

IPR2023-01313
Patent No. 9,629,551

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MEDIT CORPORATION,

Petitioner,

v.

3SHAPE A/S,

Patent Owner.

Case No.: IPR2023-01313
U.S. Patent No. 9,629,551

**PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 9,629,551**

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LIST OF EXHIBITS

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1001	U.S. Patent No. 9,629,551 (“the ’551 patent”)
1002	Excerpts of the File History for U.S. Patent No. 9,629,551
1003	Declaration of Hassan Foroosh, Ph.D. (“Foroosh Declaration”)
1004	Curriculum Vitae of Hassan Foroosh, Ph.D.
1005	U.S. Patent No. 8,401,225 (“Newcombe”)
1006	Herbst, Evan, Peter Henry, Xiaofeng Ren, and Dieter Fox. “Toward Object Discovery and Modeling via 3-D Scene Comparison.” <i>2011 IEEE International Conference on Robotics and Automation</i> (vol. 3, pp. 2623-2629). 7 vols. Piscataway, NJ: IEEE, ©2011 (“Herbst”)
1007	Hähnel, Dirk, Rudolph Triebel, Wolfram Burgard, and Sebastian Thrun. “Map Building with Mobile Robots in Dynamic Environments.” <i>2003 IEEE International Conference on Robotics and Automation</i> (vol. 2, pp. 1557-1563). 3 vols. (“Hähnel”)
1008	U.S. Patent No. 9,245,374 (“McQueston”)
1009	U.S. Provisional Patent Application No. 61/445,499 (“McQueston Provisional”)
1010	Declaration of Sylvia D. Hall-Ellis, Ph.D. regarding public availability of Herbst and Hähnel
1011	Order on Claim Construction, <i>3Shape A/S v. Medit Corp.</i> , Case No. W-22-CV-00443-ADA-DTG, Dkt. No. 76 (W.D. Tex. May 2, 2023)
1012	F. Duret, B. Péliissier, Different Dental CAD/CAM Impression Methods, EMC (Elsevier Masson SAS, Paris), Médecine buccale, 28-740-R-10, 2010.
1013	R.I. Hartley and P. Sturm, Triangulation. <i>Computer Vision and Image Understanding</i> , vol. 68, Issue 2, pp. 146–157, 1997.
1014	N. Molton, and M. Brady. Practical Structure and Motion from Stereo When Motion is Unconstrained. <i>International Journal of Computer Vision</i> , vol. 39, Issue 1, pp: 5-23, 2004.

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1015	S. Demey, A. Zisserman, and P. Beardsley, Affine and Projective Structure from Motion, Proc. of the British Machine Vision Conference, 1992.
1016	K. E. Ozden, K. Schindler and L. van Gool, Multibody Structure-from-Motion in Practice, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 32, no. 6, pp. 1134-1141, June 2010.
1017	Jason Geng, Structured-light 3D surface imaging: a tutorial, Advances in Optics and Photonics, vol. 3, pp. 128-160, 2011.
1018	P. Henry, M. Krainin, E. Herbst, X. Ren, D. Fox, RGB-D Mapping: Using Depth Cameras for Dense 3D Modeling of Indoor Environments, International Symposium on Experimental Robotics, 2010.
1019	K. Granström, Karl and T.B. Schön. Learning to close the loop from 3D point clouds, Proc. of IEEE/RSJ International Conference on Intelligent Robots and Systems, pp: 2089-2095, 2010.
1020	U. Franke, C. Rabe, H. Badino, S. Gehrig, 6d-vision: Fusion of stereo and motion for robust environment perception, Pattern Recognition, pp. 216-223, 2005.
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1022	N. Hautiere, R. Labayrade, M. Perrollaz and D. Aubert, Road Scene Analysis by Stereovision: a Robust and Quasi-Dense Approach, International Conference on Control, Automation, Robotics and Vision, pp. 1-6, 2006.
1023	R.A. Drebin, L. Carpenter, P. Hanrahan, Volume rendering, Proceedings of the 15th annual conference on Computer graphics and interactive techniques, 1988.
1024	H. Pfister, M. Zwicker, J. van Baar, M. Gross, Surfels: Surface Elements as Rendering Primitives, SIGGRAPH 2000.

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1025	N. Karlsson, E. Di Bernardo, J. Ostrowski, L. Goncalves, P. Pirjanian, M. Munich, The vSLAM Algorithm for Robust Localization and Mapping. Int. Conf. on Robotics and Automation (ICRA), 2005.
1026	Y. Jin, L. Tao, H. Di, N.I. Rao, G. Xu, Background modeling from a free-moving camera by Multi-Layer Homography Algorithm, IEEE International Conference on Image Processing, pp. 1572-1575, 2008.
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1028	P. Mountney, D. Stoyanov, A. Davison, G.-Z. Yang, Simultaneous Stereoscope Localization and Soft-Tissue Mapping for Minimal Invasive Surgery, International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI), pp.: 347-54, 2006.

Challenged Claims of U.S. Patent No. 9,629,551

Claim element	Claim 1
[Claim 1 pre]	A method for detecting a movable object in a location, when scanning a rigid object in the location by means of a 3D scanner for generating a virtual 3D model of the rigid object, wherein the method comprises:
[Claim 1a]	providing a first 3D representation of at least part of a surface by scanning at least part of the location;
[Claim 1b]	providing a second 3D representation of at least part of the surface by scanning at least part of the location;
[Claim 1c]	determining for the first 3D representation a first excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;
[Claim 1d]	determining for the second 3D representation a second excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;
[Claim 1e]	if a portion of the surface in the first 3D representation is located in space in the second excluded volume, the portion of the surface in the first 3D representation is disregarded in the generation of the virtual 3D model, and/or
[Claim 1f]	if a portion of the surface in the second 3D representation is located in space in the first excluded volume, the portion of the surface in the second 3D representation is disregarded in the generation of the virtual 3D model.
Claim element	Claim 2
[Claim 2]	The method according to claim 1, wherein the rigid object is a patient's set of teeth, and the location is the mouth of the patient.
Claim element	Claim 3
[Claim 3]	The method according to claim 1, wherein the movable

	object is a soft tissue part of a patient's mouth.
Claim element	Claim 4
[Claim 4]	The method according to claim 1, wherein the movable object is a dentist's instrument or remedy which is temporarily present in a patient's mouth.
Claim element	Claim 5
[Claim 5]	The method according to claim 1, wherein the movable object is a finger.
Claim element	Claim 6
[Claim 6]	The method according to claim 1, wherein at least part of the surface captured in the first representation and at least part of the surface captured in the second representation are overlapping the same surface part on the rigid object.
Claim element	Claim 7
[Claim 7]	The method according to claim 1, wherein the first representation of at least part of the surface is defined as the first representation of at least a first part of the surface, and the second representation of at least part of the surface is defined as the second representation of at least a second part of the surface.
Claim element	Claim 8
[Claim 8]	The method according to claim 1, wherein the method comprises determining a first scan volume in space related to the first representation of at least part of the surface, and determining a second scan volume in space related to the second representation of at least part of the surface.
Claim element	Claim 9
[Claim 9]	The method according to claim 1, wherein the scan volume is defined by focusing optics in the 3D scanner and the distance to the surface which is captured.
Claim element	Claim 10
[Claim 10]	The method according to claim 1, wherein the first scan volume related to the first representation of at least part of

	the surface is the volume in space between the focusing optics of the 3D scanner and the surface captured in the first representation; and the second scan volume related to the second representation of at least part of the surface is the volume in space between the focusing optics of the 3D scanner and the surface captured in the second representation.
Claim element	Claim 11
[Claim 11]	The method according to claim 1, wherein the first excluded volume and second excluded volume in space where no surface can be present corresponds to the first scan volume and the second scan volume, respectively.
Claim element	Claim 12
[Claim 12]	The method according to claim 1, wherein the volume of the 3D scanner itself is defined as an excluded volume.
Claim element	Claim 15
[Claim 15]	The method according to claim 1, wherein the first representation of at least part of a surface is a first subscan of at least part of the location, and the second representation of at least part of the surface is a second subscan of at least part of the location.
Claim element	Claim 16
[Claim 16]	The method according to claim 1, wherein the first representation of at least part of a surface is a provisional virtual 3D model comprising the subscans of the location acquired already, and the second representation of at least part of the surface is a second subscan of at least part of the location.
Claim element	Claim 17
[Claim 17]	The method according to claim 1, wherein acquired subscans of the location are adapted to be added to the provisional virtual 3D model concurrently with the acquisition of the subscans.
Claim element	Claim 18

[Claim 18]	The method according to claim 1, wherein the movable object is an inside of a cheek, a tongue, lips, gums and/or loose gingival.
Claim element	Claim 19
[Claim 19]	The method according to claim 1, wherein the movable object is a dental suction device, cotton rolls, and/or cotton pads.
Claim element	Claim 20
[Claim 20 pre]	The method according to claim 1, where in the method includes:
[Claim 20a]	disregarding the portion of the surface in the first 3D representation that is located in space in the second excluded volume in the generation of the virtual 3D model, and
[Claim 20b]	disregarding the portion of the surface in the second 3D representation that is located in space in the first excluded volume in the generation of the virtual 3D model.
Claim element	Claim 21
[Claim 21 pre]	The method according to claim 1, wherein:
[Claim 21a]	the first excluded volume is determined to be a space where no surface of the rigid object is present, and
[Claim 21b]	the second excluded volume is determined to be a space where no surface of the rigid object is present.
Claim element	Claim 22
[Claim 22]	A nontransitory computer readable medium encoded with a computer program product comprising program code for causing a data processing system to perform the method of claim 1, when said program code is executed on the data processing system.
Claim element	Claim 23
[Claim 23 pre]	A system for detecting a movable object in a location when scanning a rigid object in the location by means of a 3D scanner for generating a virtual 3D model of the rigid object, wherein the system comprises a hardware processor

	configured to:
[Claim 23a]	provide a first 3D representation of at least part of a surface by scanning at least part of the location;
[Claim 23b]	provide a second 3D representation of at least part of the surface by scanning at least part of the location;
[Claim 23c]	determine for the first 3D representation a first excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;
[Claim 23d]	determine for the second 3D representation a second excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;
[Claim 23e]	disregard the portion of the surface in the first 3D representation in the generation of the virtual 3D model, if a portion of the surface in the first 3D representation is located in space in the second excluded volume, and/or
[Claim 23f]	disregard the portion of the surface in the second 3D representation in the generation of the virtual 3D model, if a portion of the surface in the second 3D representation is located in space in the first excluded volume.
Claim element	Claim 24
[Claim 24 pre]	The system according to claim 23, where in the hardware processor is configured to:
[Claim 24a]	disregard the portion of the surface in the first 3D representation that is located in space in the second excluded volume in the generation of the virtual 3D model, and
[Claim 24b]	disregard the portion of the surface in the second 3D representation that is located in space in the first excluded volume in the generation of the virtual 3D model.
Claim element	Claim 25
[Claim 25 pre]	A method for detecting a movable object in a location, when scanning a rigid object in the location by means of a 3D scanner for generating a virtual 3D model of the rigid object, wherein the method comprises:

[Claim 25a]	providing a first 3D representation of at least part of a surface by scanning at least part of the location;
[Claim 25b]	providing a second 3D representation of at least part of the surface by scanning at least part of the location;
[Claim 25c]	determining for the first 3D representation a first excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation, and/or determining for the second 3D representation a second excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;
[Claim 25d]	if a portion of the surface in the first 3D representation is located in space in the second excluded volume, the portion of the surface in the first 3D representation is disregarded in the generation of the virtual 3D model, and/or if a portion of the surface in the second 3D representation is located in space in the first excluded volume, the portion of the surface in the second 3D representation is disregarded in the generation of the virtual 3D model.

I. INTRODUCTION

Medit Corporation (“Petitioner”) petitions for institution of *inter partes* review (“IPR”) of claims 1-12 and 15-25 (“challenged claims”) of U.S. Patent No. 9,629,551 (“the ’551 patent”). Ex-1001.

II. GROUNDS FOR STANDING

Petitioner certifies that the ’551 patent is available for review under 35 U.S.C. § 311(c) and that Petitioner is not estopped from requesting *inter partes* review of the challenged claims on the grounds identified in this Petition.

III. FEES

The Commissioner is hereby authorized to charge or credit the fee specified by 37 C.F.R. § 42.15(a), and any other additional fees, to Bracewell LLP Deposit Account No. 50-0259.

IV. PRECISE RELIEF REQUESTED

Petitioner requests review of the challenged claims under 35 U.S.C. § 311 and cancellation of the challenged claims under pre-AIA 35 U.S.C. §§ 102(a), 102(b), 102(e), and 103(a) in view of the prior art and grounds described herein.

A. Prior Art

For purposes of this Petition only, Petitioner assumes that the earliest priority date attributable to the ’551 patent is July 15, 2011. Petitioner does not concede,

however, that any claim of the '551 patent is entitled to that priority date and reserves its right to challenge any claim of priority related to the '551 patent in this or any other proceeding.

Each of the references on which Petitioner relies below qualify as prior art in view of the assumed priority date of July 15, 2011.

1. Newcombe

Petitioner relies on U.S. Patent No. 8,401,225 (“Newcombe”). Ex-1005. Newcombe issued on March 19, 2013, from an application filed on January 31, 2011, prior to the alleged priority date of the '551 patent, and qualifies as a prior art printed publication under at least pre-AIA 35 U.S.C. § 102(e).

2. Herbst

Petitioner relies on “Toward Object Discovery and Modeling via 3-D Scene Comparison,” by Evan Herbst et al. (“Herbst”). Ex-1006. Herbst was published at least as early as June 1, 2011, prior to the alleged priority date of the '551 patent, and qualifies as a prior art printed publication under at least pre-AIA 35 U.S.C. § 102(a). *See* Ex-1010, ¶¶ 40-45.

3. Hähnel

Petitioner relies on “Map Building with Mobile Robots in Dynamic Environments,” by Dirk Hähnel et al. (“Hähnel”). Ex. 1007. Hähnel was published

at least as early as November 10, 2003, more than one year prior to the alleged priority date of the '551 patent, and qualifies as a prior art printed publication under at least pre-AIA 35 U.S.C. § 102(b). *See* Ex-1010, ¶¶ 46-53.

4. McQueston

Petitioner relies on U.S. Patent No. 9,245,374 (“McQueston”). Ex-1008. McQueston issued on January 26, 2016, and claims priority to provisional application No. 61/445,499 (Ex-1009, the “McQueston Provisional”) filed on February 22, 2011, prior to the alleged priority date of the '551 patent, and qualifies as a prior art printed publication under at least pre-AIA U.S.C. § 102(e).

McQueston is entitled to the earlier priority date of the McQueston Provisional because it satisfies the relevant *Dynamic Drinkware* and *Giacomini* analyses. *See Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015)); *In re Giacomini*, 612 F.3d 1380, 1383 (Fed. Cir. 2010). Specifically, “under *Dynamic Drinkware*, a non-provisional child can be entitled to the benefit of a provisional application’s filing date if the provisional application provides sufficient support for at least one claim in the child.” *Ex parte Mann*, No. 2015-003571, 2016 WL 7487271, at *6 (PTAB Dec. 21, 2016). Further, under *Giacomini*, “to be entitled to a provisional application’s priority date,” it must be shown “that the subject matter relied upon in the non-provisional is sufficiently supported in the provisional application.” *Id.* at *5.

As shown in the Foroosh Declaration and as summarized in the following table, claim 1 of McQueston is supported by the disclosures of the McQueston Provisional. *See* Ex-1003, ¶¶ 385-386.

Claim 1 of McQueston	Support in McQueston Provisional (Ex-1009)
A method comprising:	¶ [0004].
storing a spatial matrix in a memory, the spatial matrix including information for a plurality of voxels in a mesh of a scan space;	¶¶ [0004], [0055]-[0056], [0060]; Fig. 5.
obtaining three-dimensional data from an object within scan space using a scanner;	¶¶ [0004], [0024]-[0026], [0032], [0061].
identifying a one of the plurality of voxels in the mesh that is unoccupied:	¶¶ [0004]-[0005], [0057]-[0058], [0062].
storing an indication in the spatial matrix for a modified processing of data from the one of the plurality of voxels, thereby identifying a prohibited volume within the scan space; and	¶¶ [0004], [0064].

Claim 1 of McQueston	Support in McQueston Provisional (Ex-1009)
processing a portion of the three-dimensional data that is not in the prohibited volume according to an unmodified processing and processing a second portion of the three-dimensional data that is in the prohibited volume according to the modified processing, wherein the modified processing includes detecting a point in the prohibited volume and displaying the point for a decay time with the second portion of the three-dimensional data.	¶¶ [0004]-[0005], [0070]-[0073].

All of the subject matter in McQueston relied upon in this Petition is also included in the McQueston Provisional, as summarized in the table below. Indeed, the disclosures of McQueston and the McQueston Provisional are nearly identical. *See* Ex-1003, ¶ 387.

Disclosures of McQueston Cited in Support of This Petition	Corresponding Disclosures in McQueston Provisional
Ex-1008 at 1:9-23	Ex-1009, ¶ [0002]
<i>Id.</i> at 3:31-61	<i>Id.</i> ¶¶ [0018]-[0020]
<i>Id.</i> at 4:4-46	<i>Id.</i> ¶ [0022]

Disclosures of McQueston Cited in Support of This Petition	Corresponding Disclosures in McQueston Provisional
<i>Id.</i> at 4:65-5:26	<i>Id.</i> ¶ [0025]
<i>Id.</i> at 5:47-63	<i>Id.</i> ¶ [0027]

In view of the foregoing, McQueston is entitled to the same priority date as the McQueston Provisional – February 22, 2011 – and therefore qualifies as prior art against the '551 patent under at least pre-AIA U.S.C. § 102(e).

B. IPR Grounds

Ground	Claims	Statutory Basis
1	1, 6-12, 15-17, 20-25	Obviousness under pre-AIA § 103(a) in view of Newcombe and Hähnel
2	2-5, 18, 19	Obviousness under pre-AIA § 103(a) in view of Newcombe, Hähnel, and McQueston
3	1, 6-12, 15-17, 20-25	Obviousness under pre-AIA § 103(a) in view of Herbst
4	2-5, 18, 19	Obviousness under pre-AIA § 103(a) in view of Herbst and McQueston

V. THE '551 PATENT

A. Overview of the '551 Patent

The '551 patent generally describes “a method for detecting a movable object in a location, when scanning a rigid object in the location by means of a 3D scanner for generating a virtual 3D model of the rigid object.” Ex-1001 at 1:6-9. The method includes the following steps shown below in Figure 1.

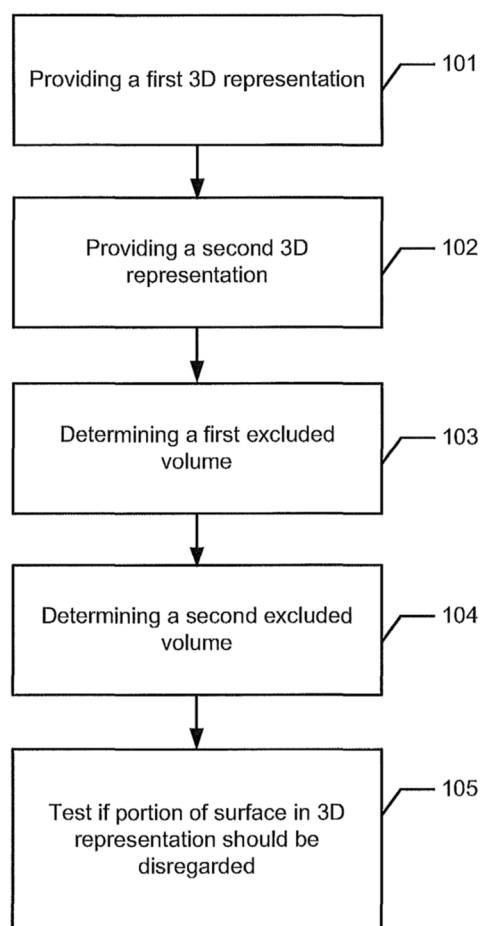


Fig. 1

The '551 patent states that obtaining one or more 3D representations of an object can generally be accomplished by using a 3D scanner to collect information about surfaces within the scanner's field of view and then developing a mathematical representation of the three-dimensional surface of the object via specialized software. *Id.* at 15:21-35. Next, one or more "excluded volumes," which "is the volume in space where no surface can be present," are determined. *Id.* at 4:32-35; 22:65-66. The '551 patent further describes the process for determining whether any portion of either 3D representation is located in an excluded volume, which may correspond to a moving object, and should be disregarded in the creation of a 3D model. *Id.* at 3:16-18; 21:4-12; 2:62-3:6.

B. Prosecution History

During examination, Patent Owner amended claim 1 on November 21, 2016, in response to a rejection asserting the applied-for claims were anticipated or obvious in view of the prior art, to include the following language:

- determining for the [first or second] 3D representation a [first or second] excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation;

See Ex-1002 at 1-26. Patent Owner amended the other two independent claims (corresponding to claims 23 and 25 in the issued patent) to add identical language. *Id.* at 20-26. The Examiner agreed the amendments overcame the rejections and

issued a Notice of Allowance on December 16, 2016. *Id.* at 30, 32-36.

VI. LEVEL OF ORDINARY SKILL IN THE ART

As of the priority date, a POSITA would have had at least a bachelor's degree in computer engineering, computer science, computer vision, or an equivalent field and at least one or two years of industry experience. A POSITA also would have had experience with three-dimensional imaging systems and three-dimensional modeling techniques. Ex-1003, at ¶¶ 72-74.

VII. CLAIM CONSTRUCTION

In an IPR, claim terms should be construed according to the *Phillips* standard. *See Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); *see also* 37 C.F.R. § 42.100(b). The Board need only construe terms to the extent necessary to resolve a controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). The Board must also consider “[a]ny prior claim construction determination concerning a term of the claim in a civil action . . . that is timely made of record.” 37 C.F.R. § 42.100(b).

For purposes of this proceeding only, Petitioner submits constructions for only the following terms and do not believe that construction of any other term is necessary.¹ Regarding the terms below, Petitioner applies the claim construction

¹ Petitioner reserves its right to revise or amend these constructions in any other

previously adopted by the district court in the co-pending litigation.

A. The Preambles of Independent Claims 1, 23, and 25

In the co-pending litigation, the parties agreed that the preambles of independent claims 1, 23, and 25 are limiting, and the district court adopted this construction in its order. *See* Ex-1011 at 2. Petitioner has applied this construction for purposes of this Petition.

B. “excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation”

In the co-pending litigation, the district court adopted Patent Owner’s preferred construction of this term: “excluded volume in space that is common to both the first and second 3D representations where no surface from either of the 3D representations should be present.” *Id.* Petitioner has applied this construction for purposes of this Petition.

VIII. OVERVIEW OF THE PRIOR ART

A. Prior Art References

1. Overview of Newcombe

Newcombe is directed to systems and methods for segmenting moving objects

action or forum and also reserves the right to challenge the validity of the challenged claims under 35 U.S.C. § 112 in another other action or forum.

from the background of a depth image of a scene. Ex-1005 at Abstract. Newcombe discloses a depth camera that is capable of capturing depth images of a room or scene and objects within the room, as well as a real-time camera tracking system. *Id.* at 2:46-53; 2:54-67; 4:11-50. Newcombe also provides a moving-object segmentation system, which “receives the depth images captured by the mobile depth camera 102, and performs a segmentation operation to identify objects in the depth images that are moving or being manipulated and which are independent of the relatively unchanging background.” *Id.* at 3:1-6. The “moving-object segmentation system 114 detects foreground objects and labels them in the depth map, enabling these objects to be separately processed as desired.” *Id.* at 3:51-54. The depth camera, a real-time tracking system and the moving-object segmentation system can be used to “allow individual depth images to be built up into an overall 3D model” utilizing the “simultaneous and localization and mapping (SLAM)” technique. *Id.* at 3:28-37.

According to the process disclosed by Newcombe, “a depth image of the scene to be segmented (as captured by the mobile depth camera) is received.” *Id.* at 6:49-50. A previous depth image, which may be the preceding frame captured by the depth camera and which overlaps with at least part of the same scene, is also retrieved. *Id.* at 6:54-7:9. An alignment process is performed that involves the use of an iterative closest point (ICP) algorithm, which “is an iterative process that

determines a set of corresponding points between the two depth images, determines a transformation that minimizes an error metric over the corresponding points, and repeats the process using the determined transformation until convergence is reached.” *Id.* at 7:10-26. Any divergent points are deemed to be “outliers,” which can be determined by two compatibility tests. *Id.* at 7:27-30; 8:27-9:16. “In the first compatibility test, a Euclidean distance is determined 414 between the source and destination points,” which “is illustrated in Fig. 5 as distance 510 and in Fig. 6 as distance 604.” *Id.* at 8:29-32; Figs. 5-6 (below); *see also id.* at 8:32-49.

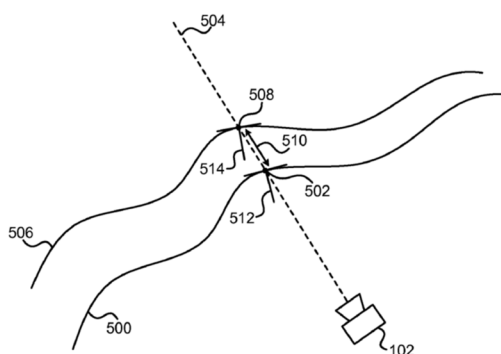


FIG. 5

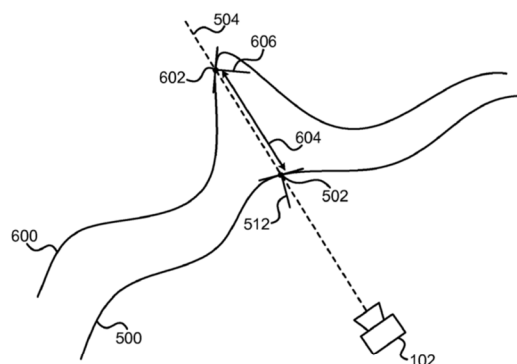


FIG. 6

The outlying points “indicate points in the depth image where something has changed since the previous depth image” and are provided as input to the object segmentation system. *Id.* at 9:24-29. For example, the object segmentation system

can segment all outlying points or a subset of outlying points and label them as foreground objects in the depth image. *Id.* at 9:29-41. These segmented portions of depth images may correspond to foreground objects, including moving objects, and can be tracked separately and independently of the background. *Id.* at 10:28-38. Independent 3D models of the moving objects may also be generated. *Id.* at 10:57-59. Newcombe further discloses that moving objects may be “deliberately ignored” or “instantly segmented upon removal from the scene.” *Id.* at 11:21-23, 51-53.

2. Overview of Herbst

Herbst is directed to methods that improve the performance of robots that scan indoor locations to create 3D maps and images. Ex-1006 at 1. Herbst discloses a method of detecting moving objects within a scene by comparing color and depth information for surfaces scanned in two separate images or maps of a scene. *Id.* Herbst further discloses that such moving objects within a scene, once scanned, detected, and segmented, can be extracted from a 3D model of the scene. *Id.* at 5.

Herbst discloses the use of an RGB-D camera, which can provide dense color and depth measurements, to obtain 3D scans of a location. *Id.* at 1. Thus, “[t]he inputs to [Herbst’s] system are two or more RGB-D videos representing separate visits to the same location.” *Id.* at 2. Herbst further discloses the use of RGB-D Mapping, which is a Simultaneous Localization and Mapping (SLAM) technique for generating dense 3D maps. *Id.* Each frame obtained by the RGB-D cameras consists

of multiple points in a point cloud, each of which is converted to a surfel according to Herbst's method. *Id.* Herbst then "probabilistically models the position, color and orientation of each surfel." *Id.* at 2-4.

Herbst further discloses that the estimated pixel measurements from two 3-D maps can be used to detect differences between the maps after the scenes in each map have been aligned, and specifically to calculate a probability that any object surface in a scene moved from one map to the next. *Id.* at 4. Thus, objects within a scene that have moved locations "are detected as high-probability areas, using [a] combination of depth, color, and orientation cues." *Id.* at 5.

Herbst discloses that its method can find all moveable objects within a scene with high accuracy. *Id.* at 5. For example, Herbst provides the following two figures, Figures 6(a) and 6(d), which show two different 3D representations of the same tabletop scene.



Fig. 6(a)

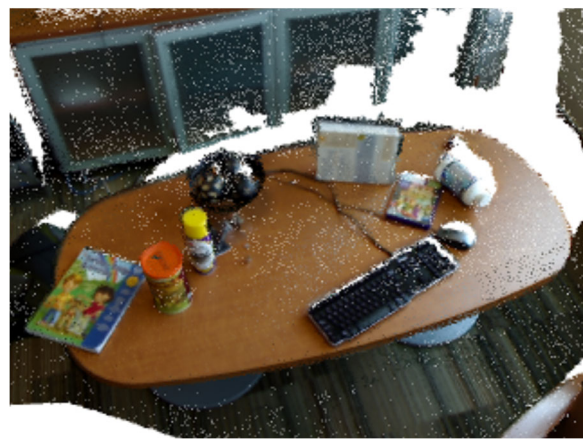


Fig. 6(d)

As can be seen in the images above, each representation shows different objects resting on the same table. As shown in Figure 7(b) of Herbst below, when the two representations are merged into a single 3D model, Herbst's disclosed method is able to accurately determine each of the objects on the table that is a moveable object because each object changes location between the two scenes. *See id.* at 5-7; Figs. 6(a), (d) & 7(b).



Fig. 7(b)

The table itself, however, is correctly identified as a stationary, or non-moveable object, and therefore remains in place in the merged image. Further, some of the “holes” – i.e., portions of the table occluded by the objects in the first two images – are “filled in” in the merged 3D model. *Id.*

3. Overview of Hähnel

Hähnel is directed to methods for creating maps with mobile robots in

dynamic environments, including, for example, environments with moving objects or people. Ex-1007 at 1. The approach disclosed by Hähnel can generate accurate 2d and 3d models in a variety of dynamic indoor and outdoor environments and builds on the simultaneous localization and mapping (SLAM) technique. *Id.* Hähnel further discloses that, by filtering and extracting the dynamic objects from the environment, accurate textured 3d models of the dynamic objects may also be generated. *Id.*

Hähnel discloses the use of laser-range scanners for obtaining measurements of the dynamic environment to be mapped. *Id.* An expectation-maximization algorithm is used to detect dynamic objects in the environment. *Id.* at 1-2. An iterative SLAM process is used that includes obtaining an initial map through an incremental mapping approach, determining expectation values based on prior probabilities that a measurement is caused by a static object, computing new expectation values, and then using the new expectations values to generate a new map. *Id.* at 2-4. Hähnel discloses that its system is robust in a variety of highly dynamic environments. *Id.* at 5.

Hähnel further discloses that its method can be used to generate textured 3d maps. *Id.* at 6. Dynamic objects can be filtered from the scene to generate a 3d model without the dynamic objects. *Id.* For example, the upper image below, from Figure 11 of Hähnel, includes an arrow pointing to “a polygon whose texture

contains fractions of an image of a person which walked through the scene while the robot was scanning it.” *Id.* at 6-7. The lower image was generated after applying the approach disclosed by Hähnel and shows the same scene with the walking person (i.e., the dynamic object) filtered out of the scene. *Id.*



Fig. 11

Hähnel further discloses that, in addition to “filtering dynamic objects and learning static aspects of environments[, its] algorithm can also be used to separate

dynamic objects from the environment.” *Id.* at 6.

4. Overview of McQueston

McQueston discloses the use of “space carving” in three-dimensional scanning to “exclude certain scan results from processing and display.” Ex-1008 at 1:27-29. The space carving techniques, which McQueston describes as “generally known in the art,” are used to maintain a spatial matrix for storing data on volumetric regions, known as voxels, that are known to be empty. *Id.* at 1:29-13, 15:9-13. “By excluding or modifying processing of subsequent outlier data from within these unoccupied voxels, a three-dimensional reconstruction process can achieve concurrent improvements in accuracy and speed.” *Id.* at 1:31-34.

McQueston’s disclosures can be used with any “scanning technology,” in which “the calculation and display of three-dimensional data can become encumbered by transient obstructions within a scanning volume.” *Id.* at 1:14-16. A POSITA could readily use McQueston’s teachings “to improve any three-dimensional acquisition or processing in which the capture of three-dimensional data occurs over a period of time.” *Id.* at 3:14-30. In particular, the reference specifically identifies the need for the disclosed technology in dental scans stating that, “[f]or example, in a dental scan, a patient’s tongue or other soft tissue may temporarily obstruct or move adjacent to a scanned surface. A technician may similarly obstruct a scanner’s view of the scanned surface with a finger, tongue depressor, or other

instrument.” *Id.* at 1:16-21.

B. A POSITA Would Have Been Motivated to Combine the Prior Art

1. It Would Have Been Obvious to Combine Newcombe, Hähnel, and McQueston

As explained in the attached Foroosh Declaration, a POSITA would have been motivated to combine Newcombe and Hähnel. Ex-1003, ¶ 127. Both references concern the use of mobile imaging devices to generate 3D maps of environments utilizing the simultaneous localization and mapping (SLAM) technique. Ex-1005 at 3:28-37; Ex-1007 at 1. Both references also recognize the utility of identifying or segmenting dynamic, moving objects in a surrounding static scene or environment when creating such maps. *See* Ex-1005 at 3:1-6 (“A moving-object segmentation system 114 receives the depth images captured by the mobile depth camera 102, and performs a segmentation operation to identify objects in the depth images that are moving or being manipulated and which are independent of the relatively unchanging background.”); Ex-1007 at 5 (“As can be seen, our approach can reliably identify dynamic aspects and is able to learn maps that include the static aspects only.”). Newcombe teaches that once a dynamic object is identified and segmented from the surrounding environment, it can be “separately processed as desired.” Ex-1005 at 3:51-54. Similarly, Hähnel teaches that once dynamic objects that have been identified, they can be filtered from a 3D map of the surrounding environment. Ex-

1007 at 6. Hähnel further teaches that such filtering is advantageous for creating accurate 3D maps and accurate 3D models of dynamic objects. *Id.* at 1.

Because Newcombe and Hähnel are from the same field and have interrelated teachings regarding the treatment of dynamic objects in 3D mapping applications, a POSITA would have been motivated to combine them. Ex-1003, ¶ 127. Specifically, a POSITA would have been motivated to incorporate Hähnel's teaching of filtering dynamic objects into Newcombe's method for segmenting moving objects from the background of a 3D depth image, because doing so would allow for the creation of more accurate 3D maps and models, pursuant to Hähnel's teachings. *Id.*

As is further discussed in the attached Foroosh Declaration, a POSITA would have further been motivated to combine McQueston with the combination of Newcombe and Hähnel. Ex-1003, ¶¶ 247-250. McQueston describes a similar, if not identical, problem as addressed in Newcombe and Hähnel, albeit in the context of intraoral imaging, where dental instruments or other objects may interfere with the 3D imaging of teeth by obstructing a scanning volume between a scanning device and the tooth surfaces. Ex-1008 at 1:9-23. As with Newcombe in view of Hähnel, McQueston teaches using laser range finding for distance measurements underlying the three-dimensional tooth modeling. *Id.* at 4:65-5:26; 5:47-63. Likewise, as with the depth imaging described by Newcombe, McQueston teaches that imaging techniques may be incorporated into the three-dimensional modeling of the teeth. *Id.*

at 3:31-61.

A POSITA would be motivated to apply the imaging and modeling techniques and components of Newcombe in view of Hähnel to the intraoral environment of McQueston to achieve the stated goal of McQueston — minimizing the interference of dental objects with the three-dimensional model of the teeth being imaged or measured. Ex-1003, ¶¶ 247-250. A POSITA would understand that the depth imaging and object segmentation of Newcombe, could be integrated into a dental scanning apparatus, like that described by McQueston to address the same problem of removing any influence or interference of moving bodies from three-dimensional modeling of stationary objects. *Id.*

2. It Would Have Been Obvious to Combine Herbst and McQueston

A POSITA would have been motivated to combine McQueston and Herbst. Ex-1003, ¶¶ 379-382. McQueston describes a similar, if not identical, problem albeit in the context of intraoral imaging, where dental instruments or other objects may interfere with the 3D imaging of teeth by obstructing a scanning volume between a scanning device and the tooth surfaces. Ex-1008 at 1:9-23. As with Herbst, McQueston teaches using laser range finding for distance measurements underlying the three-dimensional tooth modeling. *Id.* at 4:65-5:26; 5:47-63. Likewise, as with the RGB-D depth imaging described by Herbst, McQueston teaches that imaging

techniques may be incorporated into the three-dimensional modeling of the teeth. *Id.* at 3:31-61.

A POSITA would be motivated to apply the RGB-D imaging techniques and components of Herbst to the intraoral environment of McQueston to achieve the stated goal of McQueston — minimizing the interference of dental objects with the three-dimensional model of the teeth being imaged or measured. A POSITA would understand that the imaging and modeling techniques and devices of Herbst could be integrated into a dental scanning apparatus, like that described by McQueston, to address the same problem of removing any influence or interference of moving bodies from three-dimensional modeling of stationary objects, in this case teeth. Ex-1003, ¶¶ 379-382.

IX. THE CHALLENGED CLAIMS ARE UNPATENTABLE AND SHOULD BE CANCELLED

A. Ground 1: Claims 1, 6-12, 15-17, and 20-25 are Rendered Obvious by Newcombe in view of Hähnel

1. Claim 1 is Obvious in View of Newcombe and Hähnel

a. [Claim 1 pre]

Newcombe discloses this element, which, for purposes of this Petition, Petitioner construes to be limiting. Newcombe teaches detecting and identifying movable objects from a series of depth images of a scene using segmentation. Ex-

1005, Abstract. Multiple depth images are obtained using a depth camera, which a POSITA would understand to be a 3D scanner, that gathers both image and depth data. *Id.* at 2:46-53; 3:25-27; Ex-1003, ¶ 105. Newcombe further teaches detecting moving objects and segmenting them from a scene comprised of fixed objects that is being scanned by depth images, which corresponds to the claimed “method for detecting a movable object in a location when scanning a rigid object in the location.” *Id.* at 1:49-65; Ex-1003, ¶ 105. Newcombe also teaches generating a dense 3D environment model, which corresponds to “generating a virtual 3D model of the rigid object,” as claimed. *Id.* at 3:21-37; Ex-1003, ¶ 105.

b. [Claim 1a]

Newcombe teaches this element. Newcombe teaches using a mobile depth camera to obtain depth images of a location. *Id.* at 2:46-53. These depth images include both image data and depth data. *See id.* at 3:64-4:10. The depth images are used to form the dense 3D model of the environment. *Id.* at 3:25-27. The depth image of the location, as described by Newcombe, corresponds to a “first 3D representation of at least part of a surface scanning at least part of the location,” as claimed. Ex-1003, ¶ 107.

c. [Claim 1b]

Newcombe teaches this element. As discussed above, Newcombe describes obtaining multiple depth images of the location to build the dense 3D model.

Supra, §§ IX.A.1.a-b. One of the additional depth images of the location, as described by Newcombe, corresponds to a “second 3D representation of at least part of the surface by scanning at least part of the location,” as claimed. Ex-1003, ¶ 109.

Furthermore, Newcombe discloses two separate scanning processes, through which multiple depth images, including a previous and current depth image, may be provided. Ex-1005 at 6:49-67. Each of the previous and current depth images disclosed by Newcombe correspond to the first and second 3D representations recited in the claim. Ex-1003, ¶ 110.

d. [Claim 1c]

Newcombe teaches this element. Newcombe describes identifying, through segmentation, moving objects in the foreground of a location. A POSITA at the time the '551 patent was filed would understand Newcombe to disclose this claim element in connection with the disclosed segmentation process. Ex-1003, ¶ 112. As described above, Newcombe discloses a previous 3D depth image and a current 3D depth image, which a POSITA would understand correspond to first and second 3D representations. *See supra*, §§ IX.A.1.b-c. A POSITA at the time the '551 patent was filed would further understand that all the obtained depth images for the location that *do not* correspond to a surface within the background of the location would collectively constitute an excluded volume, as recited by the claims, and more particularly would constitute an excluded volume in space that is common to both

the first and second 3D representations where no surface from either of the 3D representations should be present. Ex-1003, ¶ 112. For example, a POSITA would have understood that the empty space shown in Figure 1, shown below, between camera 102 and the stationary objects in the room would constitute an excluded volume for the first 3D representation, according to the court's construction. Ex-1003, ¶ 112.

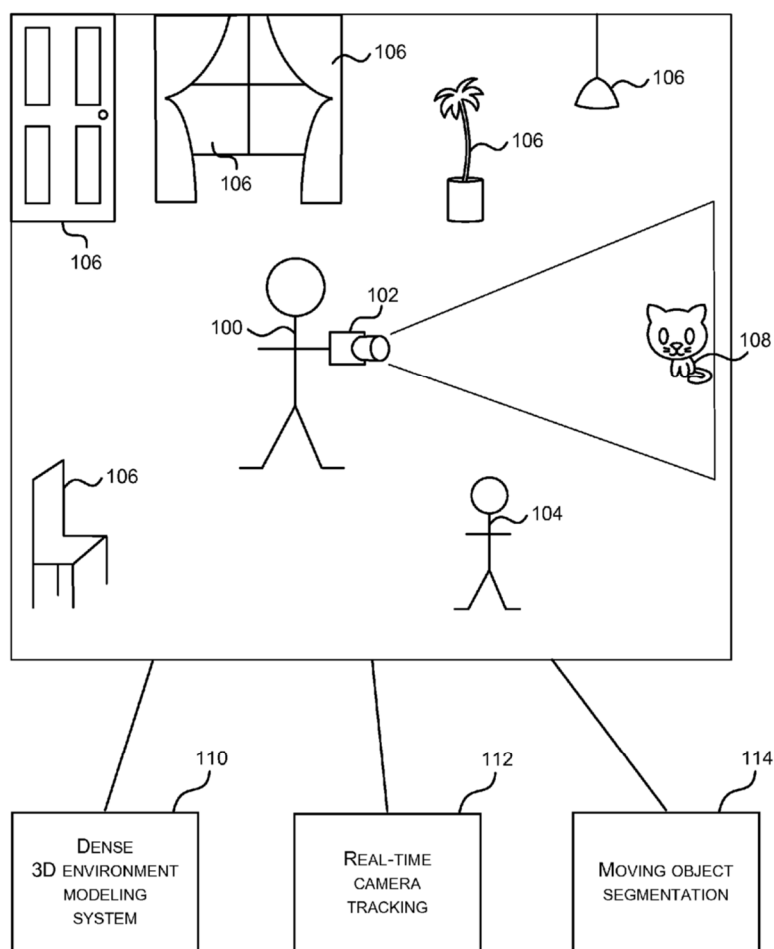


FIG. 1

This understanding of Newcombe by a POSITA is supported by the reference's disclosure of the performance of compatibility tests to determine whether points in two depth images are corresponding points, which can be attributed to rigid objects, or are outliers, which can be attributed to moving objects. *See* Ex-1005 at 8:27-29; Ex-1003, ¶ 113. Specifically, Newcombe discloses that at least the first compatibility test can be used to determine an excluded volume where no rigid object should be present in any depth image of the location, and consequently, where any object detected is therefore a moving or “non-rigid” object at the location. *See, e.g., id.* at 9:26-29; Ex-1003, ¶ 113.

As described by Newcombe, the first compatibility test relies on defining a threshold distance for a measurement between points in two 3D depth images – i.e., a “source point” in a previous depth image and a “destination point” in a current depth image. *Id.* at 8:3-33. As Newcombe explains, “[i]f the destination point is too far away from the source point, then it is considered to be an outlier (i.e. non-corresponding)” *Id.* at 8:33-35. Newcombe further explains that “outliers” or “outlying points” refer to “points in the depth image where something has changed since the previous depth image” and “can be caused by dynamic or non-rigid objects.” *Id.* at 9:26-29.

This scenario is demonstrated in Figure 6, shown below, of Newcombe: “[T]he example of Fig. 6 shows the case where differences between the previous

depth image 500 and the current depth image 600 (e.g. due to new or moving objects) result in the distance 604 between the source and destination points being greater than the predefined distance threshold, and hence the destination point is labeled as an outlier.” *Id.* at 8:42-48. Newcombe further explains the process as follows:

Moving object segmentation using depth images is described. In an example, a moving object is segmented from the background of a depth image of a scene received from a mobile depth camera. A previous depth image of the scene is retrieved, and compared to the current depth image using an iterative closest point algorithm. The iterative closest point algorithm includes a determination of a set of points that correspond between the current depth image and the previous depth image. During the determination of the set of points, one or more outlying points are detected that do not correspond between the two depth images, and the image elements at these outlying points are labeled as belonging to the moving object. In examples, the iterative closest point algorithm is executed as part of an algorithm for tracking the mobile depth camera, and hence the segmentation does not add substantial additional computational complexity.

Id. at 1:49-65.

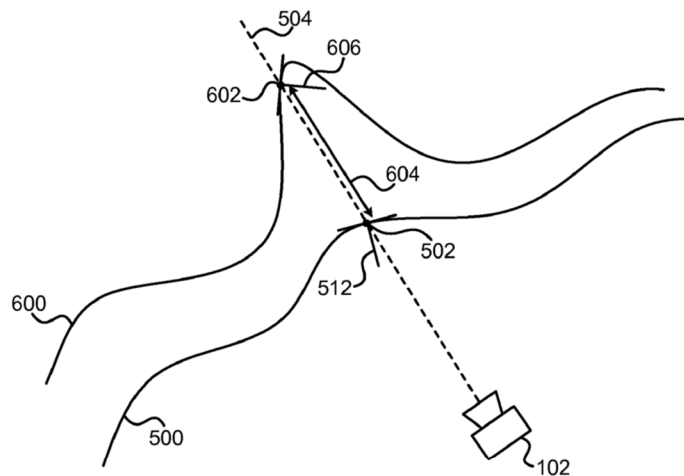


FIG. 6

Thus, a POSITA would understand that by defining a distance threshold for the two three-dimensional depth images beyond which any point will be deemed an outlier, Newcombe teaches the determination of an excluded volume, and particularly, an “excluded volume in space that is common to both the first and second 3D representations where no surface from either of the 3D representations should be present,” as construed by the district court. Ex-1003, ¶¶ 114-116.

e. [Claim 1d]

Newcombe teaches this element. As discussed above, Newcombe discloses a

previous 3D depth image and a current 3D depth image. *Id.* A POSITA would understand these depth images to correspond to the first and second 3D representations of this claim element. Ex-1003, ¶ 118. As is also discussed above, a POSITA would understand Newcombe’s disclosure of the space between the camera and the stationary objects in the background of a location in the preceding section as teaching an excluded volume necessarily applies equally to both a first depth image and a second depth image. *See supra*, § IX.A.1.d; Ex-1003, ¶ 118. Thus, a POSITA would have understood that the empty space shown in the figure – i.e., the space in the scene that is not occupied by the fixed objects in the background would constitute an excluded volume for the second 3D representation, according to the court’s construction. *Id.*

This understanding of Newcombe by a POSITA is supported by Newcombe’s disclosure of a compatibility test to determine an excluded volume where no rigid object should be present in any depth image of the location, and consequently, where any object detected is therefore a moving or “non-rigid” object at the location. *See, e.g., id.* at 9:26-29; Ex-1003, ¶ 119. As described above, the compatibility test necessarily incorporates a first 3D representation and a second 3D representation (i.e., a previous 3D depth image and a current 3D depth image). *Supra*, § X.A.1.d. Furthermore, Newcombe teaches that the excluded volume determined by the compatibility test – i.e., the space beyond the distance threshold where any observed

points will be deemed outliers corresponding to non-rigid objects – is also necessarily common to both depth images, because points in both images are required to define the threshold distance and compare the corresponding Euclidean distance between the source and destination points, as is further evidenced visually by Newcombe’s Figure 6 below. *See id.* at 8:3-48; Ex-1003, ¶ 119.

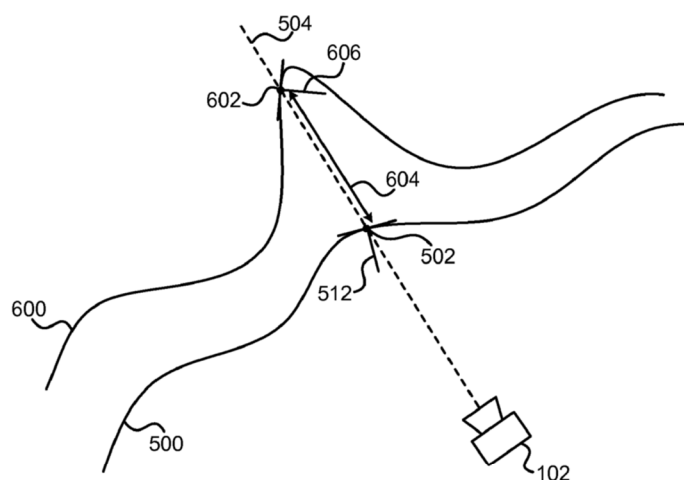


FIG. 6

f. [Claim 1e]

Newcombe in view of Hähnel teaches this element. As discussed above, a POSITA would understand Newcombe to teach a method for determining excluded

volumes corresponding to previous and current 3D depth images. *Supra*, §§ IX.A.1.d-e. As is also discussed above, Newcombe discloses that points corresponding to surfaces are identified as outliers if they are in an excluded volume (i.e., in a volume outside a predefined threshold distance), or as corresponding points if they are not. *See id.* Thus, Newcombe teaches that a surface in the first 3D representation that is located in space in the second excluded volume will be identified as an outlier. *See id.*

Newcombe further teaches that the outliers, which correspond to moving objects, can be “stored and provided as input to the object segmentation system.” Ex-1005 at 9:25-26. Newcombe discloses that the segmentation of the image can include “segment[ing] all the outlying points and label[ing] these as foreground objects in the depth image.” *Id.* at 9:30-32. The segmentation may be completed using “segmentation algorithms.” *See, e.g., id.* at 10:1-4.

Newcombe discloses that moving objects that have been segmented “can be separately processed as desired.” *Id.* at 3:51-54. For example, Newcombe teaches that “the segmentation of moving objects enables these moving objects to be tracked separately and independently of the background. This can be achieved executing a further ICP algorithm on the portion of the depth image that was identified as a moving object by the segmentation system.” *Id.* at 10:31-36.

Newcombe further discloses that, in addition to “independently tracking a

moving object in the depth image, an independent dense 3D model of the object can also be generated.” *Id.* at 10:57-59. Newcombe teaches that the creation of a “dense 3D model of a segmented object can be performed in a number of ways,” including a technique that “enables objects to be instantly segmented upon removal from the scene.” *Id.* at 11:3-23.

Additional examples of the processing of segmented objects disclosed by Newcombe include “input[ting] to an object recognition system,” classifying according to the “behavior in the scene,” and “control[ling] further aspect of the operation of the system.” *Id.* at 11:28-51. With respect to the last example, Newcombe discloses that a segmented, moving object may be either “arranged to interact” with other objects or may be “deliberately ignored.” *Id.* at 11:51-53.

Newcombe’s disclosure that segmented objects may be “separately processed as desired,” as well as the disclosure of the various ways that segmented moving objects may be processed, including with respect to the “removal from the scene” and or being “deliberately ignored,” would be understood by a POSITA to teach that these objects, which includes the surfaces of the objects, may be “disregarded” or otherwise removed or omitted from a virtual 3D model generated according to the methods disclosed by Newcombe. Ex-1003, ¶¶ 121-126.

However, to the extent that Newcombe may be deemed not to disclose the “disregarding” of a portion of a surface in a 3D representation, Hähnel supplies this

teaching. Like Newcombe, Hähnel discloses 3D modeling processes based on simultaneous localization and mapping (SLAM). *See* Ex-1005 at 3:35-37; Ex-1007 at 1. Thus, in a context of mapping a location in a dynamic environment using 3D representation analogous to that disclosed by Newcombe, Hähnel teaches that moving objects (i.e., dynamic objects), can lead to serious errors in mapping a location. *See, e.g.*, Ex-1007 at 1. Hähnel further teaches that these moving objects can be reliably filtered out to obtain accurate models of a location. *Id.* at 1, 6; Fig. 11. A POSITA would have understood Hähnel’s description of filtering out of dynamic objects to correspond to “disregard[ing]” a “portion of a surface,” as claimed. Ex-1003, ¶ 127.

As discussed above, Newcombe teaches that moving objects can be detected as outliers and segmented and integrated into separate 3D volumes. *Supra*, §§ IX.A.1.d-e. Newcombe also discloses that segmented objects can be separately processed as desired. Ex-1005, at 3:51-54; Ex-1003, ¶ 128. Thus, it would have been obvious to a POSITA to process the moving objects identified by segmentation in the depth image-based system of Newcombe with the filtering of Hähnel to reduce errors in the dense 3D environment model. Ex-1003, ¶ 128.

g. [Claim 1f]

Newcombe in view of Hähnel teaches this element. Newcombe discloses that points corresponding to surfaces are identified as outliers if they are in an excluded

volume (i.e., in a volume outside a predefined threshold distance), or as corresponding points if they are not. *See supra*, §§ IX.A.1.d-f. Thus, Newcombe teaches that a surface in the second 3D representation that is located in space in the first excluded volume will be identified as an outlier. *See id.*

A POSITA would understand Newcombe to teach that segmented, moving objects, identified as outliers in an excluded volume of a depth image, can be processed in a variety of ways. *Supra*, § IX.A.1.f; Ex-1003, ¶¶ 130-131. Such processing can include removal from a scene or deliberately ignoring the segmented objects. *Id.* Newcombe further teaches that the identification of moving objects and subsequent processing can be performed repeatedly with respect to any pair of depth images. *See* Ex-1005 at 8:3-9:23. A POSITA would therefore understand Newcombe's teachings with respect to the determination of excluded volumes and subsequent disregarding of points within those excluded volumes to be equally applicable to both first and second 3D representations. Ex-1003, ¶ 131. In other words, a POSITA would understand Newcombe to teach that, if a portion of a surface in a second 3D representation is located in space in the corresponding first excluded volume, the portion of the surface in the second 3D representation should be disregarded, just as a POSITA would understand Newcombe to teach, as described above, that if a portion of a surface in a first 3D representation is located in space in the corresponding second excluded volume, the portion of the surface in

the first 3D representation should be disregarded. *Id.* Thus, Newcombe teaches this element.

A POSITA also would have been motivated and found it obvious to combine Hähnel's filtering process with Newcombe's process of identifying and segmenting moving objects in a scene. *Supra*, §§ VIII.B.1, IX.A.1.f. As further described above, Newcombe discloses that its segmenting process can be applied repeatedly to multiple depth images to obtain multiple separate 3D volumes with respect to the multiple depth images. Ex-1005 at 8:3-9:23. A POSITA therefore would have been motivated and found it obvious to apply Hähnel's filtering process repeatedly to multiple segmented objects in the separate 3D volumes disclosed by Newcombe's iterative process to reduce any errors in location mapping caused by the segmented moving objects. Ex-1003, ¶ 132. Accordingly, Newcombe in view of Hähnel teaches this element.

2. Claim 6 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above, Newcombe teaches providing first and second 3D representations of at least part of a surface by scanning at least part of the location with depth images to generate the model of the dense 3D environment. For example, Newcombe teaches that the acquired depth images of the location at least partially overlap while the user scans the environment with the depth camera. Ex-1005 at 5:30-42; Ex-1003, ¶¶ 135-136.

3. Claim 7 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above, Newcombe teaches providing first and second 3D representations of a location by scanning at least part of the location using depth images, which are at least partially overlapping. *Supra*, §§ IX.A.1.b-c. A POSITA would understand that these overlapping depth images would comprise separate representations of the same surfaces. Ex-1003, ¶¶ 138-139.

4. Claim 8 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above, Newcombe teaches providing first and second 3D representations of at least part of a surface by scanning at least part of the location. Newcombe teaches that each depth image taken by the depth camera contains image data with corresponding distance data. *See, e.g.*, Ex-1005 at 4:17-35. In this example, because the distance data is determined by a time-of-flight reflected infra-red light, a POSITA would understand that each depth image also defines a corresponding scan volume between the depth camera and the surface being scanned. Ex-1003, ¶ 141.

Further, in describing the disclosed segmentation system, Newcombe refers to the “camera’s frustum (i.e. not only the front faces which the camera sees).” Ex-1005 at 11:15-16. A POSITA at the time the ’551 patent was filed would understand Newcombe’s reference to a frustum to refer to the entire field of view of the camera

used to obtain the 3D depth images (i.e., the first and second 3D representations). Ex-1003, ¶ 142. A POSITA would further understand that this field of view of the camera corresponds to a scan volume in space that can be determined for each of the first and second representations of a surface. *Id.*

5. Claim 9 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above, Newcombe teaches a scan volume with respect to each of the first and second 3D representations. Furthermore, as discussed above, Newcombe discloses the use of a depth camera for 3D scanning. It would have been obvious to a POSITA that the scan volume created when scanning a surface to create a 3D representation would have been defined by the focusing optics of the depth camera and the distance to the surface which is captured. Ex-1003, ¶ 145.

Newcombe describes that “[t]he depth information may be obtained using any suitable technique including, but not limited to, time of flight, structured light, and stereo images.” Ex-1005 at 4:11-13. A POSITA at the time the ’551 patent was filed would know that these technologies use one or more electro-optical sensors with associated focusing optics. Therefore, a POSITA would know that the scan volume created by the depth camera when scanning a surface to create 3D representations would depend on the field of view and the depth of field of the electro-optical sensor, both of which depend on the focusing optics and the distance

to the surface captured by the depth camera. Ex-1003, ¶ 146.

6. Claim 10 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to claim 8, Newcombe describes determining a first and second scan volume related to the first and second representations of at least a first and second part of the surface. As discussed with respect to claim 9, the depth camera taught by Newcombe would necessarily have focusing optics that a POSITA would understand to define a scan volume. Ex-1003, ¶ 149.

Further, as described above, a POSITA at the time the '551 patent was filed would have understood Newcombe's disclosure of a camera frustum to correspond to a scan volume defined by the focusing optics of the camera and the distance from the camera to the surface captured by the camera. *See supra*, §§ IX.A.4-5; Ex-1003, ¶ 150. As is also discussed above, Newcombe discloses obtaining first and second 3D representations, or depth images, with the disclosed camera. *See supra*, §§ IX.A.1.b-c.

7. Claim 11 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to the excluded volume and scan volume elements of claims 1 and 8-10, a POSITA would understand the scanned depths that do not correspond to a stationary surface in the background to be excluded volumes where the surfaces of

the background being modeled in the dense 3D environment cannot be present. Ex-1003, ¶ 153.

Further, as discussed above, a POSITA would understand the camera frustum disclosed by Newcombe to correspond to first and second scan volumes. *See supra*, §§ IX.A.4-6; Ex-1003, ¶ 154. Newcombe’s disclosure of the camera frustum is made with respect to a technique for creating a dense 3D model of a segmented object, which as described above, Newcombe teaches correspond to outlier points in a first and/or second excluded volume. *See supra*, §§ IX.A.1.a-g. Specifically, Newcombe states that “after the outliers have been detected (as described above), every voxel in the dense 3D model within the camera’s frustum (i.e. not only the front faces which the camera sees) is projected into the current depth map.” Ex-1005 at 11:13-17. A POSITA would understand this disclosure in Newcombe to teach that the first and second excluded volumes would correspond to the first and second scan volumes, respectively. Ex-1003, ¶ 154.

8. Claim 12 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. To the extent that Newcombe in view of Hähnel does not explicitly describe that the 3D scanner is defined as an excluded volume, this claim element would be obvious to a POSITA in light of the teachings of Newcombe. A POSITA would recognize that the depth camera of Newcombe would necessarily be a part of “an excluded volume in space

that is common to both the first and second 3D representations where no surface from either of the 3D representations should be present,” per the district court’s construction, because it is impossible for the depth camera to be included in any scan volume. As discussed above with respect to claims 8-11, a POSITA would understand Newcombe’s disclosure of a camera frustum to correspond to a scan volume and would further understand that a camera itself is not included in its own viewing frustum, which automatically makes the 3D camera part of an excluded volume. Ex-1003, ¶ 157.

9. Claim 15 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. Although Newcombe does not explicitly use the term “subscan” with respect to the first and second 3D representations comprising depth images that it teaches, a POSITA would understand that these multiple depth images are subscans of at least a part of the location depicted in the scene and that together these subscans will be used to generate a virtual 3D model that is the dense 3D model. *See* Ex-1003, ¶ 160; Ex-1001, 3:44-49 (“Typically when scanning an object, such as a set of teeth, more representations or subscans may be provided . . . during a complete scanning process.”).

Newcombe further discloses that a scene in a current depth frame may “at least partially overlap” with a scene in a previous depth frame. Ex-1005 at 5:36-37.

A POSITA would understand that “partially overlap,” as used by Newcombe, implies that each scan provides a subset of 3D points representing the scanned surface (some overlapping and some not overlapping), and therefore each scan is a subscan of the overall surface being scanned. Ex-1003, ¶ 161.

10. Claim 16 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. A POSITA would understand that Newcombe renders obvious the elements of claim 16. As discussed with respect to claims 1 and 15 above, a POSITA would understand that the first and second 3D representations of Newcombe can be considered subscans of the final dense 3D model of the location because the model is not complete until all the depth images are used to finalize the three-dimensional model. *See, e.g.*, Ex-1005 at 3:28-30; Ex-1003, ¶¶ 164-165.

11. Claim 17 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. It would have been obvious to a POSITA to update a real-time provisional model of a dense 3D environment to obtain a preview of the final model. Ex-1003, ¶¶ 167-168.

12. Claim 20 is Obvious in View of Newcombe and Hähnel

a. [Claim 20 pre]

[Claim 20a]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to second excluded volume element of claim 1, applying the filtering of dynamic objects described by Hähnel to the moving objects identified by Newcombe's segmentation would remove, and therefore disregard any moving objects in the excluded volumes and reduce errors in the dense 3D environment model. *See supra*, § IX.A.1.f; Ex-1003, ¶ 170.

b. [Claim 20b]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to first excluded volume element of claim 1, the filtering method described by Hähnel removes, and therefore disregards, any surface measurements corresponding to moving objects in the first excluded volume of the first representation. *See supra*, § IX.A.1.g; Ex-1003, ¶¶ 171-172.

13. Claim 21 is Obvious in View of Newcombe and Hähnel

a. [Claim 21 pre]

[Claim 21a]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to first excluded volume element of claim 1, Newcombe discloses a compatibility test to determine a first excluded volume that does not include any points corresponding to surfaces of rigid objects. *See supra*, § IX.A.1.d. Ex-1003,

¶¶ 174-175.

b. [Claim 21b]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to second excluded volume element of claim 1, Newcombe discloses a compatibility test to determine a second excluded volume that does not include any points corresponding to surfaces of rigid objects. *See supra*, § IX.A.1.e. Ex-1003, ¶¶ 176-177.

14. Claim 22 is Obvious in View of Newcombe and Hähnel

Newcombe in view of Hähnel teaches this claim element. Newcombe teaches that the steps of its algorithm and method are all performed on a computer or computer gaming system. *See, e.g.*, Ex-1005 at 13:53-59. A POSITA would therefore understand Newcombe in view of Hähnel to teach or render obvious a nontransitory computer readable medium encoded with a computer program product comprising program code for causing a data processing system to perform the method disclosed by Newcombe in view of Hähnel. Ex-1003, ¶¶ 179-180.

15. Claim 23 is Obvious in View of Newcombe and Hähnel

a. [Claim 23 pre]

As discussed above with respect to element [1pre], Newcombe discloses this element, which, for purposes of this Petition, Petitioner construes to be limiting.

Supra, § IX.A.1.a; Ex-1003, ¶¶ 182-183. Newcombe further discloses that its methods may be performed by a computer system comprising a hardware processor. Ex-1005 at 12:29-13:64; Fig. 7; Ex-1003, ¶ 184.

b. [Claim 23a]

Element [23a] is identical to element [1a] and is disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.b; Ex-1003, ¶¶ 186-187.

c. [Claim 23b]

Element [23b] is identical to element [1b] and is disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.c; Ex-1003, ¶¶ 188-190.

d. [Claim 23c]

Element [23c] is identical to element [1c] and is disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.d; Ex-1003, ¶¶ 191-196.

e. [Claim 23d]

Element [23d] is identical to element [1d] and is disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.e; Ex-1003, ¶¶ 197-199.

f. [Claim 23e]

Element [23e] is identical to element [1e] and is disclosed by Newcombe and Hähnel for the reasons discussed above. *Supra*, § IX.A.1.f; Ex-1003, ¶¶ 200-208.

g. [Claim 23f]

Element [23f] is identical to element [1f] and is disclosed by Newcombe and Hähnel for the reasons discussed above. *Supra*, § IX.A.1.g; Ex-1003, ¶¶ 209-212.

16. Claim 24 is Obvious in View of Newcombe and Hähnel

a. [Claim 24 pre]

[Claim 24a]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to claim elements [1e]-[1f], a POSITA would understand Newcombe to disclose disregarding a portion of a surface in a first 3D representation that is located in space in a second exclude volume. *Supra*, §§ IX.A.1.f-g; Ex-1003, ¶¶ 214-215. Further, as is also discussed with respect to claim elements [1e]-[1f], applying the filtering of dynamic objects described by Hähnel to the moving objects identified by Newcombe's segmentation would remove, and therefore disregard any moving objects in the excluded volumes and reduce errors in the dense 3D environment model. *Supra*, §§ IX.A.1.f-g; Ex-1003, ¶¶ 214-215.

b. [Claim 24b]

Newcombe in view of Hähnel teaches this claim element. As discussed above with respect to claim elements [1e]-[1f], a POSITA would understand Newcombe to disclose disregarding a portion of a surface in a first 3D representation that is located in space in a second exclude volume. *Supra*, §§ IX.A.1.f-g; Ex-1003, ¶¶ 216-217.

Further, as is also discussed with respect to claim elements [1e]-[1f], applying the filtering of dynamic objects described by Hähnel to the moving objects identified by Newcombe's segmentation would remove, and therefore disregard any moving objects in the excluded volumes and reduce errors in the dense 3D environment model. *Supra*, §§ IX.A.1.f-g; Ex-1003, ¶¶ 216-217.

17. Claim 25 is Obvious in View of Newcombe and Hähnel

a. [Claim 25 pre]

As discussed above with respect to element [1pre], Newcombe discloses this element, which, for purposes of this Petition, Petitioner construes to be limiting. *Supra*, § IX.A.1.a; Ex-1003, ¶¶ 219-221.

b. [Claim 25a]

Element [25a] is identical to element [1a] and disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.b; Ex-1003, ¶¶ 222-223.

c. [Claim 25b]

Element [25b] is identical to element [1b] and is disclosed by Newcombe for the reasons discussed above. *Supra*, § IX.A.1.c; Ex-1003, ¶¶ 224-227.

d. [Claim 25c]

The recited features of element [25c] are substantially identical to those of

elements [1c] and [1d]. Newcombe discloses this element for the reasons discussed above. *Supra*, §§ IX.A.1.d-e; Ex-1003, ¶¶ 228-235.

e. [Claim 25d]

The recited features of element [25d] are substantially identical to those of elements [1e] and [1f]. Newcombe and Hähnel disclose this element for the reasons discussed above. *Supra*, §§ IX.A.1.f-g; Ex-1003, ¶¶ 236-246.

B. Ground 2: Claims 2-5, 18, and 19 are Rendered Obvious by Newcombe in view of Hähnel and McQueston

1. Claim 2 is Obvious in view of Newcombe, Hähnel, and McQueston

As discussed above, claim 1 is obvious in view of Newcombe and Hähnel. McQueston describes obtaining a three-dimensional model of teeth located in an intra-oral environment. Ex-1008 at 1:9-23. It would have been obvious to a POSITA to apply the optical measurement techniques of Newcombe in view of Hähnel to the intra-oral environment of McQueston to measure tooth surfaces without the interference of moving bodies and thereby obtain a more accurate three-dimensional model of the tooth surfaces. Ex-1003, ¶ 251.

As described above, it would have been obvious to combine McQueston with Newcombe and Hähnel. *Supra*, § VIII.B.1. Therefore Newcombe in view of Hähnel, and further in view of McQueston renders obvious, and therefore invalid, that the

“rigid object is a patient’s set of teeth, and the location is the mouth of the patient,” as claimed. Ex-1003, ¶ 251.

2. Claims 3-5, 18, and 19 are Obvious in view of Newcombe, Hähnel, and McQueston

As discussed above, claim 1 is obvious in view of Newcombe and Hähnel. McQueston teaches that a variety of movable objects may interfere with the three-dimensional modeling of the teeth, including specifically “soft tissue”, a dentist’s “instrument,” a “finger,” or a “patient’s tongue.” Ex-1008 at 1:13-23, 4:4-46. It would have been obvious to a POSITA that the movable object could be a dental suction device, cotton rolls, and/or cotton pads in view of McQueston’s teaching that that moveable object can be a “tongue depressor, or other instrument.” Ex-1008 at 1:13-23, 4:4-46; Ex-1003, ¶ 252.

As described above, it would have been obvious to combine McQueston with Newcombe and Hähnel. *Supra*, § VIII.B.1. Therefore, Newcombe in view of Hähnel, and further in view of McQueston renders obvious, and therefore invalid, the claimed “movable object” being any one of the objects recited in claims 3-5, 18, and 19. Ex-1003, ¶ 252.

C. Ground 3: Claims 1, 6-12, 15-17, and 20-25 are Rendered Obvious by Herbst

1. Claim 1 is Obvious in View of Herbst

a. [Claim 1 pre]

Herbst discloses this element. Herbst teaches “a method to determine movable parts of a scene based on differencing with another scene.” Ex-1006 at 7. A POSITA would understand this method to be equivalent to the claimed method of “detecting a movable object in a location.” Ex-1003, ¶ 256. Herbst teaches the use of RGB-D cameras and RGB-D Mapping, which Herbst further discloses to be “a SLAM technique for generating dense 3-D maps.” Ex-1006 at 2. Herbst discloses that the objects in a scene captured by the cameras can be “static,” which a POSITA would equate with “rigid” objects. *Id.*; Ex-1003, ¶ 256. A POSITA would therefore understand Herbst to disclose this claim element. Ex-1003, ¶ 256.

b. [Claim 1a]

Herbst teaches this element. Herbst describes scanning objects in a location using RGB-D cameras and SLAM to create and update 3D maps. Ex-1006 at 1. For example, Figure 6(a) of Herbst, shown below, demonstrates a first 3D representation of a surface, including the various surfaces corresponding to a table and objects on the table, obtained from scanning a location. *Id.* at 1-2. A POSITA would therefore understand Herbst to disclose this claim element. Ex-1003, ¶ 258.



Fig. 6(a)

c. [Claim 1b]

Herbst teaches this element. As discussed in the preceding section above, Herbst discloses “providing a first 3D representation of at least part of a surface of the location.” Herbst further discloses that this process of providing 3D representations is iterative and performed two or more times with respect to a particular scene or location. Specifically, Herbst states that “[t]he inputs to [its] system are two or more RGB-D videos representing separate visits to the same location.” Ex-1006 at 2. For example, Figure 6(d) of Herbst, reproduced below, shows a second 3D representation of the same tabletop scene shown in Figure 6(a) above, but with different objects in different locations on the table within the scene.

A POSITA would therefore understand Herbst to disclose this claim element. Ex-1003, ¶ 260.

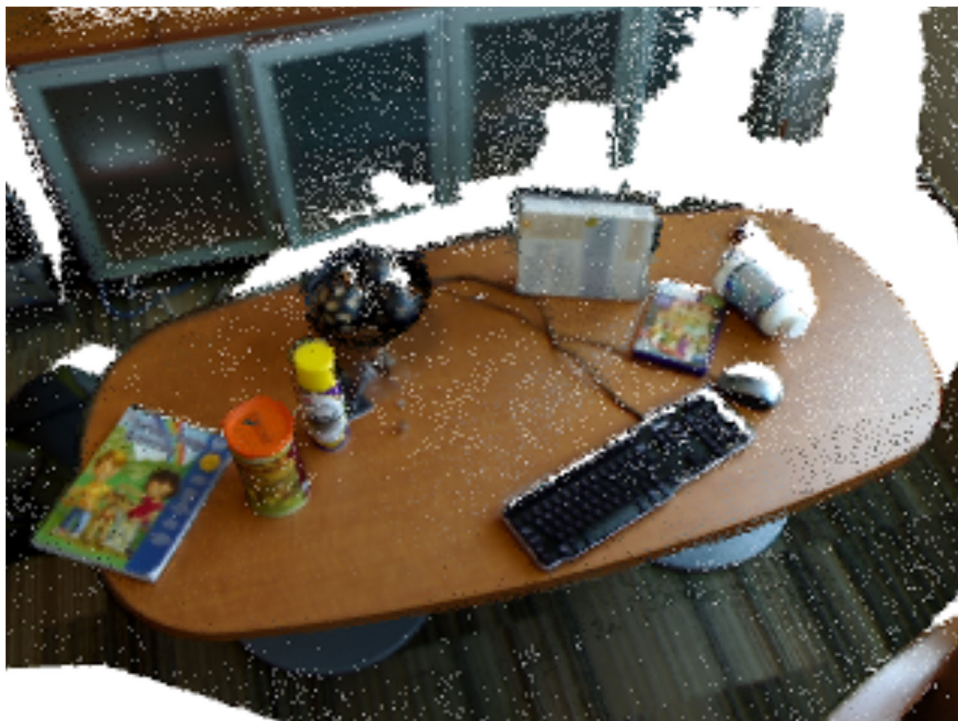


Fig. 6(d)

d. [Claim 1c]

Herbst teaches this element. Specifically, Herbst teaches the determination of an excluded volume using the probabilistic model disclosed by the reference. Ex-1003, ¶ 262. Herbst teaches a probabilistic model for obtaining pixel measurements corresponding to surfaces observed in a scene by an RGB-D camera. *See* Ex-1006 at 2-3. With respect to each of a first 3D representation and a second 3D representation, Herbst's model is able to predict the depth, and therefore the location, of all surfaces within the volume of the scene scanned by the RGB-D camera. Ex-

1003, ¶ 263.

Herbst further teaches that “[f]ollowing global registration, we convert points to surfels [14] to reduce map size and smooth evidence from multiple frames. Each 3-D point from each frame is assigned to a surfel, either an existing one or a newly created one if there is no existing surfel close to the point. Fig. 1 shows two reconstructions of a location.” Ex-1006 at 2. A POSITA at the time the ’551 patent was filed would understand Herbst to teach that the empty space between the scanner and the surface, where no 3D point on any surface is detected, is excluded from the 3D surfel representation of the corresponding scan visit, and therefore the empty space for each scanning visit would constitute an excluded volume for the 3D representation of that scanning visit. Ex-1003, ¶¶ 264-265.

For example, a POSITA would have understood Herbst to teach that, according to Herbst’s probabilistic model, the empty space shown in Figure 6(a) below – i.e., the space in the scene that is not occupied by the table, the objects on the table, or any other surface – would constitute an excluded volume for the first 3D representation. *Id.*, ¶ 266.



Fig. 6(a)

e. [Claim 1d]

Herbst teaches this element. Herbst's teaching of a probabilistic model and excluded volume, as discussed in the preceding section, necessarily applies equally to both the probabilistic model's application to a first 3D representation and to a second 3D representation. *Supra*, § IX.C.1.d; Ex-1003, ¶ 268. Thus, with respect to Figure 6(d) below, a POSITA would have understood that the empty space shown in the figure – i.e., the space in the scene that is not occupied by the table, the objects on the table, or any other surface – would constitute an excluded volume for the second 3D representation, according to the court's construction. Ex-1003, ¶ 268.

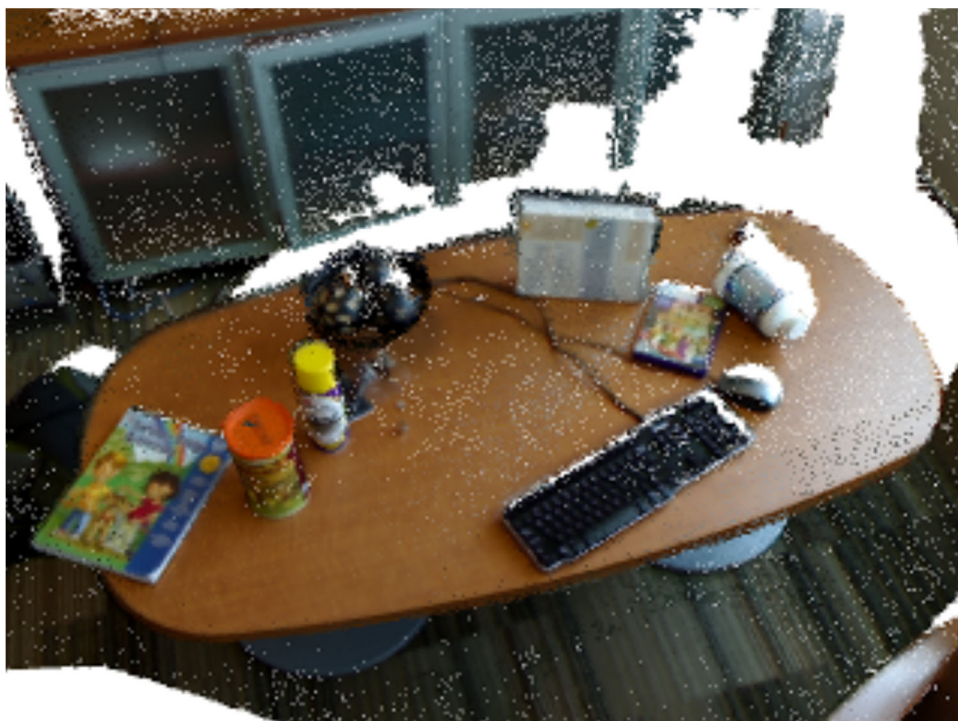


Fig. 6(d)

f. [Claim 1e]

Herbst teaches this element. As discussed above, Herbst teaches a method for comparing two or more 3D representations of a scene to determine if objects within the scene have moved between the two representations. *Supra*, §§ IX.C.1.d-e. Herbst further teaches that once all of the moveable objects have been detected, the two 3D representations can be merged into a single virtual 3D model from which all of the moveable objects are removed using Herbst's disclosed methods and probabilistic model. *See* Ex-1006 at 5; Ex-1003, ¶¶ 270-271.

For example, Herbst shows a first 3D representation of a tabletop scene in Figure 6(a) and a second 3D representation of the same tabletop scene in Figure 6(d).

Both figures are reproduced below.

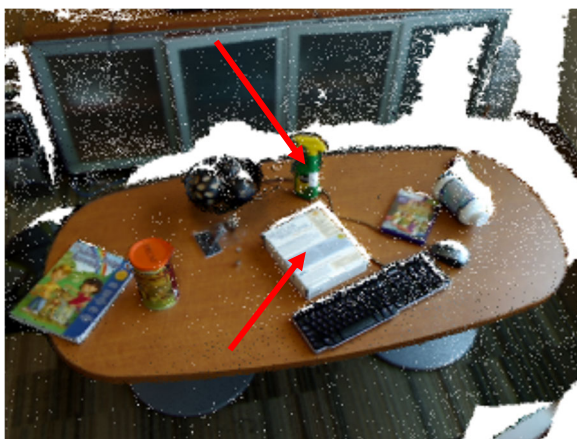


Fig. 6(a) (annotated)

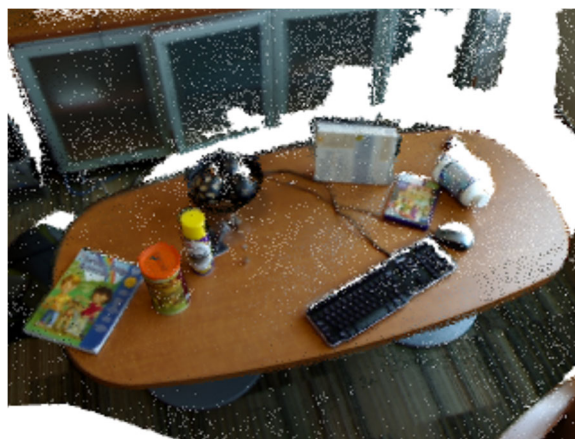


Fig. 6(d)

As discussed above, a POSITA would understand Herbst to teach that all empty space in these respective 3D representations that is not occupied by a surface would collectively constitute an excluded volume for each 3D representation. Thus, when comparing the two representations according to Herbst's probabilistic model, those surfaces in the first 3D representation that are in the excluded volume of the second 3D representation (i.e., the second excluded volume) are determined to have moved. Ex-1003, ¶ 272. Those two objects are identified in the left figure above with **red** arrows.

Furthermore, in Figure 7(b) of Herbst below, which illustrates a virtual 3D model of the scene created by merging the two 3D representations of Figures 6(a) and 6(d), the moved objects in the first 3D representation – i.e., those objects that are in the second excluded volume – have been removed. Ex-1003, ¶ 273.



Fig. 7(b)

g. [Claim 1f]

Herbst teaches this element. As described in the preceding section, Herbst discloses that its methods and probabilistic model can be used to create a merged virtual 3D model from which all of the moveable objects identified in the first and second 3D representations are removed. *See supra*, § IX.C.1.f; Ex-1006 at 5; Ex-1003, ¶ 275. A POSITA would have understood that Herbst's teachings apply equally to both 3D representations and both excluded volumes and that once all of the moveable objects have been detected, the two 3D representations can be merged into a single virtual 3D model from which all of the moveable objects are removed using Herbst's disclosed methods and probabilistic model. Ex-1003, ¶ 275.

For example, referring again to Figures 6(a) and 6(d) of Herbst, reproduced below, as stated above a POSITA would understand Herbst to teach that all empty

space in these respective 3D representations that is not occupied by a surface would collectively constitute an excluded volume for each 3D representation.



Fig. 6(a)

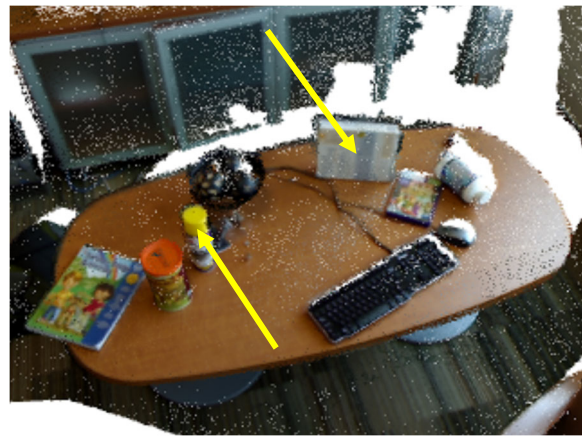


Fig. 6(d) (annotated)

Thus, when comparing the two representations according to Herbst's probabilistic model, those surfaces in the second 3D representation that are in the excluded volume of the first 3D representation (i.e., the first excluded volume) are determined to have moved. *Id.*, ¶ 276. Those two objects are identified in the right figure above with yellow arrows.

Thus, again when considering the merged virtual 3D model of Figure 7(b) of Herbst, shown below, the moved objects in the second 3D representation – i.e., those objects that are in the first excluded volume – have been removed. Thus, Herbst teaches this claim element. Ex-1003, ¶ 277.



Fig. 7(b)

2. Claim 6 is Obvious in View of Herbst

Herbst teaches this element. As discussed above, Herbst teaches providing first and second 3D representations of at least part of a surface by scanning at least part of the location. *Supra*, §§ IX.C.1.b-c. Figures 6(a) and 6(d) of Herbst, reproduced below, show examples of the first and second 3D representations disclosed by Herbst.



Fig. 6(a)

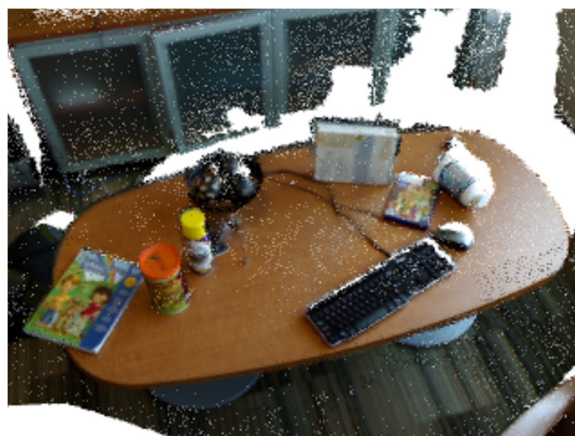


Fig. 6(d)

As is seen in the images above, at least a part of the surface captured in the first 3D representation of Herbst in Fig. 6(a) and at least part of the surface captured in the second 3D representation of Herbst in Fig. 6(d) are overlapping the same surface part on the rigid object (e.g., the table shown in Figs. 6(a) and 6(d)). Ex-1003, ¶¶ 280-282.

3. Claim 7 is Obvious in View of Herbst

Herbst teaches this claim element. As discussed above, Herbst teaches providing first and second 3D representations of at least part of a surface by scanning at least part of the location. *Supra*, §§ IX.C.1.b-c. As shown in the images below, the first representation of at least part of the surface is defined as the first representation of at least a first part of the surface, as shown in the first 3D representation of Herbst in Fig. 6(a), and the second representation of at least part of the surface is defined as the second representation of at least a second part of the surface, as shown in the second 3D representation of Herbst in Fig. 6(d). Ex-1003, ¶¶ 284-286.



Fig. 6(a)

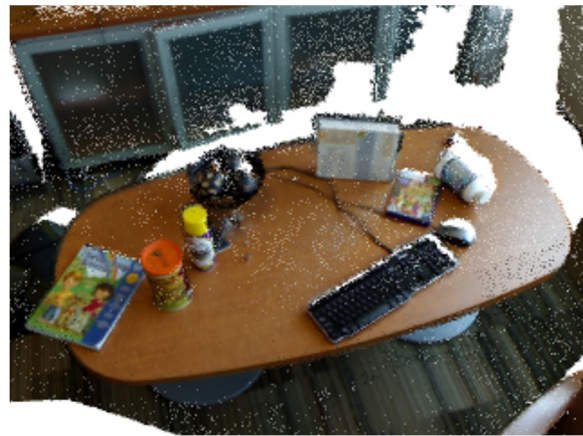


Fig. 6(d)

4. Claim 8 is Obvious in View of Herbst

Herbst teaches this claim element. Herbst discloses that “[w]e use the PrimeSensor, an RGB-D camera that provides dense registered color and depth measurements, to detect objects by means of their movement in 3-D between two maps of the same location.” Ex-1006 at 1. The disclosure of using an RGB-D sensor such as the PrimeSensor would make Claim 8 obvious, since a POSITA at the time the ’551 patent was filed would have understood that such sensors comprise of an RGB camera and an infrared laser to project a pattern in the scene (typically random spots). Ex-1003, ¶ 288. A POSITA would have known that an RGB camera would have a field of view, defining the extent of a volume in space in front of the aperture of the camera that is pictured by the camera, and a depth of field defining a range of depth within the field of view that is in focus. *Id.* Also, a POSITA would have known that laser pattern projection would have a depth range depending on the laser

strength and the environment ambient infrared light. *Id.* Therefore, a POSITA would have understood that the combination of field of view, depth of field, and the laser range associated with an RGB-D sensor would define a volume of space in front of the sensor where the scanner could effectively capture 3D point clouds. *Id.* As the user moves the sensor's position and orientation, a new scan volume is defined in space, where the RGB-D scanner can effectively produce 3D point clouds. *Id.*

Herbst also teaches providing first and second 3D representations of at least part of a surface by scanning at least part of the location. *Supra*, §§ IX.C.1.b-c. Therefore, Herbst determines a scan volume related to each 3D representation for part of the surface since, as discussed above, it determines the reduction of the scan volume into surfels and the associated excluded volume, i.e., the empty space between part of the surface being scanned and the sensor. Ex-1003, ¶ 289. Figures 1(a) and 6(a) of Herbst, reproduced below, show examples of the first 3D representations disclosed by Herbst, while Figures 1(b) and 6(d), also reproduced below, show examples of the second 3D representations disclosed by Herbst.



Fig. 1(a)



Fig. 1(b)



Fig. 6(a)

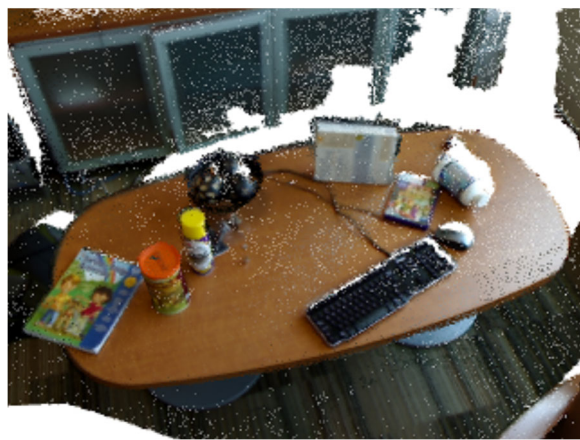


Fig. 6(d)

As seen in the images above, a scan volume in space related to each of the first and second 3D representations of at least part of the surface is taught by Herbst. Ex-1003, ¶ 290.

5. Claim 9 is Obvious in View of Herbst

Herbst teaches this claim element. As discussed above, Herbst discloses a scan volume with respect to each of the first and second 3D representations. *Supra*, § IX.C.4. Furthermore, as discussed above, Herbst discloses the use of an

RGB-D camera for 3D scanning. A POSITA at the time the '551 patent was filed would know that RGB-D cameras use electro-optical sensors with associated focusing optics for capturing depth information. Therefore, a POSITA would know that the scan volume created by an RGB-D camera when scanning a surface to create 3D representations would depend on the field of view and the depth of field of the electro-optical sensor, both of which depend on the focusing optics and the distance to the surface captured by the depth camera. Ex-1003, ¶ 293.

6. Claim 10 is Obvious in View of Herbst

Herbst teaches this claim element. As discussed above with respect to claim 8, Herbst describes determining a first and second scan volume related to the first and second representations of at least a first and second part of the surface. *Supra*, § IX.C.4. As discussed with respect to claim 9, the RGB-D camera taught by Herbst would necessarily have focusing optics that a POSITA would understand to define a scan volume between the focusing optics and the captured surface. *Supra*, § IX.C.5; Ex-1003, ¶¶ 296-297.

7. Claim 11 is Obvious in View of Herbst

Herbst teaches this claim element. As discussed above with respect to the excluded volume and scan volume elements of claims 8-10, a POSITA would understand the scanned depths that do not correspond to a surface to be excluded volumes where the surface of the stationary body cannot be present.

Supra, §§ IX.C.4-6. Further, as is shown in Figures 1(a)-1(b) and 6(a), 6(d) below, these scanned depths correspond to the scan volumes, including, for example, those volumes between the RGB-D camera and the surface. Ex-1003, ¶¶ 299-300.



Fig. 1(a)



Fig. 1(b)



Fig. 6(a)

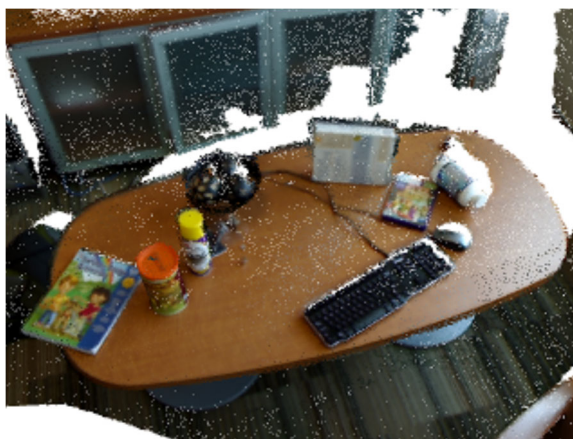


Fig. 6(d)

8. Claim 12 is Obvious in View of Herbst

Herbst teaches this claim element. Herbst does not explicitly describe that the 3D scanner is defined as an excluded volume, but this claim element would be obvious to a POSITA in light of the teachings of Herbst. Ex-1003, ¶ 302. A POSITA

would recognize that the RGB-D camera of Herbst would necessarily be a part of “an excluded volume in space that is common to both the first and second 3D representations where no surface from either of the 3D representations should be present,” per the district court’s construction, because it is impossible for the RGB-D camera to be included in any scan volume. Therefore, Herbst renders claim 12 obvious.

9. Claim 15 is Obvious in View of Herbst

Herbst teaches this claim element. Although Herbst does not explicitly use the term “subscan” with respect to the first and second 3D representations it teaches, as shown, for example, in Figures 1(a)-1(b) and 6(a), 6(d) below, a POSITA would understand that these multiple representations are subscans of at least a part of the location depicted in the scene and that together these subscans will be used to generate a virtual 3D model. *See* Ex-1003, ¶ 304; Ex-1001, 3:44-49 (“Typically when scanning an object, such as a set of teeth, more representations or subscans may be provided . . . during a complete scanning process.”)



Fig. 1(a)



Fig. 1(b)

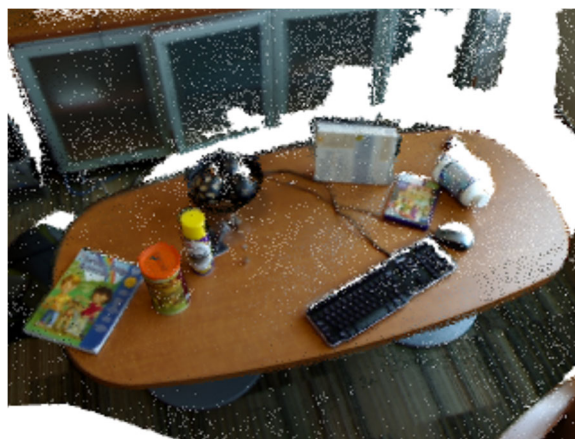


Fig. 6(a)

Fig. 6(d)

Herbst further discloses that “[i]n each experiment, the RGB-D camera was carried by hand to generate partial coverage of the scene.” Ex-1006 at 5. A POSITA would have understood each section of “partial coverage of the scene” generated by the camera to constitute multiple, separate subscans. Ex-1003, ¶¶ 304-305.

10. Claim 16 is Obvious in View of Herbst

Herbst teaches this claim element. As discussed with respect to claim 15 above, a POSITA would understand that the first and second 3D representations of Herbst, as shown, for example, in Figures 1(a)-1(b) and 6(a), 6(d) above, can be considered subscans of the final model of the tabletop scene (e.g., as shown in Fig. 7) because the model is not complete until both those scanning models are used to finalize the three-dimensional model. *See Supra*, § IX.C.9; Ex-1006 at 2 (“The inputs to our system are two or more RGB-D videos”); Ex-1003, ¶¶ 307-308.

11. Claim 17 is Obvious in View of Herbst

Herbst teaches this claim element. Herbst teaches that “We build on RGB-D Mapping [10], a SLAM technique for generating dense 3-D maps.” Ex-1006 at 2. Claim 17 would be rendered obvious by the above teaching of Herbst, since a POSITA would understand that SLAM methods are designed to update a 3D model while tracking the scanner position and orientation. Ex-1003, ¶¶ 310-311. A POSITA would have understood that adapting subscans “to be added to the provisional virtual 3D model concurrently with the acquisition of the subscans” would directly correspond to the definition of methods in the prior arts known as simultaneous localization and mapping (SLAM). *Id.* It would have been obvious to a POSITA to update a real-time provisional model of the tabletop scenes of Herbst to obtain a preview of the final model. *Id.*

12. Claim 20 is Obvious in View of Herbst

a. [Claim 20 pre]

[Claim 20a]

Herbst teaches this claim element. As discussed above with respect to second excluded volume element of claim 1, the method described by Herbst removes, and therefore disregards, any surface measurements corresponding to moving objects in

the second excluded volume of the second representation. *Supra*, § IX.C.1.f; Ex-1003, ¶ 313.

b. [Claim 20b]

Herbst teaches this claim element. As discussed above with respect to first excluded volume element of claim 1, the method described by Herbst removes, and therefore disregards, any surface measurements corresponding to moving objects in the first excluded volume of the first representation. *Supra*, § IX.C.1.g; Ex-1003, ¶¶ 314-315.

13. Claim 21 is Obvious in View of Herbst

a. [Claim 21 pre]

[Claim 21a]

Herbst teaches this claim element. As discussed above with respect to first excluded volume element of claim 1, Herbst discloses the determination of a first excluded volume that contains empty space and no rigid objects. *See supra*, § IX.C.1.d. Ex-1003, ¶ 317.

b. [Claim 21b]

Herbst teaches this claim element. As discussed above with respect to second excluded volume element of claim 1, Herbst discloses the determination of a second excluded volume that contains empty space and no rigid objects. *See supra*, §

IX.C.1.e. Ex-1003, ¶¶ 318-319.

14. Claim 22 is Obvious in View of Herbst

Herbst teaches this claim element. Herbst teaches that the steps of its algorithm and method are all performed on a “system” that comprises a “machine” that has “16 hardware threads.” *See, e.g.*, Ex-1006 at 6-7. A POSITA would therefore understand Herbst to teach or render obvious a nontransitory computer readable medium encoded with a computer program product comprising program code for causing a data processing system to perform the method disclosed by Herbst. Ex-1003, ¶¶ 321-322.

15. Claim 23 is Obvious in View of Herbst

a. [Claim 23 pre]

As discussed above with respect to element [1 pre], Herbst discloses this element, which, for purposes of this Petition, Petitioner construes to be limiting. *Supra*, § IX.C.1.a; Ex-1003, ¶¶ 324-327. Herbst further discloses that its methods may all be performed by computer system comprising a hardware processor. Ex-1006 at 6-7; Ex-1003, ¶ 326.

b. [Claim 23a]

Element [23a] is identical to element [1a] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.b; Ex-1003, ¶¶ 328-329.

c. [Claim 23b]

Element [23b] is identical to element [1b] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.c; Ex-1003, ¶¶ 330-331.

d. [Claim 23c]

Element [23c] is identical to element [1c] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.d; Ex-1003, ¶¶ 332-338.

e. [Claim 23d]

Element [23d] is identical to element [1d] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.e; Ex-1003, ¶¶ 339-340.

f. [Claim 23e]

Element [23e] is identical to element [1e] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.f; Ex-1003, ¶¶ 341-345.

g. [Claim 23f]

Element [23f] is identical to element [1f] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.g; Ex-1003, ¶¶ 346-349.

16. Claim 24 is Obvious in View of Herbst

a. [Claim 24 pre]

[Claim 24a]

Herbst teaches this claim element. As discussed above with respect to second excluded volume element of claim 23, the method described by Herbst removes, and therefore disregards, any surface measurements corresponding to moving objects in the second excluded volume of the second representation. *Supra*, § IX.C.1.e; Ex-1003, ¶¶ 351-352.

b. [Claim 24b]

Herbst teaches this claim element. As discussed above with respect to first excluded volume element of claim 1, the method described by Herbst removes, and therefore disregards, any surface measurements corresponding to moving objects in the first excluded volume of the first representation. *Supra*, § IX.C.1.d; Ex-1003, ¶¶ 353-354.

17. Claim 25 is Obvious in View of Herbst

a. [Claim 25 pre]

As discussed above with respect to element [1 pre], Herbst discloses this element, which, for purposes of this Petition, Petitioner construes to be limiting. *Supra*, § IX.C.1.a; Ex-1003, ¶¶ 356-358.

b. [Claim 25a]

Element [25a] is identical to element [1a] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.b; Ex-1003, ¶¶ 359-360.

c. [Claim 25b]

Element [25b] is identical to element [1b] and is rendered obvious by Herbst for the reasons discussed above. *Supra*, § IX.C.1.c; Ex-1003, ¶¶ 361-362.

d. [Claim 25c]

The recited features of element [25c] are substantially identical to those of elements [1c] and [1d]. Herbst discloses this element for the reasons discussed above. *Supra*, §§ IX.C.1.d-e; Ex-1003, ¶¶ 363-369.

e. [Claim 25d]

The recited features of element [25d] are substantially identical to those of elements [1e] and [1f]. Herbst discloses this element for the reasons discussed above. *Supra*, §§ IX.C.1.f-g; Ex-1003, ¶¶ 370-378.

D. Ground 2: Claims 2-5, 18, and 19 are Rendered Obvious by Herbst and McQuestion

1. Claim 2 is Obvious in view of Herbst and McQuestion

As discussed above, claim 1 is obvious in view of Herbst. McQuestion describes obtaining a three-dimensional model of teeth located in an intra-oral environment. Ex-1008 at 1:9-23. It would have been obvious to a POSITA to apply the modeling techniques of Herbst to the intra-oral environment of McQuestion to

measure tooth surfaces without the interference of moving bodies and thereby obtain a more accurate three-dimensional model of the tooth surfaces. Ex-1003, ¶ 383.

As described above, it would have been obvious to combine McQueston with Herbst. *Supra*, § VIII.B.2. Therefore Herbst, in view of McQueston, renders obvious, and therefore invalid, that the “rigid object is a patient’s set of teeth, and the location is the mouth of the patient,” as claimed. Ex-1003, ¶ 383.

2. Claims 3-5, 18, and 19 are Obvious in view of Herbst and McQueston

As discussed above, claim 1 is obvious in view of Herbst. McQueston teaches that a variety of movable objects may interfere with the three-dimensional modeling of the teeth, including specifically “soft tissue”, a dentist’s “instrument,” a “finger,” or a “patient’s tongue.” Ex-1008 at 1:13-23, 4:4-46. It also would have been obvious to a POSITA that the movable object could be a dental suction device, cotton rolls, and/or cotton pads in view of McQueston’s teaching that that moveable object can be a “tongue depressor, or other instrument.” Ex-1008 at 1:13-23, 4:4-46; Ex-1003, ¶ 384.

As described above, it would have been obvious to combine McQueston with Herbst. *Supra*, § VIII.B.2. Therefore, Herbst in view of McQueston renders obvious, and therefore invalid, the claimed “movable object” being any one of the objects recited in claims 3-5, 18, and 19. Ex-1003, ¶ 384.

X. INSTITUTION SHOULD NOT BE DISCRETIONARILY DENIED

A. The Board Should Not Exercise Its Discretion Under 35 U.S.C. § 314(a)

Petitioner hereby stipulates that, should the Petition be granted, Petitioner will not pursue in the district court the same grounds that are raised or could have reasonably been raised in this Petition pursuant to *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB Dec. 1, 2020) (precedential as to § II.A). Under the June 21, 2022, *Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation*, the Director has stated that “the PTAB will not discretionarily deny institution of an IPR” in view of such a stipulation. Interim Procedure at 7; *id.* at 3 and n.3 (discussing *Sotera*).

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

B. The Board Should Not Exercise Its Discretion Under 35 U.S.C. § 325(d)

“In evaluating arguments under § 325(d), [the PTAB] use[s] a two-part framework: (1) whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office; and (2) if either condition of the first part of the framework is satisfied, whether the petition has demonstrated that the Office

erred in a manner material to the patentability of challenged claims.” *The Data Co. Techs., Inc. v. Bright Data Ltd.*, IPR2022-00135, Paper 12 at 15 (PTAB June 1, 2022) (citing *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR 2019-01469, Paper 6 at 8 (PTAB Feb. 13, 2020)).

Here, none of the references relied on in this Petition was presented to the Office during examination of the application that led to the ’551 Patent. Nor were any other prior art references or arguments substantially similar to those presented in this Petition presented to the Office during examination.² Thus, the *Advanced*

² Petitioner notes that prior art references closely related to McQueston and Newcombe were presented to the Board by a third party in prior petitions filed against the ’551 patent. Specifically, U.S. Patent Pub. No. 2013/0335417, a publication of the application that issued as McQueston, was presented in IPR2018-00195, and U.S. Patent Pub. No. 2012/0195471, a publication of the application that issued as Newcombe, was presented in IPR2018-00196, both of which petitions were denied institution. The Board has stressed that such decisions on institution are preliminary and therefore not sufficient to satisfy the relevant analysis under § 325(d). *See Google LLC v. Uniloc 2017 LLC*, IPR2019-01584, Paper 7, at 11 (PTAB March 24, 2020). Petitioner’s reliance on McQueston and Newcombe in this Petition differs substantially from the third party’s use of the related

Bionics framework does not apply because the first part is not satisfied. *Id.* at 17 (Where “the first part of the *Advanced Bionics* framework is not satisfied, [the Board] need not consider the second part ...”).

XI. MANDATORY NOTICES

A. Real Parties in Interest—37 C.F.R. § 42.8(b)(1)

The following entities are real parties in interest to this proceeding:

- Medit Corporation
- Medit USA
- Crown Jade Co., Ltd.

references in the prior petitions. Specifically, Petitioner relies on McQueston here solely for limited teachings related to claims 2-5, 18, and 19, none of which was addressed by the Board in the denial of the petition in IPR2018-00195. *See Align Technology, Inc. v. 3Shape A/S*, IPR2018-00195, Paper 7, at 12 n.2, 13 (PTAB May 24, 2018). In IPR-00196, the related Newcombe publication was cited solely for teachings relevant to claim 14 of the ’551 patent, which is not challenged in this Petition, and the Board did not address those teachings in the denial of the earlier petition. *See Align Technology, Inc. v. 3Shape A/S*, IPR2018-00196, Paper 6, at 10-11 (PTAB May 24, 2018).

- Digital Dentistry Solution Holdings, Inc.

No other parties had access to or control over this Petition, and no other parties funded this Petition.

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

To the best of Petitioner’s knowledge, the ’551 patent has been or is involved in the following cases that would affect, or be affected by, a decision in this proceeding:

- *3Shape A/S v. Medit Corp.*, Case No. W-22-CV-00443-ADA-DTG (W.D. Tex.). This case is ongoing.
- *3Shape A/S v. Align Technology, Inc.*, Case No. 1-18-cv-00886 (D. Del.). This case has been terminated.
- *Align Technology, Inc v. 3Shape A/S*, IPR2018-00195 (PTAB). This case has been terminated.
- *Align Technology, Inc v. 3Shape A/S*, IPR2018-00196 (PTAB). This case has been terminated.

Petitioner is not aware of any other matters involving the ’551 patent.

C. Lead and Back-Up Counsel—37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

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

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at Bracewell-IP@bracewell.com.

XII. CONCLUSION

The prior art references cited herein demonstrate that the challenged claims of the '551 patent are obvious, and therefore unpatentable. Petitioner thus requests that the PTAB grant this Petition, institute *inter partes* review, and cancel the challenged claims.

IPR2023-01313
Patent No. 9,629,551

Respectfully Submitted,

Dated: August 18, 2023

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing Petition for *Inter Partes* Review contains 13,978 words excluding the caption, table of contents, table of authorities, table of exhibits, claim listing, mandatory notices, certificate of service, and certificate of word count. Petitioner has relied on the word count feature of the word processing system used to create this paper in making this certification.

Dated: August 18, 2023

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CERTIFICATE OF SERVICE

I hereby certify that on August 18, 2023, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review, associated exhibits, and power of attorney to be served via overnight courier upon the following counsel of record for Patent Owner per 37 CFR §§ 42.105(a) and 42.205(a).

Patent Office Counsel of Record	Litigation Counsel of Record
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I further certify that I served courtesy copies of the foregoing documents via electronic mail on August 18, 2023, upon Patent Owner's counsel of record as follows:

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