UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DENTAL IMAGING TECHNOLOGIES CORPORATION,
Petitioner

v.

3SHAPE A/S,
Patent Owner

U.S. Patent No. 10,695,151 to FISKER *et al.*
Issue Date: June 30, 2020
Title: DETECTING TOOTH SHADE

Petition for *Inter Partes* Review of U.S. Patent No. 10,695,151 under 35 U.S.C. §§ 311-319 and 37 C.F.R. § 42.100 *et seq.*

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TABLE OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 10,695,151
1002	File History for U.S. Patent No. 10,695,151
1003	Declaration of Ioannis A. Kakadiaris
1004	Patent Office Action
1005	U.S. Patent No. 8,532,355 ("Quadling")
1006	U.S. Patent No. 8,570,530 ("Liang")
1007	DK priority document
1008	Toriwaki *et al.*, Fundamentals of Three-Dimensional Digital Image Processing, Springer, 2009
1009	Gonzalez *et al.*, Digital Image Processing, Third Edition, Pearson Prentice Hall, 2008
1010	Richert *et al.*, Intraoral Scanner Technologies: A Review to Make a Successful Impression, Journal of Healthcare Engineering, 2017
1011	Logozzo *et al.*, Recent advances in dental optics – Part I: 3D intraoral scanners for restorative dentistry, Opt Laser Eng, 2013
1012	Kang, Three-Dimensional Lookup Table with Interpolation, Computational Color Technology, Chapter 9, 2006
1013	Vadher *et al.*, Basics of Color in Dentistry: A Review, IOSR Journal of Dental and Medical Sciences, 13(9):78-85, Sep. 2014
1014	Douglas *et al.*, Intraoral determination of the tolerance of dentists for perceptibility and acceptability of shade mismatch, Journal of Prosthetic Dentistry, 9(4):200-208, April 2007
1015	Corcodel *et al.*, Metameric effect between natural teeth and the shade tabs of a shade guide, European Journal of Oral Sciences, 2010.
1016	Borse *et al.*, Tooth shade analysis and selection in prosthodontics: A systematic review and meta-analysis, J Indian Prosthodont Soc, 20:131-40, 2020
1017	Baltzer *et al.*, The Determination of the Tooth Colors, Quintessenz Zahntechnik, 30(7):726-740, 2004

1018	Declaration of Dr. James L. Mullins ("Mullins Decl.")
1019	*Curriculum Vitae* of Dr. James L. Mullins
1020	*Curriculum Vitae* of Dr. Ioannis A. Kakadiaris
1021	Lagouvardos *et al.,* Repeatability and Interdevice Reliability of Two Portable Color Selection Devices in Matching and Measuring Tooth Color, J. Prosthetic Dentistry (2007) ("Lagouvardos")
1022	Ishikawa-Nagai *et al.,* Reproducibility of Tooth Color Gradation Using A Computer Color-Matching Technique Applied to Ceramic Restorations, J. Prosthetic Dentistry (2005) ("Ishikawa-Nagai")
1023	Tung *et al.,* The Repeatability of an Intraoral Dental Colorimeter, J. Prosthetic Dentistry (2002) ("Tung")
1105	U.S Patent No. 7,698,068 ("Babayoff")
1106	Chu et al., "Dental Color Matching Instruments and Systems. Review of Clinical and Research Aspects," Journal of Dentistry, 38 Supp 2:e2-16, 2010 ("Chu")
1107	U.S. Patent Publication No. 2005/0074718 ("Graham")
1108	WIPO Patent Publication No. 2010/145669 ("Fisker")
1109	U.S. Patent Publication No. 2010/0201986 ("Inglese")
1110	U.S. Patent No. 6,249,616 ("Hashimoto")
1111	U.S. Patent Publication No. 2011/0188726 ("Nathaniel")

LIST OF CHALLENGED CLAIMS

Claim	Limitation
1[pre]	A method for determining shade of a patient's tooth, wherein the method comprises:
1[a]	obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data and texture data for the tooth; and
1[b]	determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values,
1[c]	wherein the method comprises deriving a certainty score expressing the certainty of the determined tooth shade value.
2	The method according to claim 1, wherein determining the tooth shade value for the point comprises selecting the reference tooth shade value with the known texture value closest to the texture data of the point.
3	The method according to claim 1, wherein determining the tooth shade value for the point comprises an interpolation of the two or more reference tooth shade values having known texture values close to the texture data of the point.
6	The method according to claim 1, wherein the method comprises comparing the derived certainty score with a range of acceptable certainty score values.
7	The method according to claim 1, wherein the certainty measure relates to how uniform the sub-scan texture information is at the point, and/or to how close the texture data is to the known texture value of the determined tooth shade value, and/or to the amount of texture information used to derive the texture data at the point.
9	The method according to claim 1, wherein the one or more reference tooth shade values relate to shade values for natural

Claim	Limitation
	teeth with intact surface and/or to shade values for teeth prepared for a dental restoration.
10	The method according to claim 1, wherein the method comprises comparing the texture data with known texture values for soft oral tissue, such as gum tissue and gingiva.
11	The method according to claim 1, wherein the texture information comprises at least one of tooth color or surface roughness.
12	The method according to claim 1, wherein the method comprises creating a shade profile for the tooth from shade values determined one or more points on the tooth.
13[pre]	A method for determining shade of a patient's tooth, wherein the method comprises:
13[a]	obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data and texture data for the tooth; and
13[b]	determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values,
13[c]	wherein the method comprises creating a shade profile for the tooth from shade values determined one or more points on the tooth,
13[d]	wherein the tooth shade profile comprises a one or more tooth shade regions on the tooth surface where an average tooth shade is derived for each region from tooth shade values determined for a number of points within the region.
14[pre]	A method for determining shade of a patient's tooth, wherein the method comprises:

Claim	Limitation
14[a]	obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data and texture data for the tooth; and
14[b]	determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values,
14[c]	wherein obtaining the digital 3D representation of the tooth comprises recording a series of sub-scans of the tooth, where at least one of said sub-scans comprises both texture information and geometry information for said tooth, and generating the digital 3D representation of the tooth from the recorded series of sub-scans.
15	The method according to claim 14, wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans.
16	The method according to claim 15, wherein combining the texture information from the sub-scans comprises interpolating the texture information and/or calculating an average value of the texture information.
17	The method according to claim 16, wherein the calculated average value is a weighted average of the texture information.

I. INTRODUCTION

Petitioner Dental Imaging Technologies Corporation ("Petitioner" or "DITC"), in accordance with 35 U.S.C. §§ 311-19 and 37 C.F.R. § 42.100 *et seq.*, respectfully requests IPR of claims 1-3, 6, 7, and 9-17 (the "Challenged Claims") of U.S. Patent No. 10,695,151 ("the '151 patent") (Ex. 1001), which, according to USPTO records, is assigned to 3Shape A/S ("Patent Owner" or "3Shape").

II. STATEMENT OF RELIEF REQUESTED

Petitioner respectfully requests that the Challenged Claims be cancelled based on the following grounds (collectively, "Grounds"):

Ground 1: Claims 1, 2, 6, 7, and 9-15 are unpatentable under AIA 35 U.S.C. § 103 as obvious based on U.S. Patent No. 7,698,068 ("Babayoff") (Ex. 1105) in view of Chu *et al.*, "Dental Color Matching Instruments and Systems. Review of Clinical and Research Aspects," Journal of Dentistry 38S (2010) ("Chu") (Ex. 1106).

Ground 2: Claim 3 is unpatentable under AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Chu and U.S. Patent Publication No. 2005/0074718 ("Graham") (Ex. 1107).

Ground 3: Claims 15-17 are unpatentable under AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Chu and U.S. Patent Publication No. 2011/0188726 ("Nathaniel") (Ex. 1111).

Ground 4: Claims 1, 2, 7, and 9-15 are unpatentable under AIA 35 U.S.C. §

103 as obvious based on Babayoff in view of U.S. Patent Publication No. 2010/0201986 ("Inglese") (Ex. 1109).

Ground 5: Claim 3 is unpatentable under AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Inglese and Graham.

Ground 6: Claims 15-17 are unpatentable under AIA 35 U.S.C. § 103 as obvious based on Babayoff in view of Inglese and Nathaniel.

The '151 patent was filed as U.S. Patent Application No. 15/888,764 on February 5, 2018. The '151 patent is a continuation of U.S. Patent Application No. 15/117,078, now U.S. Patent No. 10,010,387 ("'387 patent"). The '387 patent was a national-stage entry of PCT/EP2015/052537, filed on February 6, 2015. The '151 patent and the '387 patent claim priority to Danish Patent Application No. 2014 70066 ("DK priority document"; Ex. 1007), filed on February 7, 2014. For the purposes of determining the priority date, the earliest possible priority date for the claims of the '151 patent is February 7, 2014, although Petitioner reserves the right to challenge whether that date is the effective date for one or more claims in other proceedings.

Babayoff issued on April 13, 2010. Ex. 1105, Cover. Chu published in December 2010. Ex. 1106, Cover. Ex. 1018, ¶¶34-35. Inglese published on August 12, 2010. Ex. 1109, Cover. Graham published on April 7, 2005. Ex. 1107, Cover. Nathaniel published on August 4, 2011. Ex. 1111, Cover. Therefore, Babayoff, Chu,

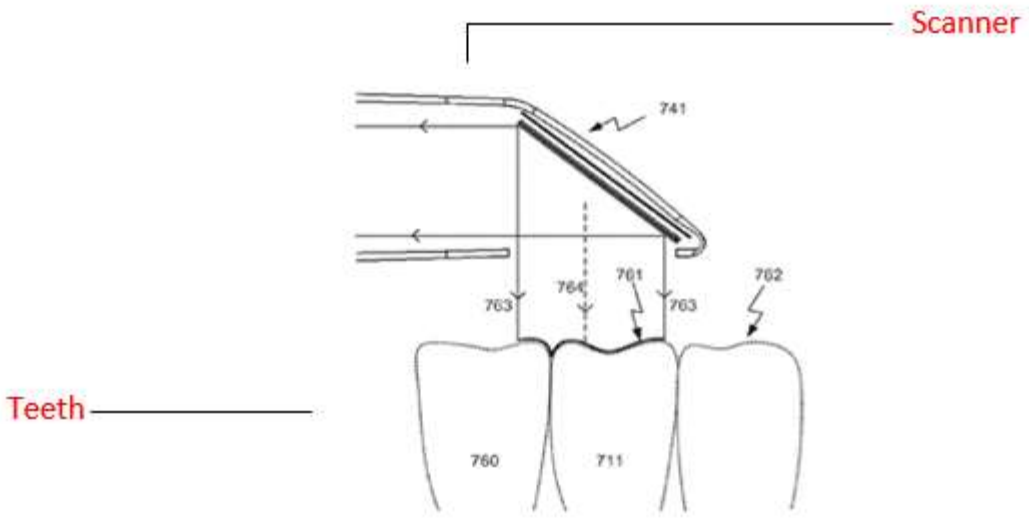
Inglese, Graham, and Nathaniel are prior art to the ’151 patent under at least AIA 35 U.S.C. § 102(a).

III. OVERVIEW OF THE ’151 PATENT AND FILE HISTORY

A. The ’151 Patent

The ’151 patent discloses methods for automating tooth shade determination by obtaining a 3D representation of the tooth comprising shape data and texture data. *See, e.g.*, Ex. 1001, 2:6-10. A tooth shade value is determined for at least one point on the tooth based on the texture data of the corresponding point and on known texture values of one or more tooth shade values. *Id.*, 2:10-15. The texture data is described as at least one of tooth color or surface roughness. *Id.*, 2:32-38. The shape data expresses the shape of the tooth. *Id.*

The ’151 patent discloses a system where both a three-dimensional model of teeth and the texture of the teeth are determined using an intraoral scanner. *Id.*, 15:52-16:32. Figure 7A illustrates scanning a set of teeth:



Id., FIG. 7A (annotated), 16:9-13. As illustrated in Figures 7B-D, sub scans are a series of scans taken as the scanner is manually moved by the user. *Id.*, FIG. 7; *see also id.*, 16:33-51.

When the texture data is tooth color, the texture data may express a color profile of the tooth, and the tooth shade value for a point on the tooth may be derived by comparing the color data of the corresponding point of the digital 3D representation with known color values of one or more reference tooth shade values. *Id.*, 2:39-45, 14:42-67. Figure 4 below shows a screen shot 410 where determined tooth shade values are derived for 15 regions on the tooth 411. *Id.*, 14:17-19.

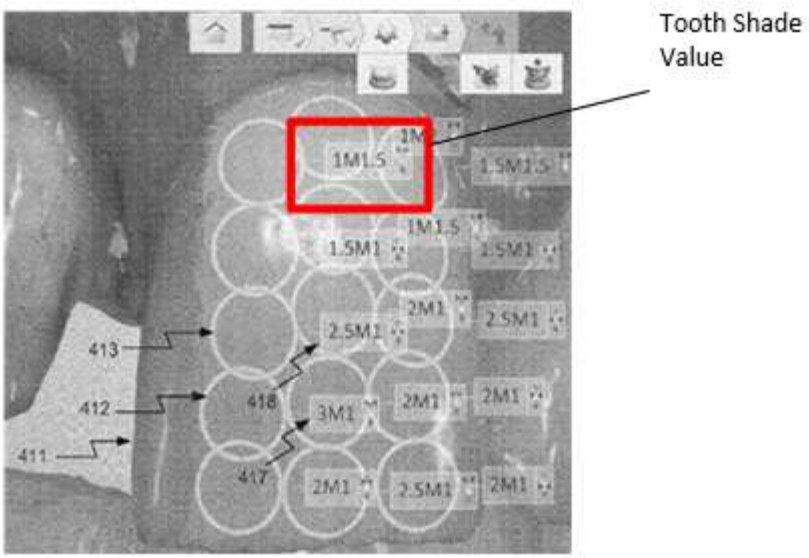


FIG. 4 (annotated).

The ’151 patent explains selecting the tooth shade value of the point can comprise calculating the color difference between the determined color data in the point and the color data of the reference tooth shade values. *Id.*, 5:51-54. This difference can, *e.g.*, be calculated as a Euclidian distance in the used color space, *e.g.*, the L*a*b* color space or the lightness-hue-chroma color space. *Id.*, 5:54-56. The Euclidian distance ΔE between two points in the L*a*b* color space may be given by the following equation:

$$\Delta E = \sqrt[2]{(L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2}$$

Id., 5:56-64. The ’151 patent explains that selecting the tooth shade value can then comprise determining for which of the reference tooth shades the color difference,

i.e., the Euclidian distance ΔE, is smallest. *Id.*, 5:65-67.

B. Prosecution History of the '151 Patent

U.S. Patent Application No. 15/888,764, which issued as the '151 patent, was filed with 18 original claims (claim 1 was independent). On September 20, 2019, the Examiner issued a non-final Office Action rejecting claims 1-18 for obviousness-type double patenting as being unpatentable over claims 1-18 of U.S. Patent No. 8,998,719 ("the '719 patent"), and over claim 1 of the '387 patent. Ex. 1004, 2-4. Claims 1-3 and 10-13 were also rejected under 35 U.S.C. §103 as being unpatentable over Quadling (Ex. 1005) and Liang (Ex. 1006).

Quadling discloses obtaining a digital 3D representation of the tooth, but does not expressly disclose determining a tooth shade value. Ex. 1004, 4-5. However, the Examiner asserted that Liang is in the same field of endeavor and discloses such a feature. *Id*. Accordingly, the Examiner concluded that it would have been obvious to a POSA to combine Liang's image data processing system with the Quadling system to achieve a system that determines both color and 3D information of scanned teeth. *Id*. The suggestion and/or motivation for doing so would have been to obtain tooth shade information. *Id*. Pending claims 4-9 and 14-18 were rejected to as being dependent upon a rejected base claim. *Id.*, 6.

On December 16, 2019, the Applicant amended claim 1 to incorporate the purported allowable subject matter of claim 4, directed to "deriving a certainty score

expressing the certainty of the determined tooth shade value." Ex. 1002. The Applicant further amended claims 14 and 15 into independent form. *Id.*, 42-48.

IV. OVERVIEW OF PRIOR ART

A. Babayoff (Ex. 1105)

Babayoff recognizes that, in procedures relating to manufacture of a dental prosthesis or restoration, it is important to match the color and texture of the prosthesis with that of the surrounding teeth. Ex. 1105, 2:24-3:49. Babayoff explains that "[t]raditional methods of color matching are based on visual comparison between a removable tooth-shaped color tab of a shade guide, such as for example Vita, and the surrounding teeth." *Id.*

Babayoff discloses systems and methods for obtaining geometric and color data of teeth. For example, Babayoff discloses "[t]he first step of the method according to the present invention relates to providing at least one numerical entity that is representative of the three-dimensional surface geometry and color of at least part of the intra-oral cavity." *Id.*, 7:53-56. Figure 1 of Babayoff illustrates a block diagram of a scanning device for doing so:

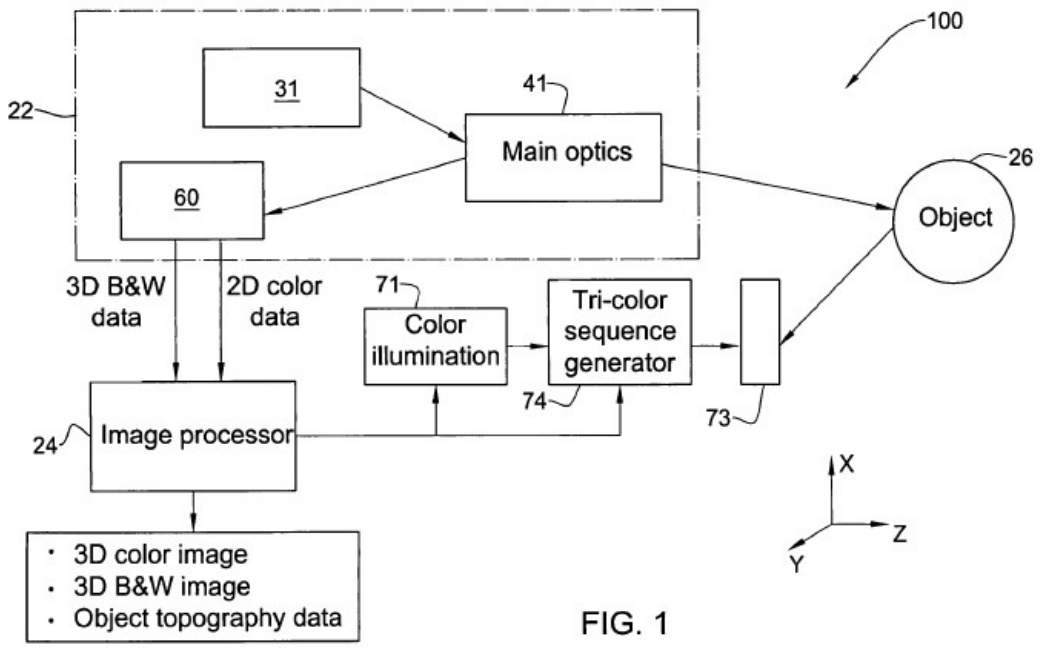


FIG. 1

Id., 8:25-27.

Babayoff separately explains the acquisition of three-dimensional geometry and color data. *Id.*, 8:30-56. Figure 2C illustrates the algebraic manipulation of geometry and color entities, E[X, Y, Z] and N [X', Y', C'], respectively, to form a new entity I[X, Y, Z, C] having both color and 3D geometric information. *Id.*, FIG. 2C; *see also* 9:12-32.

An objective of Babayoff is to provide a color map for a dental prosthesis. Babayoff summarizes a method to achieve this goal in Figure 17. *Id.*, FIG. 17 and 26:8-26. The color map provides color information for the dental prosthesis based on measured color values and color values derived from reference teeth chosen as the color base, referred to as IP1'. *Id.*, 21:23-22:33. As illustrated in Figure 19, the

shade information is transformed to a model to be sent for the purpose of fabricating a dental prosthesis:

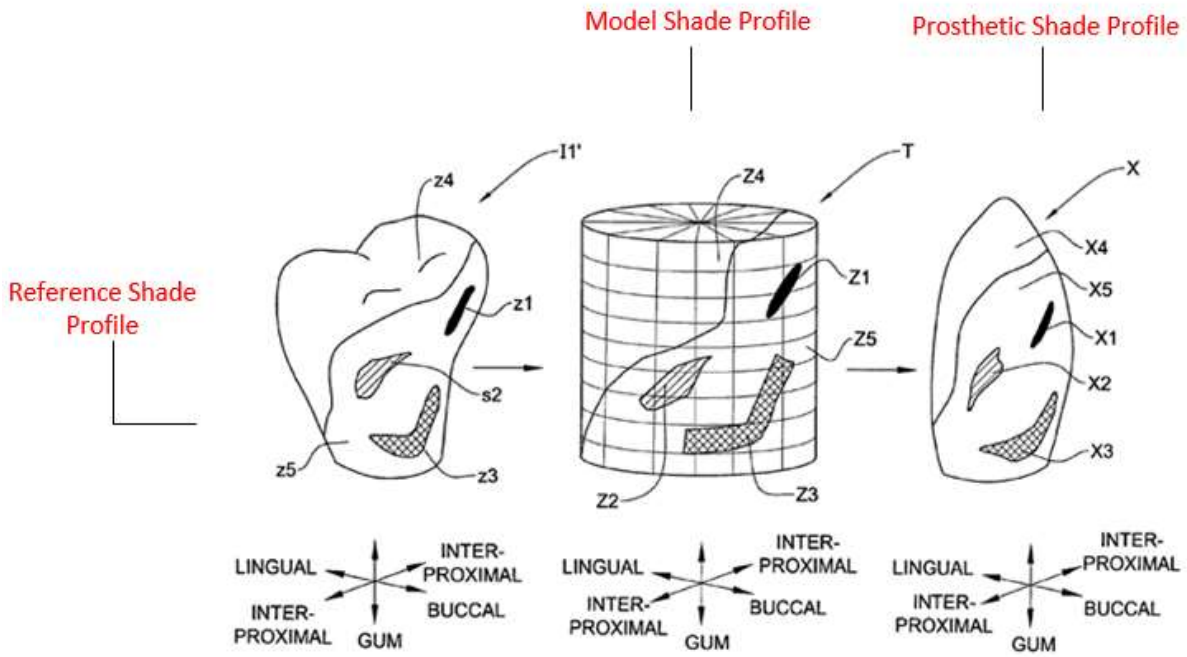


FIG. 19

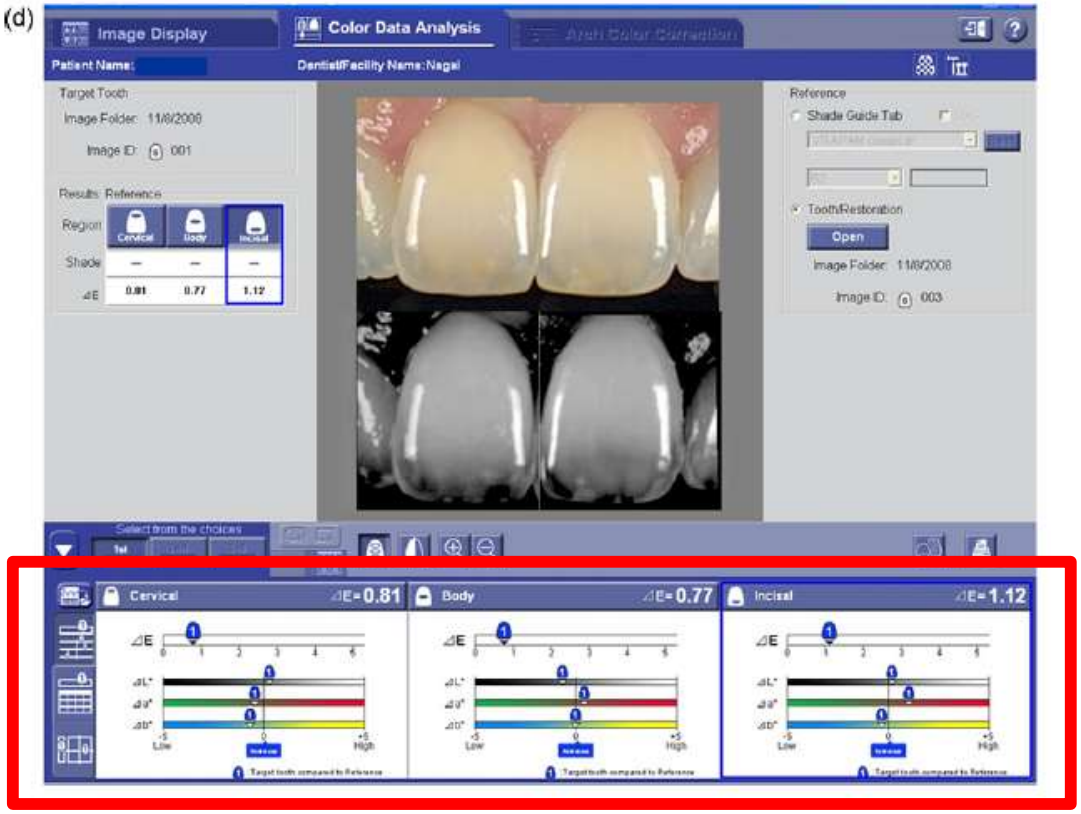
Id., FIG. 19 (annotated).

B. Chu (Ex. 1106)

Chu, published in 2010, is titled "Dental color matching instruments and systems. Review of clinical and research aspects." Ex. 1106, e1. Chu explains that spectrophotometers, colorimeters and imaging systems are useful tools for tooth color measurement and analysis—including indirect restorations, communication for indirect restorations, reproduction and verification of shade, and for quality control of color reproduction. *Id.*, e2.

Chu explains that, at the time of its publication, the most common manner of shade matching was visual, using shade guides, including the empiric-based Vita chart. *Id.* However, Chu further explains that such dental shade-matching instruments have been brought to market to reduce or overcome imperfections and inconsistencies of traditional shade matching. *Id.*, e3. Chu surveys commercially available spectrophotometers, colorimeters, and imaging systems. Chu explains that these Complete Tooth Surface Measurement ("CTSM") devices "give a color map of the gingival, body and incisal shades for the fabrication of direct or indirect restorations." *Id.*, e4.

Chu explains that ΔE values are used to mathematically to determine how well a shade will match a measured tooth color. *Id.*, e7. For example, Figure 1 of Chu depicts a clinical application of the *CrystalEye* device, with Figure 1(d) specifically noting "color difference ΔEs obtained in all 3 areas are considered to be excellent color match."



Id., e6-7 (ΔE analysis outlined in red for emphasis).

C. Inglese (Ex. 1109)

Inglese is titled "Equipment and Method for Measuring Dental Shade" and provides a manner of measuring dental shade by mapping measured color signals in three dimensional shade space alongside reference tooth shade color values and selecting proximate reference tooth shades for the prosthesis. Figure 5 illustrates Inglese's method, with an accompanying explanation that "[t]he reference 200 designates one point of the shade space. The coordinates of the point in the dimensions of the shade space are symbolized by dotted line projections on the R, G, B dimension axes." Ex. 1109, ¶¶0081-0091.

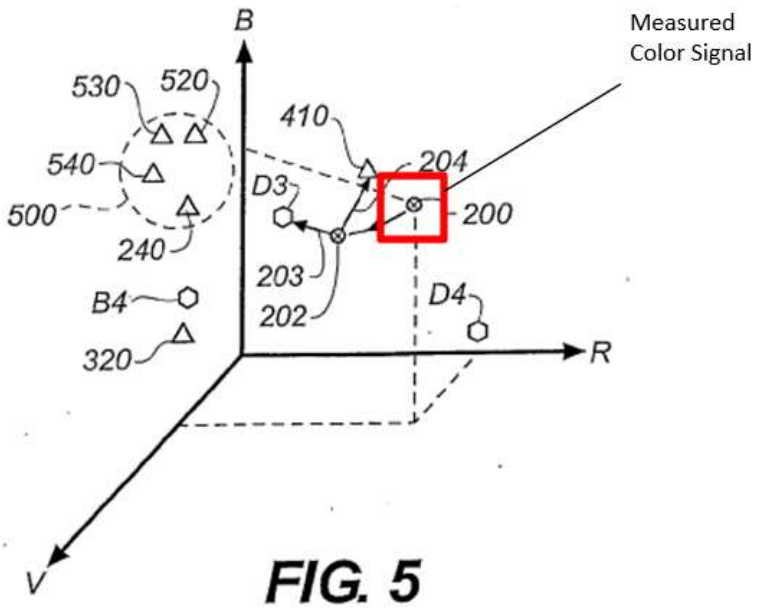
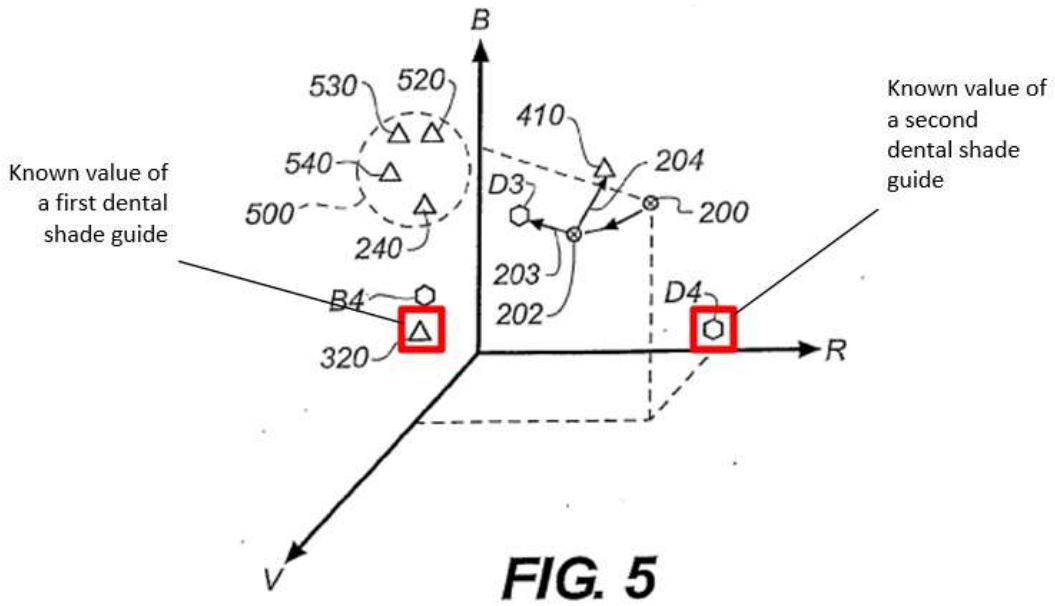


FIG. 5

Id., FIG. 5.

Inglese further explains, "[t]he reference 202 designates a new point of the shade space whose coordinates are established by correcting the coordinates of the initial measurement point 200." *Id.* Inglese continues: "Also shown in the shade space are the reference points 320, 410, 540. These are shown as small triangles. They correspond to known values of a first dental shade guide. . . . Another set of reference points B4, D3, D4, shown by small hexagons, corresponds to the shades of a second dental shade guide." *Id.* (emphasis added). Inglese explains that, "[t]he reference point closest to the measurement point, possibly corrected, is sought to establish the shade of the relevant tooth part." *Id*. This is depicted in FIG. 5 of Inglese as follows:



Id., FIG. 5 (annotated).

D. Graham (Ex. 1107)

Graham is titled, "Tooth Shade Scan System and Method." Graham summarizes his invention explaining that the tooth shade analysis tool may identify tooth shades by region, rather than by pixel or by tooth as a whole. Ex. 1107, ¶0036; *see also* Abstract. For example, the regions may be the cervical, incisal, and central tooth regions, and the color characteristics for each region (*e.g.*, RGB average values for each region) may be generated. *See id.*, FIG. 5, ¶¶0036, 0047.

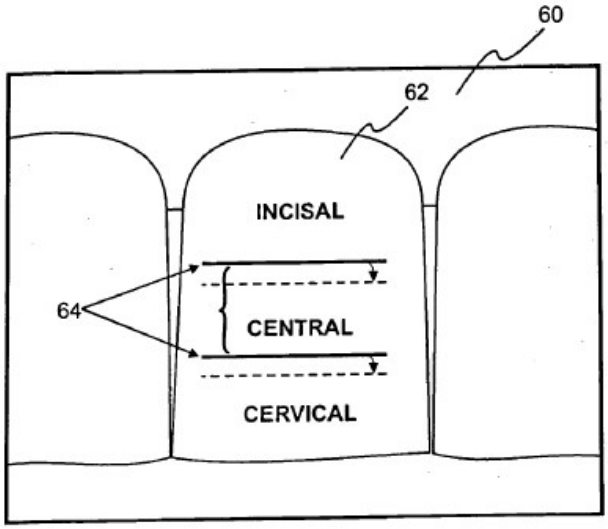


Fig. 5

The color characteristic value generated for a tooth (*e.g.*, table 70) may be compared to the database (*e.g.*, table 72) to identify appropriate shades of the region. *See id.*, FIG. 6, ¶¶0047-0051. To improve shade matching, Graham discloses, "if the color characteristics for a patient fall between two shades, some of interpolation may be applied to the two shades to produce an additional shade for the patient's tooth that suitably fits the generated color characteristics for that patient." *Id.*, ¶0050.

E. Nathaniel (Ex. 1111)

Nathaniel discloses a method of combining several images into one panoramic image. *See* Ex. 1111, Abstract. Figures 8A-D illustrate the combination of overlapping images:

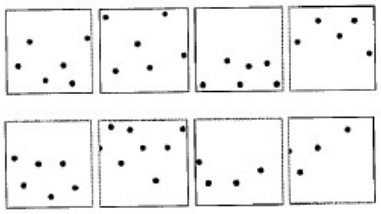


Fig. 8A

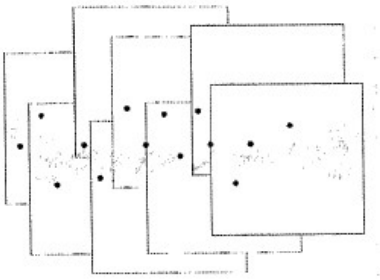


Fig. 8B

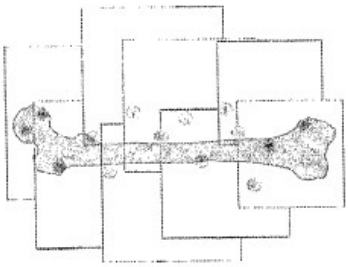


Fig. 8C

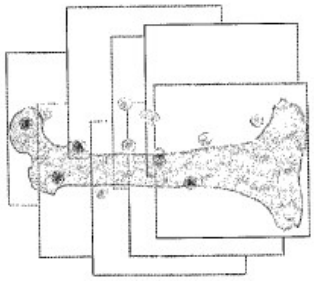


Fig. 8D

Nathaniel explains that the "generation of panoramic images requires three distinct steps: 1) correcting the distortion of each single image, generally caused by the optical system, 2) alignment and stitching of the individual images and 3) composing the final panoramic image." *Id*., ¶0005. Nathaniel further explains the panoramic image reconstruction as, following alignment of separate x-ray images, selecting for each pixel in the resulting image a value from the appropriate pixel in the appropriate image, and selects that value based on the pixel closest to the center

of the original x-ray (to minimize distortion, or otherwise based on an average or weighted average value of the original pixel (among other decision rules). *Id*., ¶0099.

V. LEVEL OF ORDINARY SKILL IN THE ART

As explained in the expert declaration of Dr. Ioannis A. Kakadiaris (Ex. 1003), a person of ordinary skill in the art ("POSA") as of the effective filing date of the '151 patent would have at least a bachelor's degree in Computer Engineering, Computer Science, Computer Vision, or an equivalent field, as well as at least two years of imaging/image analysis experience, or alternatively, at least six years of comparable industry experience. A POSA would have had experience with and knowledge of 3D imaging systems and 3D modeling techniques. Ex. 1003, ¶18.

VI. CLAIM CONSTRUCTION

The challenged claims have not been construed in any civil action. Petitioner submits that, for purposes of this proceeding, all claim terms should be given their ordinary and customary meaning.

VII. DETAILED EXPLANATION OF GROUNDS

A. Ground 1: Claims 1, 2, 6, 7, and 9-15 Are Obvious Over Babayoff and Chu

1. Claim 1

[preamble] A method for determining shade of a patient's tooth, wherein the method comprises:

To the extent that the preamble is limiting, Babayoff discloses the features of the preamble. Ex. 1003, ¶77. Babayoff discloses, "[a] method for providing data useful in procedures associated with the oral cavity, in which at ***least one numerical entity representative of the three-dimensional surface geometry*** ***<u>and color of at least part of the intra-oral cavity is provided</u>*** and then manipulated to provide desired data therefrom." Ex. 1105, Abstract (emphasis added). This comprises determination of shade: "For example, the color range R1 for the teeth will include values for c typically associated with the hard tissues including the teeth, comprising all appropriate shades appropriate for enamel, dentine, pulp and other parts of teeth." *See*, *e.g.*, *id*., 21:28-32.

[a] obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data and texture data for the tooth;

Babayoff discloses these limitations of claim 1. Ex. 1003, ¶¶78-79. Babayoff discloses obtaining a digital 3D representation of the tooth. *Id.*, ¶78. Babayoff explains that the first step of its invention "relates to providing ***at least one***

numerical entity that is representative of the three-dimensional surface geometry and color of at least part of the intra-oral cavity." Ex. 1105, 7:53-56 (emphasis added). The numerical entity "may comprise a data set of a plurality of 4-dimensional arrays—(x, y, z, c), wherein each array represents the x, y, z geometrical coordinates and the color c of a point on a surface within the intra-oral cavity." *Id.*, 8:9-12. Babayoff explains that color values may be the independent prime color variables relating to the red, blue, and green (RGB) components associated with the color parameter, or may be expressed, *e.g.*, in terms of hue, saturation and intensity, or any other optical property of teeth including parameters that provide a measure of internal reflectance and translucency. *Id.*, 7:65-8:8.

Thus, the digital 3D representation of the tooth in Babayoff comprises shape data and texture data for the tooth, since texture data includes color data. Ex. 1001, 2:37-38. With respect to shape data, Babayoff discloses, "[t]he device 100 comprises a main illumination source 31 for illuminating the object of interest 26, typically a part of the intraoral cavity, and is optically coupled to main optics 41 to provide depth Z values for an arrange range of X-Y points . . . along the surface of the object. Ex. 1105, 8:30-35. Babayoff further discloses detection optics 60, which receives image data from the main optics 41 and the image processor 24 to determine the depth Z values for each X-Y point illuminated on the object 26. *Id.*, 8:35-42. "In this manner, ***a manipulable three-dimensional numerical entity E comprising the***

surface coordinates of the object" is created. *Id.*, 8:42-44 (emphasis added). The entity E thus comprises an array of x, y, z points (shape data). Ex. 1003, ¶79.

With respect to texture data, Babayoff discloses that a processor 24 aligns a 2D color image with the previously created 3D entity "and then provides color values to this entity by mapping color values to the entity at aligned X-Y points." Ex. 1105, 8:57-60. This process is further explained with reference to Figure 3, where Babayoff explains that concurrently with determining the x, y, z points of entity E, as discussed above, a 2D color image of the object is taken using the same detection optics 60, resulting in creation of another entity N comprising x' and y' points and color c. Ex. 1105, 9:3-15. The entity N thus comprises an array of x' and y' points and color c (texture data). Ex. 1003, ¶79. Further, because the readings are taken simultaneously, the x' and y' coordinates of N represent the same part of object 26 as the x and y coordinates of E. Ex. 1105, 9:15-25.

The shape data and texture data in Babayoff are combined to form a numerical entity comprising a plurality of 4-dimensional arrays I (*i.e.*, the digital 3D representation). Ex. 1003, ¶79. Referring to Figure 2C, Babayoff explains that ***the color value c of entity N can be mapped to the data point of entity E having the same X-Y coordinates such that another entity I is created comprising surface coordinates x, y, and z and color data c***. Ex. 1105, 9:25-32. Babayoff thus discloses obtaining a digital 3D representation of the tooth, where the digital 3D representation

comprises shape data (x, y, and z points) and texture data (color c) for the tooth. Ex. 1003, ¶79.

> **[b] determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values,**

Babayoff in combination with Chu satisfies these limitations of claim 1. Ex. 1003, ¶¶80-92. As discussed *supra*, Babayoff discloses obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data (x, y, and z points) and texture data (color c) for the tooth. As will be explained below, Babayoff also discloses a manner of determining the shading of a prosthesis using the measured color c values. Ex. 1105, 26:8-27:62. However, to the extent Babayoff does not disclose determining ***a tooth shade value for at least one point on the tooth*** based on the texture data of the corresponding point on the digital 3D representation ***and on known texture values of one or more reference tooth shade values***, Chu discloses these limitations. In particular, Chu discloses determining a tooth shade value using measured color data and known color values from one or more reference tooth shade guides.

In Babayoff, the manner of determining the shading of the prosthesis is based on the shading characteristics of at least one tooth of the patent. *Id.*, 26:8-30. Babayoff explains that after creation of numerical entity I (including shape data x, y, z, and texture data color c), shade information for a prosthesis can be obtained that makes

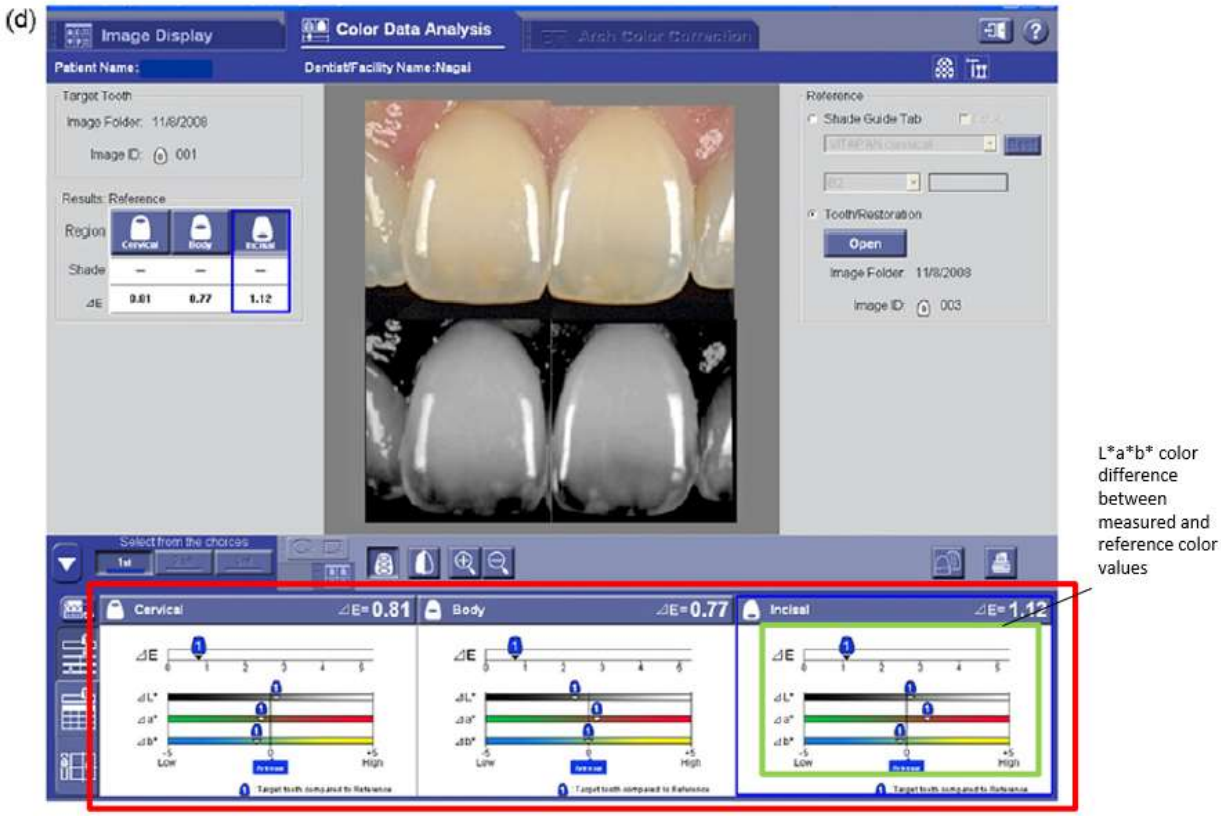
it compatible with surrounding teeth. *Id.*, 26:20-24. The desired shade for the prosthetic is determined according to a set of rules (algorithmically), or manually by the user, and involves choosing one or more teeth of the patient as a reference, referred to as data sets $I_{P1'}$. *Id.*, 26:37-61. The data from these data sets, $I_{P1'}$ are then analyzed and used to create a color map for the prosthesis or restoration. *Id.*, 26:62-27:29; *see also* FIG. 19. However, although Babayoff discloses a manner of determining color data c for a prosthesis based on the color data c of surrounding teeth, it is not apparent that Babayoff discloses determining a tooth shade value for at least one point on the tooth based on the color data c of the corresponding point of the digital 3D representation and on known color values of one or more reference tooth shade values. Chu, however, discloses these limitations.

Chu discloses commercially available imaging systems that compare measured color data with reference color data to determine a tooth shade value. Chu states, "[d]ental color matching instruments also provide the information on best matching tabs from different shade guides." Ex. 1106, e5. Chu further states, "examples of color matching, interpretation and application of shade analysis data are given in Figs. 1-6." *Id.*

Figure 1 of Chu portrays clinical application of a CrystalEye spectrophotometer. *Id.*, e6-e7. The "Reference" tooth shade guide and tooth shade value are depicted in Figure 1(d) as follows:

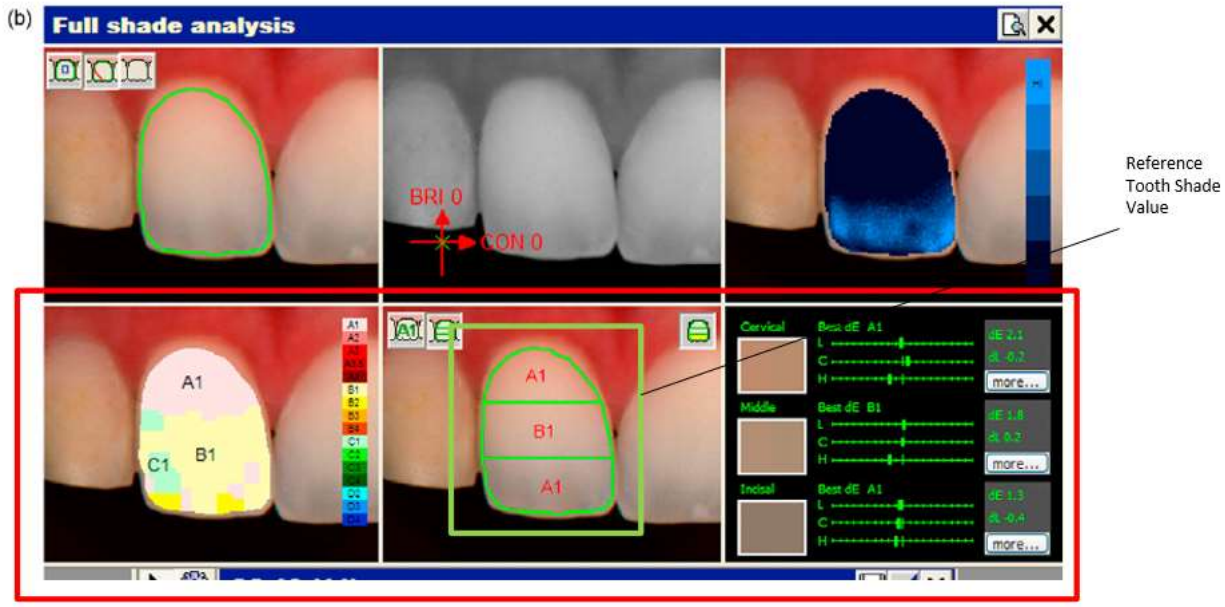
Id., FIG. 1(d) (annotated); Ex. 1003, ¶84. In Figure 1(d), the reference shade guide is "VITAPLAN classical" and the reference tooth shade value is "B2." *Id.*; Ex. 1003, ¶84.

Further referring to Figure 1(d), Chu states that "[c]olor difference ΔEs obtained in all 3 areas are considered to be excellent color match." Ex. 1106, FIG. 1(d). The closeness of the match is depicted, in part, by L*a*b* color comparisons between the measured color data and the known color values of the reference tooth shade value. Ex. 1003, ¶85. This comparison is depicted for cervical, body, and incisal tooth regions in Figure 1(d), as follows:



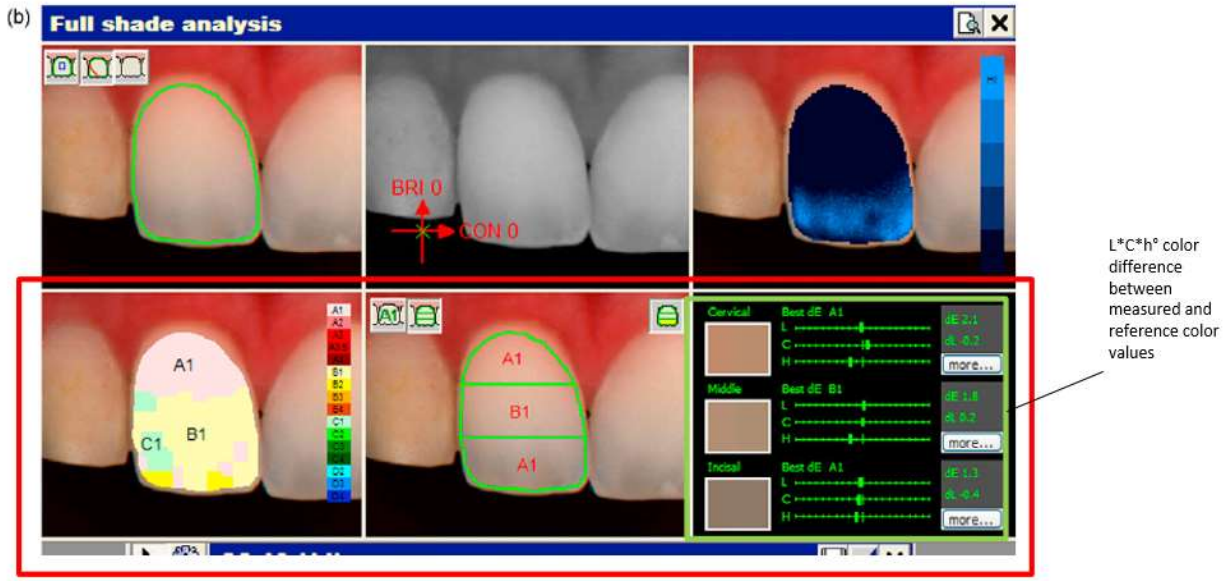
Ex. 1106, FIG. 1(d) (annotated); Ex. 1003, ¶86.

Similarly, Figure 5 of Chu portrays clinical application of a SpectroShade Micro spectrophotometer. Ex. 1106, e11. In the figure, a congenitally missing lateral incisor is to be replaced with an implant. *Id.* "The SpectroShade Micro system creates a color map which can be converted to several shade guide systems, this being the Classic Vita Shade Guide. It provides either an overall shade or the shade can be broken down into three distinct areas, cervical, middle, and incisal . . . ." *Id.* In Figure 5(b), the tooth shade values are depicted as follows:



Id., FIG. 5(b) (annotated); Ex. 1003, ¶87.

Further referring to Figure 5(b), Chu discloses the "[b]est" ΔE value, which corresponds to the determined tooth shade value. Ex. 1106, FIG. 5(b); Ex. 1003, ¶88. In this example, the closeness of the match is depicted by L*C*h° color comparisons between the measured color data and the known color values of the reference tooth shade value. Ex. 1003, ¶88. This comparison is depicted for cervical, body, and incisal tooth regions in Figure 5(b), as follows:



Ex. 1106, FIG. 5(b) (annotated). In Figure 5(b), the reference tooth shade values are A1, and B1, and A1 for the cervical, middle, and incisal regions of the tooth, respectively. *Id.*

Because Chu discloses selection of a tooth shade value, *e.g.*, A1 or B1 or B2, based on a comparison of measured color data with reference color values (expressed in terms of the difference between measured and reference color characteristics L*a*b* or L*C*h°), Chu discloses "determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values." Ex. 1003, ¶89.

Motivation to Combine Babayoff and Chu

Chu provides the motivation for determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values by explaining that automated shade matching increases the success of color matching, communication, reproduction, and verification in clinical dentistry, and increases the efficiency of esthetic restorative work. Ex. 1106, e3; Ex. 1003, ¶90. Chu further explains that automated shade matching reduces or overcomes imperfections and inconsistencies in traditional shade matching, which is subject to "innate difficulties," including metamerism; suboptimal color matching conditions, tools, and method; as well as the practitioner's age, fatigue, mood, and drugs/medications. *Id.* Chu explains that although the human eye can discern small color differences, the ability to communicate the degree and nature of these differences is lacking in traditional visual comparison. *Id.* Thus, Chu concludes, "[t]he answer whether to use visual or instrumental method for color matching in dentistry is: ***whenever if possible, use both, as they complement each other and can lead towards predictable esthetic outcome."*** Ex. 1106, e7 (emphasis added).

Although Babayoff discloses algorithmically determining tooth color based on surrounding teeth it still requires visual comparison with a reference shade guide to determine a tooth shade value. A POSA, therefore, would have been motivated to

replace the shade matching function of Babayoff with the shade matching function of Chu to create an in intraoral scanner that automatically determines a tooth shade value using the color data of the corresponding point of the digital 3D representation and on known color values of one or more reference tooth shade values. Ex. 1003, ¶91. Doing so achieves the improvements described above. *Id.*

A POSA would have expected such a combination to work for its intended purpose because Chu describes prior art imaging systems capable of determining tooth shade values from measured color data and known color values of one or more reference tooth shade values as discussed *supra*. *Id.*, ¶92. For example, Chu states "[t]hrough the development of optical and image processing technology, [Olympus's CrystalEye] product allows the practitioner to match tooth shade and color more accurately and simply." *Id*. Chu notes that spectrophotometers, such as *CrystalEye*, "provide shade tab designation and the respective ΔE values compared to shade tab values in memory." *Id.* Chu also identifies MHT's *SpectroShade* product as a digital camera/LED spectrophotometer combination, including an internal computer with analytical software, noting that the measurements of such devices "are frequently keyed to dental shade guides and converted to shade tab equivalent." *Id.* Chu also identifies X-Rite's *ShadeVision* product, and notes that a complete tooth image is provided through use of three separate gingival, middle, and incisal third databases. *Id.* With respect to imaging systems, Chu identifies Smart Technology's *ClearMatch*

product, and states the system "uses high-resolution digital images and compares shades over the entire tooth with known reference shades," further noting the product "contains the color database of industry-standard shade guides." *Id.*

Chu thus discloses that the determined tooth shade value could be based on comparison of the color data determined from the scanned teeth with the color values corresponding to tooth shades available from an "industry-standard shade guide" or "shade tab values in memory." Ex. 1003, ¶92. Thus, rather than compare the measured texture values to the measured texture values of reference teeth and manually selecting a tooth shade value, as taught by Babayoff, Chu teaches automatically comparing the color data to known color values of reference tooth shade values from a shade guide. *Id.*

A POSA would have understood how to implement the matching function of Chu. As an initial matter, the '151 patent itself is written with the understanding that a POSA would understand how to perform algorithmic matching functions since no specific function is provided in the specification. *Id.* Indeed, it was well known at the time of the alleged invention of the '151 patent how to calculate tooth color by measuring light reflected on the surface of the tooth and expressing results in the CIE L*a*b* color space and matching those results to shade tabs of a guide system. *Id.* Moreover, it was known how to express tooth shades in a shade guide system using conversion scales for CIE L*a*b* values based on internally stored data. *Id.*

A POSA, therefore, would have been able to replace the shade matching function in Babayoff with the shade matching function as taught by Chu. *Id.*

[c] wherein the method comprises deriving a certainty score expressing the certainty of the determined tooth shade value.

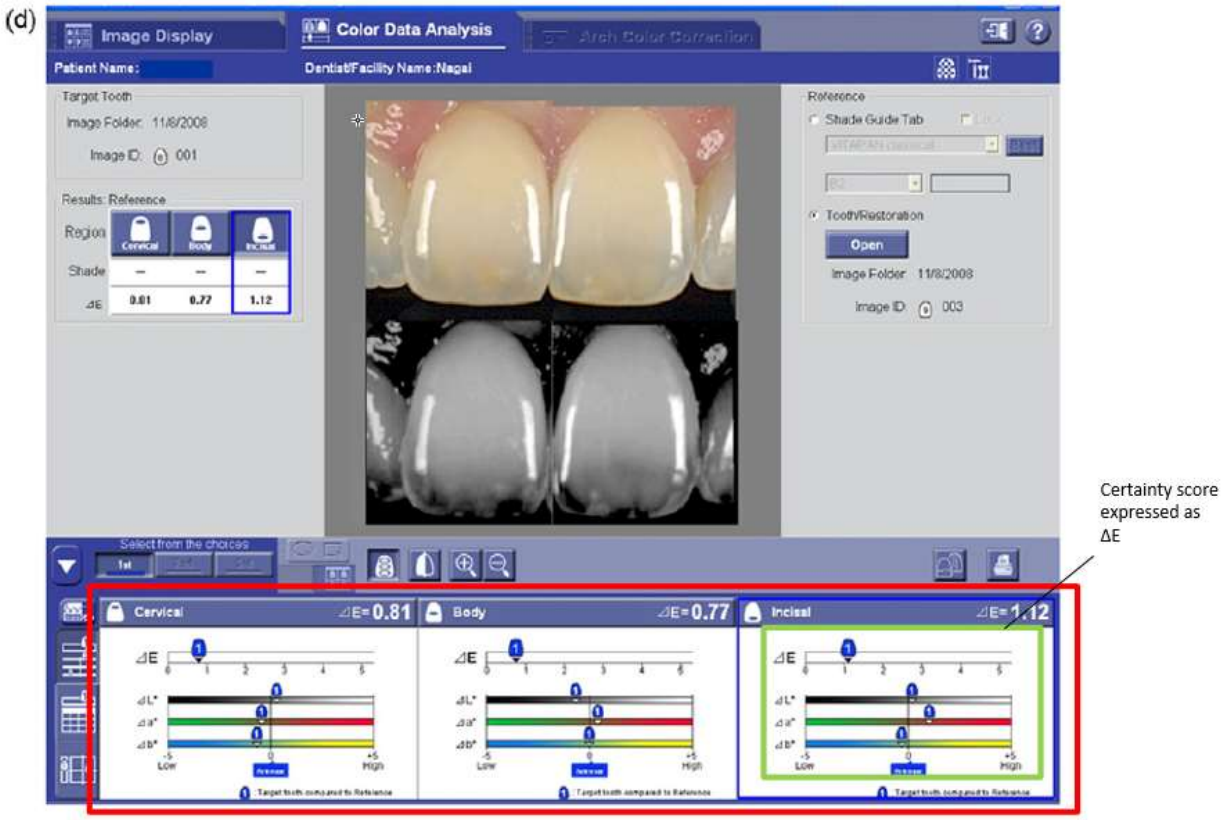
Babayoff in combination with Chu satisfies these limitations of claim 1. Ex. 1003, ¶93-97. The '151 patent explains that ΔE is an exemplary certainty score. Ex. 1001, 7:26-28. In particular, the '151 patent explains that if ΔE is above a threshold value, the uncertainty is too large. *Id*. In this manner, a POSA would understand ΔE to be an example of a certainty score provided by the '151 patent. Ex. 1003, ¶93.

As discussed *supra*, Babayoff in combination with Chu discloses determination of a tooth shade value based on comparison of the measured color value with the color value of a reference tooth shade. *Id.*, ¶94. Both references further disclose the need for the determined tooth shade value to be accurate. For example, Babayoff recognizes that, "[i]n procedures relating to the manufacture of a dental prosthesis such as a crown or bridge, or in other dental restorations, ***it is important to match the color and texture of the prosthesis with that of the surrounding teeth in the vicinity of the target area in which the prosthesis is to be implanted, to give the prosthesis or restoration a natural appearance."*** *Id.*, 2:24-29 (emphasis added). As discussed *supra*, Chu likewise recognizes that, "[t]oday's shade-matching technologies have been developed in an effort ***to increase the success of color matching, communication, reproduction and verification in clinical dentistry***, and,

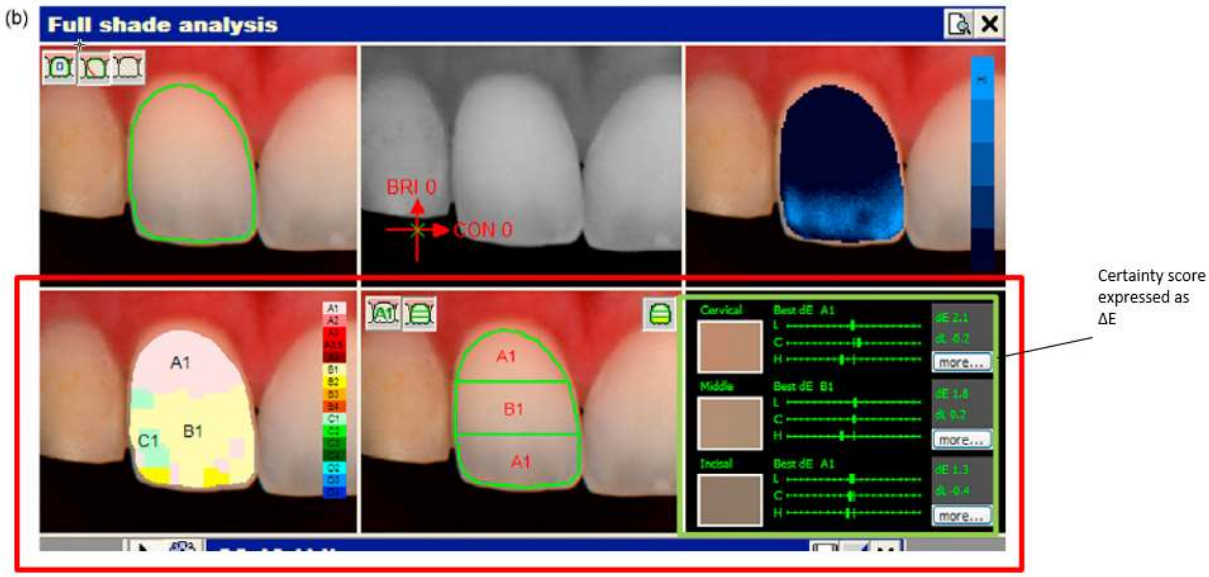
ultimately, ***<u>to increase the efficiency of esthetic restorative work</u>*** within any practice." Ex. 1106, e3.

Chu describes CTSM devices that provide a measure of the accuracy (*i.e.*, ΔE) of the determined tooth shade value and accordingly a certainty score. Ex. 1003, ¶95. As discussed *supra*, Chu discloses a perceptibility threshold in terms of ΔE, where ΔE values below that threshold are considered a clinical "match" for restoration purposes. Because a POSA would understand Chu's ΔE to be a measure of the accuracy of the determined tooth shade value and accordingly a certainty score, Chu teaches the incorporation of a certainty score by describing CTSM devices that provide tooth shade values and respective ΔE values with respect to those values. Ex. 1106, e4; Ex. 1003, ¶95.

Examples of Chu's depiction of such certainty scoring are as follows:



Ex. 1106, FIG. 1(d) (annotated).



Id., FIG 5(b) (annotated).

Motivation to Combine Babayoff and Chu

In addition providing motivation to modify Babayoff to compare texture data with reference texture values of reference tooth shade values to determine tooth shade values, Chu further provides motivation to modify Babayoff to include a certainty score expressing a measure of the accuracy of the determined tooth shade value for the reasons provided above in connection with claim 1. Ex. 1003, ¶96.

A POSA would have expected such a combination to work for its intended purpose because Chu describes prior art imaging systems capable of deriving a certainty score expressing the certainty of the determined tooth shade value as discussed *supra*. *Id.*, ¶97. Further, the modification of Babayoff to include a certainty score as taught by Chu would have been straightforward for a POSA to implement because it would require nothing more than the use of simple mathematic calculations—*e.g.*, the prior art ΔE calculation disclosed by the ’151 patent (Ex. 1001, 5:56-64), and the use of known reference guide datasets such as Vitapan classic. Ex. 1003, ¶97. Indeed, Chu surveys a variety of intraoral scanner devices that provide tooth shade values and respective ΔE values with respect to those tooth shade values.

A POSA would have understood how to derive a certainty score from the measured color values and reference color values because the ΔE calculation was known in the prior art and would require nothing more than implementing a simple

algebraic equation. *Id.* A POSA, therefore, would have been able to add the certainty score to Babayoff as taught by Chu. *Id.*

2. Claim 2

The method according to claim 1, wherein determining the tooth shade value for the point comprises selecting the reference tooth shade value with the known texture value closest to the texture data of the point.

Babayoff in combination with Chu discloses the claim 2 limitations. Ex. 1003, ¶¶98-100. Babayoff discloses that in procedures relating to the manufacture of a dental prosthesis or other dental restoration, "it is important to match the color and texture of the prosthesis with that of the surrounding teeth in the vicinity of the target area . . ., to give the prosthesis or restoration a natural appearance." Ex. 1105, 2:26-29. Indeed, Babayoff surveys prior art methods of matching tooth shade, referencing U.S. Patent No. 6,007,332 as an example of calorimetric of spectrophotometric analysis "to achieve the final selection of the closest match." *Id.*, 3:18-19.

Chu describes at length the importance shade matching, referencing multiple CTSM devices designed to select "best matching tabs from different shade guides." Ex. 1106, e5. Based on the degree of color match, determined based on ΔE, Chu explains that the color may be further adjusted in certain areas to obtain excellent color match. *See id.*, FIG. 1(c)-(d) ("Excellent color match was confirmed in the cervical and body areas. Minor modification may be required in the incisal area to increase the value and yellowness.").

Babayoff and Chu thus provides the motivation for selecting the reference tooth shade value with the known texture value closest to the texture data of the point by explaining the importance of finding the "best" match. Ex. 1003, ¶100. Indeed, that is what selection of the best ΔE value, as taught by Chu, accomplishes—*e.g.*, it determines the tooth shade value closest to the measured color value in, *e.g.*, L*a*b* or L*C*h° color space. *Id.* A POSA would have expected such a combination to work for its intended purpose because Chu already described selecting the reference tooth shade value with the known texture value closest to the texture data of the point. A POSA would have understood how to implement such a matching function because algorithmic matching was well known and taught to undergraduate students in computer science/engineering. *Id.*

3. Claim 6

The method according to claim 1, wherein the method comprises comparing the derived certainty score with a range of acceptable certainty score values.

Babayoff in combination with Chu discloses the claim 6 limitations. Ex. 1003, ¶101. As discussed *supra* in connection with claim 1, Chu discloses a perceptibility threshold in terms of ΔE. Ex. 1106, e7. In particular, Chu discloses that a ΔE of 1 met the perceptibility threshold such that the color difference between compared object (*e.g.*, a tooth and a reference shade tab) can be seen by 50% of observers (the

other 50% will notice no difference). *Id.* Chu explains "[a] color match in dentistry is a color difference at or below the perceptibility threshold. *Id.*

Thus, it would be obvious to compare the derived certainty score taught by Chu—ΔE—with a range of acceptable certainty score values. Ex. 1003, ¶101. The acceptable range, as taught by Chu, would be a ΔE between 0 and 1. Such a score would indicate a color match in dentistry since it would indicate a color difference at or below the perceptibility threshold.

Chu provides the motivation for comparing the derived certainty score with a range of acceptable certainty score values by explaining that a score between 0 and 1 would indicate a color difference at or below the perceptibility threshold. A POSA would expect such a combination to work for its intended purpose because Chu already explains determining color match can be done by comparing ΔE to the perceptibility threshold. *Id.* A POSA would have understood how implement a range of acceptable certainty score values because doing so would require nothing more than simple modification of the matching function to perform a final comparison of the calculated ΔE to the range 0 to 1. *Id.*

4. Claim 7

The method according to claim 1, wherein the certainty measure relates to how uniform the sub-scan texture information is at the point, and/or to how close the texture data is to the known texture value of the determined tooth shade value, and/or to the amount of texture information used to derive the texture data at the point.

Babayoff modified by the teachings of Chu discloses the claim 7 limitations. Ex. 1003, ¶102. In particular, the combination meets the limitation "wherein the certainty measure relates . . . to how close the texture data is to the known texture value of the determined tooth shade value." As discussed in connection with claim 2, the Babayoff-Chu combination involves calculation of a certainty score in terms of ΔE, which is a measure of how close the texture data is to the known texture value of the determined tooth shade value. *See* claim 2 discussion *supra*. Claim 7 is accordingly obvious for the reasons discuss in claim 2. *Id.*

5. Claim 9

The method according to claim 1, wherein the one or more reference tooth shade values relate to shade values for natural teeth with intact surface and/or to shade values for teeth prepared for a dental restoration.

Babayoff modified by the teachings of Chu discloses the claim 9 limitations. Ex. 1003, ¶103. In Chu, the reference tooth shade values are, for example, the color tab values of Vitapan classic or other commonly used shade guides, which are described as corresponding to the color of human teeth. Ex. 1106, e3-4. Because they correspond to the color of human teeth, they relate to shade values for natural

teeth with intact surface and/or to shade values for feeth prepared for a dental restoration. Claim 9 is obvious for the reasons discussed in claim 1. Ex. 1003, ¶103.

6. Claim 10

The method according to claim 1, wherein the method comprises comparing the texture data with known texture values for soft oral tissue, such as gum tissue and gingiva.

Babayoff discloses the claim 10 limitations. Ex. 1003, ¶104. Babayoff discloses a method of generating color data in order to distinguish between different regions of the intraoral cavity, for example between soft tissue, such as gum and gingiva, and teeth. Ex. 1105, 20:65-23:7; FIG. 15. In the described embodiment, the measured color values c are compared to known color range R1 and R2, corresponding to two different tissues, *e.g.*, teeth and gums, respectively. Based on comparison of the color values c to these ranges, Babayoff explains, "data points for entity I are sorted into at least two sub-data sets, I1, I2, according to the color criteria, that is, for example, whether the value of the color parameter of each data point is within R1 or R2, respectively. . . . I2 should contain all data points in which the color parameter thereof corresponds to the color of the soft tissues, and thus should comprise the coordinates relating to the soft tissues only within the original entity I." Ex. 1105, 22:22-33. Babayoff uses the comparison to determine the finish line of the tooth, which is useful in preparation of dental prosthetics. *Id.*, 22:62-23:47. Thus,

Babayoff discloses "comparing the texture data with known texture values for soft oral tissue, such as gum tissue and gingiva." Ex. 1003, ¶105.

7. Claim 11

The method according to claim 1, wherein the texture information comprises at least one of tooth color or surface roughness.

Babayoff discloses the claim 11 limitations. Ex. 1003, ¶106. As discussed in claim 1, the texture information in Babayoff is the color c, which is tooth color. *See*, *e.g.*, *id*., 21:23-60, 26:30-36; Ex. 1003, ¶106.

8. Claim 12

The method according to claim 1, wherein the method comprises creating a shade profile for the tooth from shade values determined one or more points on the tooth.

Babayoff discloses the claim 12 limitations. Ex. 1003, ¶107. Babayoff discloses using the shape data (x, y, z) and texture data (color c) to generate a shade profile of the tooth. In particular, sub-data set I1 (distinguished from set I2 corresponding to gums and gingiva) contains a color value c for each cartesian coordinate x, y, and z. "Thus, I1 will contain all data points in which the color parameter thereof corresponds to the color of teeth . . ." Ex. 1105, 22:26-27.These coordinates and color c values are used to create a shade profile for the tooth. This is depicted graphically in Figure 19, where the color data of I1 are used to create a dental prosthesis X having a shade profile based on I1. *Id.*, 26:8-27-38, FIG. 19; Ex. 1003, ¶107.

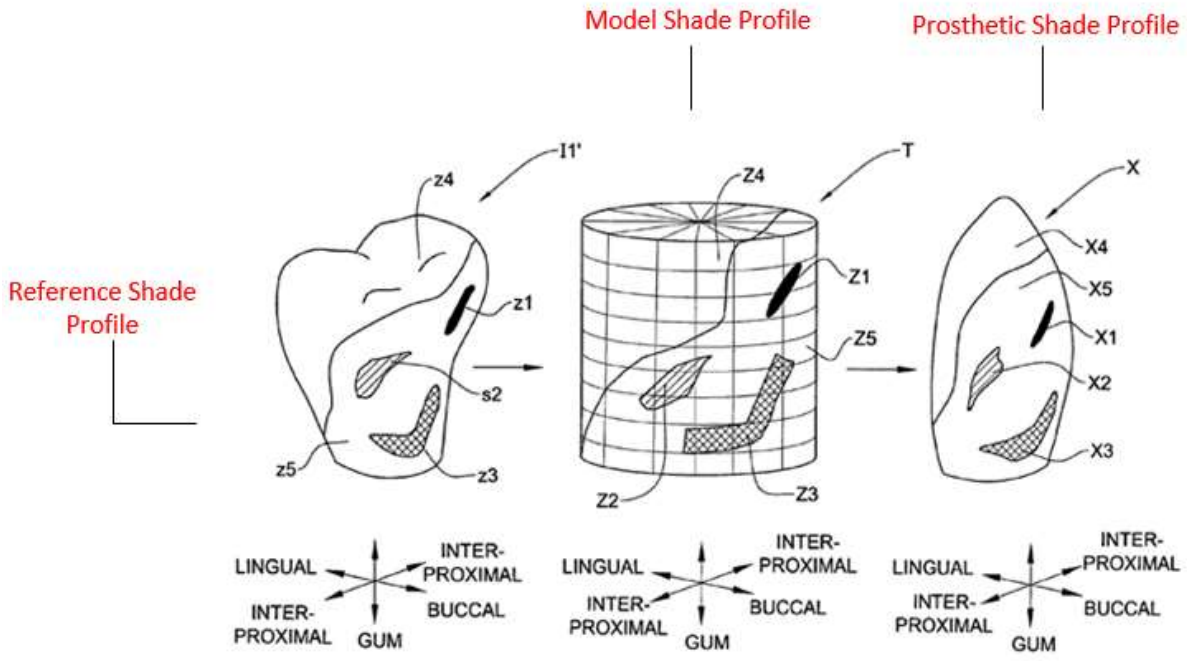


FIG. 19

Ex. 1105, FIG. 19 (annotated).

9. Claim 13

Independent claim 13 is substantially identical to claim 12 except it omits the certainty score limitation and adds the following:

> **13[d] wherein the tooth shade profile comprises a one or more tooth shade regions on the tooth surface where an average tooth shade is derived for each region from tooth shade values determined for a number of points within the region.**

Babayoff in combination with Chu discloses the claim 13 limitations, with the limitations shared with claims 1 and 12 disclosed by Babayoff and Chu for the reasons set forth above in this Ground relating to those claims. In addition to the shade profile discussed above in claim 12 that uses directly measured color c values

to determine a shade profile, Babayoff also discloses a manner of generating a shade profile from average shade values determined from a number of points within the region.

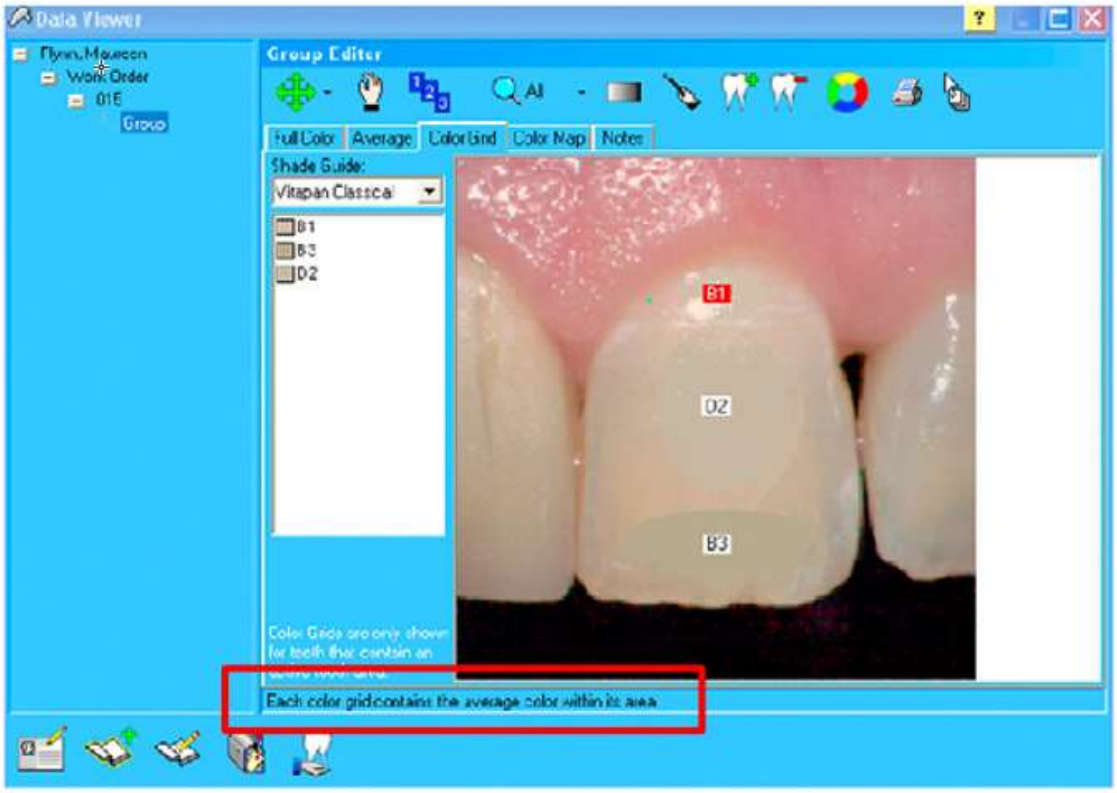
Babayoff states that rather than matching the shade of an entire tooth, "the tooth may be divided into three general zones: a gingival zone close to the gums, an intermediate body zone, and an incisal zone comprising the cusp of the tooth." Ex. 1105, 27:33-33-36. Babayoff explains that the colors can be mapped into each of the zones independently, and then smoothed out between the zones to avoid sharp discontinuities in color. *Id.*, 27:33-38. A POSA would understand that averaging is a manner of smoothing out differently colored zones. Ex. 1003, ¶110.

Babayoff also describes a manner of averaging tooth shade values and using those average values to determine a tooth shade value. *Id.*, 27:39-57. Babayoff teaches that rather than selecting a reference color c from one tooth, the color c from a set of teeth can be averaged and used as a tooth shade value. *Id.* Babayoff thus teaches a tooth shade profile comprising a region of tooth shade determined from the average of tooth shades within the region.

Chu likewise describes use of averages to determine a tooth shade value. Chu notes that a drawback of certain CTSM devices is that they "average out" color data over the complete tooth surface or larger defined areas. Ex. 1106, e4. Chu further discloses that several areas of the tooth should be considered to obtain a

representative evaluation of tooth shade. *Id.* ("At a minimum, a limited area measurement of the gingival, body, and incisal areas of the tooth should be assed and recorded . . . ."). Chu summarizes, "[d]ifferent measurement devices either measure the complete tooth surface providing a 'color map' or an 'average' color of the limited area [3-5 mm] on the tooth surface." *Id.*, e2. Chu portrays clinical application of a ShadeVision colorimeter and expressly notes that "[e]ach color grid contains the average color within its area." *Id.*, e7.

(b)



Id., FIG 5 (b) (annotated).

Motivation to Combine Babayoff and Chu

Babayoff and Chu both provide the motivation to generate a tooth shade profile that averages values within the gingival, body, and incisal areas of the tooth because both references teach advantages to smoothing between regions and generating a shade profile of a region using average values within the region. Ex. 1003, ¶113. A POSA would have expected such a combination to work since both Babayoff and Chu had already accomplished generating a tooth shade profile using average tooth shade values within a region. A POSA would have understood how to generate such a profile using average values because modifying the algorithm in Babayoff to generate the profile in this manner would be straightforward and routine in the field of image processing. *Id.*

10. Claim 14

Independent claim 14 is substantially identical to claim 1 except it omits the certainty score limitation and adds the following:

> **14[c] wherein obtaining the digital 3D representation of the tooth comprises recording a series of sub-scans of the tooth, where at least one of said sub-scans comprises both texture information and geometry information for said tooth, and generating the digital 3D representation of the tooth from the recorded series of sub-scans.**

Babayoff in combination with Chu discloses the claim 14 limitations. Ex. 1003, ¶¶115-19. The limitations shared with claim 1 are disclosed by Babayoff modified by the teachings of Chu for the reasons discussed *supra* in connection with

claim 1. Babayoff also discloses "obtaining a digital 3D representation of a tooth by recording a series of sub-scans of the tooth, where at least one of the sub-scans comprises both texture information and geometry information for said tooth, and generating the digital 3D representation of the tooth from the recorded series of sub-scans.

Babayoff discloses an embodiment where data sets of overlapping areas are stitched together to form an accurate scan of the intra-oral cavity. Ex. 1105, 23:48-51. A scanner is used in the manner described above, but high-resolution numerical sub-entities are formed that represent surface topography and the color of zones. *Id.*, 23:51-56. The scanned zones fully span the target of interest and overlap one another such that certain sub-entities, "shall have a portion of their data identical to one another within the overlap zone." *Id.*, 23:56-61. The sub-entities represent sub-scans, representing surface topology (geometry information) and the color of zones (texture information).

Babayoff explains that "by identifying the overlap zone within the entities, the spatial relationship between the entities may be established, and the various entities stitched together or combined to form a global numerical entity that comprises the full geometry and color representation of the target zone. The larger the overlap zone, the greater the accuracy with which the different zones may be synchronized together spatially." *Id.*, 23:65-24:5. By combining to form a global

numerical entity, the sub entities generate a digital 3D representation of the tooth. This is akin to the '151 patent's explanation of sub-scans, "[d]eriving the texture data based on texture information from two or more sub-scan can provide a more accurate measurement of the texture data." Ex. 1001, '151 patent, 4:33-35.

Motivation to Combine Babayoff and Chu

To the extent that Patent Owner argues that the second embodiment of Babayoff (*e.g.*, Ex. 1105, Babayoff, 23:48-25:3) is separate from the fourth embodiment of Babayoff (*e.g.*, Ex. 1105, Babayoff, 26:8-28:7), Babayoff provides the motivation to implement the stitching described in the second embodiment to form the entity of the fourth embodiment because it explains the resulting overlap zone increases the accuracy of the scan. Ex. 1105, Babayoff, 26:31-36.; Ex. 1003, ¶118.

A POSA would have a reasonable expectation of success implementing the stitching of the second embodiment of Babayoff could have been used to obtain the claimed digital 3D representation within the context of the fourth embodiment because stitching to form a digital 3D representation of the scanned area is well known and expected in the art. Ex. 1003, ¶119. *Id.* Further, it would have been obvious to try to implement the stitching of Babayoff's second embodiment in Babayoff's fourth embodiment because such techniques were readily available to

Babayoff and could save unneeded experimentation with other ways to form a digital 3D representation. *Id.*

11. Claim 15

The method according to claim 14, wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans.

Babayoff in combination with Chu discloses the claim 15 limitations for the reasons discussed *supra* in connection with claim 14. Ex. 1003, ¶120. In particular, Babayoff explains that,

> by identifying the overlap zone within the entities, the spatial relationship between the entities may be established, and the various entities stitched together or combined to form a global numerical entity that comprises the full geometry and color representation of the target zone. The larger the overlap zone, the greater the accuracy with which the different zones may be synchronized together spacially.

Id., 23:65-24:5. In at least this respect, the combination discloses "wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans." Ex. 1003, ¶120.

B. Ground 2: Claim 3 Is Obvious Over Babayoff and Chu and Graham

The method according to claim 1, wherein determining the tooth shade value for the point comprises an interpolation of the two or more reference tooth shade values having known texture values close to the texture data of the point.

Babayoff in combination with Chu and Graham discloses these limitations of claim 3. Ex. 1003, ¶¶121-24. It would have been obvious to combine Babayoff and Chu for the reasons described *supra* in connection with claim 1 and the requirements of claim 1 are satisfied for that reason. The remaining limitations are satisfied by Graham. Graham discloses, "if the color characteristics for a patient fall between two shades, some of ***interpolation*** ***may be applied to the two shades*** ***to produce an additional shade for the patient's tooth that suitably fits the generated color characteristics for that patient.***" Ex. 1107, ¶0050 (emphasis added).

Motivation to Combine Babayoff and Chu with Graham

As discussed *supra* in claim 1, Babayoff in combination with Chu uses measured color values compared with reference tooth shade vales to determine tooth shade values for dental prosthetics and restorations. A POSA would have been motivated to modify the tooth shade values determined by Babayoff and Chu using the teachings of Graham in order to generate a more accurate tooth shade value. Ex. 1003, ¶122. A POSA would have been motivated to increase the accuracy in this fashion because both Babayoff and Chu discuss efforts to obtain accurate and

natural-looking tooth shade and Graham provides a straightforward solution using interpolation.

Moreover, Babayoff, Chu, and Graham are all in the field of determining appropriate shade values for dental restorations. *See*, *e.g.*, Ex. 1105, 27:59-62; Ex. 1107, ¶0036. The addition of the interpolation of shade values to Babayoff and Chu would have required nothing more than the addition of a database of known shade values as disclosed by Chu (Ex. 1106, e4) and Graham (Ex. 1107, ¶¶0049-50), and a simple code to perform the interpolation when a measured color falls between two reference tooth shade values. Ex. 1003, ¶123. Both of these things are well known and could have been implemented by a POSA. *Id.* Thus, it would have been obvious to a POSA to combine Babayoff-Chu with Graham to arrive at the claim 3 limitations. *Id.*

C. Ground 3: Claims 15-17 Are Obvious Over Babayoff and Chu and Nathaniel

1. Claim 15

The method according to claim 14, wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans.

Babayoff in combination with Chu and Nathaniel discloses these limitations of claim 15. Ex. 1003, ¶¶125-29. The limitations of claim 14 are met by Babayoff and Chu for the reasons discussed *supra* in connection with Ground 1. As discussed *supra* in connection with claim 15 of Ground 1, Babayoff in combination with Chu

discloses using the texture data of overlapping scans to build a 3D representation of a tooth, which includes "combining the texture information from corresponding parts of a number of the sub-scans." Ex. 1105, 23:48-25:3. However to the extent Patent Owner argues Babayoff-Chu does not disclose this limitation, it is disclosed by Babayoff combined with Chu and Nathaniel.

Babayoff recognizes that "theoretically the corresponding entities should have a portion of their data identical to one another within the overlap zone. However, since the scanner itself moves in orientation and position from scan to scan, the coordinates relating to these overlap zones will usually vary between adjacent scans, even though they relate to the same spatial feature." *Id.*, 23:59-65. Babayoff also recognizes that, "ambiguity may occur . . . if a part of the intra-oral cavity (corresponding to part of the overlapping scanned data in some of the entities) moves in relation to other parts." *Id.*, 24:14-18. A POSA reading Babayoff may recognize that for values of the same tissue type (*e.g.*, teeth), Babayoff does not address ambiguity arising from the variance between adjacent scans. Ex. 1003, ¶126.Thus, confronting this ambiguity, a POSA would look elsewhere to improve the determination of color values in overlapping scan regions. *Id.*

Nathaniel is similarly directed to the creation of 3D models from a series of scan images and is analogous art. Ex. 1003, ¶127. Nathaniel addresses the problem of determining an appropriate value of a pixel in overlapping images. Ex. 1111,

¶¶0024, 0043. To determine the appropriate value for a given pixel, Nathaniel computes an "average" or "weighted average" of the pixels in each of the overlapping images. *Id*., ¶0099 ("If such appropriate pixel occurs in more than one X-ray image, the preferred embodiment of the invention uses the pixel which is closest to the center in its original X-ray image in order to minimize image distortion. For this pixel, the X-rays are closest to perpendicular to the imaging Surface. Other embodiments may use an average value of the original pixels, a weighted average, the maximal or minimal gray level value, or any other decision rule.").

Motivation to Combine Babayoff and Chu with Nathaniel

A POSA would have recognized that methods of combining appropriate pixel data from the overlapping images might result in a more accurate determination of color data when combining the sub-entities of Babayoff. Ex. 1003, ¶128. Thus, a POSA would have been motivated to try to improve the color determinations of the Babayoff and Chu combination using the "average" and "weighted average" of Nathaniel. *Id.* A POSA would have encountered no technical hurdles when implementing the methods of Nathaniel in the context of Babayoff-Chu. *Id.* A POSA would have merely needed to implement simple computer code to take the average or weighted average of the datasets rather than combining datasets or disregarding one data set in view of the other. *Id.* Any undergraduate student of computer science could implement such code. *Id.*

Thus, it would have been obvious to a POSA to combine Babayoff-Chu with Nathaniel to achieve the limitations of claim 15. *Id.*

2. Claim 16

The method according to claim 15, wherein combining the texture information from the sub-scans comprises interpolating the texture information and/or calculating an average value of the texture information.

Babayoff in combination with Chu and Nathaniel discloses these limitations of claim 16. Ex. 1003, ¶130. As discussed in claim 15 of this Ground, Babayoff in combination with Chu and Nathaniel calculates the average value of the texture information. Claim 16 is obvious for the same reasons. *Id.*

3. Claim 17

The method according to claim 16, wherein the calculated average value is a weighted average of the texture information.

Babayoff in combination with Chu and Nathaniel discloses these limitations of claim 16. Ex. 1003, ¶131. As discussed in claim 15 of this Ground, Babayoff in combination with Chu and Nathaniel calculates the weighted average value of the texture information. Claim 17 is obvious for the same reasons. *Id.*

D. Ground 4: Claims 1, 2, 7, and 9-15 Are Obvious Over Babayoff and Inglese

To the extent the Board concludes that Chu does not disclose the shade matching and certainty scoring limitations discussed in connection with Ground 1

(*e.g.*, 1[b], 1[c], 2, 7, 9, and 13), Inglese discloses these limitations and its combination with Babayoff was obvious for the reasons provided below.

1. Claim 1

Babayoff discloses "[preamble] A method for determining shade of a patient's tooth" and "[a] obtaining a digital 3D representation of the tooth, where the digital 3D representation comprises shape data and texture data for the tooth" for the reasons discussed above in connection with Ground 1. The remaining limitations are met by Babayoff in combination with Inglese as set forth below.

> **[b] determining a tooth shade value for at least one point on the tooth based on the texture data of the corresponding point of the digital 3D representation and on known texture values of one or more reference tooth shade values**

Babayoff in combination with Inglese discloses these limitations of claim 1. Ex. 1003, ¶¶133-37. As discussed *supra*, Babayoff determines a color c for each Cartesian point on a 3D representation of a tooth, and further, discloses a method determining the shade of a prosthesis or restoration using this information. *Id.*, 21:9-13, 26:8-65. Babayoff explains that after creation of numerical entity I (including x, y, z, and color c), shade information for a prosthesis can be obtained in order to provide a natural-looking appearance compatible with the patient's other teeth. *Id.*, 26:20-24.

Inglese describes an intra-oral scanning device and method for determining tooth shade. Ex. 1109, ¶0001. In particular, Inglese describes a manner of measuring

tooth shade where a sensor receives a measurement signal from the illuminated tooth and that signal is converted into Cartesian x, y, z coordinates in three dimensional shade space where reference points are also defined. *Id.*, ¶¶0011-14. This is depicted graphically below:

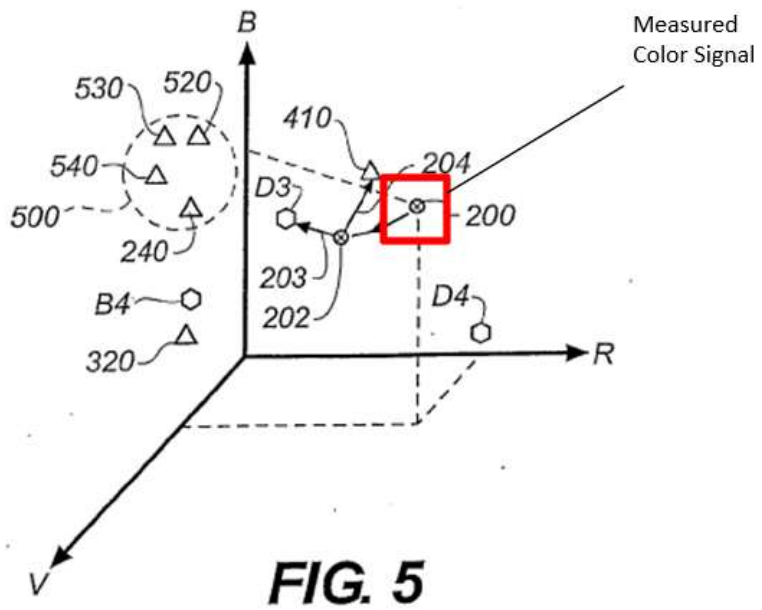


FIG. 5

Id., FIG. 5 (annotated).

Inglese further discloses that an automatic search is performed where the shade corresponding to the reference point close to the measurement point is established. *Id.*, ¶0015], ¶¶0031-35. "The reference 200 designates one point of the shade space. ***The coordinates of the point in the dimensions of the shade space are symbolized by dotted line projections on the <u>R, G, B dimension axes</u>.***" Ex. 1109, ¶¶0081-0091 (emphasis added). Inglese continues: "Also shown ***in the shade space***

are the reference points 320, 410, 540. These are shown as small triangles. They correspond to known values of a first dental shade guide. Another set of reference points B4, D3, D4, shown by small hexagons, corresponds to the shades of a second dental shade guide." *Id.* (emphasis added). Inglese explains that, "[t]he reference point closest to the measurement point, possibly corrected, is sought to establish the shade of the relevant tooth part." *Id*. This is shown below in annotated Figure 5 of Inglese.

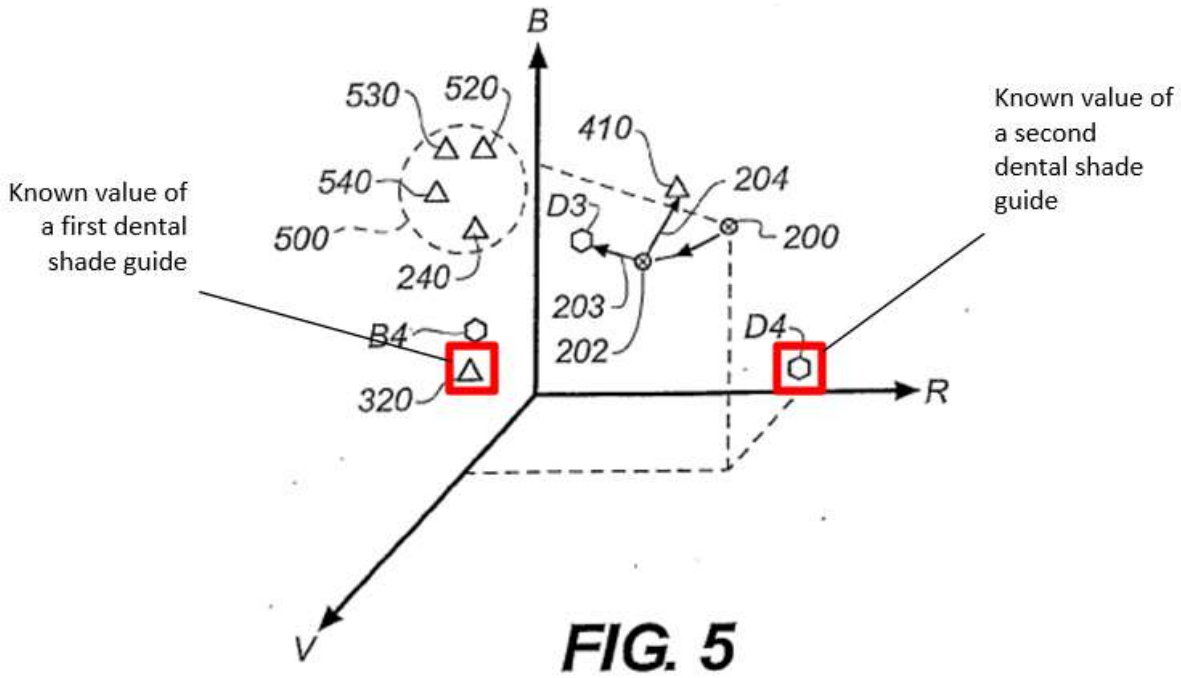


FIG. 5

Motivation to Combine Babayoff and Inglese

Inglese provides the motivation for using known texture values of reference tooth shade values with Babayoff's process of generating a 3D representation of a

tooth using shape data and texture data by explaining that the aim in measuring dental shade is to establish the appearance of the tooth as faithfully as possible and providing a means of doing so "freed from the subjectivity part related to the practitioner." Ex. 1106, ¶¶0001, 0006.; Ex. 1003, ¶136. It would have been obvious to a POSA, therefore, to replace the manual or algorithmic process of shading a restoration using texture data from surrounding teeth, with the automated process of shading a restoration using texture data from reference tooth shade values of a shade guide as taught by Inglese. *Id.* Indeed, in Babayoff, at the conclusion of the process the user is still left to fabricate the prosthetic from a mold having a certain color. Ex. 1004, 2:47-49. Inglese provides an automated manner of determining that color, and expressly suggests automating that otherwise manual process is advantageous. Ex. 1003, ¶136.

A POSA would have a reasonable expectation of success modifying Babayoff to compare tooth shade with tooth shade guide values, rather than tooth shade values from the patient's teeth, and would know how to do so. Ex. 1003, ¶137. The modification would require nothing more than modifying Babayoff's algorithm to compare measured texture values with known texture values of reference tooth shade values, and select the closest match. *Id*. The teachings of Inglese are thus similar in all relevant respects to the teachings of Chu, discussed *supra* in connection with claim 1. *Id.* Accordingly, it would have been obvious to combine Babayoff with

Inglese for the same reasons it would have been obvious to combine Babayoff with Chu. *Id.*

[c] wherein the method comprises deriving a certainty score expressing the certainty of the determined tooth shade value.

Babayoff modified by the teaching of Inglese discloses this limitation of claim 1. Ex. 1003, ¶¶138-45. Inglese describes a manner of deriving a measure of the accuracy of the determined tooth shade value and thus discloses the required "certainty score," and it would have been obvious to modify Babayoff with Inglese to incorporate Inglese's certainty score in the determination of tooth shade. Ex. 1003, ¶138.

As discussed *supra*, Babayoff modified by the teachings of Inglese discloses determination of a tooth shade value based on comparison of the measured texture value with the texture value of a reference tooth shade to determine shade. Ex. 1003, ¶139. As also discussed *supra*, Babayoff recognized the need for the determined tooth shade to be accurate, and so did Inglese, explaining that the aim in measuring dental shade is to establish the appearance of the tooth as faithfully as possible. Ex. 1109, ¶0001.

As discussed *supra*, Inglese describes a process whereby the measured color signal is modeled in three-dimensional shade space alongside reference tooth shade values. In particular, reference points 320, 410, 540 are shown in Figure 5 as small triangles and correspond to reference shades of shade guide acquired by the

measuring instrument in a learning phase or are preprogrammed. *Id.*, ¶0084. Similarly, reference points B4, D3, D4, shown as small hexagons, correspond to shades of a second dental shade guide. *Id.* Inglese explains that the reference point closest to the measurement point, possibly corrected, is sought to establish the shade of the relevant tooth part. *Id.*, ¶0085 ("This point is sought for a given dental shade guide.").

The certainty score of Inglese is the algebraic distance between the measured tooth shade and the reference tooth shade. Inglese notes "that the measurement point does not exactly coincide with the reference points. A correction vector 203, 204, of the shade space, pointing from the measurement point to the reference point, indicates the distance and direction of the gap present between the measurement point and the selected reference point." *Id.*, ¶0086. This is depicted in annotated Figure 5 below.

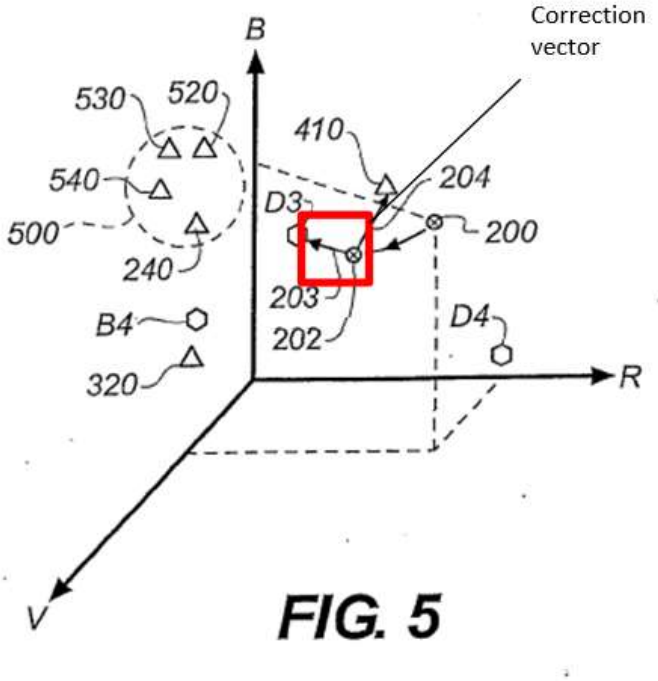


FIG. 5

Inglese explains, "[d]ata representative of the length and direction of the correction vector can be displayed with the shade, on a control screen or dedicated display." *Id.* A POSA would understand that the vector between 200 and 202 represents a measure of the accuracy of the determined tooth shade value and thus discloses the required "certainty score." Ex. 1003, ¶141.

Motivation to Combine Babayoff and Inglese

A POSA would have been motivated to combine Babayoff with Inglese for the reasons discussed *supra*, and would be motivated to further modify the combination to include a certainty score at least because Inglese teaches ways to correct measurement errors in tooth shade measurement occurring due to transparency, ambient light, and incident light. Ex. 1003, ¶142. For example, Inglese

explains that visual evaluation generates errors resulting from faulty color perception or the practitioner's visual fatigue. Ex. 1109, ¶0004. Inglese further explains that a more objective evaluation can be performed using a colorimeter, which analyzes the spectral response of the tooth and can be linked to a suitable visualization software to prepare a shade map of the tooth, displayed on a control screen. *Id.*, ¶0005. Inglese describes a manner of eliminating difficulties in using colorimeters to evaluate dental shade and, further, of selecting a tooth shade from a set of reference tooth shade values. *Id.*, ¶0006-49.

It would have been obvious to a POSA to incorporate the correction vectors into Babayoff in the manner disclosed by Inglese to improve the certainty of shade match, as Inglese suggests. Ex. 1003, ¶143. A POSA would have had a reasonable expectation of success when incorporating these vector computations into Babayoff because it would require nothing more the use of simple mathematic computations, including the prior art calculation disclosed by the '151 patent (Ex. 1001, 5:56-64), and the use of known datasets such as Cromascop and Vita Lumin Classic. Ex. 1109, ¶0085; Ex. 1003, ¶143.

A POSA could have implemented the correction and shade determination methods of Inglese on the N[X', Y', C] space of Babayoff with a reasonable expectation of success. Ex. 1003, ¶144. Inglese explains its algebraic operations for shade determination can be performed on a 2D space such as N[X', Y', C]. *Id.*

Implementing Inglese in Babayoff would require nothing more than the addition known and well understood software. *Id.*

Therefore, it would have been obvious to a POSA to improve Babayoff by using the shade determination methods of Inglese to obtain more accurate shade values in the presence of ambient/reflected/refracted light interference, and deriving a certainty score expressing the certainty of the determined tooth shade value, *i.e.*, "a measure of the accuracy of the determined tooth shade value." Ex. 1003, ¶145.

2. Claim 2

The method according to claim 1, wherein determining the tooth shade value for the point comprises selecting the reference tooth shade value with the known texture value closest to the texture data of the point.

Babayoff in combination with Inglese discloses these limitations of claim 2. Ex. 1003, ¶146. In Inglese, the known shade values are, for example, 320, 410, 540, B4, D3, and D5 of Figure 5 shown above. Ex. 1109, ¶¶0084 ("Also shown in the shade space are the reference points 320, 410, 540. These are shown as small triangles. They correspond to known values of a first dental shade guide."). As explained in more detail *supra* in connection with claim 1 of this Ground, Inglese further explains, "[t]he reference point closest to the measurement point, possibly corrected, is sought to establish the shade of the relevant tooth part." *Id.*, ¶0085. The combination of Babayoff with Inglese thus discloses "wherein determining the tooth

shade value for the point comprises selecting the reference tooth shade value with the known texture value closest to the texture data of the point." Ex. 1003, ¶146.

3. Claim 7

The method according to claim 1, wherein the certainty measure relates to how uniform the sub-scan texture information is at the point, and/or to how close the texture data is to the known texture value of the determined tooth shade value, and/or to the amount of texture information used to derive the texture data at the point.

Babayoff in combination with Inglese discloses these limitations of claim 7. Ex. 1003, ¶147. In particular, Babayoff modified by the teachings of Inglese discloses a certainty measure relating to "how close the texture data is to the known texture value of the determined tooth shade value." As explained in more detail *supra* in connection with claim 1 of this Ground, Inglese discloses "[t]he reference point closest to the measurement point, possibly corrected, is sought to establish the shade of the relevant tooth part," and involves calculation of a correction vector, which "indicates the distance and direction of the gap present between the measurement point and the selected reference point." Ex. 1109, ¶¶0085. The combination of Babayoff with Inglese thus discloses "wherein the certainty measure relates . . . to how close the texture data is to the known texture value of the determined tooth shade value." Ex. 1003, ¶147.

4. Claim 9

The method according to claim 1, wherein the one or more reference tooth shade values relate to shade values for natural teeth with intact surface and/or to shade values for teeth prepared for a dental restoration.

Babayoff in combination with Inglese discloses these limitations of claim 9. Ex. 1003, ¶148. Babayoff modified by the teachings of Inglese discloses shade values for teeth prepared for a dental restoration. Ex. 1003, ¶148. Inglese discloses "shade 410 [is] of the 'Cromascop' dental shade guide. The selected shade can also be that corresponding to point D3 of the second dental shade guide. For example, this is shade D3 of the 'Vita Lumin Classic' dental shade guide." Ex. 1109, ¶0085. Accordingly, the combination of Babayoff with Inglese discloses "wherein the one or more reference tooth shade values relate to shade values for natural teeth with intact surface and/or to shade values for teeth prepared for a dental restoration." Ex. 1003, ¶148.

5. Claim 10

The method according to claim 1, wherein the method comprises comparing the texture data with known texture values for soft oral tissue, such as gum tissue and gingiva.

Babayoff discloses these limitations of claim 10. Ex. 1003, ¶149. As discussed *supra* in connection with Ground 1, Babayoff discloses a method of generating color data in order to distinguish between different regions of the intraoral cavity, for example between soft tissue, such as gum and gingiva, and teeth, involving

comparison of texture data with known texture values for soft oral tissue, such as gum tissue and gingiva. Ex. 1105, 20:65-23:7; FIG. 15. Thus, Babayoff discloses "comparing the texture data with known texture values for soft oral tissue, such as gum tissue and gingiva." Ex. 1003, ¶149.

6. Claim 11

The method according to claim 1, wherein the texture information comprises at least one of tooth color or surface roughness.

Babayoff in combination with Inglese discloses these limitations of claim 11. Ex. 1003, ¶150. As explained *supra* in connection with claim 1 of Ground 1, Babayoff obtains a digital 3D representation of a tooth using an intraoral scanning device 100, where the 3D representation comprises shape data and color data for the tooth. *Id*., 8:30-44, 8:57-9:32, FIGS. 1, 4. Babayoff explains, "[a]dvantageously, such a scanner makes use of confocal imaging for providing an accurate three-dimensional representation of the target surface within the intra-oral cavity. Color values are then added to each data point of this data set by obtaining a two-dimensional color image of the target surface, and then mapping the color values of the two-dimensional image onto the three-dimensional 'image.'" *Id.*, 8:15-22. The combination with Inglese adds a manner of plotting the derived color values relative to known reference color values from shade guides in three-dimensional shade space. Ex. 1109, ¶¶0001, 11-14, 31-35. The combination of Babayoff with Inglese

thus discloses "wherein the texture information comprises at least one of tooth color or surface roughness." Ex. 1003, ¶150.

7. Claim 12

The method according to claim 1, wherein the method comprises creating a shade profile for the tooth from shade values determined one or more points on the tooth.

Babayoff in combination with Inglese discloses these limitations of claim 12. Ex. 1003, ¶151. As explained *supra* in connection with claim 12 of Ground 1, a POSA would understand the sub-data set I1 in Babayoff to be a shade profile for a tooth. Babayoff explains: "Thus, I1 will contain all data points in which the color parameter thereof corresponds to the color of teeth . . ." *Id.*, 22:26-27. Babayoff further explains that the color data of I1 are used to create a dental prosthesis X having a shade profile based on I1. *Id.*, 26:8-27-38. Babayoff also discloses various shade profiles for a tooth including measured N[X', Y', C], base I[X, Y, Z, C] (I1 for extracted tooth values), transform T[X, Y, Z, C] and model X[X, Y, Z, C], as depicted in Figure 19:

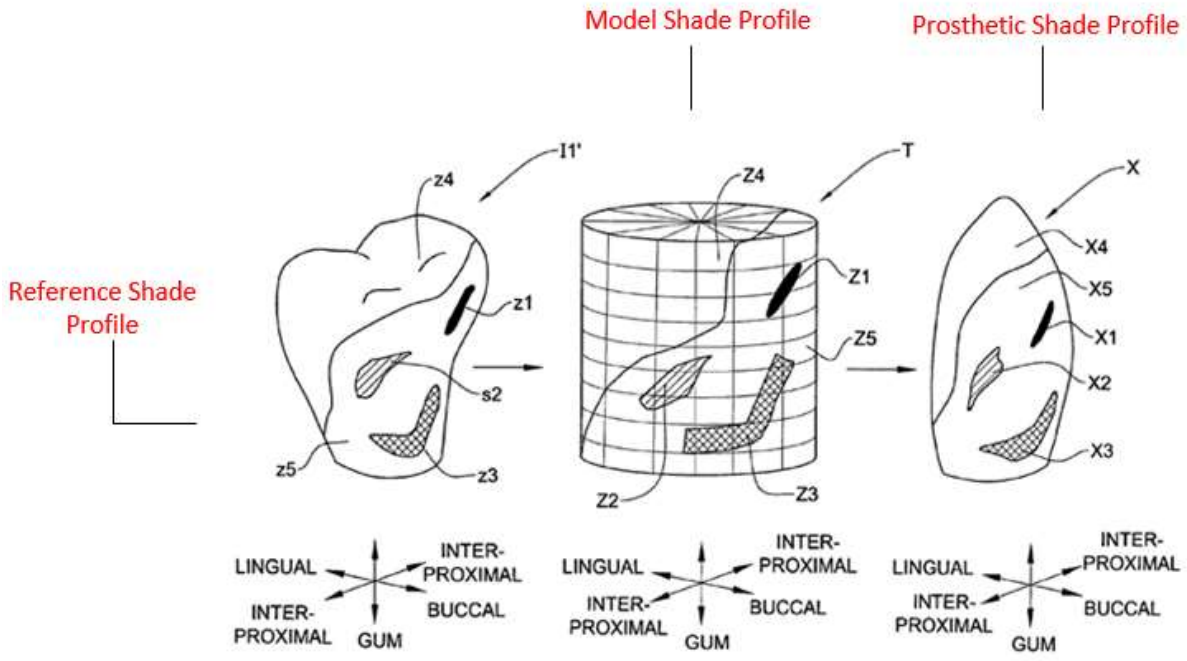


FIG. 19

Further, Inglese discloses a shade map 100, and explains that the shade map is prepared from shade measurements taken from separate parts of the tooth. Inglese, ¶0070, FIG. 1. The combination of Babayoff and Inglese thus discloses "wherein the method comprises creating a shade profile for the tooth from shade values determined one or more points on the tooth." Ex. 1003, ¶151.

8. Claim 13

Independent claim 13 is substantially identical to claim 12 except it omits the certainty score limitation and adds the following:

13[d] wherein the tooth shade profile comprises a one or more tooth shade regions on the tooth surface where an average tooth shade is derived for each region from tooth shade values determined for a number of points within the region.

Babayoff in combination with Inglese discloses the claim 13 limitations, with the limitations shared with claims 1 and 12 disclosed by Babayoff and Inglese for the reasons set forth above in connection with those claims. In addition to the shade profile discussed above in claim 12 that uses directly measured color c values to determine a shade profile, Babayoff also discloses a manner of generating a shade profile from average shade values determined from a number of points within the region as discussed in connection with claim 13 of Ground 1. Ex. 1003, ¶153.

Inglese likewise discloses this limitation. Inglese discloses that a shade profile is prepared from shade measurements taken from separate parts of the tooth. Ex. 1109, ¶0070, FIG. 1. Inglese further discloses that the shade of relevant tooth part can be compensated for by a shades average calculated based on shades of other neighboring tooth parts. *Id.* Inglese also discloses establishing a tooth's shade based on measurements of individual pixels, where averages can then be performed on pixel groups. *See id.*, ¶0077; *see also* claim 26.

Motivation to Combine Babayoff and Inglese

It would be obvious based on the teachings of Babayoff and Inglese, to generate a tooth shade profile that averages values between neighboring tooth parts. Ex. 1003, ¶155. Babayoff and Chu both provide the motivation to generate a tooth

shade profile that averages values within the gingival, body, and incisal areas of the tooth because both references teach advantages to smoothing between regions and generating a shade profile of a region using average values within the region. *Id.* A POSA would have expected such a combination to work since both Babayoff and Chu had already accomplished generating a tooth shade profile using average tooth shade values within a region. *Id.* A POSA would have understood how to generate such a profile using average values because modifying the algorithm in Babayoff to generate the profile in this manner would be straightforward and routine in the field of image processing. *Id.*

9. Claim 14

Independent claim 14 is substantially identical to claim 1 except it omits the certainty score limitation and adds the following:

> **14[c] wherein obtaining the digital 3D representation of the tooth comprises recording a series of sub-scans of the tooth, where at least one of said sub-scans comprises both texture information and geometry information for said tooth, and generating the digital 3D representation of the tooth from the recorded series of sub-scans.**

Babayoff modified by the teachings of Inglese discloses the claim 14 limitations. Ex. 1003, ¶157. The limitations shared with claim 1 are disclosed by Babayoff modified by the teachings of Inglese for the reasons discussed *supra* in connection with claim 1. The added limitation of claim 15 is disclosed by Babayoff for the reasons provided in connection with claim 14 of Ground 1. *Id.* It would have

been obvious to incorporate the stitching concept in the second embodiment of Babayoff with the fourth embodiment of Babayoff for the reasons provided in connection with claim 14 of Ground 1. *Id.*

10. Claim 15

The method according to claim 14, wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans.

Babayoff in combination with Inglese discloses the claim 15 limitations. Ex. 1003, ¶158. Babayoff, modified by the teachings of Inglese discloses the limitations of claim 14 for the reasons discussed above in connection with claim 14 of this Ground. The added limitation of claim 15 is disclosed by Babayoff for the reasons provided in connection with claim 15 of Ground 1.

E. Ground 5: Claim 3 Is Obvious Over Babayoff and Inglese and Graham

The method according to claim 1, wherein determining the tooth shade value for the point comprises an interpolation of the two or more reference tooth shade values having known texture values close to the texture data of the point.

Babayoff in combination with Inglese and Graham satisfies these limitations of claim 3. Ex. 1003, ¶¶159-62. It would have been obvious to combine Babayoff and Inglese for the reasons described in connection with claim 1 and the requirements of claim 1 are satisfied for that reason. Graham further discloses, "if the color characteristics for a patient fall between two shades, some of ***interpolation***

may be applied to the two shades to produce an additional shade for the patient's tooth that suitably fits the generated color characteristics for that patient." Ex. 1107, ¶0050 (emphasis added).

Motivation to Combine Babayoff and Inglese with Graham

As discussed in claim 1 of this Ground, Babayoff modified by the teachings of Inglese uses measured color values compared with reference tooth shade vales to determine tooth shade values for dental prosthetics and restorations. A POSA would have been motivated to modify the tooth shade values determined by the Babayoff-Inglese combination using the teachings of Graham in order to generate a more accurate tooth shade value. Ex. 1003, ¶160. A POSA would have been motivated to increase the accuracy in this fashion because both Babayoff and Inglese discuss efforts to obtain accurate and natural looking tooth shade, and Graham provides a straightforward solution using interpolation.

Moreover, Babayoff, Inglese, and Graham are all in the field of determining appropriate shade values for dental prosthetics and restorations. *See*, *e.g.*, Ex. 1105, 27:59-62; Ex. 1107, ¶0036. The addition of the interpolation of shade values to the Babayoff-Inglese combination would have required nothing more than the addition of a database of known shade values as disclosed by Inglese (Ex. 1109, ¶0085) and Graham (Ex. 1107, ¶¶0049-50) and a simple code to perform the interpolation when a measured color falls between two reference tooth shade values. Ex. 1003, ¶161.

Both of these things are well known and could have been implemented by a POSA. *Id.*

Thus, it would have been obvious to a POSA to combine Babayoff and Inglese with Graham to arrive at the claim 3 limitations. *Id.*

F. Ground 6: Claims 15-17 Are Obvious Over Babayoff and Inglese and Nathaniel

1. Claim 15

The method according to claim 14, wherein the texture data at least partly are derived by combining the texture information from corresponding parts of a number of the sub-scans.

Babayoff in combination with Inglese and Nathaniel discloses these limitations of claim 15. Ex. 1003, ¶¶163-67. The limitations of claim 14 are met by Babayoff and Inglese for the reasons discussed *supra* in connection with Ground 4. As discussed *supra* in connection with claim 15 of Ground 4, Babayoff in combination with Chu discloses using the texture data of overlapping scans to build a 3D representation of a tooth, which includes "combining the texture information from corresponding parts of a number of the sub-scans." Ex. 1105, 23:48-25:3. However, to the extent Patent Owner argues the Babayoff in combination with Inglese does not disclose this limitation, it is disclosed by Babayoff and Inglese in combination with Nathaniel. The relevant disclosures of Babayoff and Nathaniel are discussed supra in connection with Ground 3.

Motivation to Combine Babayoff and Inglese with Nathaniel

A POSA would have recognized that methods of combining appropriate pixel data from the overlapping images might result in a more accurate determination of color data when combining the sub-entities of Babayoff. Ex. 1003, ¶166. Thus, a POSA would have been motivated to try to improve the color determinations of Babayoff and Inglese using the "average" and "weighted average" of Nathaniel. *Id.* A POSA would have encountered no technical hurdles when testing the methods of Nathaniel in the context of Babayoff in combination with Inglese. *Id.* A POSA would have merely needed to write and execute simple computer code to take the average or weighted average of the datasets rather than combining datasets or disregarding one data set in view of the other. *Id.* An undergraduate student of computer science could write and execute such code. *Id.*

Thus, it would have been obvious to a POSA to combine Babayoff with Inglese and Nathaniel to achieve the limitations of claim 15.

2. Claim 16

The method according to claim 15, wherein combining the texture information from the sub-scans comprises interpolating the texture information and/or calculating an average value of the texture information.

Babayoff in combination with Inglese and Nathaniel discloses these limitations of claim 16. Ex. 1003, ¶168. As discussed in claim 15 of this Ground,

Babayoff in combination with Inglese and Nathanield etermines the average value of the texture information. Claim 16 is obvious for the same reasons. *Id.*

3. Claim 17

The method according to claim 16, wherein the calculated average value is a weighted average of the texture information.

Babayoff in combination with Inglese and Nathaniel discloses these limitations of claim 17. Ex. 1003, ¶169. As discussed in claim 15 of this Ground, Babayoff in combination with Inglese and Nathaniel determines the weighted average value of the texture information. Claim 17 is obvious for the same reasons. *Id.*

VIII. MANDATORY NOTICES PURSUANT TO 37 C.F.R. § 42.8

A. Real Party-In-Interest (37 C.F.R. § 42.8(b)(1))

Pursuant to 37 C.F.R. § 42.8(b)(1), Petitioner certifies that DITC is the real party-in-interest in this matter. Petitioner also identifies an additional real party-in-interest, Carestream Dental LLC, which was the original defendant in related district court litigation (*3Shape A/S v. Carestream Dental LLC*, *see infra*) and which as of April 20, 2022 has no past or future liabilities associated with the claims, accused products, or associated business in that litigation.

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

Pursuant to 37 C.F.R. § 42.8(b)(2), Petitioner hereby states that the ’146 patent is a subject of civil action *3Shape A/S v. Carestream Dental LLC et al.*, Civil No.

1:22-cv-01829 (N.D. Ga.), which was transferred from the Western District of Texas and was previously styled as *3Shape A/S v. Carestream Dental LLC*, Civil No. 6:21-cv-01110 (W.D. Tex.), filed October 26, 2021. The ’146 patent is also a subject of civil action *3Shape A/S v. Medit Corporation*, Civil No. 6:22-cv-00443 (W.D. Tex.), filed May 2, 2022.

C. Counsel and Service Information (37 C.F.R. § 42.8(b)(3), 42.8(b)(4))

Pursuant to 37 C.F.R. §§ 42.8(b)(3) and 42.10(a), Petitioner provides the following counsel and service information. Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney accompanies this Petition.

LEAD COUNSEL	BACK-UP COUNSEL
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D. Payment of Fees

The Office is authorized to charge fees for this Petition to Deposit Account No. 50-5708. Any additional fees that might be due are also authorized.

IX. GROUNDS FOR STANDING

Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '151 patent is available for *inter partes* review and that Petitioner is not barred or estopped from

requesting *inter partes* review of any claim of the '151 patent on the grounds identified herein. This Petition is filed in accordance with 37 C.F.R. § 42.106(a) along with a Power of Attorney and an Exhibit List pursuant to 37 C.F.R. § 42.10(b) and § 42.63(e).

X. DISCRETIONARY ANALYSIS

In addition to the strong merits presented herein, Petitioner also hereby provides a *Sotera*-type stipulation and stipulates that if the PTAB institutes *inter partes* review in relation to any petition filed by DITC with respect to the '151 patent, the Petitioner will not pursue in the district court litigation any ground raised or that could have been reasonably raised in the instituted IPR with respect to the patent claim subject to the instituted IPR. This stipulation precludes discretionary denial under §314(a). *See* Director Vidal Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation, at 3-5, 7-8 (June 21, 2022).

Regarding §325(d), the '151patent has not previously been challenged at the PTAB. Nor was any reference relied upon herein as part of any ground cited during prosecution or considered by the Examiner. Accordingly, discretionary denial under §325(d) and *General Plastic* is not warranted.

XI. CONCLUSION

For the foregoing reasons, Petitioner respectfully requests that Trial be

instituted and that the Challenged Claims of the ’151 patent be canceled.

Respectfully submitted,

Dated: December 21, 2022

By: */s/ John T. McKee*
John T. McKee (Reg. No. 65,926)

Counsel for Petitioner

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the word count for the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,695,151 totals 13,794 words, which complies with the 14,000 allowed under 37 CFR § 42.24(a)(1)(i). This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Dated: December 21, 2022

By: */s/ John T. McKee*

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,695,151 together with all exhibits and other papers filed therewith was served on December 21, 2022, by Federal Express directed to the attorneys of record for the patent at the following address:

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A courtesy copy is also provided to the Patent Owner's litigation attorneys by FedEx at the address below:

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