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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

3SHAPE A/S and 3SHAPE INC.
Petitioners

v.

MEDIT CORPORATION
Patent Owner

Case No. IPR2024-01268
Patent 9,191,648

**PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,191,648
UNDER 35 U.S.C. §§311–19 and 37 C.F.R. §42.100 *et seq.***

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I. INTRODUCTION

3SHAPE A/S and 3SHAPE INC. (“Petitioners”) respectfully request *inter partes* review for Claims 1-24 of U.S. Patent No. 9,191,648 (“the ’648 Patent”) (EX1001) in accordance with 35 U.S.C. §§311–19 and 37 C.F.R. §42.100 *et seq.*

II. MANDATORY NOTICES PURSUANT TO 37 C.F.R. §42.8(a)(1)

A. Real Parties-In-Interest

Pursuant to 37 C.F.R. §42.8(b)(1), Petitioners certify that 3Shape A/S, 3Shape Inc., 3Shape Holding A/S, 3Shape Trios A/S, and 3Shape Poland sp. z.o.o. are real parties-in-interest. Out of an abundance of caution, 3Shape Germany GmbH, 3Shape France SAS, 3Shape Italy SRL, 3SHAPE UK LIMITED, 3SHAPE DOOEL Skopje, 3Shape S.A.S., 3Shape (Shanghai) Co., Ltd., 3Shape Do Brasil Soluções Tecnológicas Para Saude Ltda, 3Shape Australia Pty Ltd., 3Shape Trios Sociedad Limitada, 3Shape Japan GK, 3Shape Ukraine Ltd., SC Investment Company, LLC, SoundBite Technology, LLC, Shenzhen Full Contour Design Company Ltd., 3Shape Design Services Costa Rica, S.R.L., 3Shape Design Services, LLC, 3Shape A/S Medical Device Manufacturing (Shanghai) Co. Ltd., 3Shape Korea Ltd., 3Shape Manufacturing US LLC, 3Shape India Limited, EQT IX JAWS BIDCO S.A.R.L., Clausen Engineering APS, Tais Clausen, DM Family Office ApS, Deichmann Media APS, and Nikolaj Hoffmann Deichmann are also identified as real parties-in-interest, for purposes of compliance with 35 U.S.C. §312(a)(2).

B. Identification of Related Matters Under 37 C.F.R. §42.8(b)(2)

The following is a list of any judicial or administrative matters that would affect, or be affected by, a decision in this proceeding:

Related District Court Proceedings

3Shape A/S v. Medit Corporation, Civ. Action No. 22-cv-00443 (W.D. Tex.) (“the 443 Litigation”); and

Medit Corporation v. 3Shape A/S, Civ. Action No. 23-cv-00658 (W.D. Tex.) (“Related Litigation”).¹

Related Applications

The ’648 Patent issued from U.S. Patent Application No. 14/000,442, which is a National Stage of PCT International Application No. PCT/US2012/025554, filed

¹Medit filed its claim of patent infringement of U.S. Patent No. 9,191,648 as an affirmative counterclaim in *3Shape A/S v. Medit Corp.*, Case No. 22-cv-00443 (W.D. Tex.) (“the ’443 Litigation”) on August 18, 2023. On September 8, 2023, the Court ordered Medit’s four affirmative counterclaims for patent infringement to be severed from the ’443 Litigation and be placed in a separate action. EX1013. Medit’s Answer to 3Shape’s Complaint and Affirmative Counterclaims then became the operative complaint in the Related Litigation. EX1014.

on February 17, 2012, which claims priority to U.S. Provisional Application No. 61/445,464, filed on February 22, 2011.

C. Lead and Backup Counsel

Pursuant to 37 C.F.R. §§42.8(b)(3) and 42.10(a), Petitioners hereby identify its lead and backup counsel as follows:

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Powers of Attorney are being filed concurrently herewith in accordance with 37 C.F.R. §42.10(b).

D. Service Information Under 37 C.F.R. §42.8(b)(4)

Petitioners consent to e-mail service at the addresses listed above.

III. PAYMENT OF FEES

The undersigned authorizes the Office to charge Deposit Account No. 02-4800 for fees required by 37 C.F.R. §42.15(a).

IV. REQUIREMENTS UNDER 37 C.F.R. §42.104

A. Grounds for Standing

Pursuant to 37 C.F.R. §42.104(a), Petitioners hereby certify that the '648 Patent is available for *inter partes* review in accordance with 37 C.F.R. §42.102(a)(2). Petitioners are not barred or estopped from requesting *inter partes* review challenging the claims of the '648 Patent on the grounds identified herein.

This Petition is filed within one year from the date on which Petitioners were served counterclaims by Patent Owner in the '443 Litigation, which asserted infringement of the '648 Patent. EX1014.

Neither Petitioners nor its privies have received a final written decision under 35 U.S.C. §318(a) regarding any claim of the '648 Patent on any ground that was raised or could have been raised by Petitioners or its privies in any *inter partes* review, post grant review, or covered business method patent review.

B. Identification of Challenges and Precise Relief Requested

Pursuant to 37 C.F.R. §42.104(b), Petitioners challenge Claims 1-24 ("the Challenged Claims") of the '648 Patent, and request that these claims be found unpatentable over the prior art for the reasons given below. The Grounds for challenging the patentability of Claims 1-24 are as follows:

Ground	References	Basis	Claims Challenged
1	US Patent Application Publication No. 2007/0171220 (“Kriveshko”, EX1005) and International Publication No. WO 2009/089129 (“Zhang”, EX1006)	§103	1-24
2	Kriveshko and Zhang, further in view of Estépar, R. S. J., Brun, A., & Westin, C. F. (2004). Robust generalized total least squares iterative closest point registration. In <i>Medical Image Computing and Computer-Assisted Intervention—MICCAI 2004: 7th International Conference, Saint-Malo, France, September 26-29, 2004. Proceedings</i> , Part I, pp. 234-241, Springer Berlin Heidelberg (EX1008) and Szeliski, R. (2006). <i>Image Alignment and Stitching: A Tutorial, Foundations and Trends in Computer Graphics and Vision</i> , vol. 2, issue 1, pp. 1-104 (EX1009)	§103	4, 7

Petitioners also rely upon evidence listed in the Exhibit List, including the Declaration and *Curriculum Vitae* of Dr. Eli Saber, Ph.D. (EXs1016-1017) and the Declaration and *Curriculum Vitae* of Dr. Ingrid Hsieh-Yee, Ph.D. (EXs1018-1019). EX1016, ¶¶1-331 support this Petition, and citations are provided below.

C. Prior Art Qualification of Asserted References

The ’648 Patent was filed on August 20, 2013 as U.S. Patent Application No. 14/000,442 (“the ’442 Application”). The ’442 Application is a National Stage of

PCT International Application No. PCT/US2012/025554 (EX1003), filed on February 17, 2012, which claims priority to U.S. Provisional Application No. 61/445,464 (EX1004), filed on February 22, 2011.

Even if the '648 Patent is deemed entitled to its earliest claimed priority date of February 22, 2011, all of the applied references in this Petition are prior art.

Kriveshko (EX1005), published on July 26, 2007 and filed on May 16, 2006, constitutes prior art at least under 35 U.S.C. §§102(a), 102(b), and 102(e).

Zhang (EX1006), published on July 16, 2009 and having an international filing date of January 4, 2009, constitutes prior art at least under 35 U.S.C. §§102(a), 102(b), and 102(e).

Estépar (EX1008) was published and publicly accessible as early as November 13, 2004 and no later than December 5, 2004, and constitutes prior art at least under 35 U.S.C. §§102(a) or 102(b). EX1018, ¶¶1-86.

Szeliski (EX1009) was published and publicly accessible as early as April 20, 2007 and no later than October 4, 2007, and constitutes prior art at least under 35 U.S.C. §§102(a) or 102(b). EX1018, ¶¶1-86.

V. BACKGROUND

A. The '648 Patent

The '648 Patent discloses that the purported invention relates to three-dimensional imaging and more specifically to techniques for combining disparate

scans of a common three-dimensional surface. EX1001, 1:5-7. The '648 Patent discloses a method where three-dimensional data is acquired as a sequence of frames of data along a camera path. *Id.*, 1:35-40, 4:15-21. EX1016, ¶¶37-39.

Figure 9 is a flow chart of a hybrid stitching process for combining disparate three-dimensional scans of a common surface. EX1001, 18:15 to 19-61.

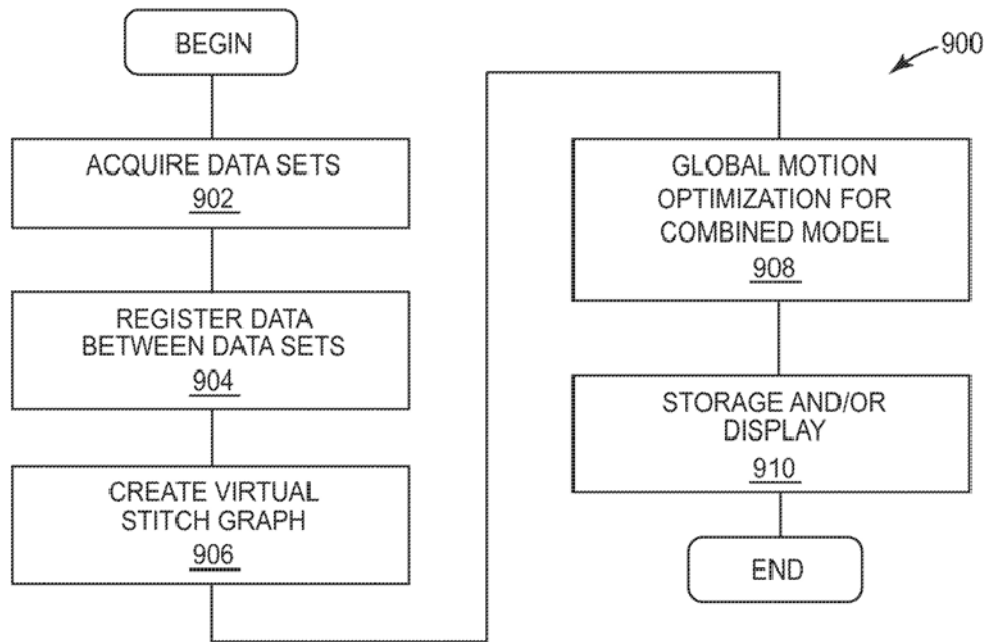


FIG. 9

Figure 9 of the '648 Patent

EX1016, ¶40.

The '648 Patent purports to provide a novel technique that combines “disparate” scans of a common three-dimensional surface. EX1001, 1:5-7, 18:17-21. The '648 Patent discloses examples of a “disparate” scan:

The second model may, for example, be obtained *after a first scan is automatically or manually interrupted, or after a first scan is completed and additional data is required or desired*, either by a user or in response to prompting from a scanning system as contemplated above. More generally, the second three-dimensional model may be any disparate data set that is not directly spatially related to the first three-dimensional model through a single scan or camera path. [Emphasis added.]

Id., 18:47-55. According to the '648 Patent, a “disparate” scan encompasses a scan that is obtained after an interruption or completion of an initial scan, *e.g.*, “after a first scan is completed and additional data is required or desired”. *Id.* EX1016, ¶¶41-42.

Combining disparate scans is nothing new. Kriveshko discloses techniques for fitting and stitching data from disparate scans “where a scan is purposely interrupted by the user” and “after a first scan is completed and additional data is desired”, as well as where scans “have been lost due to signal degradation or scans that have been explicitly stopped through user operation”. EX1005, [0074]. EX1016, ¶43.

B. The '648 Patent Examination History

The '442 Application was allowed in the first action on the merits without any prior art rejection. EX1002, pp.9-16. The Examiner discussed Hausler

(2010/0303341)(EX1011) and Lopes (US2010/0194863)(EX1012) in the reasons for allowance. No mention is made of Kriveshko or Zhang. Nor did the Examiner consider the combination of Kriveshko with Zhang, much less appreciate that such references disclose the subject matter of the Challenged Claims. Kriveshko was merely cited in an IDS and was never substantively discussed, and Zhang was not even considered. *See* §VIII.C.

C. Summary of the Applied Prior Art

1. Kriveshko (EX1005)

Kriveshko discloses registration and stitching of two disparate 3D models obtained from scanning tooth surfaces. EX1005, [0005], [0008], [0100], [0103]. Kriveshko discloses techniques for combining newly acquired data—for example, obtained after an interruption in scanning—with previously acquired data. *Id.* Kriveshko relates to “three-dimensional scanning” and provides “techniques for resuming a three-dimensional scan after losing data acquisition.” *Id.*, [0002]. Kriveshko’s methods and systems are useful in dentistry applications. *Id.*, [0008] (“a full three-dimensional surface scan may be obtained for two dental arches in occlusion”). *See also id.*, [0054], [0100]. EX1016, ¶¶44-47.

Kriveshko discloses “techniques that identify and aid in recovery from errors in incremental scans” and “support recovery from a lost scanning sequence while the scan is in progress.” EX1005, [0007]. For example, Kriveshko discloses

techniques that address the problem when fitting or stitching fails. *Id.*, [0059]. Kriveshko discloses techniques for fitting and stitching data from separate scans “where a scan is purposely interrupted by the user” and where scans “have been lost due to signal degradation or scans that have been explicitly stopped through user operation”. *Id.*, [0074]. Kriveshko discloses exemplary techniques for operating an image capture system in Figures 2-3. EX1016, ¶¶48-51.

2. Zhang (EX1006)

Zhang relates to data processing techniques and systems applicable to dental applications and scanning of “human dentition” and “tooth surface[s]”. EX1006, [0023], [0027]-[0034]. EX1016, ¶¶52-53.

Zhang is entitled “Global Camera Path Optimization” and discloses the same “global motion optimization” as the ’648 Patent. EX1006, [0045]. The ’648 Patent describes “global motion optimization” as follows, and Zhang contains a word-for-word identical description:

In the systems and methods described herein, a number of techniques for global motion optimization are employed to improve accuracy of three-dimensional reconstructions based upon camera path. [EX1001, 2:16-19; EX1006, [0022].]

Global motion optimization, also referred to herein as global path optimization or global camera path

optimization, may be performed by a global motion optimization module 357 in order to reduce errors in the resulting three-dimensional model 358. [EX1001, 8:57-61; EX1006, [0045].]

Figure 3 of Zhang—which is identical to Figure 3 of the '648 Patent—depicts use of a global motion optimization module 357 which, as described above, provides means for refining and “reduc[ing] errors in the resulting three-dimensional model”. EX1006, [0045]. EX1016, ¶¶54-55.

The '648 Patent discloses examples of global motion optimization techniques. Zhang discloses the exact same techniques. Both the '648 Patent and Zhang disclose, in identical fashion, a global motion optimization technique involving minimizing accumulation of errors along the length of the camera path by supplemental frame-to-frame motion estimation with some or all of the global path information. EX1001, 8:63-9:14; EX1006, [0045]. Both the '648 Patent and Zhang disclose, in identical fashion, a global motion optimization technique involving reducing errors in the calculated camera path based upon available data for the complete camera path such as, for example, cross links that interrelate temporally distant measurements. EX1001, 12:25-33; EX1006, [0060]. EX1016, ¶¶56-58.

3. Estépar (EX1008) and Szeliski (EX1009)

Estépar is entitled “Robust Generalized Total Least Squares Iterative Closest Point Registration”. Szeliski is entitled “Image Alignment and Stitching: A Tutorial”.

Estépar and Szeliski disclose well known registration techniques that were available to a POSITA for implementing the techniques disclosed by Kriveshko, including iterative closest point (ICP) algorithm. *See e.g.*, EX1008, abstract; EX1009, 36-37. EX1016, ¶59.

D. Person of Ordinary Skill in the Art (“POSITA”)

A POSITA is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. Regarding the ’648 Patent, a POSITA would have at least (1) a bachelor’s degree in electrical engineering, computer engineering, computer science, or an equivalent field, as well as at least two to three years of industry or research experience with computer vision/graphics making use of three-dimensional virtual models; or (2) a master’s degree in electrical engineering, computer engineering, computer science, or an equivalent field with a focus in making use of three-dimensional virtual models in the area of computer vision/graphics. EX1016, ¶¶35-36.

VI. CLAIM CONSTRUCTION

The Board only construes the claims when necessary to resolve the underlying controversy. *Toyota Motor Corp. v. Cellport Systems, Inc.*, IPR2015-00633, Paper 11 at 16 (PTAB Aug. 14, 2015) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)). The Challenged Claims are unpatentable under all potential constructions.

A. “(first/second) three-dimensional model”

In the Related Litigation, Petitioners asserted that the term “(first/second) three-dimensional model” (Claims 1, 2, 12, 13, 23, 24) should be construed as “a disparate data set that is not directly related to another three-dimensional model through a single scan or camera path.” EX1015, pp. 2-3. Patent Owner asserted that this term should be given its plain and ordinary meaning. *Id.* The District Court construed the term as having its plain and ordinary meaning. *Id.*

B. “camera path”

In the Related Litigation, Petitioners asserted that the term “camera path” (Claims 1, 12, 23, 24) should be construed as “physical path(s) taken by a scanner during a scan.” EX1015, pp. 2-3. Patent Owner asserted that this term should be given its plain and ordinary meaning. *Id.* The District Court construed the term as having its plain and ordinary meaning. *Id.*

C. “virtual stitch graph”

In the Related Litigation, Petitioners asserted that the term “virtual stitch graph” (Claims 1, 19, 12, 20, 23, 24) should be construed as “spatial relationship between models using data from disparate models”. EX1015, pp. 2-3. Patent Owner asserted that the term should be construed as “a rigid transformation and/or other descriptive data that characterizes camera motion in a manner that permits path-based reconstruction of a 3D surface based on multiple disparate scans.” *Id.* The

District Court construed this term as “spatial relationship between data sets and/or models using data from disparate data sets and/or models”. *Id.*

D. “scanning means”, “processing means”

Claim 24 recites the terms “scanning means” and “processing means”. In the Related Litigation, the District Court and both parties did not construe any claim term of the ’648 Patent as a means-plus-function or step-plus-function limitation under §112(6)/112(f). EX1015.

For purposes of compliance with 37 C.F.R. §42.104(b)(3) in this IPR, Petitioners submit that the function of the “scanning means” is scanning for obtaining a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path, and a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related to one another by a second camera path. For purposes of compliance with the above rule, Petitioners submit that the corresponding structure encompasses the following: a scanner that captures images from a surface of an object (EX1001, 4:17-18); any camera or camera system suitable for capturing images from which a three-dimensional point cloud or other three-dimensional data may be recovered (EX1001, 4:26-29); and/or a handheld, freely positionable probe having at least one user-input device such as a button, lever,

dial, thumb wheel, switch, or the like, for user control of the image capture system such as starting and stopping scans (EX1001, 5:4-9).

For purposes of compliance with 37 C.F.R. §42.104(b)(3) in this IPR, Petitioners submit that the function of the “processing means” is registering one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-dimensional model and the second three-dimensional model in a shared coordinate system, creating a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph, and refining the combined model with a global motion optimization of the virtual stitch graph. For purposes of compliance with the above rule, Petitioners submit that the corresponding structure encompasses the following: a personal computer or other processing device (EX1001, 5:58-63); one or more microprocessors, microcontrollers, embedded microcontrollers, programmable digital signal processors or other programmable devices, along with internal and/or external memory (EX1001, 22:19-23); one or more application specific integrated circuits, programmable gate arrays, programmable array logic components; and/or any other device or devices that may be configured to process electronic signals (EX1001, 22:23-27).

While the proper metes and bounds of certain terms are disputed, the cited prior art falls within these bounds whatever they may be. The prior art meets the language of the claims under the District Court’s constructions as well as Petitioners’ non-adopted litigation construction. The Challenged Claims are unpatentable under all the potential constructions. EX1016, ¶¶60-66.

VII. PETITIONERS HAVE A REASONABLE LIKELIHOOD OF PREVAILING

Claims 1-24 of the ’648 Patent are unpatentable for at least the following reasons. EX1016, ¶¶33-329.

A. Claims 1-24 Would Have Been Obvious Over Kriveshko in View of Zhang (Ground 1).

Claims 1-24 would have been obvious over Kriveshko in view of Zhang. EX1016, ¶¶67-68.

1. Claim 1 (Preamble): A method comprising:

Kriveshko discloses and suggests the Preamble of Claim 1. Kriveshko discloses methods and systems for “three-dimensional scanning” including “techniques for resuming a three-dimensional scan after losing data acquisition.” EX1005, [0002]. Kriveshko discloses methods and systems that acquire three-dimensional images and are useful in dentistry applications, for example, “a full three-dimensional surface scan may be obtained for two dental arches in occlusion”. *Id.*, [0008]. EX1016, ¶¶69-71.

Kriveshko discloses “techniques that identify and aid in recovery from errors in incremental scans” and “real time feedback systems to support recovery from a lost scanning sequence while the scan is in progress.” EX1005, [0007]. Kriveshko discloses combining newly acquired data—for example, obtained after an interruption in scanning—with previously acquired data. *Id.*, [0005], [0008], [0059], [0100]. For example, “[f]rom time to time in such incremental data acquisition systems, the fitting or stitch may fail”, and Kriveshko provides techniques (*e.g.*, a “recover mode” and a “landing mode”) that “seek to reacquire the previous scan by test fitting new scan data to previously acquired data” and “initiate a new scan registered or connected to an existing three-dimensional model”. *Id.*, [0059]. Kriveshko discloses exemplary techniques for operating an image capture system in Figures 2-3. EX1016, ¶¶72-75.

- a. **[1.1]: obtaining a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path;**

Kriveshko discloses and suggests Element [1.1]. Kriveshko discloses “providing three-dimensional surface data for a subject, and acquiring an image set for a three-dimensional image of the subject”. EX1005, [0011]. *See also id.*, [0008]. Kriveshko discloses “acquiring at least one subsequent three-dimensional image; fitting the at least one subsequent three-dimensional image to a second three-dimensional surface reconstruction; and test fitting the at least one subsequent three-

dimensional image to the three-dimensional surface data.” *Id.*, [0011]. Kriveshko discloses obtaining a “new” (second) three-dimensional model and adding/fitting same to an “original” (first) three-dimensional model obtained from a previous scan. *Id.*, [0059] (“reacquire the previous scan by test fitting new scan data to previously acquired data”), [0070] (“new or incremental three-dimensional data may be added to the three-dimensional model”), [0074], [0097] (“create a supplemental three-dimensional model ... before a successful fit to the original three-dimensional model”). EX1016, ¶¶76-79.

Kriveshko discloses that the terms “three-dimensional image” and “three-dimensional data” are “used interchangeably” with “three-dimensional model”. EX1005, [0061] (“the terms three-dimensional data, three-dimensional representation, three-dimensional model, three-dimensional image, three-dimensional surface map, and the like are used interchangeably to describe the three-dimensional representation assembled from incremental scan results captured by the scanning device, or a portion thereof...”). *See also id.*, [0063]. Thus, Kriveshko’s techniques relate to obtaining and combining first and second three-dimensional models, given that Kriveshko discloses techniques for combining newly acquired three-dimensional images/data (*e.g.*, obtained after an interruption in scanning) with previously acquired three-dimensional images/data. *Id.*, [0005], [0100]. *See also id.*, [0008] (“[a] scanning system that acquires three-dimensional images as an

incremental series of fitted three-dimensional data sets is improved by testing for successful incremental fits in real time and providing ... process modifications depending upon the relationship of newly acquired data to previously acquired data.”). EX1016, ¶¶80-81.

Further, the ’648 Patent discloses that the term “three-dimensional model” encompasses “any three-dimensional surface map of an object, such as a point cloud of surface data, a set of two-dimensional polygons, *or any other data representing all or some of the surface of an object*, as might be obtained through the capture and/or processing of three-dimensional scan data”. EX1001, 2:54-63 (emphasis added). The three-dimensional data and three-dimensional images disclosed by Kriveshko constitute “three-dimensional models” as claimed at least because they constitute “data representing all or some of the surface of an object”. *Id.* EX1016, ¶¶82-83.

Kriveshko discloses first and second “three-dimensional models” under all constructions. Concerning Petitioners’ construction (*see* §VI.A.), according to the ’648 Patent, “disparate” scans, data sets, and models encompass an embodiment in which a second model is “obtained after a first scan is automatically or manually interrupted, or after a first scan is completed and additional data is required or desired”. EX1001, 18:47-55. The ’648 Patent discloses that “the full scan data for an object may include any number of disparate scans with camera paths, or more

generally stitch graphs, that are not directly spatially related to one another.” *Id.*, 18:17-21. EX1016, ¶¶84-85.

Like the ’648 Patent, Kriveshko is directed to techniques for fitting and stitching disparate data sets and models obtained from disparate scans “where a scan is purposely interrupted by the user” as well as where scans “have been lost due to signal degradation or scans that have been explicitly stopped through user operation”. EX1005, [0074]. *See also id.*, [0059]. Kriveshko discloses that in such situations, the system “may seek to reacquire the previous scan by test fitting new scan data to previously acquired data” and “a user may attempt to initiate a new scan registered or connected to an existing three-dimensional model.” *Id.*, [0059]. Kriveshko discloses “techniques for resuming a three-dimensional scan after losing data acquisition.” *Id.*, [0002]. Kriveshko discloses registration and stitching of two disparate 3D models to address the problem of “errors or gaps in incremental data” during intraoral scanning and seeks to combine newly acquired data—for example, obtained after an interruption in or completion of scanning—with previously acquired data. *Id.*, [0005], [0008], [0100]. Such newly acquired data constitutes “a disparate data set that is not directly related to another three-dimensional model through a single scan or camera path” with respect to the previously acquired data. Exhibit 1010 further demonstrates that it was well known to “acquire additional data

where a void or deviation is detected” in the initial digital model.² EX1010, [0060].
EX1016, ¶¶86-91.

Figure 2 of Kriveshko discloses an exemplary process for 3D scanning:

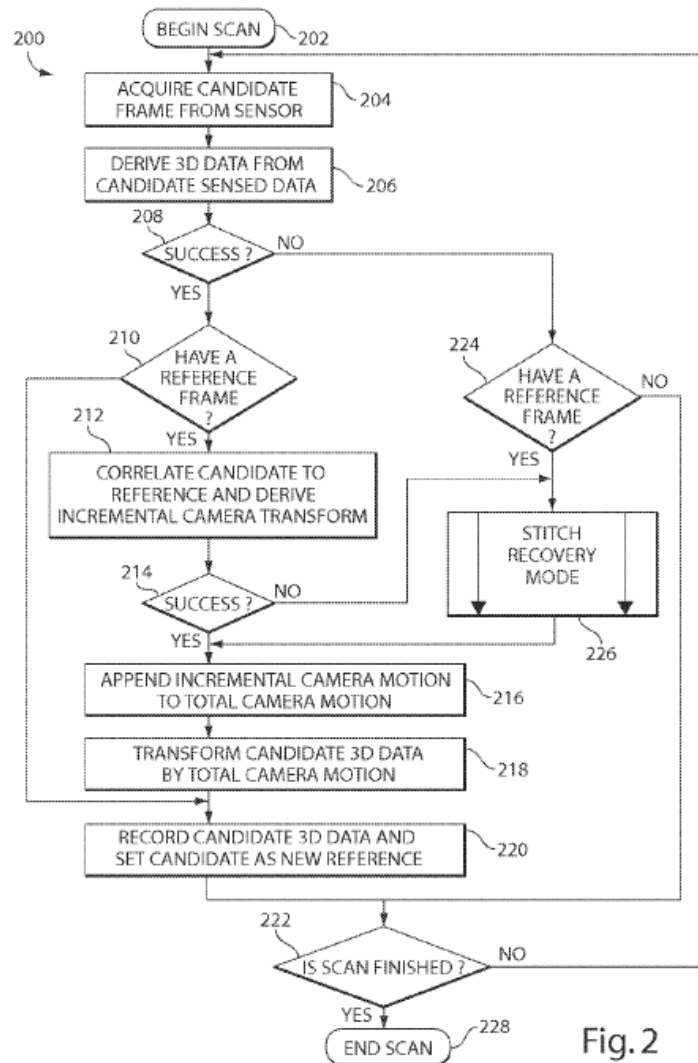


Fig.2

Figure 2 of Kriveshko

² Paley (EX1010), published on July 26, 2007, constitutes prior art at least under 35 U.S.C. §102(b).

In Step 206, three-dimensional data is derived from the candidate frame, *e.g.*, two-dimensional data may be converted into three-dimensional data or a three-dimensional image. EX1005, [0061]. Each set of “three-dimensional data” constitutes a “three-dimensional model” at least because Kriveshko discloses that the terms “three-dimensional model” and “three-dimensional data” are “used interchangeably”, as discussed above. *Id.* EX1016, ¶¶92-94.

Kriveshko discloses that each of the first/second three-dimensional models includes “a first/second plurality of sets of three-dimensional points” as claimed. EX1005, [0008] (“incremental series of fitted three-dimensional data sets”), [0009] (“acquiring an image set for a next three-dimensional image”), [0050] (“a number of such point clouds may also be registered and combined into an aggregate point cloud constructed from images captured by a moving camera”). EX1016, ¶95.

Kriveshko discloses a “camera path” under all constructions. Concerning Petitioners’ construction requiring “physical path(s) taken by a scanner during a scan” (*see* §VI.B.), Kriveshko discloses use of a scanner that is “handheld” and “freely positionable” allowing the scanner to move along a physical path during a scan. EX1005, [0052], [0062] (“images captured by a moving camera”). *See also id.*, [0060] (“acquiring a candidate frame from a sensor, such as an image set from the scanner 102 described above”), [0086] (“new frame of data may be acquired from the scanner 102”), Figure 1 (depicting freely positionable scanner 102).

Kriveshko discloses scanning the subject such as dentition over a “scan path”. *Id.*, [0103], Figure 10 (depicting scan path 1006). Each of the initial and subsequent scans for obtaining the first and second three-dimensional models in Kriveshko are obtained over a physical path taken as the scanner is moved during a scan. *Id.*, [0050] (“a number of such point clouds may also be registered and combined into an aggregate point cloud constructed from images captured by a moving camera”), [0052], [0060] (“the view will continuously shift as the user moves the scanner 102 about the subject 104”), [0103].³ For each model, the plurality of sets of three-dimensional points are spatially related to one another at least because they are all

³ The plain and ordinary meaning of “camera path” (*i.e.*, under the District Court’s and Patent Owner’s constructions) at least encompasses Petitioner’s construction. The ’648 Patent discloses that “the camera path may correspond to a physical camera path that describes the path actually taken by a scanner during a scan, or the camera path may also or instead include a virtual camera path formed from a plurality of different physical camera paths or other virtual camera paths that intersect with one another”. EX1001, 16:38-43. *See also id.*, 19:23-35 (“the term virtual ... is intended to distinguish models using data from multiple disparate scans” but “there may be little to distinguish a virtual stitch or a virtual stitch graph from those that are not virtual”).

associated with data obtained during the same scan over the same (*e.g.*, physical) camera path, as noted above. Kriveshko also discloses using camera motion estimation including use of rigid transformations. *See, e.g.*, EX1005, [0070]. Thus, Kriveshko discloses that the first/second plurality of sets of three-dimensional points are “spatially related to one another by a first/second camera path” as claimed. EX1016, ¶¶96-98.

In addition, the ’648 Patent does not require each “set” to be anything more than a plurality of 3D points. Thus, a “set” encompasses any grouping of points including, for example, 3D points pertaining to a specific feature such as a specific tooth or tooth surface. Kriveshko teaches scanning multiple “complex surfaces” and multiple teeth (“quadrant of teeth”, “full collection of teeth”, “two opposing arches”), and thus teaches obtaining models that each include a plurality of sets of three-dimensional points. *See, e.g.*, EX1005, [0054]. EX1016, ¶¶99-100.

b. [1.2]: obtaining a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related to one another by a second camera path;

Kriveshko discloses and suggests Element [1.2] for at least the reasons discussed above concerning Element [1.1]. *See* §VII.A.1.a. Furthermore, Kriveshko discloses that “new or incremental three-dimensional data may be added to the three-dimensional model”. EX1005, [0070]. Kriveshko discloses registering “all of the three-dimensional data acquired during the recover mode ... to the original three-

dimensional model”. *Id.*, [0074]. Kriveshko discloses initiating a “new scan” in order to “create a supplemental three-dimensional model ... before a successful fit to the original three-dimensional model”. *Id.*, [0097]. Each of the “new or incremental three-dimensional data”, “three-dimensional data acquired during the recover mode”, and “supplemental three-dimensional model” disclosed by Kriveshko satisfies the claimed second three-dimensional model, and the “original three-dimensional model” satisfies the first three-dimensional model. *Id.* As noted above, Kriveshko discloses that the terms “three-dimensional data” and “three-dimensional image” are “used interchangeably” with “three-dimensional model”. *Id.*, [0061]. EX1016, ¶¶101-106.

A second three-dimensional model is also created in Kriveshko’s “stitch recover mode” (Figure 3), which is also a “disparate” data set obtained from a “disparate” scan. EX1005, [0082] (“This superposition may indicate to a user both where the scanner is currently positioned and where the scanner should be positioned in order to reacquire a scan, so that a user may manipulate the scanner to a suitable position for recovery.”), [0083] (“three-dimensional data may be derived from the new frame of data...”), [0085] (“the newly derived three-dimensional data may be test fitted to the reference frame(s) from the acquisition mode...”), [0086] (“the test fit may be evaluated for success. If new data is successfully test fitted to the reference frame(s), the process 300 may proceed to step 320 and exit the recover mode....

When a successful test fit is made to the original (acquisition mode) three-dimensional model, the entire new three-dimensional model, or a selected portion thereof, may be registered to the original three-dimensional model using a transformation based upon the successfully fitted frames or three-dimensional images.”). EX1016, ¶107.

Kriveshko discloses that the second three-dimensional model includes “a second plurality of sets of three-dimensional points spatially related to one another by a second camera path” for at least the reasons discussed above concerning Element [1.1]. *See* §VII.A.1.a. EX1016, ¶¶108-109.

- c. **[1.3]: registering one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-dimensional model and the second three-dimensional model in a shared coordinate system;**

Kriveshko discloses and suggests Element [1.3]. Kriveshko discloses “register[ing] new three-dimensional data to existing three-dimensional data”. EX1005, [0066]. Kriveshko discloses that “[a]ll such techniques that might usefully be employed to register new three-dimensional data to existing three-dimensional data” may be used. *Id. See also id.*, [0070] (“any suitable technique for registering new three-dimensional data to existing three-dimensional data may be usefully employed in step 216, and the choice of a particular technique may vary according to the scanning technology and/or sensor data of a particular image capture system.”).

Kriveshko discloses that “the entire new three-dimensional model, or a selected portion thereof, may be registered to the original three-dimensional model”. *Id.*, [0086] (“[w]hen a successful test fit is made to the original (acquisition mode) three-dimensional model, the entire new three-dimensional model, or a selected portion thereof, may be registered to the original three-dimensional model using a transformation based upon the successfully fitted frames or three-dimensional images.”). Kriveshko teaches that registration is for the purpose of placing the first three-dimensional model and the second three-dimensional model in a shared coordinate system. *Id.*, [0005] (“registration of the incremental data to a common coordinate system”). *See also id.*, [0006] (“the subject of the scan has also retained its position and orientation within the same global coordinate system.”). EX1016, ¶¶110-114.

Kriveshko discloses registering “one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points” as claimed. As explained above concerning Elements [1.1]-[1.2], the first three-dimensional model includes the “first plurality of sets of three-dimensional points” and the second three-dimensional model includes the “second plurality of sets of three-dimensional points”. Kriveshko discloses registering the first and second three-dimensional models as explained above and in doing so, registers the “first plurality of sets of three-dimensional points” (which is included in the first three-

dimensional model) to the “second plurality of sets of three-dimensional points” (which is included in the second three-dimensional model). EX1016, ¶¶115-118.

- d. **[1.4]: creating a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph; and**

Kriveshko discloses and suggests Element [1.4]. Kriveshko discloses creating a “virtual stitch graph” under all constructions. *See* §VI.C. As discussed above with respect to Elements [1.1] to [1.3], Kriveshko discloses creating a “spatial relationship between models using data from disparate models” (Petitioners’ construction) and a “spatial relationship between data sets and/or models using data from disparate data sets and/or models” (District Court’s construction). Kriveshko discloses “testing for successful incremental fits” of data “depending upon the relationship of newly acquired data to previously acquired data.” EX1005, [0008]. Kriveshko discloses that “the incremental three-dimensional image data may be fitted or stitched to the existing three-dimensional model.” *Id.*, [0066]. Kriveshko further discloses a “stitch recover mode” wherein the process “may attempt to reacquire or resume a scan by test fitting each newly acquired data set to some portion of the three-dimensional model”. *Id.*, [0074]. EX1016, ¶¶119-121.

As explained above concerning Element [1.1], Kriveshko discloses fitting and stitching using data from “disparate” models (as well as “disparate” data sets of such

models). According to the '648 Patent, “disparate” scans, “disparate” data sets, and “disparate” models encompass an embodiment in which a second data set or model is “obtained after a first scan is automatically or manually interrupted, or after a first scan is completed and additional data is required or desired”. EX1001, 18:47-55. *See also* §V.C.1. Kriveshko discloses fitting and stitching disparate data sets and disparate models obtained from disparate scans “where a scan is purposely interrupted by the user” as well as where scans “have been lost due to signal degradation or scans that have been explicitly stopped through user operation”. EX1005, [0074]. *See also id.*, [0059]. EX1016, ¶¶122-124.

Furthermore, all three constructions of “virtual stitch graph” encompass a rigid transformation, and Kriveshko discloses creating a rigid transformation concerning the model data obtained from the initial and subsequent scans. Kriveshko discloses that “new or incremental three-dimensional data may be added to the three-dimensional model” and “[i]n one embodiment using camera motion estimation, this step may include **a rigid transformation** of the incremental three-dimensional data to the coordinate system of the three-dimensional model, as depicted in step 218.” EX1005, [0070] (emphasis added). *See also id.*, Fig. 2 (“**transform** candidate 3D data by total camera motion”) (emphasis added). A POSITA would have understood that a rigid transformation is an expression of the spatial relationship between the data sets and models (*see, e.g.*, EX1005, [0070]; EX1009, pp. 7-14; EX1008, pp.

234-236), and thus Kriveshko's disclosure of creating a rigid transformation satisfies all constructions. EX1016, ¶¶125-127.

The "first plurality of sets of three-dimensional points" is included in the first three-dimensional model and the "second plurality of sets of three-dimensional points" is included in the second three-dimensional model. As explained above, Kriveshko discloses creating a spatial relationship (such as a stitch or rigid transformation) between the first and second three-dimensional models and in doing so, creates a spatial relationship (*e.g.*, stitch or rigid transformation) between the "first plurality of sets of three-dimensional points" (which is included in the first three-dimensional model) and the "second plurality of sets of three-dimensional points" (which is included in the second three-dimensional model). EX1016, ¶¶128-129.

Further, a virtual stitch graph is created during the "recover mode" and "landing mode" which involves "stitch recovery" as described in Kriveshko. *See, e.g.*, EX1005, [0059]. Kriveshko discloses employing such modes to address situations where "the fitting or stitch" fails. *Id.* Kriveshko discloses that "[i]n the recover mode, the system 100 may seek to reacquire the previous scan by test fitting new scan data to previously acquired data.... In a related landing mode, a user may attempt to initiate a new scan registered or connected to an existing three-dimensional model." *Id.* In the recover and landing modes, a "spatial relationship"

(District Court’s and 3Shape’s construction) and “a rigid transformation and/or other descriptive data” (Medit’s construction) are created between the model obtained from the initial scan and the additional model obtained from the subsequent scan. *Id.* EX1016, ¶¶130-133.

Kriveshko discloses that “[t]he method may include fitting each new one of the one or more additional three-dimensional images to one another to provide a second set of three-dimensional data, and upon a successful fit, adding the second set of three-dimensional data to the first set of three-dimensional data.” EX1005, [0024]. Kriveshko discloses that “[u]pon a successful fit, the method may further include adding the second set of three-dimensional data to the first set of three-dimensional data.” *Id.*, [0031]. In Kriveshko, the “new or incremental three-dimensional data may be added to the three-dimensional model.” *Id.*, [0070]. In the context of “dentistry application”, “a full three-dimensional surface scan may be obtained for two dental arches in occlusion.” *Id.*, [0008]. *See also id.*, [0022], [0093] (“Over a number of successive acquisitions and fits, a large three-dimensional model may be acquired”). Thus, Kriveshko discloses providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph. EX1016, ¶¶134-139.

e. [1.5]: refining the combined model with a global motion optimization of the virtual stitch graph.

Kriveshko in view of Zhang disclose and teach Element [1.5]. Patent Owner may argue that Kriveshko does not disclose Element [1.5] (*i.e.*, an alleged difference between claim 1 and Kriveshko). However, Zhang expressly discloses using “global motion optimization ... to reduce errors in the resulting three-dimensional model” and “to improve accuracy of three-dimensional reconstructions based upon camera path”. EX1006, [0045], [0022]. *See also id.* (“the high-accuracy model 370 may be processed to reduce errors”), [0060]. Zhang discloses that global motion optimization is a “refinement” of the model. *Id.*, [0011] (“three-dimensional model may be refined”), [0045] (“post-processing refinement procedure”), [0046] (“model refinement process”). It would have been obvious to refine Kriveshko’s combined model using global motion optimization of the virtual stitch graph in view of Zhang for the purpose of, for example, reducing errors and refining the resulting three-dimensional model as taught by Zhang. *Id.*, [0045]-[0046], [0011], [0022], [0060]. For example, Kriveshko discloses use of “a more computationally intensive post-processing step, which might yield greater accuracy and density” (EX1005, [0062]) and contemplates use of additional process steps (EX1005, [0087]), and Zhang provides such an additional step for refining the combined model. EX1016, ¶¶140-145.

Zhang discloses the same “global motion optimization” as the ’648 Patent. The ’648 Patent describes “global motion optimization” as follows, and Zhang contains a word-for-word identical description:

In the systems and methods described herein, a number of techniques for global motion optimization are employed to improve accuracy of three-dimensional reconstructions based upon camera path. [EX1001, 2:16-19; EX1006, [0022].]

Global motion optimization, also referred to herein as global path optimization or global camera path optimization, may be performed by a global motion optimization module 357 in order to reduce errors in the resulting three-dimensional model 358. [EX1001, 8:57-61; EX1006, [0045].]

For example, Figure 3 of Zhang—which is identical to Figure 3 of the ’648 Patent—depicts use of a global motion optimization module 357 which, as described above, provides means for refining and “reduc[ing] errors in the resulting three-dimensional model” (EX1006, [0045]):

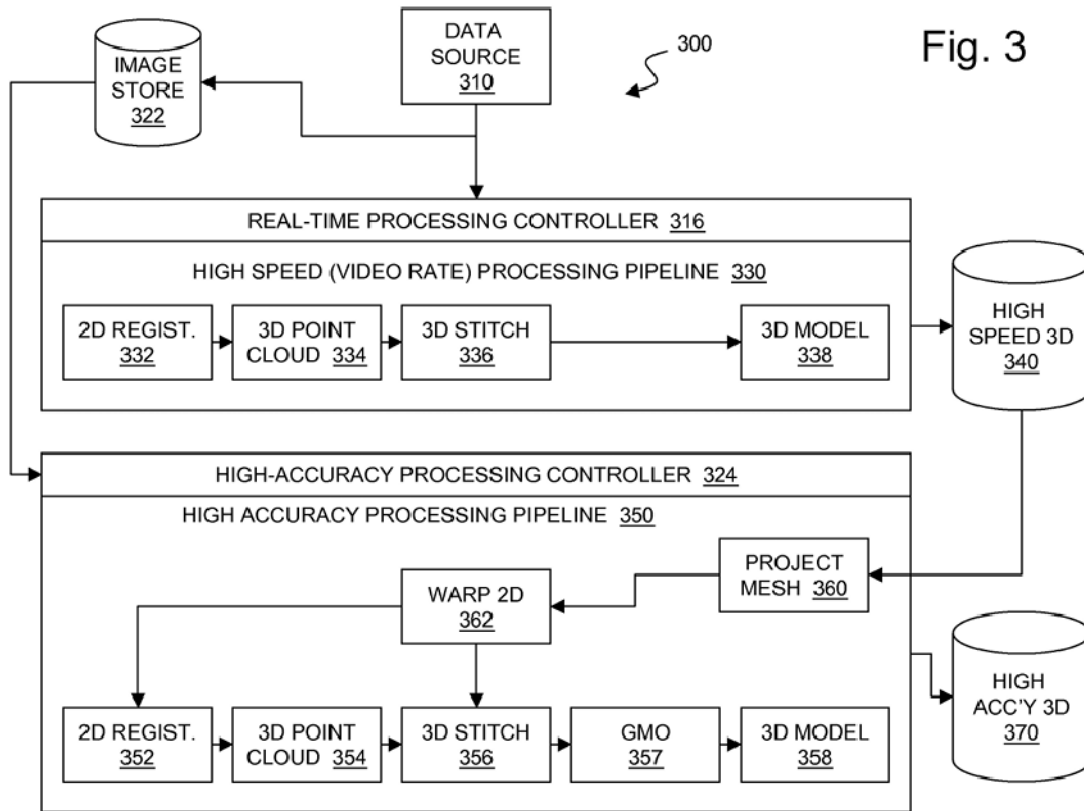


Figure 3 of Zhang

EX1016, ¶¶146-147.

Zhang further discloses identical examples of global motion optimization techniques as those disclosed by the '648 Patent. For example, both the '648 Patent and Zhang disclose, in identical fashion, a global motion optimization technique involving minimizing accumulation of errors along the length of the camera path by supplemental frame-to-frame motion estimation with some or all of the global path information:

In a post-processing refinement procedure, the calculation of camera path may be optimized—that is, the

accumulation of errors along the length of the camera path may be minimized by supplemental frame-to-frame motion estimation with some or all of the global path information. Based on global information Such as individual frames of data in the image store 322, the high speed three-dimensional model 340, and intermediate results in the high-accuracy processing pipeline 350, the high-accuracy model 370 may be processed to reduce errors in the camera path and resulting artifacts in the reconstructed model. As a further refinement, a mesh may be projected onto the high-speed model by a mesh projection module 360. [EX1001, 8:63-9:14; EX1006, [0045].]

EX1016, ¶¶148-149.

In addition, both the '648 Patent and Zhang disclose, in identical fashion, a global motion optimization technique involving reducing errors in the calculated camera path based upon available data for the complete camera path such as, for example, cross links that interrelate temporally distant measurements:

As shown in step 720, a numerical optimization may be performed to reduce errors in the calculated camera path based upon available data for the complete camera path such as, for example, cross links that interrelate temporally distant measurements. In general, the objective of numerical optimization is to minimize a calculated error based upon an error function for the camera path and/or

reconstructed three-dimensional model. A useful formulation of the error minimization problem for a global camera path is presented below. [EX1001, 12:25-33; EX1006, [0060].]

EX1016, ¶150.

Zhang teaches that its global motion optimization technique is applied to 3D stitches because global motion optimization (module 357) follows three-dimensional 3D stitching (356). *See, e.g.*, EX1006, Fig. 3. In the obvious combination of Kriveshko and Zhang, the global motion optimization would be “of the virtual stitch graph” as claimed because global motion optimization would involve refining the combined model obtained from the first and second models (as taught by Kriveshko) that are spatially related by the virtual stitch graph (*e.g.*, the rigid transformation). The ’648 Patent discloses that “any of the global motion optimization techniques described above” (again, which correspond to techniques disclosed by Zhang) may be suitable for performing this optimization “of the virtual stitch graph”. EX1001, 19:36-43. EX1016, ¶¶151-153.

It would have been obvious to modify Kriveshko to refine the combined model with a global motion optimization of the virtual stitch graph for several reasons. One, Zhang provides express teaching, suggestion, or motivation that would have led a POSITA to modify Kriveshko to employ a global motion optimization as discussed above. *See, e.g.*, EX1006, [0045] (“to reduce errors in the resulting three-

dimensional model”), [0011], [0022], [0046], [0060]. Two, Kriveshko also provides such teaching, suggestion, or motivation, recognizing that there is room for improvement/refinement in its process by suggesting use of “a more computationally intensive post-processing step, which might yield greater accuracy and density” (EX1005, [0062]) and adding steps to its process (EX1005, [0087]). Zhang provides such additional steps for refining the combined model. EX1006, [0045]-[0046], [0011], [0022], [0060]. Three, such a modification would have merely constituted use of a known technique (global motion optimization refinement as expressly taught by Zhang) to improve similar methods/systems (as disclosed by Kriveshko) in the same way, *e.g.*, to reduce errors in the resulting three-dimensional model as taught by Zhang. Four, such a modification would have merely constituted applying a known technique (global motion optimization refinement taught by Zhang) to the known method/system of Kriveshko that is ready for improvement (*see* EX1005, [0062], [0087] discussed above) to yield predictable results. Five, such a modification would have merely constituted combining prior art elements (the techniques/systems disclosed by Kriveshko) according to known methods (global motion optimization refinement taught by Zhang) to yield predictable results. Six, such modification would have merely involved selection of Zhang’s global motion optimization from a finite number of identified, predictable solutions, to improve the

techniques/systems of Kriveshko with a reasonable expectation of success. EX1016, ¶¶154-160.

Such modification would have been predictable—and a POSITA would have had a reasonable expectation of success—at least because Zhang discloses that its global motion optimization is used as a process for refining a three-dimensional model like that of the combined model disclosed by Kriveshko. *See, e.g.*, EX1006, [0011] (“A three-dimensional model may be generated based upon the camera path and the data for the three-dimensional reconstruction, and the three-dimensional model may be refined based upon the optimized camera path.”), [0045] (“the high-accuracy model 370 may be processed to reduce errors in the camera path and resulting artifacts in the reconstructed model.”), [0060] (“the objective of numerical optimization is to minimize a calculated error based upon an error function for the camera path and/or reconstructed three-dimensional model”). As explained in §V.C., Kriveshko and Zhang both relate to techniques for three-dimensional image processing useful for dental applications and the same field of endeavor. EX1016, ¶¶161-162.

2. Claim 2: The method of claim 1 further comprising generating a first surface mesh of the first three-dimensional model and a second surface mesh of the second three-dimensional model.

Kriveshko in view of Zhang disclose and suggest claim 2. *See* §VII.A.1. (base claim 1). Kriveshko teaches generating a “sparse mesh” of the first and second three-

dimensional models. EX1005, [0062]. Kriveshko discloses that “[r]egular rectangular grids, for example, are particularly suited to hierarchical methods using subsampling of images” and “other meshes may be used, such as triangular, square, quadrilateral, or the like, to select regularly or irregularly spaced pixels within the image set for derivation of a point cloud”. *Id.* Thus, Kriveshko discloses that the “sparse mesh” is a surface mesh. *Id.* Kriveshko also discloses use of “a three-dimensional map of interconnected polygons, such as triangles or other regular or irregular polygons” which also satisfies a “surface mesh”. EX1005, [0063]. The surface meshes are also generated when rendered/visualized. *Id.*, [0076]. EX1016, ¶¶163-166.

The '648 Patent discloses that a surface mesh encompasses “polygonal surface representations” (EX1001, 18:61-66), and Kriveshko discloses various polygonal surface representations (*e.g.*, “rectangular grids”, “triangular, square, quadrilateral” meshes, “triangles or other regular or irregular polygons”) as explained above. EX1016, ¶167.

Further, Zhang discloses that “[a]s a further refinement, a mesh may be projected onto the high-speed model by a mesh projection module 360” (EX1006, [0045]). The '648 Patent provides an identical description of how the mesh is generated. EX1001, 9:7-8. It would have been obvious to generate the surfaces mesh of the models as a further refinement as taught by Zhang. *See also* §VII.A.1.e.

(discussing KSR reasons and reasonable expectation of success for employing Zhang’s refinements). EX1016, ¶¶168-171.

3. Claim 3: The method of claim 2 wherein registering includes registering the first surface mesh to the second surface mesh, thereby providing a combined surface.

Kriveshko in view of Zhang disclose and suggest claim 3. *See* §VII.A.2. (base claim 2). Kriveshko discloses (i) generating first and second surface meshes of the first and second three-dimensional models (*see* claim 2), (ii) registering the second model to the first model (*see* Element [1.3]), and (iii) providing a combined model, which includes a combined surface (*see* Element [1.4]). §VII.A.1. *See also* EX1005, abstract (“a full three-dimensional surface scan may be obtained for two dental arches”). Kriveshko teaches that its processing techniques are applied to meshes. *See, e.g.,* EX1005, [0062]. The registering of the models taught by Kriveshko would result in registering the corresponding meshes and providing a combined surface, and it would have been obvious to register data associated with the second model to data associated with the first model (*see* Element [1.3]). EX1016, ¶¶172-176.

4. Claim 4: The method of claim 3 wherein registering includes registering with an iterative closest point algorithm.

Kriveshko in view of Zhang disclose and suggest claim 4. *See* §VII.A.3. (base claim 3). Kriveshko discloses using “any number of quantitative techniques for comparing some or all of the newly acquired three-dimensional data to the previously acquired three-dimensional data”. EX1005, [0067]. Kriveshko discloses

that such comparison “may be tested for success”. *Id.* (“the fit obtained in step 212, which may be considered a test fit until accepted for addition to the previously acquired three-dimensional data, may be tested for success”). EX1016, ¶¶177-179.

One such technique contemplated by Kriveshko is iterative closest point algorithm. Kriveshko discloses use of a “fitting algorithm” which involves “any number” of iterations. EX1005, [0067] (“[u]ser evaluation and feedback may also be incorporated into a fitting algorithm, which may, for example, be in response to a frequently recurring failure to fit, or to a specific failure event” and that “any number of test fits may be performed”, “where a quantitative limit or range is employed to measure a successful fit, the limit or range may be user-controlled either by explicit selection of a numeric fit parameter or by selection of a qualitative fit parameter (e.g., tight, moderate, loose, etc.)”). A POSITA would have recognized that Kriveshko’s “fitting algorithm” constitutes disclosure and suggestion of using an iterative closest point algorithm. *See, e.g.*, EX1007, abstract (“The iterative closest point algorithm includes a determination of a set of points that correspond between the current depth image and the previous depth image”)⁴, 7:21-26 (“the ICP algorithm is an iterative process that determines a set of corresponding points

⁴ Newcombe (EX1007), filed on January 31, 2011, constitutes prior art at least under 35 U.S.C. §102(e).

between the two depth images, determines a transformation that minimizes an error metric over the corresponding points, and repeats the process using the determined transformation until convergence is reached”). *See also* EX1008, abstract (“The iterative closest point (ICP) algorithm ... has been extensively used as optimization technique for rigid model based registration based on features extracted from medical datasets. ICP ... seeks to minimize the sum of the squared distances between all points in a source and their closest points in a target model.”); EX1009, 36-37 (disclosing an “Iteratively Re-weighted Least Squares algorithm”). EX1016, ¶¶180-182.

At a minimum, it would have been obvious to employ an iterative closest point algorithm in Kriveshko’s registration process given that Kriveshko discloses that “any number of quantitative techniques for comparing some or all of the newly acquired three-dimensional data to the previously acquired three-dimensional data” may be used (EX1006, [0067]) and contemplates use of fitting algorithms. As explained above, iterative closest point algorithm is a well-known technique for comparing some or all of the newly acquired three-dimensional data to the previously acquired three-dimensional data and minimizing error, and a POSITA would have recognized its suitability and advantages. EX1008, abstract (“[r]obustness against outliers is guaranteed”), EX1007 (ICP “minimizes an error metric ... until convergence is reached”). EX1007, EX1008, and EX1009 disclose

well known registration techniques (ICP) that were available to a POSITA for implementing the techniques disclosed by Kriveshko. Thus, use of ICP in Kriveshko-Zhang would have been predictable, and a POSITA would have had a reasonable expectation of success, at least because Kriveshko and the references discussing ICP all relate to the same general field of endeavor, *e.g.*, techniques for three-dimensional image processing and model refinement. EX1016, ¶¶183-185.

The '648 Patent merely discloses ICP as one of several possible “suitable techniques” that can be used for three-dimensional registration of points and/or surfaces. EX1001, 18:56-61. *See also id.*, 21:1-5. EX1016, ¶¶186-187.

5. Claim 5: The method of claim 3 further comprising selecting a first selected one of the first plurality of sets and a second selected one of the second plurality of sets that overlap on the combined surface.

Kriveshko in view of Zhang disclose and suggest claim 5. *See* §VII.A.3. (base claim 3). As explained above, Kriveshko “seek[s] to *reacquire* the previous scan by test fitting new scan data to *previously acquired data*” and “initiate a new scan registered or connected to an existing three-dimensional model”. EX1005, [0059] (emphasis added). Kriveshko combines newly acquired data—for example, obtained after an interruption or completion in scanning—with previously acquired data. *Id.*, [0005]. The “reacquisition” of data would involve use of data obtained from the scans that overlap on the combined surface, and it would have been obvious to obtain

overlapping data in the reacquisition process, *e.g.*, to ensure that the target surface is completely scanned. EX1016, ¶¶188-191.

In addition, Kriveshko discloses selecting data based on “*spatial proximity* to the new incremental data” and that “a group of image sets or three-dimensional data sets that are *physically closest* to the last known point on the subject may be used”. EX1005, [0068] (emphasis added). *See also id.*, [0010] (data selected “based upon a spatial proximity of the at least one subsequent three-dimensional image to one or more of the sequence of three-dimensional images”). Given that Kriveshko discloses selecting data based on “spatial proximity” and being “physically closest” to data obtained in a previous scan, Kriveshko teaches selection of overlapping data and such selection would have been obvious. Further, Kriveshko discloses use of “correlation or feature matching ... to obtain a confidence score or other objective measure of fitting” and this would also involve data that overlaps on the combined surface. *Id.*, [0067]. EX1016, ¶¶192-195.

- 6. Claim 6: The method of claim 5 wherein at least one of the first selected one and the second selected one is a set of three-dimensional data closest to a centroid of the combined surface.**

Kriveshko in view of Zhang disclose and suggest claim 6. *See* §VII.A.5. (base claim 5). Zhang discloses “a post-processing refinement procedure” in which “the accumulation of errors along the length of the camera path may be minimized by supplemental frame-to-frame motion estimation with some or all of the global path

information” and employs a centroid of the combined surface in such minimization. EX1006, [0045], [0011]. Zhang discloses minimizing error with use of “a *centroid of common surface data* for two or more three-dimensional reconstructions”. *Id.*, [0011] (emphasis added). *See also id.*, page 36 (claim 40). Zhang discloses storing “point cloud *centroid* calculations, and any other measured or calculated data to support use of the key frames in a three-dimensional reconstruction process as described herein”. *Id.*, [0055] (emphasis added). It would have been obvious to modify Kriveshko to select sets of three-dimensional data closest to a centroid of the combined surface as a further refinement procedure to minimize errors, as taught by Kriveshko and Zhang (*see* §VII.A.1.e.). A POSITA would have had a reasonable expectation of success given that Kriveshko and Zhang relate to similar techniques, and Zhang teaches a refinement procedure for processing data of the type disclosed by Kriveshko (*see, e.g.*, §VII.A.1.e., §V.C.). EX1016, ¶¶196-202.

7. Claim 7: The method of claim 5 further comprising calculating a rigid transformation and a mean error between the first selected one and the second selected one.

Kriveshko in view of Zhang disclose and suggest claim 7. *See* §VII.A.5. (base claim 5). As discussed above concerning Elements [1.3]-[1.4] and Claim 5, Kriveshko discloses calculating a rigid transformation between the first selected one of the first plurality of sets and the second selected one of the second plurality of sets. *See* §VII.A.1.c.-d., §VII.A.5. Patent Owner may argue that Kriveshko does not

disclose calculating a mean error. However, Kriveshko discloses that “it will be appreciated that any suitable technique for registering new three-dimensional data to existing three-dimensional data may be usefully employed”. EX1005, [0070]. Use of mean error values was well known in the context of data alignment and stitching including, for example, in registration and/or usage of an iterative closest point algorithm. *See, e.g.*, EX1008, p.235 (“the transformation that minimizes a mean square metric is computed”), pp.235-240; EX1009, pp.22-25. *See also* EX1010, [0044]. Calculating mean error as a refinement to Kriveshko would have been obvious for at least the reasons discussed with respect to claim 4 and Element [1.5]. *See* §VII.A.4, §VII.A.1.e. EX1016, ¶¶203-209.

8. Claim 8: The method of claim 7 further comprising selecting a first neighborhood of the first plurality of sets from about the one of the first plurality of sets and a second neighborhood of the second plurality of sets from about the one of the second plurality of sets.

Kriveshko in view of Zhang disclose and suggest claim 8. *See* §VII.A.7. (base claim 7). Kriveshko discloses selecting a “reference frame” which can be “three-dimensional data” to assist with the “fit[ting] or stitch[ing]” of “the incremental three-dimensional image data ... to the existing three-dimensional model”. EX1005, [0065]. Kriveshko discloses that the “reference frames may be selected for a test fit” and “[t]he number of reference frames may be selected using various criteria”. *Id.*, [0068]. The reference frames may be selected according to “*temporal proximity*” or

“spatial proximity” to the new incremental data. *Id.* Kriveshko also discloses that “a group of image sets or three-dimensional data sets that are **physically closest** to the last known point on the subject may be used”. *Id.* In Kriveshko, the reference frame (of the first three-dimensional model) and the new incremental data (of the second three-dimensional model) are selected based on “temporal proximity”, “spatial proximity”, and/or being “physically closest to the last known point”. *Id.* Thus, Kriveshko discloses selecting a first neighborhood “from about the one of the first plurality of sets” and a second neighborhood “from about the one of the second plurality of sets”. Similarly, the ’648 Patent discloses that selection of some or all data sets according to proximity results in selection of a neighborhood. EX1001, 20:18-45. EX1016, ¶¶210-217.

9. Claim 9 (Preamble): The method of claim 8 further comprising:

Kriveshko in view of Zhang disclose and suggest the preamble of claim 9. *See* §VII.A.8. (base claim 8). EX1016, ¶¶218-219.

a. [9.1]: extracting a sub-region of the combined surface;

Kriveshko in view of Zhang disclose and suggest Element [9.1]. Kriveshko discloses that “a number of different reference frames (also referred to herein as reference images) may be selected for a test fit.” EX1005, [0068]. The selection of reference frame(s) constitutes extracting a part (“sub-region”) of the entirety of the combined surface. Further, ICP is based on certain features “extracted” from

“datasets” (EX1008, p.234), and it would have been obvious to employ ICP in Kriveshko (*see* Claim 4, §VII.A. 4.). *See also* EX1005, [0067] (use of 3D data “in whole or in part”), [0016] (processing a “portion” of 3D data). EX1016, ¶¶220-224.

b. [9.2]: spatially relating two or more of the first plurality of sets to two or more of the second plurality of sets within the sub-region to provide a virtual stitch graph; and

Kriveshko in view of Zhang disclose and suggest Element [9.2]. As explained above, Kriveshko discloses and teaches creating a “spatial relationship” between disparate models and data sets under the District Court’s and Petitioners’ constructions of “virtual stitch graph”. *See* §VII.A.1.d. (Element [1.4]). For similar reasons, Kriveshko discloses “spatially relating” two or more of the first plurality of sets to two or more of the second plurality of sets. Kriveshko discloses that the first three-dimensional model (*e.g.*, data obtained from an initial scan) includes two or more sets of three-dimensional points, and the second three-dimensional model (*e.g.*, new incremental data obtained from a disparate scan) includes two or more sets of three-dimensional points, as explained above. *See* §VII.A.1.a.-c. Kriveshko discloses “spatially relating” the first three-dimensional model to the second three-dimensional model and in doing so, spatially relates the “two or more of the first plurality of sets” of three-dimensional points (which are included in the first three-dimensional model) to the “two or more of the second plurality of sets” of three-dimensional points (which are included in the second three-dimensional model).

Such spatially relating occurs within the extracted sub-region of the combined surface given that the sub-region constitutes the portion of data selected by the user. A virtual stitch graph is provided (*see* Element [1.5], §VII.A.1.e.). EX1016, ¶¶225-232.

c. [9.3]: minimizing an error among spatial relationships in the virtual stitch graph, thereby providing a combined data set for the sub-region.

Kriveshko in view of Zhang disclose and suggest Element [9.3]. As discussed above, it would have been obvious to refine Kriveshko's combined model using global motion optimization in view of Zhang (*see* Element [1.5], §VII.A.1.e.). The global motion optimization disclosed by Zhang involves "minimizing an error" among spatial relationships in the virtual stitch graph between respective data of the first and second three-dimensional models. *See, e.g.*, EX1006, [0060] ("the objective of numerical optimization is to minimize a calculated error based upon an error function for the camera path and/or reconstructed three-dimensional model."), [0011] ("minimizing an error function for a plurality of camera positions along the camera path"). Such global motion optimization results in providing combined data for the sub-region given that the sub-region is a part of the provided combined model, and the sub-region constitutes the portion of data selected by the user (*see* §VII.A.1.e.). EX1016, ¶¶233-236.

10. Claim 10: The method of claim 9 further comprising creating at least one virtual stitch between two unstitched ones of the first plurality of sets.

Kriveshko in view of Zhang disclose and suggest claim 10. *See* §VII.A.9. (base claim 9). Kriveshko discloses that the first three-dimensional model includes a plurality of sets of three-dimensional points (*see* Element [1.1], §VII.A.1.a.). Kriveshko discloses stitching together unstitched sets of three-dimensional points, and this involves creating a virtual stitch between unstitched data sets. EX1005, [0058] (“The three-dimensional data for each newly acquired two-dimensional image set may be derived and fitted or ‘stitched’ to existing three-dimensional data”), [0062] (“each set of three-dimensional data need not include all, or even most, of the points that might be recovered from the candidate frame.”). *See also* EX1001, 19:32-34 (“there may be little to distinguish a ‘virtual’ stitch ... from those that are not virtual”). Further, Kriveshko discloses creating at least one virtual stitch between disparate data sets (*see* §VII.A.1.d., Element [1.4]), and performing additional stitching as necessary (*e.g.*, EX1005, Fig. 2, [0072]). Such subsequent stitching would involve creating a virtual stitch between unstitched data sets/models, *e.g.*, between both disparate and non-disparate data sets/models. *Id.* EX1016, ¶¶237-241.

11. Claim 11: The method of claim 1 further comprising refining the combined model with a deformable registration.

Kriveshko in view of Zhang disclose and suggest claim 11. *See* §VII.A.1. (base claim 1). The '648 Patent discloses that “deformable registration” encompasses the example in which stitches or steps of the camera path are “moved spatially to minimize global error”. EX1001, 19:43-47. In the obvious combination, the stitches or steps of the camera path of the combined model are moved spatially as a result of the “global motion optimization” taught by Zhang as explained above (*see* Element [1.5], §VII.A.1.e.), *e.g.*, given that the second model is combined with the first model, and thus the combination teaches refining with a “deformable registration”. *See, e.g.*, EX1006, [0022], [0045]. EX1016, ¶¶242-244.

Furthermore, Zhang discloses that “[a]s a further refinement”, the mesh “may be *warped or deformed* by a warping module 362” and “[w]arped images may be used to ease alignment and stitching between images, such as by reducing the initial error in a motion estimate.” EX1006, [0045] (emphasis added). *See also* EX1009, 39-41 (it was known to warp “target image I_1 according to the current motion estimate”). It would have been obvious to employ deformable registration in Kriveshko’s process given that (i) Kriveshko discloses that “any number of quantitative techniques for comparing some or all of the newly acquired three-dimensional data to the previously acquired three-dimensional data” may be used (EX1005, [0067]), (ii) Kriveshko contemplates further refinements and steps in its

process (EX1005, [0062] (use of “a more computationally intensive post-processing step, which might yield greater accuracy and density”), [0087]), and (iii) deformable registration was a well-known technique for data refinement and minimizing error (EX1006, [0045]; EX1009, 39-41). A POSITA would have had a reasonable expectation of success given that Kriveshko and Zhang are from the same field of endeavor (*see* §V.C.), and Zhang teaches a refinement procedure for processing data of the type disclosed by Kriveshko (*see* §VII.A.1.e.). EX1016, ¶¶245-248.

12. Claim 12 (Preamble): A computer program product comprising computer executable code embodied on a non-transitory computer readable medium that, when executing on one or more computing devices, performs the steps of:

Kriveshko discloses and suggests the preamble of Claim 12. *See* §VII.A.1. (preamble of claim 1). Kriveshko discloses that the “computer program product disclosed herein may include computer executable code which may be embodied on a computer readable medium that, when executing on one or more computing devices, performs the steps” of the processes described in Kriveshko. EX1005, [0027]. *See also id.*, [0028]-[0029], [0034]-[0035], [0051], [0056] (disclosing memory and hard drive), [0088], Fig. 1. EX1016, ¶¶249-250.

- a. **[12.1]: obtaining a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path;**

Kriveshko discloses and suggests Element [12.1]. *See* §VII.A.1.a. (Element [1.1]). EX1016, ¶¶251-252.

- b. **[12.2]: obtaining a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related to one another by a second camera path;**

Kriveshko discloses and suggests Element [12.2]. *See* §VII.A.1.b. (Element [1.2]). EX1016, ¶253.

- c. **[12.3]: registering one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-dimensional model and the second three-dimensional model in a shared coordinate system;**

Kriveshko discloses and suggests Element [12.3]. *See* §VII.A.1.c. (Element [1.3]). EX1016, ¶254.

- d. **[12.4]: creating a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph; and**

Kriveshko discloses and suggests Element [12.4]. *See* §VII.A.1.d. (Element [1.4]). EX1016, ¶255.

- e. **[12.5]: refining the combined model with a global motion optimization of the virtual stitch graph.**

Kriveshko in view of Zhang disclose and suggest Element [12.5]. *See* §VII.A.1.e. (Element [1.5]). EX1016, ¶256.

- 13. Claim 13: The computer program product of claim 12 further comprising code that performs the step of generating a first surface mesh of the first three-dimensional model and a second surface mesh of the second three-dimensional model.**

Kriveshko in view of Zhang disclose and suggest claim 13 for at least the same reasons discussed above with respect to claim 2. *See* §§VII.A.2. (claim 2) and VII.A.12. (base claim 12). EX1016, ¶¶257-259.

- 14. Claim 14: The computer program product of claim 13 wherein registering includes registering the first surface mesh to the second surface mesh, thereby providing a combined surface.**

Kriveshko in view of Zhang disclose and suggest claim 14 for at least the same reasons discussed above with respect to claim 3. *See* §VII.A.3. (claim 3) and §VII.A.13. (base claim 13). EX1016, ¶¶260-262.

- 15. Claim 15: The computer program product of claim 14 wherein registering includes registering with an iterative closest point algorithm.**

Kriveshko in view of Zhang disclose and suggest claim 15 for at least the same reasons discussed above with respect to claim 4. *See* §VII.A.4. (claim 4) and §VII.A.14. (base claim 14). EX1016, ¶¶263-265.

- 16. Claim 16: The computer program product of claim 14 further comprising code that performs the step of selecting a first selected one of the first plurality of sets and a second selected one of the second plurality of sets that overlap on the combined surface.**

Kriveshko in view of Zhang disclose and suggest claim 16 for at least the same reasons discussed above with respect to claim 5. *See* §VII.A.5. (claim 5) and §VII.A.14. (base claim 14). EX1016, ¶¶266-268.

- 17. Claim 17: The computer program product of claim 16 wherein at least one of the first selected one and the second selected one is a set of three-dimensional data closest to a centroid of the combined surface.**

Kriveshko in view of Zhang disclose and suggest claim 17 for at least the same reasons discussed above with respect to claim 6. *See* §VII.A.6. (claim 6) and §VII.A.16. (base claim 16). EX1016, ¶¶269-271.

- 18. Claim 18: The computer program product of claim 16 further comprising code that performs the step of calculating a rigid transformation and a mean error between the first selected one and the second selected one.**

Kriveshko in view of Zhang disclose and suggest claim 18 for at least the same reasons discussed above with respect to claim 7. *See* §VII.A.7. (claim 7) and §VII.A.16. (base claim 16). EX1016, ¶¶272-274.

- 19. Claim 19: The computer program product of claim 18 further comprising code that performs the step of selecting a first neighborhood of the first plurality of sets from about the one of the first plurality of sets and a second neighborhood of the second plurality of sets from about the one of the second plurality of sets.**

Kriveshko in view of Zhang disclose and suggest claim 19 for at least the same reasons discussed above with respect to claim 8. *See* §VII.A.8. (claim 8) and §VII.A.18. (base claim 18). EX1016, ¶¶275-277.

- 20. Claim 20 (Preamble): The computer program product of claim 19 further comprising code that performs the steps of:**

Kriveshko discloses and suggests the preamble of Claim 20. *See* §VII.A.9. (preamble of claim 9) and §VII.A.19. (base claim 19). EX1016, ¶¶278-279.

- a. [20.1]: extracting a sub-region of the combined surface;**

Kriveshko in view of Zhang disclose and suggest Element [20.1] for at least the same reasons discussed above with respect to Element [9.1]. *See* §VII.A.9.a. EX1016, ¶280.

- b. [20.2]: spatially relating two or more of the first plurality of sets to two or more of the second plurality of sets within the sub-region to provide a virtual stitch graph; and**

Kriveshko in view of Zhang disclose and suggest Element [20.2] for at least the same reasons discussed above with respect to Element [9.2]. *See* §VII.A.9.b. EX1016, ¶281.

- c. **[20.3]: minimizing an error among spatial relationships in the virtual stitch graph, thereby providing a combined data set for the sub-region.**

Kriveshko in view of Zhang disclose and suggest Element [20.3] for at least the same reasons discussed above with respect to Element [9.3]. *See* §VII.A.9.c. EX1016, ¶282.

21. **Claim 21: The computer program product of claim 20 further comprising code that performs the step of creating at least one virtual stitch between two unstitched ones of the first plurality of sets.**

Kriveshko in view of Zhang disclose and suggest Claim 21 for at least the same reasons discussed above with respect to Claim 10. *See* §VII.A.10. (claim 10) and VII.A.20 (base claim 20). EX1016, ¶¶283-285.

22. **Claim 22: The computer program product of claim 12 further comprising code that performs the step of refining the combined model with a deformable registration.**

Kriveshko in view of Zhang disclose and suggest Claim 22 for at least the same reasons discussed above with respect to Claims 11 and 12. *See* §§VII.A.11. (claim 11) and §VII.A.12. (base claim 12). EX1016, ¶¶286-288.

23. **Claim 23 (Preamble): A system comprising:**

Kriveshko discloses and suggests the preamble of Claim 23. *See* §§VII.A.1. (preamble of claim 1), VII.A.12. (preamble of claim 12). Kriveshko discloses “[a] scanning system that acquires three-dimensional images as an incremental series of fitted three-dimensional data sets is improved by testing for successful incremental

fits in real time and providing a variety of visual user cues and process modifications depending upon the relationship of newly acquired data to previously acquired data.”

EX1005, abstract. Kriveshko discloses an image capture system 100 including a scanner 102 that captures images of a subject 104 within an image plane 106, and forwards the images to a computer 108, which may include a display 110 and one or more user input devices such as a mouse 112 or a keyboard 114. *Id.*, [0051].

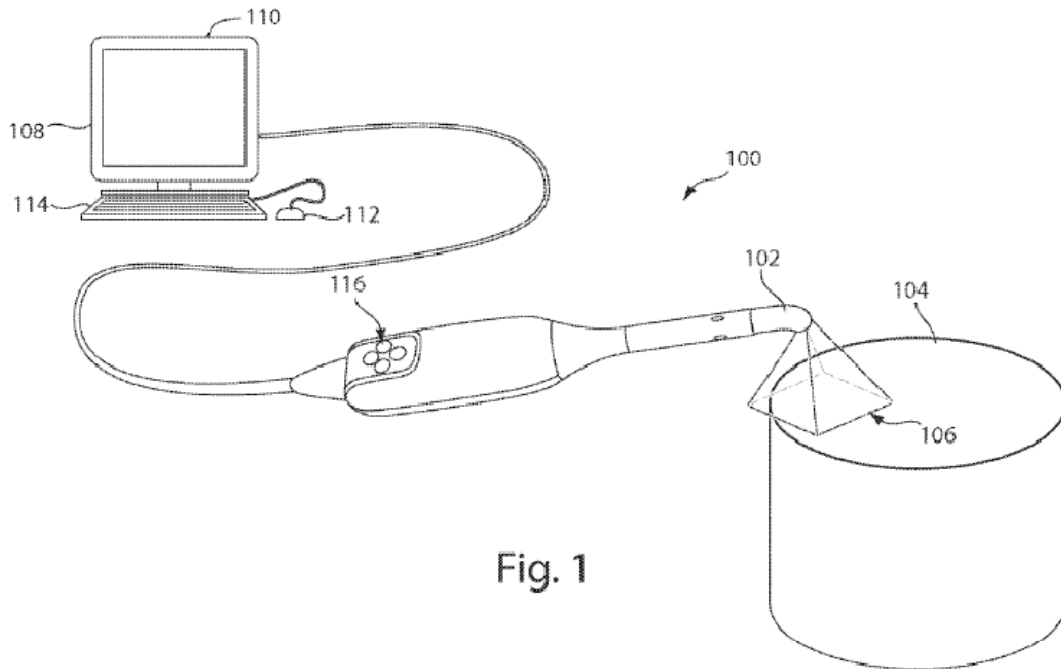


Fig. 1

Figure 1 of Kriveshko

See also EX1005, [0027]-[0029], [0034]-[0035], [0088]. EX1016, ¶¶289-292.

- a. **[23.1]: a scanner configured to obtain a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path and**

Kriveshko discloses and suggests Element [23.1] for at least the same reasons as Elements [1.1] and [12.1]. *See* §§VII.A.1.a, VII.A.12.a. Kriveshko discloses that the system “may include a scanning device that acquires three-dimensional surface data from a subject as a sequence of three-dimensional images, each one of the sequence of three-dimensional images fitted to at least one previous one of the sequence of three-dimensional images.” EX1005, [0013]. Kriveshko discloses that first and second three-dimensional models and data associated therewith are obtained by a scanner. *Id.*, [0060] (“The process 200 may begin 202 by acquiring a candidate frame from a sensor, such as an image set from the scanner 102 described above”), [0086] (“new frame of data may be acquired from the scanner 102. At this point, the newly derived three-dimensional data may be fitted to three-dimensional data previously derived in the recover mode.”), Figure 1 (scanner 102). EX1016, ¶¶293-296.

- b. **[23.2]: a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related with one another by a second camera path;**

Kriveshko discloses and suggests Element [23.2] for at least the same reasons as Elements [1.2], [12.2], and [23.1]. *See* §§VII.A.1.b., VII.A.12.b., VII.A.23.a. EX1016, ¶297.

- c. **[23.3]: a processor and memory configured to register one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-dimensional model and the second three-dimensional model in a shared coordinate system,**

Kriveshko discloses and suggests Element [23.3] for at least the same reasons as Elements [1.3] and [12.3]. *See* §§VII.A.1.c., VII.A.12.c. Further, Kriveshko discloses a processor and memory used to perform the various processes disclosed therein. EX1005, [0056] (“The computer 108 may be, for example, a personal computer or other processing device. In one embodiment, the computer 108 includes a personal computer with a dual 2.8 GHz Opteron central processing unit, 2 gigabytes of random access memory, a TYAN Thunder K8WE motherboard, and a 250 gigabyte, 10,000 rpm hard drive.”). *See also id.*, [0088]. EX1016, ¶¶298-300.

- d. **[23.4]: to create a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph, and**

Kriveshko discloses and suggests Element [23.4] for at least the same reasons as Elements [1.4], [12.4], and [23.3]. *See* §§VII.A.1.d., VII.A.12.d., VII.A.23.c. EX1016, ¶301.

- e. **[23.5]: to refine the combined model with a global motion optimization of the virtual stitch graph; and**

Kriveshko in view of Zhang disclose and suggest Element [23.5] for at least the same reasons as Elements [1.5], [12.5], and [23.3]. *See* §§VII.A.1.e., VII.A.12.e., VII.A.23.c. *See also* EX1006, [0045], Fig. 3. EX1016, ¶302.

- f. **[23.6]: a display configured to render the combined model.**

Kriveshko in view of Zhang disclose and suggest Element [23.6]. Kriveshko's system includes a display 110 (Figure 1). EX1005, [0051]. Kriveshko discloses that the display is configured to render the combined model. *Id.*, [0093] (“a large three-dimensional model may be acquired, and the aggregate point cloud may be rendered with shading to simulate a three-dimensional view of the point cloud”). *See also id.*, [0062] (“relatively sparse subset of pixel data may be employed for real time rendering and feedback”), [0076] (“The computer may render the three-dimensional

model, which may be a three-dimensional point cloud of surface data acquired for the subject 104”). [0013]-[0014]. EX1016, ¶¶303-305.

24. Claim 24 (Preamble): A system comprising:

Kriveshko discloses and suggests the subject matter of the preamble of Claim 24. *See* §VII.A.23 (preamble of claim 23). EX1016, ¶306.

a. [24.1]: scanning means for obtaining a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path and

Kriveshko discloses and suggests Element [24.1] for at least the same reasons as Element [23.1]. *See* §VII.A.23.a. As explained above in §VI.D., the District Court and parties did not construe the term “scanning means” under §112(f)/112(6). Nonetheless, Kriveshko discloses performing the function of scanning for obtaining a first three-dimensional model including a first plurality of sets of three-dimensional points spatially related to one another by a first camera path, and a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related to one another by a second camera path. *See, e.g.,* Elements [1.1]-[1.2] above (§VII.A.1.). Kriveshko discloses structure for performing this function, *e.g.,* a scanner that captures images from a surface of an object (EX1005, [0051], [0063]); a camera or camera system suitable for capturing images from which a three-dimensional point cloud or other three-dimensional data may be recovered (EX1005, [0052], [0063]); and a handheld, freely positionable

probe having at least one user-input device such as a button, lever, dial, thumb wheel, switch, or the like, for user control of the image capture system such as starting and stopping scans (EX1005, [0052]). §VII.A.23.a. Thus, Kriveshko discloses and suggests Element [24.1] under any construction. EX1016, ¶¶307-310.

- b. [24.2]: a second three-dimensional model including a second plurality of sets of three-dimensional points spatially related with one another by a second camera path; and**

Kriveshko discloses and suggests Element [24.2] for at least the same reasons as Element [23.2]. *See* §VII.A.23.b. Kriveshko discloses and suggests “scanning means” under any construction. *See* §VII.A.24.a. (Element [24.1]). EX1016, ¶¶311-312.

- c. [24.3]: processing means for registering one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-dimensional model and the second three-dimensional model in a shared coordinate system,**

Kriveshko in view of Zhang disclose and suggest Element [24.3] for at least the same reasons as Element [23.3]. *See* §VII.A.23.c. As explained above in § VI.D., the District Court and parties did not construe the term “processing means” under §112(f)/112(6). Nonetheless, Kriveshko-Zhang discloses performing the function of registering one of the first plurality of sets of three-dimensional points to one of the second plurality of sets of three-dimensional points to place the first three-

dimensional model and the second three-dimensional model in a shared coordinate system, creating a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph, and refining the combined model with a global motion optimization of the virtual stitch graph. *See, e.g.*, Elements [1.3]-[1.5] above (§VII.A.1.c.-e.). Kriveshko discloses structure for performing this function, *e.g.*, a personal computer or other processing device (EX1005, [0056]); one or more microprocessors, microcontrollers, embedded microcontrollers, programmable digital signal processors or other programmable devices, along with internal and/or external memory (EX1005, [0088]); and an application specific integrated circuit, a programmable gate array, programmable array logic, or any other device that may be configured to process electronic signals (EX1005, [0088]). Kriveshko-Zhang discloses and suggests Element [24.3] under any construction. EX1016, ¶¶313-316.

- d. [24.4]: creating a virtual stitch graph that spatially relates the first plurality of sets and the second plurality of sets, thereby providing a combined model that includes the first plurality of sets and the second plurality of sets all spatially related by the virtual stitch graph, and**

Kriveshko in view of Zhang disclose and suggest Element [24.4] for at least the same reasons as Element [23.4]. *See* §VII.A.23.d. Kriveshko-Zhang discloses

and suggests “processing means” under any construction. *See* §VII.A.24.c. (Element [24.3]). EX1016, ¶¶317-318.

e. [24.5]: refining the combined model with a global motion optimization of the virtual stitch graph.

Kriveshko in view of Zhang disclose and teach Element [24.5] for at least the same reasons as Element [23.5]. *See* §VII.A.23.e. *See also* EX1006, [0045], Fig. 3. Kriveshko-Zhang discloses and suggests “processing means” under any construction. *See* §VII.A.24.c. (Element [24.3]). EX1016, ¶¶319-320.

B. Claims 4 and 7 Would Have Been Obvious Over Kriveshko in View of Zhang, Further in View of Estépar and Szeliski (Ground 2).

Patent Owner may argue that Kriveshko-Zhang does not disclose the steps recited in dependent claims 4 and 7. Any such argument is untenable. As explained above, claims 4 and 7 would have been obvious over Kriveshko-Zhang as evidenced by Estépar and Szeliski. *See* §§VII.A.4., VII.A.7. EX1016, ¶¶321-322.

Further, each of Estépar and Szeliski disclose, suggest, and teach claims 4 and 7 for the reasons discussed above in Ground 1. *See* §§VII.A.4., VII.A.7. A POSITA would have had reason to combine Kriveshko-Zhang with each of Estépar and Szeliski with a reasonable expectation of success to arrive at claims 4 and 7 for the reasons discussed above. For example, Kriveshko discloses use of a “fitting algorithm” and “any number of quantitative techniques” (EX1005, [0067]), and Estépar and Szeliski disclose one such well-known technique with recognized

advantages—ICP. *See also* EX1007, abstract (discussed above). Use of ICP in Kriveshko-Zhang would have been predictable, and a POSITA would have had a reasonable expectation of success, at least because Kriveshko-Zhang and the references discussing ICP all relate to the same general field of endeavor, *e.g.*, techniques for three-dimensional image processing and model refinement. Thus, claims 4 and 7 would have been obvious for a number of reasons. EX1016, ¶¶323-327.

VIII. OTHER CONSIDERATIONS

A. Any Purported Secondary Considerations Evidence Does Not Overcome the Strong Evidence of the Obviousness of the Claims

All elements of Claims 1-24 are known in the art, and any differences between the claims of the '648 Patent and the cited art would have been obvious to a POSITA based on the disclosures of the applied references and the knowledge in the art. EX1016, ¶329.

Petitioners are not aware of any secondary considerations evidence bearing any nexus to the purported claimed invention. EX1016, ¶328. Any purported evidence of secondary considerations that Patent Owner may present in this proceeding would be insufficient to overcome the strong evidence of obviousness of the Challenged Claims.

B. The Board Should Not Deny This Petition Under §314(a)

Petitioners hereby stipulate that, should the Petition be granted, Petitioners will not pursue in the Related Litigation the same grounds or any grounds that are raised or could have reasonably been raised in this Petition pursuant to *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB Dec. 1, 2020). The Director has stated that “the PTAB will not discretionarily deny institution of an IPR” in view of such a stipulation. Katherine K. Vidal, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (June 21, 2022) at 3 and n.3 (discussing *Sotera*); *see id.* at 7–9.

Accordingly, Petitioners’ stipulation is dispositive in establishing that institution should not be discretionarily denied under 35 U.S.C. §314(a).

C. The Board Should Not Deny This Petition Under §325(d)

There is no reason to deny institution under §325(d). The totality of the *Becton, Dickinson* factors favor institution. The ’442 Application was allowed in the first action on the merits without any prior art rejection. EX1002, pp.9-16. In the present Petition, aspects of the prior art and arguments not considered by the USPTO due to material error during prosecution warrant institution. *See Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 at 8-9 (PTAB Feb. 13, 2020) (precedential). While the Examiner initialed an IDS citing Kriveshko during prosecution, the Examiner did not substantively discuss

Kriveshko, much less present any rejection based on Kriveshko. The Board has found such consideration without further analysis to be insufficient to warrant discretionary denial. *See e.g., Amgen Inc. v. Alexion Pharm., Inc.*, IPR2019-00740, Paper 15 (PTAB Aug. 30, 2019); *Scientific Design Co. v. Shell Oil Co.*, IPR2021-01537, Paper 7 (PTAB Mar. 18, 2022) and IPR2022-00158, Paper 7 (PTAB Apr. 4, 2022). Moreover, the Patent Office failed to appreciate the obviousness of the Challenged Claims in view of the combination of Kriveshko and Zhang—the grounds presented in this Petition. And certainly, the Patent Office did not previously rely on the specific disclosures of Kriveshko which Petitioners now rely on to address the claimed subject matter discussed above (*see* §VII. above). The Patent Office’s overlooking of the specific teachings of Kriveshko discussed herein constitutes material error. *Advanced Bionics* at 8 n.9 (“material error may include misapprehending or overlooking specific teachings of the relevant prior art where those teachings impact patentability of the challenged claims”). The Board has consistently declined to discretionarily deny institution under such circumstances. *See, e.g., DISH Network LLC v. Sound View Innovations, LLC*, IPR2020-01041, Paper 13, 22 (PTAB Jan 19, 2021); *Roku, Inc. v. Universal Electronics, Inc.*, IPR2019-01615 (PTAB April 17, 2020); *Trans Ova Genetics, LC v. XY, LLC*, IPR2018-00250, Paper 9, 18-19 (PTAB June 27, 2018). Zhang, Estépar, and Szeliski were also not before the Examiner during prosecution. Assuming (incorrectly) that

Zhang, Estépar, and/or Szeliski are cumulative, their combination with Kriveshko creates no basis for denial.

Further, with respect to factor (f), the Petition is supported by an expert declaration by Dr. Eli Saber explaining how a POSITA would have understood the prior art combinations. EX1016, ¶¶1-331. This new evidence also weighs against discretionary denial. *See, e.g., Puma N. Am., Inc. v. Nike, Inc.*, IPR2019-01058, Paper 10, 19 (PTAB Oct. 31, 2019) (instituting where petition presented “new non-cumulative evidence.... probative to issues of patentability and helpful to our consideration of a prior art combination that was not before the Examiner”).

IX. CONCLUSION

For at least the foregoing reasons, Claims 1-24 of the '648 Patent are unpatentable. Since Petitioners have shown the claims to be *prima facie* obvious, Petitioners have also shown a likelihood of success on the merits. Therefore, this Petition should be granted, and the Board should institute trial.

Date: August 13, 2024

Respectfully submitted,

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APPENDIX A—LIST OF EXHIBITS

EXHIBIT	DESCRIPTION
1001	U.S. Patent No. 9,191,648, issued on November 17, 2015 to I. Kriveshko and B. Frantzdale (“the ’648 Patent”)
1002	File History of U.S. Patent Application No. 14/000,442, filed on August 20, 2013
1003	International PCT Publication No. WO 2012/115863, published on August 30, 2012 (Int’l Appln. No. PCT/US12/25554)
1004	U.S. Provisional Application No. 61/445,464, filed on February 22, 2011
1005	U.S. Patent Application Publication No. 2007/0171220 (“Kriveshko”)
1006	International Publication No. WO 2009/089129 (“Zhang”)
1007	U.S. Patent No. 8,401,225 (“Newcombe”)
1008	Estépar, R. S. J., Brun, A., & Westin, C. F. (2004). Robust generalized total least squares iterative closest point registration. In <i>Medical Image Computing and Computer-Assisted Intervention–MICCAI 2004: 7th International Conference, Saint-Malo, France, September 26-29, 2004. Proceedings, Part I</i> , pp. 234-241, Springer Berlin Heidelberg (“Estépar”)
1009	Szeliski, R. (2006). <i>Image Alignment and Stitching: A Tutorial, Foundations and Trends in Computer Graphics and Vision</i> , vol. 2, issue 1, pp. 1-104 (“Szeliski”)
1010	U.S. Patent Application Publication No. 2007/0172112 (“Paley”)
1011	U.S. Patent Application Publication No. 2010/0303341 (“Häusler”)
1012	U.S. Patent Application Publication No. 2010/0194863 (“Lopes”)

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EXHIBIT	DESCRIPTION
1013	Order Severing Claims Related to Counterclaim Patents filed on September 8, 2023 in <i>3Shape A/S v Medit Corporation</i> , Civ. Action No. 6:22-cv-00443 (WDTX)
1014	Defendant Medit Corporation's Answer to Plaintiff's Complaint and Affirmative Counterclaims filed on August 18, 2023 in <i>3Shape A/S v Medit Corporation</i> , Civ. Action No. 6:22-cv-00443 (WDTX)
1015	Claim Construction Order for U.S. Patent Nos. 7,912,257; 9,191,648; 9,245,374; 9,262,864 filed on May 31, 2024 in <i>Medit Corporation v. 3Shape A/S</i> , Civ. Action No. 6:23-cv-00658 (WDTX)
1016	Declaration of Eli Saber, Ph.D.
1017	<i>Curriculum Vitae</i> of Eli Saber, Ph.D.
1018	Declaration of Ingrid Hsieh-Yee, Ph.D.
1019	<i>Curriculum Vitae</i> of Ingrid Hsieh-Yee, Ph.D.

CERTIFICATE OF COMPLIANCE WITH 37 C.F.R. §42.24

I hereby certify that the word count for the foregoing Petition totals 13,903 words, excluding the parts which are exempted by 37 C.F.R. §42.24(a)(1).

Date: August 13, 2024

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that on this 13th day of August, 2024, a true and correct copy of the foregoing **PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,191,648 UNDER 35 U.S.C. §§311–19 and 37 C.F.R. §42.100 *et seq.* and EXHIBITS 1001–1019** are being served by USPS Priority Mail Express on the correspondence address of record as follows:

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