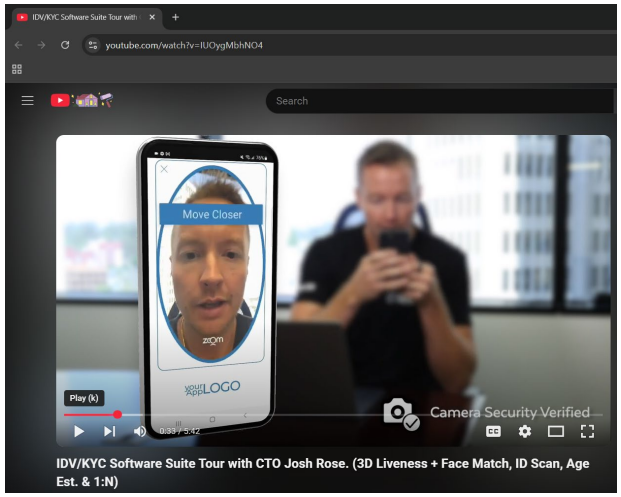
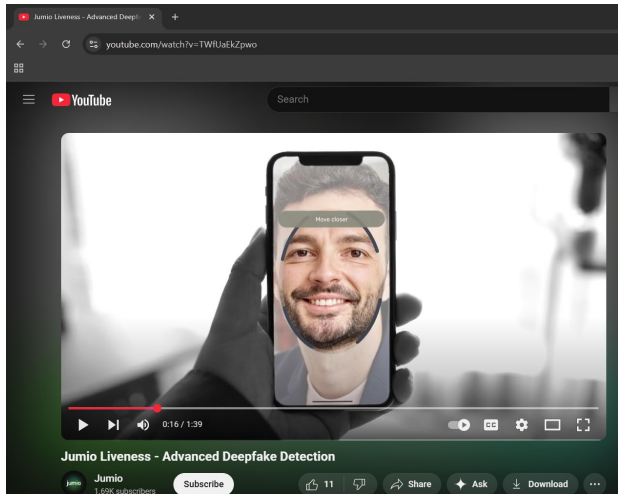
U.S. Patent No. 11,874,910		FaceTec	Jumio
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.
		[redacted]	Jumio's "system compares the images and automatically provides scores on validity/liveness and similarity." Ex. 2076 at 2.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		Ex. 2067 ([redacted]). Ex. 2067 ("[redacted]").	
Claim 10			
10[pre]	A method for evaluating three-dimensionality of a user, the method comprising:	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre].

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10[a]	capturing at least one first image of the user taken with a camera at a first location which is a first distance from the user;	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].
10[b]	processing the at least one first image or a portion thereof to create first data;	*See, e.g.*, claim 1[d2].	*See, e.g.*, claim 1[d2].
10[c]	moving the camera from the first location to a second location, the second location being a second distance from the user, or the user moving to change the distance between	FaceTec's 3D liveness detection technology practices this element. For example, in FaceTec's 3D liveness detection technology, the user's computing device captures at least one second image of the user taken with the camera at a second distance from the user. Ex. 2059 (Rose) ¶ 12. When using FaceTec's 3D liveness detection technology, to change the distance	Jumio's system practices this element.

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	the user and the camera from the first distance to the second distance;	between the user and the camera, the user may move the camera, the user may move their head relative to the camera, or both. Ex. 2059 (Rose) ¶ 13. In FaceTec's 3D liveness detection technology, the computing device may be a hand-held device that the user holds at the first distance and the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 23. Alternatively, the computing device may be a laptop or desktop computer and the user may move from the first distance to the second distance to capture the first image(s) and the second image(s). Ex. 2059 (Rose) ¶ 24. 	

U.S. Patent No. 11,874,910		FaceTec	Jumio
		Ex. 2067 ([redacted]"). Because the distance is decreased, the first distance is greater than the second distance. The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.	The images below show a prompt on the screen asking the user to move closer indicating movement of the camera, movement of the user, or both.

U.S. Patent No. 11,874,910		FaceTec	Jumio
		 Excerpt from Ex. 2072.	 Excerpt from Ex. 2072.
		 Excerpt from Ex. 2069.	 Excerpt from Ex. 2070.

U.S. Patent No. 11,874,910		FaceTec	Jumio
10[d]	capturing at least one second image of the user taken with the camera when the camera is the second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].
10[e]	processing the at least one second image or a portion thereof to create second data;	*See, e.g.*, claim 1[d4].	*See, e.g.*, claim 1[d4].
10[f]	comparing the first data to the second data to determine whether expected differences exist between the first data and the	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].

U.S. Patent No. 11,874,910		FaceTec	Jumio
	second data which indicate three-dimensionality of the user;		
10[g]	verifying the images of the user exhibit three-dimensional traits when the first data and the second data have expected differences resulting from the at least one first image being captured with the camera at a different distance from the user than when the at least one second image is captured.	*See, e.g.*, claim 1[d6].	*See, e.g.*, claim 1[d6].
Claim 22			

U.S. Patent No. 11,874,910		FaceTec	Jumio
22[pre]	A method, performed by a user using a user's computer device, for verifying three-dimensionality of the user, the method comprising:	*See, e.g.*, claim 1[pre].	*See, e.g.*, claim 1[pre]. For example, in response to the Frequently Asked Question: "What devices can users use for selfie submissions?," Jumio discloses that "Users can use any device — everything from laptops to Android tablets to Apple iPhones — to take and upload their selfie into the business's app. If a device can only capture low-resolution facial images (such as a webcam), Jumio's software allows a user to start the journey on their computer and then take the selfie using their mobile device." Ex. 2076 at 4.
22[a]	capturing a first image of the user's head with a camera at a first distance from the user, the camera associated with	*See, e.g.*, claim 1[d1].	*See, e.g.*, claim 1[d1].

U.S. Patent No. 11,874,910		FaceTec	Jumio
	the user's computing device;		
22[b]	changing a distance between the user and the camera to a second distance by the user moving the camera, or the user moving relative to the camera, or both;	*See, e.g.*, claims 10[e].	*See, e.g.*, claims 10[e].
22[c]	capturing a second image of the user's head with the camera when the camera is at the second distance from the user, the second distance being different than the first distance;	*See, e.g.*, claim 1[d3].	*See, e.g.*, claim 1[d3].

U.S. Patent No. 11,874,910		FaceTec	Jumio
22[d]	comparing one or more aspects of the user's head from the first image to one or more aspects of the user's head from the second image to determine whether expected differences, between the first image and the second image, exist which indicates three-dimensionality of the user, such that the expected differences between the first image and the second image	*See, e.g.*, claim 1[d5].	*See, e.g.*, claim 1[d5].

U.S. Patent No. 11,874,910		FaceTec	Jumio
	result from the first image being captured when the camera is at a different distance from the user than when the second image is captured; and		
22[e]	responsive to the comparing determining that expected differences between the first image and the second image exist, providing notice to the user, a third party, or both that the three-dimensionality of	*See, e.g.*, claim 1[d6].	*See, e.g.*, claim 1[d6].

U.S. Patent No. 11,874,910		FaceTec	Jumio
	the user is verified.		

Appendix I: Curriculum Vitae of Dr. Matthew A. Turk

CURRICULUM VITAE

Matthew A. Turk, Ph.D.
Fellow, Association for Computing Machinery (ACM)
Life Fellow, Institute of Electrical & Electronics Engineers (IEEE)
Fellow, International Association for Pattern Recognition (IAPR)
Fellow, Asia-Pacific Artificial Intelligence Association (AAIA)
Fellow, Artificial Intelligence Industry Alliance (AIIA)

Professor Emeritus
University of California, Santa Barbara
Santa Barbara, CA 93106-5110

https://home.ttic.edu/~mturk/
mturk@ucsb.edu
+1 (805) 729-0534

PRIMARY RESEARCH INTERESTS AND EXPERTISE:

Computer vision and image processing, artificial intelligence and machine learning, pattern recognition, multimodal human-computer interaction, augmented and virtual reality, computer graphics and imaging, biometrics, AI ethics and regulation

PROFESSIONAL EXPERIENCE:

2000-pres. **University of California, Santa Barbara** Santa Barbara, CA
Professor Emeritus (2019-pres.)
Professor (2005-2019), Associate Professor (2000-2005)
Co-director, Four Eyes Laboratory

Appointments: Computer Science (67%), Media Arts & Technology (33%), Electrical & Computer Engineering (0%), Dynamical Neuroscience (0%)
Chair, Department of Computer Science (2017-2019)
Chair, Media Arts and Technology (2005-2010)
Vice Chair, Media Arts and Technology (2005)

2019-2025 **Toyota Technological Institute at Chicago** Chicago, IL
President and Professor
Member of the Board of Trustees

2020-2025 **Toyota Technological Institute at Japan** Nagoya, Japan
Board Councilor

2014-2016 **Caugnate** Santa Barbara, CA
Co-founder and CEO
Startup company commercializing remote telecollaboration augmented reality software. Participated in UCSB Technology Management Program New Venture Competition and in the Citrix Innovator's Program. Acquired by PTC Inc. – now the Vuforia Chalk product.

2012 **University of Oulu** Oulu, Finland
Visiting Professor, Department of Computer Science & Engineering

(Jun-Aug)

2011 **University of Tampere** Tampere, Finland
Visiting Professor, School of Information Science (Aug-Sept)

2003, 2004 **Ecole Polytechnique Fédérale de Lausanne (EPFL)** Lausanne, Switzerland
Visiting faculty – August 2003, July 2004

1994-2000 **Microsoft Research** Redmond, WA
Researcher
Founded the Vision Technology Research Group; research in computer vision, vision-based human-computer interaction and perceptual user interfaces.

1993-94 **Teleos Research** Palo Alto, CA
Computer Scientist
Research in vision-based interaction with people, object recognition, mobile robots.

1993 **Stanford University** Palo Alto, CA
Lecturer
Computer Science Department

1992 **LIFIA-IMAG** Grenoble, France
Postdoc / Visiting Researcher
Research in face recognition and visual interpretation of human gestures, applications to human-computer interfaces.

1991 **Massachusetts Institute of Technology** Cambridge, MA
Postdoctoral Fellow, MIT Media Laboratory
Research on human face recognition for applications to security and man-machine communication; image database indexing and retrieval.

1984-87 **Martin Marietta Denver Aerospace** Denver, CO
Senior Engineer
Research in vision algorithm development and implementation for mobile robot navigation (DARPA Autonomous Land Vehicle program).

1983-84 **University of Pittsburgh** Pittsburgh, PA
Computer Technician, Dept. of Neurophysiology
Electronics, image processing, and computer system support.

EDUCATION:

1987-91 **Massachusetts Institute of Technology** Cambridge, MA
Ph.D. from the Media Laboratory, Vision and Modeling Group
Committee: Alex P. Pentland (advisor), Ted Adelson, Nicholas Negroponte

Dissertation: *Interactive-Time Vision: Face Recognition as a Visual Behavior*

The dissertation introduced "Eigenfaces," an appearance-based approach to face and object recognition. A prototype system was built to track and recognize people as they entered a room; we showed how this approach could be used to represent, detect, and recognize other

object properties such as facial expression. Papers on this work received an "Outstanding Paper" award (1991) and a "Most Influential Paper of the Decade" award (2000).

1982-84 **Carnegie Mellon University** Pittsburgh, PA
M.S. in Electrical and Computer Engineering
Advisors: Matt Mason, Marc Raibert

Thesis: *A Fine Motion Planning Algorithm for Robots*
The thesis investigated robot manipulation planning techniques in the face of uncertainty in sensing and world modeling. A 2D planner was developed to automatically construct a plan, by reasoning in configuration space, to successfully manipulate an object along a constrained path.

1978-82 **Virginia Tech (VPI&SU)** Blacksburg, VA
B.S. in Electrical Engineering, *magna cum laude*
Advisor: Robert Haralick

Senior Honors Project in computer vision; segmentation algorithms implemented in the GYPSY image processing system.

HONORS AND AWARDS:

2024 Recognized by the IEEE as *IEEE Life Fellow*
2023 Elected as *AIIA Fellow* (Artificial Intelligence Industry Alliance)
2022 Elected as *AAIA Fellow* (Asia-Pacific Artificial Intelligence Association)
2022 Appointed to the *Computing Community Consortium (CCC) Council*, charged with catalyzing and empowering the U.S. computing research community to articulate and advance major research directions for the field (term: 2022-2025)
2020 Elected as *ACM Fellow* (Association for Computing Machinery) for "contributions to face recognition, computer vision, and multimodal interaction"
2016 *Best Paper Honorable Mention* at the 2016 IEEE Symposium on 3D User Interfaces (3DUI) for "Interpreting 2D Gesture Annotations in 3D Augmented Reality," with B. Nuernberger, K. Lien, and T. Höllerer
2015 *Winner, ACM Multimedia Open Source Software Competition* for "Theia: A Fast and Scalable Structure-from-Motion Library," with C. Sweeney and T. Höllerer
2015 *Best Short Paper Award* at the 2015 International Symposium on Mixed and Augmented Reality (ISMAR), for "Efficient Computation of Absolute Pose for Gravity-Aware Augmented Reality," with C. Sweeney, B. Nuernberger, and T. Höllerer
2015 *Outstanding Reviewer Award* at the 2015 IEEE International Conference on Automatic Face and Gesture Recognition
2014 Elected as *IAPR Fellow* (International Association for Pattern Recognition) for "contributions to computer vision and vision-based interaction"
2014 Received inaugural *ICMI Community Service Award* for organizational and service contributions to the multimodal interaction research community
2012 Elected as *IEEE Fellow* (Institute of Electrical and Electronics Engineers) for "contributions to computer vision and perceptual interfaces"
2012 *Best Paper Award* at the 2012 International Symposium on Mixed and Augmented Reality (ISMAR), for "Live tracking and mapping from both general and rotation-only camera

	motion," with S. Gauglitz, C. Sweeney, J. Ventura, and T. Höllerer
2012	*Best Paper Honorable Mention* at the 2012 International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI), for "Integrating the physical environment into mobile remote collaboration," with S. Gauglitz, C. Lee, and T. Höllerer
2012	*Best Student Paper Finalist* (PhD student Victor Fragoso) at the 2012 International Conference on Image Processing (ICIP), for "Locating Binary Features for Keypoint Recognition using Noncooperative Games," with V. Fragoso and J. Hespanha
2012	Selected to participate in the National Academy Keck Futures Initiative on The Informed Brain in a Digital World (invitation only)
2011	Awarded the *2011-2012 Fulbright-Nokia Distinguished Chair in Information and Communications Technologies*
2010	*Best Paper Award* at the 2010 IEEE International Workshop on Mobile Vision, for "Location-based augmented reality on mobile phones," with R. Paucher
2006	*One of the Best Image Processing and Computer Vision Papers* in SIBGRAPI 2006, for "Dealing with multi-scale depth changes and motion in depth edge detection," with R. Feris and R. Raskar
2004	*Best Paper Award* at the 2004 IEEE Workshop on Real-Time Vision for Human Computer Interaction, for "Fast 2D hand tracking with flocks of features and multi-cue integration," with M. Kölsch
2004	*Communication and Technology Top Paper Award*, for "Non-zero sum gaze and persuasion," with J. Bailenson, A. Beal, J. Blascovich, and J. Loomis; selected for presentation at the 54th Annual Conference of the International Communication Association (2004)
2000	*Most Influential Paper of the Decade Award* from the International Association for Pattern Recognition (IAPR) Workshop on Machine Vision Applications (MVA-2000)
1999	Selected to attend the National Academy of Engineering Symposium on Frontiers of Engineering (one of 70 chosen nationwide)
1992	Selected to attend *Comparative Approaches to Cognitive Science* international summer school (with scholarship)
1991	C.N.O.U.S. post-doctoral fellowship grant (France)
1991	IEEE Computer Society Outstanding Paper Award, Conference on Computer Vision and Pattern Recognition (CVPR), for "Face recognition using eigenfaces," with A. Pentland
1988-90	SPIE Scholarships in Optical Engineering
1990	MIT Japan Science, Technology, Management Prize
1988	Author of the Year award, Martin Marietta Information Systems , for "VITS – a vision system for autonomous vehicle navigation," with D. Morgenthaler, K. Gremban, and M. Marra
1978-82	Marshall Hahn Engineering Scholarship (Virginia Tech)

SELECT KEYNOTE AND INVITED TALKS:

May 2024	Invited Speaker, IEEE Computer Society San Diego Chapter (San Diego, CA)
Feb 2024	Session Organizer and Panel Moderator, *Generative AI and Science*, AAAS Annual Conference (Denver, CO)
Jan 2023	Keynote Speaker, IEEE International Conference on Face and Gesture Recognition (Kona, HI)
Jan 2023	Keynote Speaker, WACV Workshop on Demographic Variations in Performance of

	Biometric Algorithms (Kona, HI)
Feb 2022	Milestone Systems (Brondby, Denmark)
Jan 2022	Keynote Speaker, WACV Workshop on Real-World Surveillance: Applications and Challenges (Waikoloa, Hawaii)
Dec 2021	Keynote Speaker, International Conference on 4th Industrial Revolution and Beyond (Dhaka, Bangladesh)
Oct 2021	Keynote Speaker, IEEE International Workshop on Machine Learning for Signal Processing
Mar 2021	Brandeis University (Waltham, MA)
Nov 2020	Keynote Speaker, IEEE Conference on Automatic Face and Gesture Recognition
Aug 2020	Invited Speaker, ECCV Workshop on Fair Face Recognition and Analysis
Mar 2020	Invited Speaker and Panelist, California State Assembly Committee on Privacy and Consumer Protection (Sacramento, CA)
Nov 2019	Distinguished Speaker, Ohio State University ECE Department (Columbus, OH)
Oct 2019	Invited speaker, ICCV Workshop on Real-World Recognition from Low-Quality Images and Videos (Seoul, South Korea)
Oct 2019	Toyota Technological Institute Japan (Nagoya, Japan)
Jul 2019	Keynote speaker, 14th International Symposium on Signals, Circuits, and Systems (Iasi, Romania)
Aug 2018	Invited talk, Forum on The Future of ISEA (Port Hueneme, CA)
Mar 2018	University of Primorska (Slovenia)
Mar 2018	Arizona State University
Jul 2017	PTC (San Diego, CA)
Jun 2017	Keynote speaker, Global Virtual Reality Conference (CVRC) (Shanghai, China)
Jun 2017	Invited talk, Shanghai Tech (Shanghai, China)
Feb 2017	Santa Barbara Science & Religion Study Group
Nov 2016	Keynote speaker, The Chinese Conference on Pattern Recognition (Chengdu, China)
Oct 2016	Invited talk, Science and Engineering Council of Santa Barbara (Santa Barbara, CA)
May 2016	UCSB Dean's Cabinet
Apr 2016	Invited talk, Field Service USA 2016 (Palm Springs, CA)
Apr 2016	Invited talk, Computer Science Academy, Santa Barbara High School (Santa Barbara, CA)
Mar 2016	Invited panelist, Graduate Student Workshop on Computing, UCSB (Santa Barbara, CA)
Feb 2016	University of Massachusetts, Amherst (Amherst, MA)
Oct 2015	University of Notre Dame (South Bend, IN)
Sept 2015	Invited talk, Andreessen Horowitz Academic Roundtable (Menlo Park, CA)
Sept 2015	Invited talk, Citrix Online (Santa Barbara, CA)
June 2015	Keynote speaker, 4th International Conference on Informatics, Electronics, and Vision (Fukuoka, Japan)
May 2015	Keynote speaker, 11th IEEE International Conference on Face and Gesture Recognition (Ljubljana, Slovenia)
May 2015	Invited panelist, 11th IEEE International Conference on Face and Gesture Recognition (Ljubljana, Slovenia)
Mar 2015	Invited speaker, San Marcos High School Distinguished Educator/Innovative Researcher (Santa Barbara, CA)
Dec 2014	Keynote speaker, 17th International Conference on Computer and Information Technology

	(Dhaka, Bangladesh)
Dec 2014	Daffodil University (Dhaka, Bangladesh)
Nov 2014	Zhejiang University (Hangzhou, CA)
Nov 2014	CTO Forum: Rethink Disruption (San Francisco, CA)
Jan 2014	Keynote speaker, Gsolutionz, Inc. (Carpinteria, CA) annual company meeting
Dec 2013	Panelist, ICCV Workshop on Visual Commerce
Oct 2013	Ohio State University
Jul 2013	Google (Mountain View, CA)
Apr 2013	Amazon (Seattle, WA)
Sept 2012	Proceedings of the IEEE 100th Anniversary Forum on Improving Quality of Life Through Engineering Innovations (scheduled keynote)
Aug 2012	University of Oulu, Finland
May 2012	Invited talk, HK-UST International Workshop on Embedded System Design
Apr 2012	Qualcomm Research (San Diego, CA)
Aug 2011	University of Oulu, Finland
Aug 2011	University of Tampere, Finland
Aug 2011	Nokia Innovation Center, Tampere, Finland
Apr 2011	University of Texas, Austin
Mar 2011	Keynote speaker, Infoplosion Symposium (Tokyo, Japan)
Mar 2011	University of Kyoto
Feb 2011	University of Houston
Jan 2011	University of California, Riverside
Nov 2010	Keynote speaker, 15th Ibero-American Congress on Pattern Recognition (Sao Paulo, Brazil)
Sept 2010	Keynote speaker, IEEE Fourth International Conference On Biometrics: Theory, Applications and Systems (BTAS 2010), Washington, D.C.
Jul 2010	Lecturer, Sino-USA Summer School in Vision, Learning and Pattern Recognition (Xi'an, China)
Feb 2010	University of Denver (Denver, CO)
Apr 2010	Rensselaer Polytechnic Institute (Troy, NY)

GRANTS, CONTRACTS, AND INDUSTRY GIFTS:

2019-2022	"Robust Inside-Out Simultaneous Localization and Mapping for Environment Monitoring and Equipment Maintenance," U.S. Navy (PI), $447,845
2018-2019	"EAGER: Attention-Aware Mixed Reality Interfaces," NSF (Co-PI), $244,997
2015	Equipment gift (in-kind), Nokia Corp., OZO professional VR camera, $60,000
2015-2017	"One+ Class Support Vector Machine Learning for Interactive Object Detection," U.S. Navy, $47,000
2015-2016	"Improving Live Telecollaboration," Citrix Online, $80,000
2015	Equipment gift (in-kind), FLIR Systems, Inc.: FLIR ONE thermal infrared cameras
2014-2015	"Eye Gaze Correction for Improving Video Interaction," Citrix Online, $70,500
2014-2017	"Crowd-Sourcing the World: Scalable Methods for Dynamic Structure from Motion," NSF (PI), $477,428
2012-2015	"US-Finland Planning Visit: Transformed Social Interaction and Telecollaboration for Collaborative Learning," NSF (PI), $40,791

2012-2016 "Telecollaboration in Physical Spaces," NSF (PI), $499,970
2012-2015 "Interactive Panoramas on Google Glass," Google, Inc. Google Glass Research Awards Program, $18,000 + $4500 equipment gift (in-kind)
2011-2012 Equipment gift (in-kind), NVIDIA Research: Tegra Tablet, $1500
2009-2013 "CRI: Equipping the Allosphere, an Environment for Immersive Data Exploration," NSF (PI), $749,894
2010 Research and equipment gift funding, Nokia Corp., $9,600
2009 Equipment gift (in-kind), Nokia Corp., $11,033
2009 Equipment gift (in-kind), HRL Labs, $16,832
2009 Research gift funding, Nokia Corp., $10,000
2008-2011 Internal funding for Allosphere facility and research, UCSB (PI), $622,052
2008-2011 "MRI: Development of the Allosphere, an Immersive Instrument for Scientific Exploration," NSF (PI), $500,000
2008-2009 "Scalable Visualization and Constrained Interaction for Large Graphs – Supporting the Collaborative Analysis of High-dimensional Data Sets," NSF (Co-PI), $263,000
2006-2007 "Scalable Visualization and Constrained Interaction for Large Graphs – Supporting the Collaborative Analysis of High-dimensional Data Sets," NSF (Co-PI), $230,000
2008-2009 "Multimodal Wireless Sensor Network Infrastructure," DARPA (Key personnel), $655,174
2006-2007 "Scalable Visualization and Constrained Interaction for Large Graphs," DOD/NSF (Co-PI), $234,321
2005-2009 "A Tangible Interaction Window between Korea and the United States," Korean Institute of Science and Technology (Co-PI), $274,605
2006 "Foundations of Multimedia Research," UC Opportunity Award, $14,950
2005-2008 "Detecting and Analyzing Discontinuities in Computer Vision," NSF (PI), $328,303
2003 Microsoft unrestricted gift, $65,000
2003 "STTR Phase I: Sensors and Methods to Handle UAV," U.S. Navy Air Systems Command (PI, subcontract to Develosoft Corp.), $21,000
2003 Lawrence Livermore Laboratory UCRP Award (PI), $40,000
2003 Microsoft Research Learning Science and Technology (co-PI), $40,000
2003 Mitsubishi Equipment Gift, $650
2003 UCSB Instructional Improvement Grant (PI), $12,150
2003 DiMI Opportunity Award (PI), $14,000
2003 Microsoft Equipment Gifts, $50,000
2003-2008 NSF, "Digital Multimedia IGERT: Graduate Training Program in Interactive Digital Multimedia" (Co-PI), $3,426,376
2002-2005 NSF, "ITR: Using Virtual Environment Technology to Understand and Augment Social Interaction" (Co-PI), $1,100,000
2002 UCSB Research Across Disciplines (Co-PI), $14,400
2002 UCSB Research Across Disciplines (Co-PI), $11,000
2001 DiMI Opportunity Award (Co-PI), $8000

TEACHING EXPERIENCE:
(** - created new course*)

2000-2019 *Graduate courses*: Human Computer Interaction Technologies*, Computer Imaging*,

	Mobile Imaging*, Computer Vision, Probabilistic Models and Methods in Computer Science*, Artificial Intelligence, Multimodal Interaction on Mobile Computing Platforms* *Undergraduate courses*: Foundations of Computer Science, Computer Graphics, Artificial Intelligence*, Machine Learning, Introduction to Computer Vision, Introduction to C, C++, and Unix *Seminar courses*: Topics in Computer Vision, Human-Computer Interaction, A History of Computing*, Perceptual User Interfaces*, Visualization, Media Arts and Technology*
2012	Mobile Computer Vision course, Computer Science and Engineering Department, University of Oulu, Finland
2011	Computational Illumination course, School of Information Sciences, University of Tampere, Finland
2010	Guest lecturer, Sino-US Summer School in Vision, Learning, and Pattern Recognition (Perception, Motion, and Events), Xi'an, China
1993	Lecturer, Stanford University – Taught *Concurrent Programming* (CS140) in the Department of Computer Science, televised via the Stanford Instructional Television Network.
1990, 1991	MIT Media Lab – Co-organized and co-taught *Practical Issues in Color Processing* (4.999), lecturing on color imaging and human color vision.*
1989-90	MIT – Guest lecturer at MIT Summer Course on flight simulation.
1989-90	Graduate Tutor at "pika," an MIT undergraduate living group. Responsible for tutoring students in a variety of subjects.
1986	Created and taught *Computer Vision* course (CS-369) for the Martin Marietta Institute *
1985-86	Organized weekly computer vision seminars at Martin Marietta. Lectured on topics in vision and AI.

STUDENTS SUPERVISED:

Postdoctoral researcher supervised:

Changbo Hu (2001-2003)
Ismo Rakkolainen (2004-2006)
Jae Sik Chang (2005-2007)
Chunghoon Kim (2007-2009)
Stefan Arisona (2007-2008)
Masahiro Toyoura (2008-2009)
Erno Makinen (2009)
Steffen Gauglitz (2014)
Julia Kuosmanen (2015)

Ph.D. Thesis Committees Chaired (in addition to 25+ M.S. committees chaired and 27+ undergraduate projects directed)**:**

UCSB Computer Science students, unless otherwise noted

Rainer Stiefelhagen (University of Karlsruhe, co-chair), 2002
Mathias Kölsch, 2004
Rogerio Feris, 2006
Ya Chang, 2006
Haiying Guan, 2007
Longbin Chen, 2010

Daniel Vaquero, 2012
Steffen Gauglitz (co-chair), 2014
Victor Fragoso, 2014
Chris Sweeney (co-chair), 2016
Kuo-Chin Lien (ECE), 2016
Domagoj Baricevic (co-chair), 2016
Dianna Han, 2017
Ben Nuernberger (co-chair), 2017
Jedrzej Kozerawski, 2021
Pushkar Shukla (TTIC), current

SELECT PROFESSIONAL ACTIVITIES AND SERVICE:

Academic advisory boards and external reviews:

Member, International Advisory Board, Idiap Research Institute, Martigny, Switzerland (2021-present)
Member, Advisory Board, CHIL (Computers in the Human Interaction Loop) Program, University of Karlsruhe (2005)
Member, Traumatic Brain Injury Resource Optimization Center Advisory Board (2008-2018)
Member, Project Career Advisory Board, National Institute on Disability and Rehabilitation Research (NIDDR) Field Initiated Program research study on Cognitive Support Technologies for Traumatic Brain Injury, (2014-2018)
External Reviewer, University of Toronto Department of Computer Science (2022)
External Reviewer, John Hopkins University Department of Computer Science and Engineering (2021)
External Reviewer, Virginia Tech Center for Human Computer Interaction (2017)
Member, External Review Committee for Korean Institute of Science and Technology (2009)
Member, DARPA IXO Immersive Operations Planning Panel (2006-2007)
Member, NSF Committee of Visitors for CISE-IIS (2005)

Journal editorships, conference board positions, professional society positions, key service:

Member, CRA Computing Community Consortium (CCC) (2022-2025)
Founding Associate Editor, ACM Transactions on Interactive Intelligent Systems (2009-present)
Chair, Editor-in-Chief Search Committee, ACM Transactions on Interactive Intelligent Systems (2015)
Associate Editor, Journal of Image and Vision Computing (2006-2019)
Associate Editor, International Journal of Computer Vision and Signal Processing (2011-present)
Guest Editor, Special Issue on Behavior Understanding for Arts and Entertainment, ACM Transactions on Interactive Intelligent Systems (TiiS) (2015)
Guest Editor, Special Issue on Machine Learning for Vision Based Motion Analysis, Journal of Image and Vision Computing (2012)
Guest Editor, Special Issue on Real-World Face Recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) (2011)
Guest Editor, Special Issue on Mobile Computer Vision, International Journal of Computer Vision (2011)
Chair, ICMI Steering Committee (2006-2009)
Member, ACM ICMI Steering Committee (2003-2015)
Member, ACM ICMI Advisory Committee (2024-pres.)
Member, ICMI Career Awards Committee (2016)
Chair, IEEE PAMI-TC Open Access Committee (2013)

Member, Advisory Board, IEEE International Conference on Imaging, Vision, & Pattern Recognition (2016-present)
Member, STEAM Advisory Council, MOXI: The Wolf Museum of Exploration and Innovation, Santa Barbara, CA (2012-2016)
Member, IEEE Automatic Face and Gesture Recognition Steering Committee (2011-2015)
Member, IEEE International Conference on Social Computing Steering Committee (2010-2015)
Member, ACM Transactions on Interactive Intelligent Systems (TiiS) Best Article Award Committee (2015)
Member, Maria Petrou Prize Committee, International Association for Pattern Recognition (2022-2028)

Key organizing committee positions:

IEEE Conference on Computer Vision and Pattern Recognition (CVPR) (General Chair 2014, Area Chair 2001, 2007, 2009, 2012, 2017, 2019, 2022)
International Conference on Computer Vision (ICCV) (Area Chair 2019, 2021, 2025)
IEEE Winter Conference on Applications of Computer Vision (WACV) (Program Chair 2017, Area Chair 2005, 2024, Best Paper Award Committee 2023)
International Conference on Informatics, Electronics & Vision (General Chair 2012, 2013, 2014, 2015, 2016, 2019, 2021, 2023)
IEEE Conference on Automatic Face and Gesture Recognition (General Chair 2011, Special Session Chair 2008, 2013, Test of Time Award Committee 2013, Best Paper Award Committee 2023)
ACM Conference on Multimedia (General Chair 2006)
International Conference on Multimodal Interfaces (ICMI) (General Chair 2008, 2019, Paper Awards Committee Chair 2007, 2008, Program Chair 2004, Area Chair 2005, 2006, Publicity Chair 2010)
ACM CHI (Area Chair 2001, Area Chair 2013, Associate Chair for CHI Notes 2006)
IEEE Workshop on Analysis and Modeling of Faces and Gestures (AMFG) (General Chair 2013, 2018, Honorary Chair 2021)
IEEE Workshop on Recognizing Families In the Wild (RFIW) (Honorary Chair 2020)
ACM Conference on Intelligent User Interfaces (IUI) (Senior Program Committee 2018)
IEEE Workshop on CVPR for Human Communicative Behavior Analysis (2008, 2009, 2010, 2011)
IEEE Workshop on Machine Learning for Vision-Based Motion Analysis (2011)
Workshop on Media Arts, Science, and Technology (2009)
Workshop on Perceptive User Interfaces (2001)
Workshop on Multimodal User Authentication (2003, 2006)
DiMI Workshop on Perceptive Animated Interfaces (2003)
NSF Virtual Human Workshop (2004)
Award Committee, Outstanding Young Researcher in Automatic Human Behaviour Analysis (2011)

UNIVERSITY SERVICE AT UC SANTA BARBARA:

Campus and UC Level Service

2018-2019	Proposing team and advisory board, Mellichamp Academic Initiative for Mind and Machine Intelligence
2017-2019	Faculty Grievance Advisor to the Committee on Privilege and Tenure
2017	Judge, Grad Slam Competition
2016-2019	Faculty Advisor, UCSB Machine Learning Club
2015	Advisor, TMP New Venture Competition Finalist Team
2014-2019	Affiliate, Center for Digital Games Research

2013-2019 Member, Executive Council, SAGE Center for the Study of the Mind
2011-2015 Member, Committee on Privilege and Tenure
2009-2019 Member, Steering Committee, Center for Information Technology and Society (CITS)
2009-2019 Member, Steering Committee, Cognitive Science Program
2008-2019 Member, Executive Committee, Center for Spatial Studies
2007-2009 Member, Council on Planning and Budget
2006-2010 Member, CNSI Administrative Committee
2006-2009 UCSB Representative, IUCRP Digital Media Executive Committee
2006 Member, Academic Personnel Ad Hoc Committee
2005-2008 Member, College of Engineering Administrative Committee
2004-2008 Founding Member, Transliteracies Project
2002-2005 Member, Central Fellowships Committee
2002 Member, Dissertation Awards Committee
2001-2004 Member, Graduate Council

Primary Department Level Service

2017-2019 Chair, Department of Computer Science
2016-2017 Chair, CS Faculty Recruiting Committee
2013 Chair, CS Business Officer Search Committee
2012-2013 Chair, MAT Graduate Admissions Committee
2011-2019 Chair, CS Public Relations Committee
2009-2010 Chair, MAT Academic Program Review Committee
2007-2009 Chair, MAT Faculty Search Committee
2006-2010 Chair, MAT Curriculum Committee
2005-2010 Chair, MAT Web and Public Relations Committee
2005-2010 Chair, Media Arts and Technology Graduate Program
2005-2010 Chair, MAT Graduate Program
2005 Vice Chair, Media Arts and Technology Graduate Program
2004-2006 Chair, MAT By-Laws Committee
2003-2007 Co-Chair, MAT Colloquium Series Committee
2003-2005 CS Graduate Advisor
2003-2005 Chair, CS Graduate Affairs and Advising Committee
2001-2002 Chair, MAT Graduate Admissions Committee
2000-2001 Chair, CS External Relations Committee

CONSULTING (selected):

2017-pres. Clear Protocol, Inc. (Healthcare IT company)
Advisor
2010-pres. Various patent-related and other litigation-related consulting engagements
2016-2018 PTC, Inc. (San Diego, CA)
Technical consulting on augmented reality for remote collaboration
2013-2018 Kent State University
NIDRR Project Career – Development of technology to support the transition of students with traumatic brain injuries from postsecondary education to employment
2011-2013 3DiVi Inc. (Chelyabinsk, Russia) – 3D gesture recognition

2011-2012 InTouch Health, Inc. – Computer vision
2009 Scholastic, Inc.
2007 I2R, Singapore
2006 Capstone Press for Inventions and Discovery
2005 National ICT Australia (NICTA), Sydney, Australia
2004 Biometrics Engineering Research Center, Yonsei University (Korea)
2004 Korea Institute of Science and Technology (KIST), Seoul, Korea
2004 Samsung Corporation (Korea)
2001 Toyon Corporation (Santa Barbara)

PATENTS:

2016 U.S. Patent #9,495,761 – "Environment Mapping with Automatic Motion Model Selection," with S. Gauglitz, C. Sweeney, J. Ventura, and T. Höllerer
2004 U.S. Patent #6,674,877 – "System and method for visually tracking occluded objects in real time," with N. Jojic
1999 German Patent DE69,130,616, "A Face Recognition System," with A. Pentland
1992 US Patent #5,164,992: "A Face Recognition System," with A. Pentland

OPEN SOURCE SOFTWARE, DATA SETS:

2014 Theia: A Fast and Scalable Structure-from-Motion Library, available at http://www.theia-sfm.org/
Winner, ACM Multimedia Open Source Software Competition (C. Sweeney, T. Höllerer, M. Turk)
2010 Visual tracking dataset with ground truth, available at http://ilab.cs.ucsb.edu/index.php/datasets
2009 Partial shape matching source code, available at https://code.google.com/p/shapematching/source/list
2004 "The HandVu Vision-Based Hand Gesture Interface," available at http://www.movesinstitute.org/~kolsch/HandVu

PEER-REVIEWED DEMONSTRATIONS:

2014 "World-Stabilized Annotations and Virtual Scene Navigation for Remote Collaboration," S. Gauglitz, B. Nuernberger, M. Turk, and T. Höllerer, ACM Conference on User Interface Software and Technology (UIST), Honolulu, HI, October 2014.

2012 "A Prototype Setup to Integrate the Physical Environment into Mobile Remote Collaboration," S. Gauglitz, C. Lee, M. Turk, and T. Höllerer, MobileHCI, San Francisco, September 2012.

2005 "Depth Edges in Real Time using Multi-Flash Camera," A. Agrawal, V. Branzoi, R. Chellappa, R. Feris, R. Raskar, K. Tan, and M. Turk, CVPR, New York, 2005.

2004 "HandVu – Vision-Based Hand Gesture Recognition," M. Kölsch, M. Turk, and T. Höllerer), ISMAR '04, Arlington, VA, Oct 31-Nov 5, 2004

CO-AUTHORED REPORTS for the CRA Computing Community Consortium (CCC) Council:

Jensen, D., Danks, D., Elbaum, S., Regli, W., Turk, M., Wierman, A., Yanco, H., Maher, M., Griffin, H., *CCC White Paper: Envisioning Possible Futures for AI Research,* July 2025.

A. Aiken, G. Allen, O. Daescu, D. Danks, S. Elbaum, R. Ghani, C. Gill, W. Gropp, D. Jensen, M. Lin, B. Mosley, M. Parashar, R. Rajaraman, W. Regli, E. Schooler, S. Shekhar, R. Sloan, M. Taufer, M. Turk, H. Wright, H. Yanco, *CRA's Response to the Request for Information on the Development of an Artificial Intelligence (AI) Action Plan*, March 2025.

M Taufer, R. Mihalcea, M. Turk, D. Lopresti, A. Wierman, K. Butler, S. Koenig, D. Danks, W. Gropp, M. Parashar, Y. Gil, W. Regli, R. Rajaraman, D. Jensen, N. Bliss, M.L. Maher, *CCC Quad Paper: Now More Than Ever, Foundational AI Research and Infrastructure Depends on the Federal Government*, 2025.

R. Mihalcea, N. Andalibi, D. Jensen, M. Turk, P. Wisniewski, H. Yanco, *CCC Quad Paper: Which Humans? Inclusivity and Representation in Human-Centered AI*, 2025.

D. Danks, C. Gill, I. Foster, W. Gropp, D. Lopresti, M. Parashar, M. Turk, K. Yelick, *CCC's Response to the Notice of Request for Information (RFI) on Frontiers in AI for Science, Security, and Technology (FASST) Initiative*, November 2024.

D. Danks, C. Gill, M. Lin, D. Lopresti, M. Parashar, W. Regli, M. Turk, *CCC's Response to the Request for Comments on the U.S. Artificial Intelligence Safety Institute's Draft Document: Managing Misuse Risk for Dual-Use Foundation Models*, September 2024.

A. Aiken, N. Bliss, D. Danks, C. Gill, D. Jensen, D. Lopresti, M.L. Maher, C. Moore, W. Regli, M. Turk, *CCC's Response to the Defense Industrial Base Adoption of Artificial Intelligence for Defense Applications*, July 2024.

A. Aiken, N. Bliss, D. Danks, C. Gill, D. Jensen, D. Lopresti, M.L. Maher, C. Moore, W. Regli, M. Turk, *CCC's Response to the Defense Industrial Base Adoption of Artificial Intelligence for Defense Applications; Notice of Availability*, July 2024.

Bliss, N., Butler, K., Danks, D., Topcu, U., Turk, M., *CCC White Paper: Addressing the Unforeseen Harms of Technology*, June 2024.

N. Bliss, K. Butler, D. Danks, S. Forrest, C. Gill, D. Lopresti, M.L. Maher, H. Mentis, C. Moore, S. Shekhar, A. Stent, M. Turk., *CCC's Response to the National Institute of Justice's Request for Input on Section 7.1(b) of Executive Order 14110, "Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence,"* May 2024.

D. Danks, C. Gill, D. Lopresti, R. Rajaraman, M. Taufer, Ufuk Topcu, M. Turk, H. Yanco, *CCC's Response to the Request for Information (RFI) Related to NIST's Assignments Under Sections 4.1, 4.5 and 11 of the Executive Order Concerning Artificial Intelligence*, February 2024.

D. Danks, H. Griffin, D. Jensen, C. Krintz, D. Lopresti, R. Rajaraman, M. Turk, H. Yanco, *CCC's Response to the Office of Management and Budget's Request for Comments on Advancing Governance, Innovation, and Risk Management for Agency Use of Artificial Intelligence Draft Memorandum*, December 2023.

M. Gini, M. Hunter, S. Koenig, D. Lopresti, R. Rajaraman, U. Topcu, M. Turk, H. Yanco, *CCC's Response to PCAST Working Group on Generative AI Invites Public Input*, July 2023.

J. Biddle, E. Bradley, D. Danks, M. Gini, A. Goel, A. Guha, M. Hunter, D. Jensen, S. Koenig, C. Krintz, D. Lopresti, A. McGovern, D. Molzahn, R. Rajaraman, A. Singh, M. Turk, H. Yanco, *CCC's Response to*

RFI on National Priorities for Artificial Intelligence, July 2023.

D. Lopresti, M. Turk, A. Schwartz, and C. Gill, *CCC's Response to RFI on Federal Video and Image Analytics Research and Development Action Plan,* September 2022.

REFEREED PUBLICATIONS and BOOKS:

P. Shukla, A. Chinchure, E. Diana, K. Hosanagar, A. Tolbert, and M. Turk, "Mitigate One, Skew Another? Tackling Intersectional Biases in Text-to-Image Models," Findings of the Association for Computational Linguistics: EMNLP 2025, November 2025 (to appear).

C. Moore, C. Gill, N. Bliss, K. Butler, S. Forrest, D. Lopresti, M.L. Maher, H. Mentis, S. Shekhar, A. Stent, and M. Turk, "Concerning the Responsible Use of AI in the U.S. Criminal Justice System," Communications of the ACM, September 2025.

A. Chinchure, P. Shukla, G. Bhatt, K. Salij, K. Hosanagar, L. Sigal, and M. Turk, "TIBET: Identifying and Evaluating Biases in Text-to-Image Generative Models," European Conference on Computer Vision (ECCV), October 2024.

Md. A. R. Ahad, U. Mahbub, M. Turk, and R. Hartley (editors), Computer Vision: Challenges, Trends, and Opportunities, Chapman and Hall / CRC Press, 2024.

Y. Gizatdinova, O. Špakov, O. Tuisku, M. Turk, and V. Surakka, "Vision-based interfaces for character-based text entry: comparison of errors and error correction properties of eye typing and head typing," Advances in Human-Computer Interaction, Hindawi, June 2023.

P. Shukla, S. Bharati, and M. Turk, "CAVLI – Using image associations to produce local concept-based explanations," CVPR Workshop on Explainable AI for Computer Vision (XAI4CV), June 2023.

E.R. Davies and M. Turk (editors), Advanced Methods and Deep Learning in Computer Vision, Elsevier 2021.

J. Robinson, C. Qin, M. Shao, M. Turk, R. Chellappa, and Y. Fu, "Recognizing Families In the Wild (RFIW): The 5th Edition," IEEE Conference on Automatic Face and Gesture Recognition, December 2021.

J. Kozerawski, V. Fragoso, N. Karianakis, G. Mittal, M. Turk, and M. Chen, "BLT: Balancing Long-Tailed Datasets with Adversarially-Perturbed Images," Asian Conference on Computer Vision (ACCV), Nov-Dec 2020.

J. Robinson, Y. Yin, Z. Khan, M. Shao, S. Xia, M. Stopa, S. Timoner, M. Turk, R. Chellappa, and Y. Fu, "Recognizing Families In the Wild (RFIW): The 4th Edition," IEEE Conference on Automatic Face and Gesture Recognition, November 2020.M. Turk and V. Athitsos, "Gesture recognition," in Computer Vision: A Reference Guide, Springer 2019.

Y. Ding, B. Huynh, A. Xu, T. Bullock, H. Cecotti, M. Turk, B. Giesbrecht, and T. Höllerer, "Multimodal classification of EEG during physical activity," International Conference on Multimodal Interfaces (ICMI), Suzhou, China, October 2019.

P. Shukla, C. Elmadjian, R. Sharan, V. Kulkarni, M. Turk, and W. Y. Wang, "What should I ask? Using conversationally informative rewards for goal-oriented visual dialog," Association for Computational Linguistics (ACL), Florence, Italy, July-August 2019.

B. Nuernberger, T. Höllerer, and M. Turk, “Hybrid orbiting-to-photos in 3D reconstructed visual reality,” ACM Symposium on Virtual Reality Software and Technology (VRST), Tokyo, Japan, November 2018.

I. Rakkolainen, R. Raisamo, M. Turk, and T. Höllerer, “Illumination for 360 degree cameras” (poster), ACM Symposium on Virtual Reality Software and Technology (VRST), Tokyo, Japan, November 2018.

Y. Gizatdinova, O. Špakov, O. Tuisku, M. Turk, and V. Surakka, “Gaze and head pointing for hands-free text entry: applicability to ultra-small virtual keyboards,” ACM Symposium on Eye Tracking Research & Applications (ETRA), Warsaw, Poland, June 2018.

P. Shukla, H. Sadana, A. Bansal, D. Verma, C. Elmadjian, B. Raman, and M. Turk, “Automatic cricket highlight generation using event-driven and excitement-based features,” 4th International Workshop on Computer Vision in Sports (CVsports), Salt Lake City, June 2018.

J. Kozerawski and M. Turk, “CLEAR: Cumulative LEARning for One-Shot One-Class Image Recognition,” IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Salt Lake City, June 2018.

B. Nuernberger, M. Turk, and T. Höllerer, “Evaluating snapping-to-photos virtual travel interfaces for 3D reconstructed visual reality,” ACM Symposium on Virtual Reality Software and Technology (VRST), Gothenburg, Sweden, November 2017.

V. Fragoso, C. Sweeney, P. Sen, and M. Turk. “ANSAC: Adaptive Non-Minimal Sample and Consensus,” British Machine Vision Conference (BMVC), London, September 2017.

I. Rakkolainen, R. Raisamo, M. Turk, and T. Höllerer, “Field-of-View Extension for VR Viewers,” Mindtrek 2017: 21th International Technology Conference, Tampere, Finland, September 2017.

D. Baričević, T. Höllerer, P. Sen, and M. Turk, “User-perspective AR magic lens from gradient-based IBR and semi-dense stereo,” IEEE Transactions on Visualization and Computer Graphics, Vol. 23, Issue 7, pp. 1838-1851, 2017.

I. Rakkolainen, R. Raisamo, M. Turk, and T. Höllerer, “Extreme field-of-view for head-mounted displays,” 3DTV Conference (3DTV-CON), Copenhagen, Denmark, June 2017.

D. Baričević, T. Höllerer, and M. Turk, “Densification of semi-dense reconstructions for novel view generation of live scenes,” IEEE Winter Conference on Applications of Computer Vision (WACV), Santa Rosa, CA, March 2017.

I. Rakkolainen, M. Turk, and T. Höllerer, “A superwide-FOV optical design for head-mounted displays,” International Conference on Artificial Reality and Telexistence / European Symposium on Virtual Environments (ICAT-EGVE), Little Rock, AR, December 2016.

D. Baričević, T. Höllerer, P. Sen, and M. Turk, “User-perspective AR magic lens from gradient-based IBR and semi-dense stereo,” IEEE Transactions on Visualization and Computer Graphics, Vol. 23, Issue 7, pp. 1838-1851, 2017.

V. Fragoso, W. Scheirer, J. Hespanha, and M. Turk, “One-class slab support vector machine,” International Conference on Pattern Recognition, Cancun, Mexico, December 2016.

I. Rakkolainen, M. Turk, and T. Höllerer, “A compact, wide-FOV optical design for head-mounted displays,” ACM Symposium on Virtual Reality Software and Technology (VRST), Munich, Germany, November 2016.

B. Nuernberger, K.-C. Lien, L. Grinta, C. Sweeney, M. Turk, and T. Höllerer, “Multi-view gesture

annotations in image-based 3D reconstructed scenes," ACM Symposium on Virtual Reality Software and Technology (VRST), Munich, Germany, November 2016.

C. Sweeney, V. Fragoso, M. Turk and T. Höllerer, "Large scale SfM with the distributed camera model," International Conference on 3D Vision (3DV), Stanford, CA, October 2016.

I. Rakkolainen, R. Raisamo, M. Turk, and T. Höllerer, "Casual immersive viewing with smartphones," Mindtrek 2016: 20th International Technology Conference, Tampere, Finland, October 2016.

K. Lien, B. Nuernberger, M. Turk, and T. Höllerer, "PPV: pixel-point-volume segmentation for object referencing in collaborative augmented reality," IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Merida, Mexico, September 2016.

X. Zhao, M. Turk, W. Li, and K. Lien, "A multilevel image thresholding segmentation algorithm based on two-dimensional K-L divergence and modified particle swarm optimization," Applied Soft Computing, Vol. 48, pp. 151-159, 2016.

B. Nuernberger, K. Lien, M. Turk and T. Höllerer, "Anchoring 2D gesture annotations in augmented reality," IEEE Virtual Reality (VR 2016), Greenville, SC, March 2016.

B. Nuernberger, K. Lien, M. Turk and T. Höllerer, "Interpreting 2D gesture annotations in 3D augmented reality," IEEE Symposium on 3D User Interfaces (3DUI 2016), Greenville, SC, March 2016. (Best Paper Honorable Mention)

M. Turk and V. Fragoso, "Computer vision for mobile augmented reality," in G. Hua and X.-S. Hua (eds.), Mobile Cloud Visual Media Computing, Springer International Publishing, 2015.

C. Sweeney, T. Sattler, M. Turk, T. Höllerer, and M. Pollefeys, "Optimizing the viewing graph for structure-from-motion," International Conference on Computer Vision, Santiago, Chile, December 2015.

Y. Qin, K. Lien, M. Turk, and T. Höllerer, "Eye gaze correction with a single webcam based on eye-replacement," 11th International Symposium on Visual Computing, Las Vegas, NV, December 2015.

C. Sweeney, T. Höllerer, and M. Turk, "Theia: a fast and scalable structure-from-motion library," ACM Conference on Multimedia, Brisbane, Australia, October 2015.

C. Sweeney, J. Flynn, B. Nuernberger, M. Turk, and T. Höllerer, "Efficient computation of absolute pose for gravity-aware augmented reality," IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Fukuoka, Japan, October 2015. (Best Short Paper Award)

K. Lien, B. Nuernberger, M. Turk, and T. Höllerer, "2D-3D co-segmentation for AR-based remote collaboration" (poster), IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Fukuoka, Japan, October 2015.

K. Lien and M. Turk, "On preserving structure in stereo seam carving," IEEE International Conference on 3D Vision (3DV), Lyon, France, October 2015.

A. A. Salah, H. Hung, O. Aran, H. Gunes, and M. Turk, "Behavior understanding for arts and entertainment," ACM Transactions on Interactive Intelligent Systems Vol. 5, No. 3, September 2015.

K. Lien, J. Gibson, and M. Turk, "High-order regularization for stereo color editing," IEEE International Conference on Image Processing (ICIP), Québec City, Canada, September 2015.

A. A. Salah, H. Hung, O. Aran, H. Gunes, and M. Turk, “Brief Introduction to the Special Issue on Behavior understanding for arts and entertainment,” ACM Transactions on Interactive Intelligent Systems Vol. 5, No. 2, July 2015.

C. Sweeney, L. Kneip, T. Höllerer, and M. Turk, “Computing similarity transformations from only image correspondences,” IEEE Conference on Computer Vision and Pattern Recognition, Boston, MA, June 2015.

N. Moreno, J. Cornick, S. Savage, M. Turk, A. Leal, and T. Höllerer, “Motivating crowds to volunteer neighborhood data,” ACM Conference on Computer-Supported Cooperative Work (CSCW), Vancouver, CA, March 2015.

N. Moreno, J. Cornick, S. Savage, M. Turk, A. Leal, and T. Höllerer, “Inspiring neighborhood data contributions through different motivators,” SCSW Workshop on Information Technology and City Life, Vancouver, CA, March 2015.

M. Rodrigue, J. Son, B. Giesbrecht, M. Turk, and T. Höllerer, “Spatio-temporal detection of divided attention in reading applications using EEG and eye tracking,” ACM Conference on Intelligent User Interfaces (IUI), Atlanta, GA, March 2015.

D. Vaquero and M. Turk, “Composition context photography,” IEEE Winter Conference on Applications of Computer Vision (WACV), Waikoloa Beach, HI, January 2015.

M. Turk, “Gesture Recognition,” in K. Hale and K. Stanney (eds.)*, Handbook of Virtual Environments: Design, Implementation, and Applications*, CRC Press, 2015. (Book chapter)

C. Sweeney, J. Flynn, and M. Turk, “Solving for relative pose with a partially known rotation is a quadratic eigenvalue problem,” International Conference on 3D Vision (3DV), Tokyo, Japan, December 2014.

D. Baričević, T. Höllerer, P. Sen, and M. Turk, “User-perspective augmented reality magic lens from gradients,” ACM Symposium on Virtual Reality Software and Technology (VRST), Edinburgh, UK, November 2014.

S. Gauglitz, B. Nuernberger, M. Turk, and T. Höllerer, “In touch with the remote world: remote collaboration with augmented reality drawings and virtual navigation,” ACM Symposium on Virtual Reality Software and Technology (VRST), Edinburgh, UK, November 2014.

E. Fujimoto and M. Turk, “Non-visual navigation using combined audio music and haptic cues,” ACM International Conference on Multimodal Interaction (ICMI), Istanbul, Turkey, November 2014.

S. Gauglitz, B. Nuernberger, M. Turk, and T. Höllerer, “World-stabilized annotations and virtual scene navigation for remote collaboration,” ACM Symposium on User Interface Software and Technology (UIST), Honolulu, Hawaii, USA, October 2014.

C. Sweeney, V. Fragoso, M. Turk, and T. Höllerer, “gDLS: A scalable solution to the generalized pose and scale problem,” European Conference on Computer Vision, Zurich, Switzerland, September 2014.

M. Toyoura, H. Aruga, M. Turk, and X. Mao, “Mono-spectrum marker: an AR marker robust to image blur and defocus,” The Visual Computer, Vol. 30, Issue 9, September 2014.

V. Fragoso, M. Turk, G. Srivastava, A. Nagar, Z. Li, and K. Park, “Cascade of Box (CABOX) Filters for

Optimal Scale Space Approximation," IEEE International Workshop on Mobile Vision, June 2014.

S. Gauglitz, C. Sweeney, J. Ventura, M. Turk, and T. Höllerer, "Model Estimation and selection towards unconstrained real-time tracking and mapping," IEEE Transactions on Visualization and Computer Graphics, Vol. 20, Issue 6, pp. 825-838, 2014.

B. Nuernberger, S. Gauglitz, T. Höllerer, and M. Turk, "Investigating Viewpoint Visualizations for Click & Go Navigation" (poster), IEEE Symposium on 3D User Interfaces, 2014.

M. Turk, "Multimodal interaction – a review," Pattern Recognition Letters, Vol. 36, pp. 189-195, January 2014.

M. Turk and G. Hua, *Vision-Based Interaction,* Morgan & Claypool Synthesis Lectures on Computer Vision, 2013. (Book)

V. Fragoso, P. Sen, S. Rodriguez, and M. Turk, "EVSAC: accelerating hypotheses generation by modeling matching scores with Extreme Value Theory," IEEE International Conference on Computer Vision, Sydney, Australia, December 2013.

M. Turk, "Over 20 years of Eigenfaces," ACM Transactions on Multimedia Computing Communications and Applications, Volume 9, Issue 1s, October 2013.

V. Fragoso and M. Turk, "SWIGS: a swift guided sampling method," IEEE Conference on Computer Vision and Pattern Recognition, Portland, OR, June 2013.

M. Toyoura, H. Aruga, M. Turk, and X. Mao, "Detecting markers in blurred and defocused images," International Conference on Cyberworlds, Yokohama, Japan, May 2013

M. Pietikäinen, M. Turk, L. Wang, G. Zhao, and L. Cheng, "Machine learning in motion analysis: New advances," Image and Vision Computing, available online 3 May 2013.

S. Gauglitz, C. Lee, M. Turk, and T. Höllerer, "Live tracking and mapping from both general and rotation-only camera motion," IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Atlanta, GA, November 2012. (Best Paper Award)

D. Baričević, C. Lee, M. Turk, T. Höllerer, and D. Bowman, "A hand-held AR magic lens with user-perspective rendering," IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Atlanta, GA, November 2012.

V. Fragoso, M. Turk, and J. Hespanha, "Locating binary features for keypoint recognition using noncooperative games," IEEE International Conference on Image Processing, Sept/Oct 2012.

S. Gauglitz, C. Lee, M. Turk, and T. Höllerer, "Integrating the physical environment into mobile remote collaboration," ACM SIGCHI International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI), September 2012

D. Vaquero and M. Turk, "Composition context photography," International Conference on Computational Photography, April 2012.

C. Kim and M. Turk, "A new biased discriminant analysis using composite vectors for eye detection," IEEE Transactions on Systems, Man, and Cybernetics B, Vol. 42, No. 4, pp. 1095-1106, August 2012.

C. Chen, D. Vaquero, and M. Turk, "Illumination demultiplexing from a single image," International

Conference on Computer Vision, Barcelona, Spain, November 2011.

M. Petter, V. Fragoso, M. Turk, and C. Baur, "Automatic text detection for mobile augmented reality translation," Workshop on Mobile Computer Vision, Barcelona, Spain, November 2011.

S. Gauglitz , M. Turk, and T. Höllerer, "Improving keypoint orientation assignment," British Machine Vision Conference (BMVC 2011), Dundee, Scotland, Aug-Sept 2011.

S. Gauglitz , L. Foschini, M. Turk, and T. Höllerer, "Efficiently selecting spatially distributed keypoints for visual tracking," IEEE International Conference on Image Processing (ICIP 2011), Brussels, Belgium, September 2011.

S. Gauglitz, T. Höllerer, and M. Turk, "Evaluation of interest point detectors and feature descriptors for visual tracking," International Journal of Computer Vision, vol. 94(3), pp. 335-360, 2011.

D. Vaquero, N. Gelfand, M. Tico, K. Pulli, and M. Turk, "Generalized autofocus," IEEE Workshop on Applications of Computer Vision (WACV 2011), January 2011.

V. Fragoso, S. Gauglitz, S. Zamora, J. Kleban, and M. Turk, "TranslatAR: A mobile augmented reality translator," IEEE Workshop on Applications of Computer Vision (WACV 2011), January 2011.

M. Jang and M. Turk, "Car-Rec: A real-time car recognition system," IEEE Workshop on Applications of Computer Vision (WACV 2011), January 2011.

E. Eyjolfsdottir and M. Turk, "Multisensory, embedded pose estimation," IEEE Workshop on Applications of Computer Vision (WACV 2011), January 2011.

M. Turk, "Computational illumination," in I. Bloch and R. M. Cesar, Jr. (Eds.), CIARP 2010, LNCS 6419, p. 5, Springer-Verlag, 2010. (Abstract of keynote talk)

D. Vaquero, M. Turk, K. Pulli, M. Tico, and N. Gelfand, "A survey of image retargeting techniques," SPIE Applications of Digital Image Processing XXXIII, San Diego, CA, August 2010.

S. Venkatesha and M. Turk, "Human activity recognition using local shape descriptors," International Conference on Pattern Recognition, Istanbul, Turkey, August 2010.

R. Paucher and M. Turk, "Location-based augmented reality on mobile phones," IEEE International Workshop on Mobile Vision (Best Paper Award), San Francisco, June 2010.

J.-K. Na, J.-Y. Park, J.-H. Yi and M. Turk, "Parameterized structured light imaging for depth edge detection," Electronics Letters, Vol. 46, No. 1, pp. 46-47, 2010.

D. Vaquero, R. Feris, L. Brown, A. Hampapur, and M. Turk, "Attribute-based people search," Y. Ma and G. Qian (eds.), *Intelligent Video Surveillance: Systems and Technology*, Taylor & Francis, 2009.

D. Vaquero, R. Feris, L. Brown, A. Hampapur, and M. Turk, "Attribute-based people search in surveillance environments," Workshop on Applications of Computer Vision (WACV 2009), Snowbird, UT, Dec. 7-8, 2009.

D. Vaquero, R. Raskar, R. Feris, and M. Turk, "A projector-camera setup for geometry-invariant frequency demultiplexing," IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2009), Miami, FL, June 2009.

L. Chen, J. McAuley, R. Feris, T. Caetano, and M. Turk, “Shape classification through structured learning of matching measures,” IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2009), Miami, FL, June 2009.

C. Kim, M. Turk, and C.-H. Choi, “Biased discriminant analysis using composite vectors for eye detection,” IEEE Conference on Automatic Face and Gesture Recognition, Amsterdam, September 2008.

L. Chen, R. S. Feris, and M. Turk, “Efficient partial shape matching using Smith-Waterman algorithm,” CVPR Workshop on Non-Rigid Shape Analysis and Deformable Image Alignment (NORDIA'08), Anchorage, Alaska, June 27-28, 2008.

D. A. Vaquero, R. S. Feris, M. Turk, and R. Raskar, “Characterizing the shadow space of camera-light pairs,” IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2008), Anchorage, Alaska, June 24-26, 2008.

J. Park, C. Kim, J. Na, J. Yi, and M. Turk, “Using structured light for efficient depth edge detection,” Journal of Image and Vision Computing, Vol. 26, Issue 11, pp. 1449-1465, November 2008.

M. Turk, T. Höllerer, S. M. Arisona, J. Kuchera-Morin, C. Coffin, R. Hoetzlein, L. Putnam, and D. Overholt, “Creative collaborative exploration in multiple environments,” AAAI Spring Symposium on Creative Intelligent Systems, Stanford University, March 26-28, 2008.

R. Feris, R. Raskar, L. Chen, K. Tan, and M. Turk, “Multi-flash stereopsis: depth edge preserving stereo with small baseline illumination,” IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 30, No. 1, pp. 147-159, January 2008.

S. Zhang and M. Turk, “Eigenfaces,” Scholarpedia, 3(9):4244, 2008.

H. Guan and M. Turk, “The hierarchical isometric self-organizing map for manifold representation”, IEEE Workshop on Component Analysis Methods for Classification, Clustering, Modeling, and Estimation Problems in Computer Vision (in conjunction with CVPR07), Minneapolis, Minnesota, June 18-23, 2007.

R. Feris, R. Raskar, and M. Turk, “Dealing with multi-scale depth changes and motion in depth edge detection,” Brazilian Symposium on Computer Graphics and Image Processing, October 2006. (Awarded “One of the Best Image Processing and Computer Vision Papers”)

Y. Zana, R. M. Cesar-Jr., R. Feris, and M. Turk, “Local approach for face verification in polar frequency domain,” Image and Vision Computing, Vol. 24, No. 8, pp. 904-913, 2006.

Y. Chang, C. Hu, R. Feris, and M. Turk, “Manifold based analysis of facial expression,” Image and Vision Computing, Vol 24, No. 6, pp. 605-614, 2006.

H. Guan, T. Kubota, X. Huang, X. S. Zhou, and M. Turk, “Automatic hot spot detection and segmentation in whole body FDG-PET images,” IEEE International Conference on Image Processing (ICIP 2006), Atlanta, GA, October 2006.

H. Guan, J. Chang, L. Chen, R. Feris, and M. Turk, “Multi-view appearance-based 3D hand pose estimation,” IEEE Workshop on Vision for Human Computer Interaction, New York, NY, June 2006.

M. Turk, “Vision-Based Interaction,” in H. Ip (Ed.), *Encyclopedia of Multimedia*, Springer, 2006.

M. Kölsch, R. Bane, T. Höllerer, and M. Turk, “Multimodal interaction with a wearable augmented reality system,” IEEE Computer Graphics and Applications, Vol. 26, No. 3, pp. 62 -71, May/June 2006.

J. Muncaster and M. Turk, “Continuous multimodal authentication using dynamic Bayesian networks,” Second Workshop on Multimodal User Authentication, Toulouse, France, May 11-12, 2006.

H. Guan, R. Feris, and M. Turk, “The isometric self-organizing map for 3D hand pose estimation,” International Conference on Face and Gesture Recognition, Southampton, UK, pp. 263-268, April 2006.

R. Feris, R. Raskar, K. Tan, and M. Turk, “Specular highlights detection and reduction with multi-flash photography,” Journal of the Brazilian Computer Society, Vol. 1, No. 12, pp. 35-42, 2006.

C. Kim, J. Park, J. Yi, and M. Turk, “Efficient depth edge detection using structured light,” International Symposium on Visual Computing, Lake Tahoe, NV, December 5-7, 2005.

Y. Zana, R. Cesar, R. Feris, and M. Turk, “Face verification in polar frequency domain: a biologically motivated approach,” International Symposium on Visual Computing, Lake Tahoe, NV, December 5-7, 2005.

V. Nayak and M. Turk, “Emotional expression in virtual agents through body language,” International Symposium on Visual Computing, Lake Tahoe, NV, December 5-7, 2005.

H. Guan and M. Turk, “3D hand pose reconstruction with ISOSOM,” International Symposium on Visual Computing, Lake Tahoe, NV, December 5-7, 2005.

M. Kölsch and M. Turk, “Flocks of features for tracking articulated objects,” in B. Kisacanin, V. Pavlovic, and T. Huang (eds.), *Real-Time Vision for Human-Computer Interaction*, Springer, 2005.

R. Feris, M. Turk, R. Raskar, K. H. Tan, and G. Ohashi, “Recognition of isolated fingerspelling gestures using depth edges,” in B. Kisacanin, V. Pavlovic, and T. Huang (eds.), *Real-Time Vision for Human-Computer Interaction*, Springer, 2005.

M. Turk, “Multimodal human-computer interaction,” in B. Kisacanin, V. Pavlovic, and T. Huang (eds.), *Real-Time Vision for Human-Computer Interaction*, Springer, 2005.

M. Turk, “RTV4HCI: A historical overview,” in B. Kisacanin, V. Pavlovic, and T. Huang (eds.), *Real-Time Vision for Human-Computer Interaction*, Springer, 2005

M. Turk, “Eigenfaces and beyond,” in W. Zhao and R. Chellappa (eds.), *Face Processing: Advanced Modeling and Methods*, Academic Press, 2005.

Y. Chang, M. Vieira, M. Turk, and L. Velho, “Automatic 3D facial expression analysis in videos,” IEEE International Workshop on Analysis and Modeling of Faces and Gestures, Beijing, China, October 2005.

R. Feris, R. Raskar, L. Chen, K. Tan, and M. Turk, “Discontinuity preserving stereo with small baseline multi-flash illumination,” International Conference on Computer Vision (ICCV'05), Beijing, China, 2005.

J. N. Bailenson, A. C. Beall, J. Blascovich, J. Loomis, and M. Turk, “Transformed social interaction, augmented gaze, and social influence in immersive virtual environments,” Human Communication Research, Vol. 31, No. 4, pp. 511-537, October 2005.

Y. Chang, R. Cutler, Z. Liu, Z. Zhang, A. Acero, and M. Turk, “Automatic head-size equalization in panorama images for video conferencing,” IEEE International Conference on Multimedia & Expo

(ICME), Amsterdam, The Netherlands, July 2005.

C. Kim, J. Park, J. Yi, and M. Turk, “Structured light based depth edge detection for object shape recovery,” IEEE International Workshop on Projector-Camera Systems, San Diego, June 25, 2005.

J. Kim, J. Choi, J. Yi, and M. Turk, “Effective representation using ICA for face recognition robust to local distortion and partial occlusion,” IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 27, No. 12, pp. 1977-1981, December 2005.

R. Raskar, K. Tan, R. Feris, J. Kobler, J. Yu, and M. Turk, “Harnessing real-world depth edges with multi-flash imaging,” IEEE Computer Graphics and Applications, Vol. 25, Issue 1, pp 32-38, January 2005.

Y. Wang, Y. Jia, C. Hu, and M. Turk, “Non-negative matrix factorization framework for face recognition,” International Journal of Pattern Recognition and Artificial Intelligence, Vol. 19, No. 4, pp. 1-17, 2005.

R. Feris, R. Raskar, K. Tan, and M. Turk, “Specular reflection reduction with multi-flash imaging,” Brazilian Symposium on Computer Graphics and Image Processing, pp. 316-323, Curitiba, PR, Brazil, October 2004.

M. Turk, J. Bailenson, A. Beall, J. Blascovich, and R. Guadagno, “Multimodal transformed social interaction,” Proc. International Conference on Multimodal Interfaces, pp. 46-52, State College, PA, October 13-15, 2004.

M. Kölsch, M. Turk, and T. Höllerer, “Vision-based interfaces for mobility,” In Proc. MobiQuitous '04 (1st IEEE Intl. Conf. on Mobile and Ubiquitous Systems: Networking and Services), pages 86-94, Boston, MA, Aug. 22-26 2004.

M. Kölsch and M. Turk, “Analysis of rotational robustness of hand detection with a Viola-Jones detector,” International Conference on Pattern Recognition, Cambridge, U.K., August 2004.

R. Raskar, K. Tan, R. Feris, J. Yu, and M. Turk, “A non-photorealistic camera: depth edge detection and stylized rendering using multi-flash imaging,” ACM SIGGRAPH, Los Angeles, August 2004 (also ACM Transactions on Graphics, Vol. 23, No. 3, pp. 676-685, August 2004.)

R. Feris, M. Turk, R. Raskar, K. Tan, and G. Ohashi, “Exploiting depth discontinuities for vision-based fingerspelling recognition,” IEEE Workshop on Real-Time Vision for Human-Computer Interaction, Washington DC, USA, June 2004.

M. Kölsch and M. Turk, “Fast 2D hand tracking with flocks of features and multi-cue integration,” IEEE Workshop on Real-Time Vision for Human-Computer Interaction, Washington DC, USA, June 2004. Best Paper Award

C. Hu, Y. Chang, R. Feris, and M. Turk, “Manifold based analysis of facial expression,” IEEE Workshop on Face Processing in Video, Washington, D.C., June 2004.

Y. Chang, C. Hu, and M. Turk, “Probabilistic expression analysis on manifolds,” International Conference on Computer Vision and Pattern Recognition, pp. 520-527, Washington, D.C., June 2004.

M. Kölsch and M. Turk, “Robust hand detection,” IEEE Conference on Automatic Face and Gesture

Recognition, pp. 614-619, Seoul, Korea, May 17-19, 2004.

J. N. Bailenson, A. Beall, J. Blascovich, J. Loomis, and M. Turk, "Non-zero-sum gaze and persuasion," The 54th Annual Conference of the International Communication Association: Communication in the Public Interest, New Orleans, May 27-31, 2004. (Top Papers in Communication and Technology session – 4 or 5 top papers out of ~120 submissions)

Y. Wang, Y. Jiar, C. Hu, and M. Turk, "Fisher non-negative matrix factorization for learning local features," Proc. Asian Conference on Computer Vision (ACCV-2004), Jeju Island, Korea, Jan. 28-30, 2004.

Y. Wang, Y. Jiar, C. Hu, and M. Turk, "Face recognition based on kernel radial basis function networks," Proc. Asian Conference on Computer Vision (ACCV-2004), Jeju Island, Korea, Jan. 28-30, 2004.

M. Turk, "Computer vision in the interface," Communications of the ACM, Vol. 47, No. 1, pp. 60-67, January 2004.

J. Bailenson, A. Beall, J. Blascovich, J. Loomis, and M. Turk, "Transformed social interaction: decoupling representation from behavior and form in collaborative virtual environments," PRESENCE: Teleoperators and Virtual Environments, MIT press, Vol. 13, No. 4, pp. 428-441, August 2004.

M. Turk and M. Kölsch, "Perceptual Interfaces," G. Medioni and S.B. Kang (eds.), *Emerging Topics in Computer Vision*, Prentice Hall, 2004.

A. Altinok and M. Turk, "Temporal integration for continuous multimodal biometrics," Proc. Workshop on Multimodal User Authentication, Santa Barbara, CA, Dec. 11-12, 2003.

Y. Chang, C. Hu, and M. Turk, "Manifold of facial expression," Proc. IEEE International Workshop on Analysis and Modeling of Faces and Gestures, Nice, France, Oct. 17, 2003.

C. Hu, R. Feris, and M. Turk, "Real-time view-based face alignment using active wavelet networks," Proc. IEEE International Workshop on Analysis and Modeling of Faces and Gestures, Nice, France, Oct. 17, 2003.

C. Hu, R. Feris, and M. Turk, "Active wavelet networks for face alignment," Proc. British Machine Vision Conference, Norwich, U.K., Sept. 9-11, 2003.

M. Kölsch, A. Beall, and M. Turk, "Postural comfort zone for reaching gestures," Human Factors and Ergonomics Society Annual Meeting, 2003.

M. Kölsch, A. Beall, and M. Turk, "An objective measure for postural comfort," Human Factors and Ergonomics Society Annual Meeting, 2003.

M. Turk, C. Hu, R. Feris, F. Lashkari, and A. Beall, "TLA based face tracking," International Conference on Vision Interface, Calgary, Canada, May 27-29, 2002.

M. Kölsch and M. Turk, "Keyboards without keyboards: a survey of virtual keyboards," Workshop on Sensing and Input for Media-centric Systems, Santa Barbara, CA, June 20-21, 2002.

M. Turk, "A random walk through eigenspace," IEICE Trans Information and Systems, 2001.

M. Turk, "Perceptive media: machine perception and human computer interaction," Chinese Computing

Journal, 2001.

M. Turk, “Gesture Recognition,” in K. Stanney (ed*.), Handbook of Virtual Environment Technology*, Lawrence Erlbaum Associates, Inc., 2001.

M. Turk, “Perceptual User Interfaces,” in Earnshaw et al. (eds.), *Frontiers of Human-Centred Computing, Online Communities and Virtual Environments*, Springer-Verlag, 2001.

P. Hong, M. Turk, and T. Huang, “Constructing finite state machines for fast gesture recognition,” Proc. International Conference on Pattern Recognition, September 2000.

M. Turk and G. Robertson, “Perceptual user interfaces,” Communications of the ACM, March 2000.

P. Hong, M. Turk, and T. Huang, “Gesture modeling and recognition using finite state machines,” Proc. IEEE International Conference on Face and Gesture Recognition, Grenoble, France, March 2000.

N. Jojic, T. Huang, and M. Turk, “Tracking articulated structures in stereo image sequences,” Proc. IT Workshop on Detection, Estimation, Classification, and Imaging, Sante Fe, NM, Feb. 24-25, 1999.

N. Jojic, M. Turk, and T. Huang, “Tracking self-occluding articulated objects in dense disparity maps,” Proc. International Conference on Computer Vision, Corfu, Greece, 1999.

M. Turk, “Moving from GUIs to PUIs*,”* Proc. Fourth Symposium on Intelligent Information Media, Tokyo, Japan, December 1998. (also Microsoft Research Technical Report #MSR-TR-98-69)

R. Cutler and M. Turk, “View-based interpretation of real-time optical flow for gesture recognition,” Proc. 1998 IEEE Conference on Automatic Face and Gesture Recognition, April 14-16, 1998, Nara, Japan.

M. Turk and Y. Takebayashi (eds.), Proceedings of the Workshop on Perceptual User Interfaces, Banff, Canada, October 1997.

M. Turk, “Visual interaction with lifelike characters,” Proc. IEEE Conference on Automatic Face and Gesture Recognition, Killington, Vermont, October 13-16, 1996.

M. Turk and S. Rosenschein, “A vision architecture for perceiving human action,” in Proc. Looking at People: Recognition and Interpretation of Human Action, IJCAI Workshop, Chambery, France, Aug. 1993.

A. Pentland, T. Starner, N. Etcoff, A. Masoiu, O. Oliyide, and M. Turk, “Experiments with Eigenfaces,” Looking at People Workshop, IJCAI'93, Chambery, France, August 1993.

M. Turk and A. Pentland, “Face recognition using eigenfaces,” Proc. IEEE Conference on Computer Vision and Pattern Recognition, Maui, Hawaii, pp. 586-591, 1991. (IEEE Computer Society Outstanding Paper Award)

M. Turk and A. Pentland, “Eigenfaces for recognition,” Journal of Cognitive Neuroscience, Vol. 3, No. 1, pp. 71-86, 1991.

M. Turk and A. Pentland, “Face recognition without features,” Proc. IAPR MVA, Tokyo, Nov. 1990.

M. Turk and A. Pentland, “Recognition in face space,” Intelligent Robots and Computer Vision IX, SPIE Vol. 1381, Boston, MA, 1990. (Reprinted in H. Nasr (ed.), *Selected Papers on Automatic Object*

Recognition, SPIE Optical Engineering Press, Washington, 1991.)

M. Turk and A. Pentland, “Face processing: models for recognition,” Intelligent Robots and Computer Vision VIII, SPIE, Philadelphia, PA, 1989.

A. Pentland, T. Darrell, M. Turk, and W. Huang, “A simple, real-time range camera,” Proc. IEEE Conference on Computer Vision and Pattern Recognition, San Diego, CA, June 1989.

M. Turk, “A review of color vision and imaging,” Intelligent Robots and Computer Vision VII, SPIE, Cambridge, MA, 1988.

M. Turk, D. Morgenthaler, K. Gremban, M. Marra, “VITS - a vision system for autonomous land vehicle navigation,” IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 10, No. 3, pp. 342-361, May, 1988. (Reprinted in S. Iyengar and A. Elfes (eds.), *Autonomous Mobile Robots: Control, Planning, and Architecture*, IEEE Computer Society Press, Los Alamitos, California, 1991.)

M. Turk, D. Morgenthaler, K. Gremban, M. Marra, “Video road-following for the Autonomous Land Vehicle,” Proc. IEEE International Conference on Robotics and Automation, Raleigh, N. C., April, 1987.

M. Turk and M. Marra, “Color road segmentation and video obstacle detection,” Advances in Intelligent Robotic Systems: Mobile Robots, SPIE, Cambridge, MA, 1986.

M. Turk, “A fine-motion planning algorithm,” Intelligent Robots and Computer Vision, Proc. SPIE 579, Cambridge, MA, 1985.

J. Lowrie, M. Thomas, K. Gremban, and M. Turk, “The Autonomous Land Vehicle (ALV) preliminary road-following demonstration,” Intelligent Robots and Computer Vision, Proc. SPIE 579, Cambridge, MA, 1985.

M. Turk, “Range image correction and its effect on range data processing,” Proc. 1985 Conference on Intelligent Systems and Machines, Rochester, MI, 1985.