

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MEDIT CORPORATION,
Petitioner,

v.

3SHAPE A/S,
Patent Owner.

IPR2023-01313
Patent 9,629,551 B2

Before HUBERT C. LORIN, MICHELLEN. WORMMEESTER, and
JAMES J. MAYBERRY, *Administrative Patent Judges*.

WORMMEESTER, *Administrative Patent Judge*.

DECISION
Denying Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

Medit Corporation (“Petitioner”) filed a Petition (Paper 2, “Pet.”) requesting *inter partes* review of claims 1–12 and 15–25 of U.S. Patent No. 9,629,551 B2 (Ex. 1001, “the ’551 patent”). 3Shape A/S (“Patent Owner”) filed a Preliminary Response (Paper 5, “Prelim. Resp.”). We have authority under 35 U.S.C. § 314 and 37 C.F.R. § 42.4(a). Pursuant to 35 U.S.C. § 314(a), an *inter partes* review may not be instituted “unless . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition.” For the reasons that follow, we decline to institute an *inter partes* review of the challenged claims.

II. BACKGROUND

A. Related Proceedings

The only pending proceeding that the parties identify is a federal district court case: *3Shape A/S v. Medit Corp.*, No. 6:22-cv-00443 (W.D. Tex.). Pet. 77; Paper 3, 1 (Patent Owner’s mandatory notices).

B. The ’551 Patent

The ’551 patent relates to “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, 1:6–9. This method can be applied in the context of dentistry, where a dental patient’s teeth are scanned using a handheld scanner. *Id.* at 1:9–11. According to the ’551 patent, movable objects such as the patient’s tongue or the dentist’s instruments are captured in subscans when they pass between

the surface of the teeth and the scanner, obstructing the view of the teeth from the scanner. *Id.* at 1:29–37. Multiple subscans are used to generate a virtual 3D model. *Id.* at 1:40–43. The method of the '551 patent differentiates between surfaces of a movable object and surfaces of a rigid object, so that only the surfaces of the rigid object are used when generating the virtual 3D model. *Id.* at 1:56–60.

To illustrate one embodiment of the method, Figure 1 of the '551 patent is reproduced below.

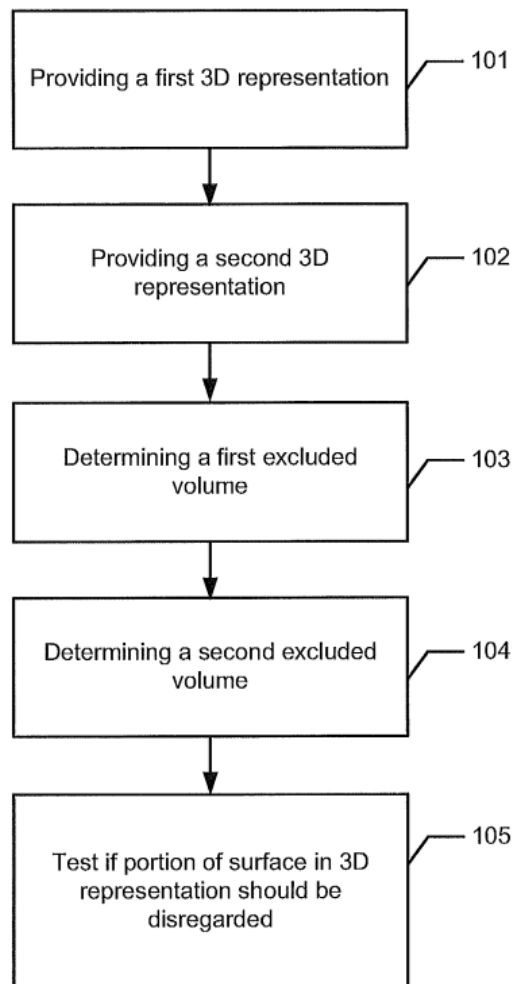
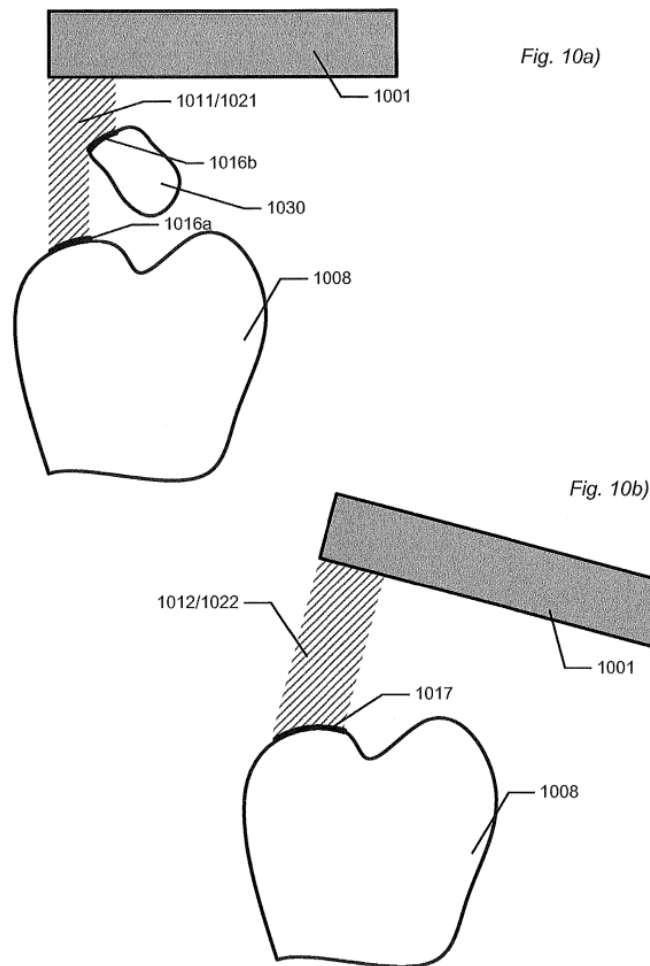


Fig. 1

Figure 1 is a flowchart of a method for detecting a movable object in a location, when scanning a rigid object in the location using a 3D scanner for generating a virtual 3D model of the rigid object. Ex. 1001, 20:56–59. In step 101, a first 3D representation of at least a part of a surface is provided by scanning at least a part of the location. *Id.* at 20:60–61. In step 102, a second 3D representation of at least a part of the surface is provided by scanning at least a part of the location. *Id.* at 20:62–64. In step 103, a first excluded volume in space where no surface can be present is determined for the first 3D representation. *Id.* at 20:65–67. In step 104, a second excluded volume in space where no surface can be present is determined for the second 3D representation. *Id.* at 21:1–3. In step 105, a portion of the surface in the first 3D representation is disregarded in the generation of the virtual 3D model if that portion of the surface is located in space in the second excluded volume. *Id.* at 21:4–12. Likewise, a portion of the surface in the second 3D representation is disregarded in the generation of the virtual 3D model if that portion is located in space in the first excluded volume. *Id.*

As noted above, the method of the '551 patent can be applied in the context of dentistry. To illustrate, Figures 10a and 10b are reproduced below.



Figures 10a and 10b show the use of scanner 1001 to acquire first and second 3D representations 1016 and 1017 of a surface of tooth 1008, where movable object 1030 is captured in a part of first representation 1016.¹ Ex. 1001, 23:36–39. In Figure 10a, part 1016a of first representation 1016 includes a surface of tooth 1008, and part 1016b of first representation 1016 includes a surface of movable object 1030. *Id.* at 23:42–46. First scan volume 1011 in space relates to first representation 1016, and first excluded volume 1021 corresponds to first scan volume 1011. *Id.* at 23:46–49.

¹ Although Figures 10a and 10b do not include a label “1016,” we understand the ’551 patent’s reference to first representation 1016 as a collective reference to parts 1016a and 1016b.

In Figure 10b, second representation 1017 is acquired with a different angle between scanner 1001 and tooth 1008 than first representation 1016. Second scan volume 1012 in space relates to second representation 1017, and second excluded volume 1022 corresponds to second scan volume 1012. *Id.* at 23:52–55.

The '551 patent explains that “it is an advantage to disregard a surface portion from one representation if the surface portion is located in space in the excluded volume of another representation, because a surface portion detected in an excluded volume represents a movable object which is not part of the rigid object.” Ex. 1001, 2:56–61. Thus, “[s]ince the surface portion 1016b of the first representation 1016 lies in the second excluded volume 1022, this surface portion 1016b is disregarded in the generation of the virtual 3D model.” *Id.* at 23:58–61.

An excluded volume can be determined in various ways. *See* Ex. 1001, 27:48–49. To illustrate one embodiment, Figure 17 is reproduced below.

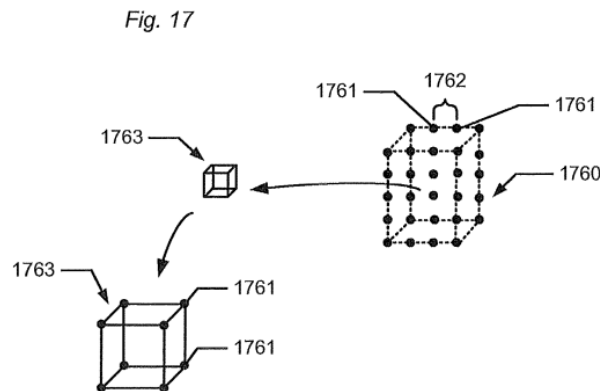


Figure 17 shows one way to determine an excluded volume. *Id.* at 27:48–49. The space is quantized in 3D volume grid 1760, which includes single cells 1763. *Id.* at 27:50–55. Each cell 1763 has eight corners 1761. *Id.* at 27:50–55. Distances 1762 between corners 1761 are equidistant. *Id.* at

27:51–52. If all eight corners 1761 of a single cell 1763 are in the scan volume of a representation, then cell 1763 is marked as excluded volume. *Id.* at 27:55–58. The '551 patent notes that the space of a representation may include tens, hundreds, thousands, or millions of cells. *Id.* at 27:59–60.

C. Illustrative Claim

The challenged claims of the '551 patent are claims 1–12 and 15–25, where claims 1, 23, and 25 are independent. Claim 1 is illustrative:

1. 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:

providing a first 3D representation of at least part of a surface by scanning at least part of the location;

providing a second 3D representation of at least part of the surface by scanning at least part of the location;

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;

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;

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.

D. Asserted Grounds of Unpatentability

Petitioner challenges claims 1–12 and 15–25 of the ’551 patent on the following four grounds. Pet. 6, 22–73.

Claims Challenged	35 U.S.C. § ²	References/Basis
1, 6–12, 15–17, 20–25	103(a)	Newcombe, ³ Hähnel ⁴
2–5, 18, 19	103(a)	Newcombe, Hähnel, McQueston ⁵
1, 6–12, 15–17, 20–25	103(a)	Herbst ⁶
2–5, 18, 19	103(a)	Herbst, McQueston

In support of its arguments, Petitioner relies on a Declaration of Hassan Foroosh, Ph.D. (Exhibit 1003).

III. DISCUSSION

A. Claim Construction

In an *inter partes* review proceeding, we construe a claim of a patent “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” *See* 37 C.F.R. § 42.100(b). That standard involves construing claims in accordance with

² The Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112-29, 125 Stat. 284 (2011), amended 35 U.S.C. § 103, effective March 16, 2013.

Because the application from which the ’551 patent issued was filed before this date, the pre-AIA version of § 103 applies.

³ Newcombe et al., U.S. Patent No. 8,401,225 B2, issued Mar. 19, 2013 (Ex. 1005).

⁴ Dirk Hähnel et al., *Map Building with Mobile Robots in Dynamic Environments*, 2 IEEE INT’L CONF. ON ROBOTICS & AUTOMATION, at 1557–63 (2003) (Ex. 1007).

⁵ McQueston et al., U.S. Patent No. 9,245,374 B2, issued Jan. 26, 2016 (Ex. 1008).

⁶ Evan Herbst et al., *Toward Object Discovery and Modeling via 3-D Scene Comparison*, 3 IEEE INT’L CONF. ON ROBOTICS & AUTOMATION, at 2623–29 (2011) (Ex. 1006).

the ordinary and customary meaning of such claims as would have been understood by one of ordinary skill in the art and the prosecution history pertaining to the patent. *See id.*; *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–14 (Fed. Cir. 2005) (en banc).

Regarding the preambles of independent claims 1, 23, and 25, as well as the claim term “excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation,” Petitioner asserts that it “applies the claim construction previously adopted by the district court in the co-pending litigation.” Pet. 9–10. Petitioner asserts that “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.” *Id.* at 10 (citing Ex. 1011, 2 (district court claim construction order)). Petitioner also asserts that “the district court adopted Patent Owner’s preferred construction of [‘excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation’]: ‘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.* (citing Ex. 1011, 2).

Patent Owner does not respond other than to repeat Petitioner’s assertions regarding the district court’s claim constructions. Prelim. Resp. 9–10.

For purposes of this Decision, we conclude that no claim term requires express interpretation to resolve any controversy in this proceeding. *See Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

B. Obviousness over Newcombe and Hähnel

Petitioner asserts that claims 1, 6–12, 15–17, and 20–25 of the '551 patent would have been obvious over Newcombe and Hähnel. Pet. 22–47. Patent Owner challenges certain aspects of Petitioner's analysis. Prelim. Resp. 11–33. For the reasons explained below, we determine that Petitioner has not demonstrated a reasonable likelihood of prevailing on its asserted ground.

1. Overview of Asserted Prior Art

We start with an overview of the asserted prior art, Newcombe and Hähnel.

a. Newcombe

Newcombe describes moving object segmentation using depth images. Ex. 1005, 1:49–50. Segmentation refers to a process that differentiates certain objects in an image and labels the associated pixels accordingly. *See id.* at 1:27–30. To illustrate one embodiment of Newcombe's system, Figure 1 of Newcombe is reproduced below.

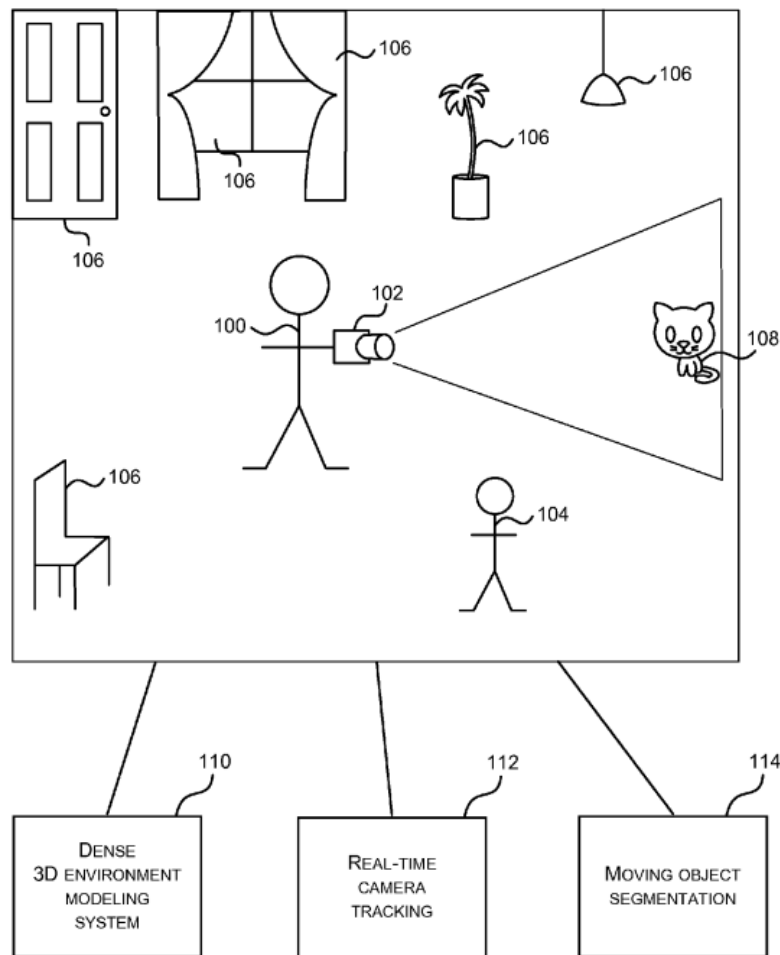


FIG. 1

Figure 1 shows person 100 in a room holding mobile depth camera 102, which is used to generate a 3D model or map of the room. Ex. 1005, 2:9–11, 2:46–47. The room includes objects 106, such as a chair, a door, a window, a plant, a light, another person 104, and cat 108, where many objects 106 are static and some objects like person 104 and cat 108 may move. *Id.* at 2:47–51. As person 100 moves around the room, camera 102 captures depth images of the room and objects. *Id.* at 2:51–53.

Real-time camera tracking system 112 monitors the location and orientation of camera 102 in the room. Ex. 1005, 2:54–55. Real-time

camera tracking system 112 provides input to moving-object segmentation system 114, which receives depth images captured by camera 102 and performs a segmentation operation to identify objects in the images that are moving or being manipulated. *Id.* at 3:1–6. For example, person 104 may move and therefore be segmented as a foreground object and differentiated from background objects like the door. *Id.* at 3:6–9. Person 104 may also manipulate (move) the chair such that the chair is therefore segmented as a foreground object. *Id.* at 3:9–13.

Real-time camera tracking system 112 also provides input to dense 3D environment modeling system 110, where images captured by camera 102 are used to generate a dense 3D model of the environment as the person moves about the room. Ex. 1005, 3:21–30. Moving-object segmentation system 114 provides input to dense 3D environment modeling system 110 as well so objects in the 3D model are segmented and labeled. *Id.* at 3:30–33.

In the process of segmenting a moving object from a depth image, a depth image of the scene to be segmented is received from camera 102. Ex. 1005, 6:38–40, 6:49–50. A previous depth image of at least a portion of the scene is then retrieved. *Id.* at 6:54–55. Thereafter, the current depth image and the previous depth image are compared using an iterative closest point (ICP) algorithm. *Id.* at 1:52–54. In particular, a set of source points (i.e., pixels) in the previous depth image is selected for analysis, and a destination point in the current depth image is selected for each source point. *Id.* at 7:51–56, 8:22–23. For each iteration, the ICP algorithm determines whether a set of source and destination points comprises corresponding points. *Id.* at 1:54–57, 6:21–26, 7:56–57.

As the ICP algorithm is determining corresponding points between the two depth images, it may detect points that diverge substantially between the images. Ex. 1005, 6:27–30. These outlying points are called outliers, and the image elements at these outlying points are labeled as belonging to the moving object. *Id.* at 1:57–62, 6:30. To illustrate, Figure 6 of Newcombe is reproduced below.

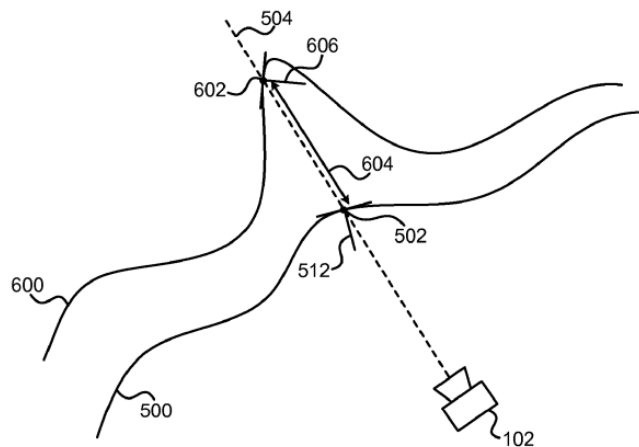


FIG. 6

Figure 6 of Newcombe shows the determination of an outlying point during execution of the ICP algorithm. *Id.* at 2:21–22. The ICP algorithm maps destination point 602 on current depth image 600 to source point 502 on previous depth image 500. *Id.* at 8:4–7. To do this, the ICP algorithm projects destination point 602 through camera projection 504 of source point 502 of previous depth image 500. *Id.* at 8:7–9. Camera projection 504 projects from the capture pose of previous depth image 500 through source

point 502, where the capture pose of previous depth image 500 is the location and orientation of the camera 102 when capturing previous depth image 500. *Id.* at 8:9–13.

The ICP algorithm then performs a first compatibility test on source point 502 and destination point 602 to determine whether they are corresponding points or outliers. Ex. 1005, 8:27–29. For the first compatibility test, Euclidean distance 604 is determined between source point 502 and destination point 602. *Id.* at 8:29–32. Euclidean distance 604 is compared to a predefined distance threshold. *Id.* at 8:32–33. In Figure 6 of Newcombe, Euclidean distance 604 is greater than the predefined distance threshold. *Id.* at 8:33–36, 8:42–48. That is, destination point 602 is too far away from source point 502, which means it belongs to a new or moving object, and is therefore labeled as an outlier. *Id.*

If Euclidean distance 604 were found to be within the predefined distance threshold, then a second compatibility test would be performed, where the angle between the surface normal at source point 502 and the surface normal at destination point 602 is compared to a predefined angle threshold. Ex. 1005, 8:49–9:6.

b. Hähnel

Hähnel describes generating maps with mobile robots in dynamic environments. Ex. 1007, 1 (abstract). Hähnel uses an algorithm to isolate the dynamic objects and generate a three-dimensional representation of them. *Id.* The algorithm can additionally filter dynamic objects, so that the resulting model only contains textures showing static objects. *Id.* at 6, § 4.4; *see also id.*, Fig. 11.

2. Analysis

Turning to the claims, we address independent claims 1, 23, and 25 together. Claims 1 and 25 are directed to 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.”

Claim 23 is directed to 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.” Claims 23 and 25 recite similar limitations as claim 1. Petitioner relies primarily on its discussion of claim 1 for claims 23 and 25. Pet. 32–33. Accordingly, we focus on the language of claim 1 in particular. Our analysis of claim 1 applies to claims 23 and 25.

Claim 1 recites various limitations, including the step of determining a first excluded volume and the step of determining a second excluded volume. We address these two limitations in turn.

a. Limitation 1c: determining a first excluded volume

Claim 1 recites “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.” For this limitation, which Petitioner designates as limitation 1c, Petitioner identifies Newcombe’s previous depth image 500 as a “first 3D representation” and Newcombe’s current depth image 600 as a “second 3D representation.” Pet. 24, 26–27. Petitioner asserts 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,” and, more

specifically, “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.” *Id.* at 24–25 (citing Ex. 1003 ¶ 112). As an example, Petitioner asserts that “the empty space shown in Figure 1 [of Newcombe] between camera 102 and the stationary objects in the room would constitute an excluded volume for the first 3D presentation.” *Id.* at 25.

Petitioner further points to “[Newcombe’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.” Pet. 26 (citing Ex. 1005, 8:27–29). Petitioner asserts that “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.” *Id.* As support, Petitioner directs us to Newcombe’s teaching that “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 26–27 (quoting Ex. 1005, 8:42–48). According to Petitioner, “a [person of ordinary skill in the art] 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.” *Id.* at 28.

Patent Owner responds that “Petitioner offers no explanation as to how Newcombe discloses or suggests ‘determining’ . . . excluded volumes as a part of a method for detecting a movable object as is required by [c]laim 1.” Prelim. Resp. 13–14. As support, Patent Owner asserts that “Newcombe is merely concerned with measuring the *distance* between points—not determining an excluded *volume* as claimed.” *Id.* at 18. In particular, Patent Owner asserts that “Newcombe’s technique identifies dynamic objects by measuring the distance between two points (a source point and a destination point) on two surfaces to determine if the distance is within a predefined distance threshold.” *Id.* at 21. Patent Owner further asserts that Petitioner “attempts to determine an excluded volume in Newcombe’s disclosure by pointing out the existence of an ‘empty space’ in Figure 1,” but that Petitioner “does not explain how Newcombe’s technique involves determining the excluded volume of such empty space based on the threshold distance.” *Id.* at 14, 20. Patent Owner adds that “Petitioner asserts that Newcombe’s compatibility test ‘*can* be used to determine an excluded volume’ . . . but fails to provide any reason why a person *would* have modified Newcombe to determine the excluded volume.” *Id.* at 20.

We agree with Patent Owner. Claim 1 requires “determining . . . a first excluded volume in space where no surface can be present in both the first 3D representation and the second 3D representation.” Petitioner contends that Newcombe’s “first compatibility test can be used to determine an excluded volume,” where “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.” Pet. 26. According to Petitioner, “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.” *Id.* at 28. Without more, Petitioner does not sufficiently explain how defining a threshold distance teaches determining a first excluded volume in space where no surface can be present in both the previous and current depth images.

Nor is it clear from the record how defining a threshold distance in Newcombe teaches determining a first excluded volume in space where no surface can be present in both the previous and current depth images. Regarding Figure 6 of Newcombe, for instance, “only a single destination point is selected for each source point.” Ex. 1005, 8:22–23. According to Newcombe, if *that* single destination point is in space beyond the distance threshold, then it will be labeled as belonging to a moving object. *See id.* at 1:57–61, 8:42–48. Contrary to Petitioner’s position, Newcombe does not say that *any* point in space beyond the distance threshold will be labeled as belonging to a moving object. *See* Pet. 28.

Indeed, labeling every point in space beyond the distance threshold as belonging to a moving object would be inconsistent with Newcombe’s teachings. To illustrate, we provide an annotated version of Figure 1 of Newcombe, reproduced below.

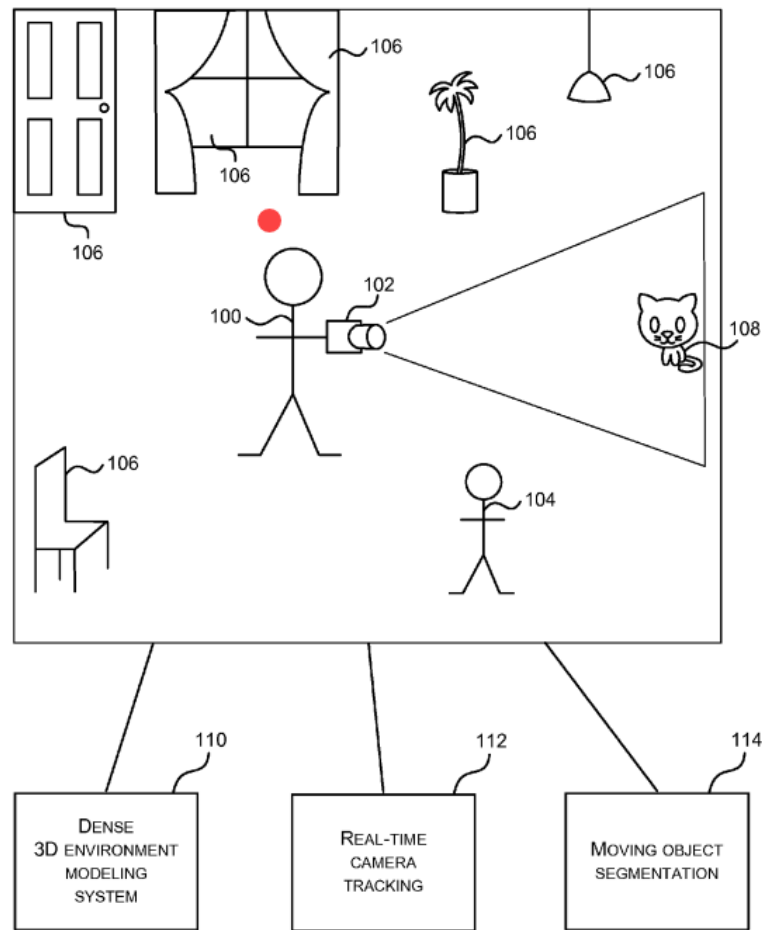


FIG. 1

Figure 1 of Newcombe, as annotated, shows person 100 holding mobile depth camera 102 in a room that contains various objects 106 such as a chair, a door, a window, a plant, a light, another person 104, and a cat 108. *See Ex. 1005, 2:46–49.* As discussed above, Petitioner asserts that “the empty space shown in Figure 1 between camera 102 and the stationary objects in the room would constitute an excluded volume for the first 3D presentation.” Pet. 25. Thus, we consider a hypothetical example where Newcombe’s ICP algorithm determines that a destination point (shown in red) in space between camera 102 and the window belongs to a moving

object. Under Petitioner’s reasoning, “any point” in space beyond the destination point (shown in red) would also be labeled as a moving object. *See* Pet. 28 (“[B]y 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.”). That means points belonging to the window would be labeled as belonging to a moving object. As described in Newcombe, however, the window is not a moving object. *See* Ex. 1005, 2:47–51 (“Many of the objects 106 are static although some of the objects such as the person 104 and cat 108 may move.”); *id.* at 3:6–9 (“[T]he person 104 or cat 108 can move, and hence are segmented as foreground moving objects and differentiated from background objects such as the door and window.”).

Moreover, claim 1 requires a first excluded volume in *space where no surface can be present* in both the first and second 3D representations. Under Petitioner’s reasoning, however, the window is in space that Petitioner identifies as a first excluded volume because points belonging to the window are in space beyond the destination point (shown in red). *See* Pet. 28 (“[B]y 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.”). Space where the window is present does not satisfy “space where no surface can be present.”

In view of the foregoing, we are not persuaded that Petitioner has sufficiently shown for purposes of this Decision that Newcombe teaches the recited step of determining a first excluded volume.

b. Limitation 1d: determining a second excluded volume

Claim 1 further recites “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.” For this limitation, which Petitioner designates as limitation 1d, Petitioner cross-references its discussion of limitation 1c and relies on similar arguments presented for limitation 1c. Pet. 28–30. For example, Petitioner asserts that “Newcombe’s disclosure of the space between the camera and the stationary objects in the background of a location . . . as teaching an excluded volume necessarily applies equally to both a first depth image and a second depth image.” *Id.* at 29. Based on this reasoning, Petitioner further asserts that “the empty space 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.” *Id.*

Petitioner additionally asserts that “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.” Pet. 29–30 (citing Ex. 1005, 8:3–48, Fig. 6).

Patent Owner makes the same arguments discussed above with respect to limitation 1c. Prelim. Resp. 11–23 (“Newcombe and Hähnel do not disclose or suggest determining an excluded volume (Elements 1c and 1d).” (emphasis omitted)).

On this record, and for the reasons given above for limitation 1c, we are not persuaded that Petitioner has sufficiently shown for purposes of this Decision that Newcombe teaches determining a second excluded volume. *See supra* Part III.B.2.a. In particular, we find that Petitioner does not sufficiently explain how defining a threshold distance in Newcombe teaches determining a second excluded volume in space where no surface can be present in both the previous and current depth images. *Id.*

3. *Summary*

In view of the foregoing, we determine that Petitioner has not demonstrated a reasonable likelihood of showing that independent claims 1, 23, and 25 would have been obvious over Newcombe and Hähnel. Claims 6–12, 15–17, 20–22, and 24 depend from claims 1 or 23. Petitioner’s contentions regarding these dependent claims rely on the same analysis for the limitations of claim 1 discussed above. *See* Pet. 35–47. Accordingly, we also determine that Petitioner has not demonstrated a reasonable likelihood of showing that dependent claims 6–12, 15–17, 20–22, and 24 would have been obvious over Newcombe and Hähnel.

C. *Obviousness over Herbst*

Petitioner asserts that claims 1, 6–12, 15–17, and 20–25 of the ’551 patent would have been obvious over Herbst. Pet. 48–72. Patent Owner challenges certain aspects of Petitioner’s analysis. Prelim. Resp. 35–44. For the reasons explained below, we determine that Petitioner has not demonstrated a reasonable likelihood of prevailing on its asserted ground.

Before addressing the parties' arguments, we provide an overview of the asserted prior art, Herbst.

1. Overview of Herbst

Herbst is a paper that proposes a system for discovering and modeling objects via 3D scene comparison. Ex. 1006, 1 (title).

Herbst describes using “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, 1. The RGB-D camera provides inputs to Herbst's system. *Id.* at 2. Herbst teaches in particular that “inputs to [its] system are two or more RGB-D videos representing separate visits to the same location,” where “[o]bjects can move between visits.” *Id.* Herbst further describes using an “algorithm [that] aligns the frames of each RGB-D video . . . , then reconstructs each scene as a dense set of surface elements.” *Id.* at 1. To illustrate, Figure 1 of Herbst is reproduced below.

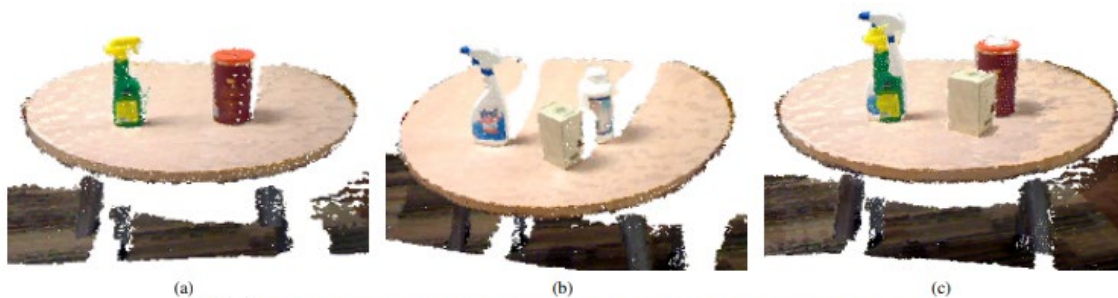


Fig. 1: (a), (b) reconstruction of two scenes; (c) their superimposition after alignment.

Figure 1 shows two reconstructions of a location as well as the superimposition of the two aligned scenes. *Id.* at 2. In Herbst, “[e]ach frame consists of 250,000 colored 3-D points,” where “each 3-D point from each frame is assigned to a surfel.” *Id.* Herbst explains that its system “convert[s] points to *surfels* . . . to reduce map size and smooth evidence

from multiple frames.” *Id.* Herbst also teaches “probabilistically model[ing] the position, color and orientation of each surfel.” *Id.* at 2.

Herbst further describes using a “measurement model for RGB-D cameras” that “tells . . . how likely each surface element is to have moved between two scenes.” Ex. 1006, 1–2 (capitalization omitted). Herbst “employ[s] the model to detect differences between scenes,” and also “spatially regularize[s] to find large surface regions that may belong to movable objects.” *Id.* at 1. Specifically, Herbst “consider[s] a single surface patch in the first scene.” *Id.* at 4. Herbst explains that the surface patch is described by its location, color, and surface orientation, and that Herbst’s “alignment technique . . . can determine all camera poses of the second scene relative to the [surface patch].” *Id.* Herbst uses the camera poses and the surface patch descriptors to determine the probability that the surface patch moved away from its location in the first scene. *Id.* In Herbst, “[t]he changed objects are detected as high-probability areas, using the combination of depth, color, and orientation cues.” *Id.* at 5. Herbst notes that its “color and orientation models take the expected color and orientation into account, but also model dependence on the expected vs. measured distance of the surface patch,” which “generates the correct probabilities.” *Id.*

In order to evaluate the system’s ability to discover and model objects, experiments were performed in a tabletop setting. Ex. 1006, 5. To illustrate the results of one experiment, Figure 5 of Herbst is reproduced below.

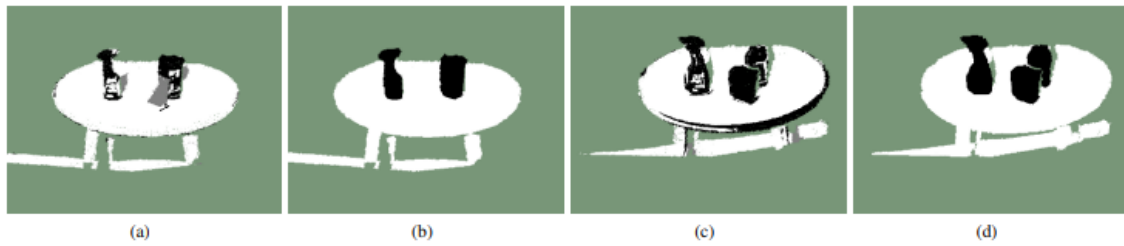


Fig. 5: (a) surfel-wise differencing and (b) regularization results for the first scene of Fig. 1; (c), (d) similarly for the second scene.

Figure 5 shows results for the scene pair of Figure 1. *Id.* Each scene includes “a spray bottle and a cylindrical object in about the same location, such that simple nearest-neighbor point search would consider them the same objects.” *Id.* Using color and orientation information, changed surfaces were detected at these locations in both scenes. *Id.* Herbst notes that “[o]ne of the objects is also occluded, necessitating the use of [a] depth-dependent color model.” *Id.* According to Herbst, all movable objects were found. *Id.*

To illustrate results of another experiment, Figure 6 of Herbst is reproduced below.

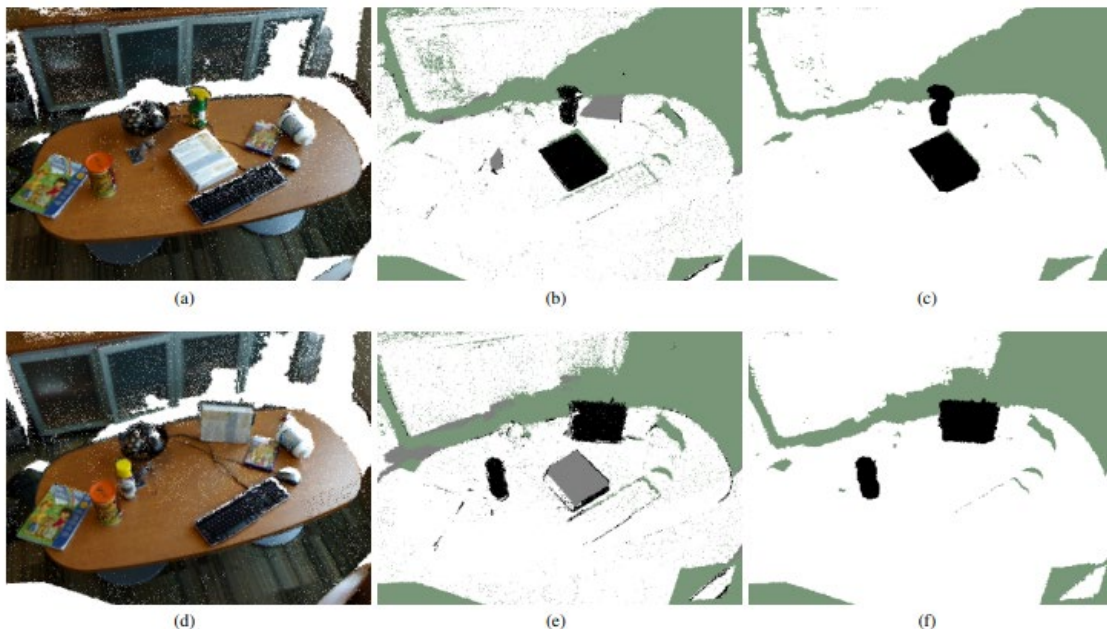


Fig. 6: (a), (d) two scenes from the tvtable dataset; (b), (e) surfel-wise differencing results for the two scenes; (c), (f) regularization results. A few surfels shown in the surfelwise result do not appear in the final output due to culling we perform prior to regularization. Three large occluded areas in (b) and (e) show as medium gray (movedness uncertain).

Figure 6 shows results for a different scene pair, where small objects were moved around on a cluttered table. Ex. 1006, 5.

For both experiments, the movable objects were extracted as a 3D model. Ex. 1006, 5. To illustrate, Figure 7 of Herbst is reproduced below.



Fig. 7: Objects extracted from the scene pairs of Fig. 1 and Fig. 6, and the merged background components of each pair of scenes. In the right panel some of the background is faded for clarity.

The left and right panels of Figure 7 show the extracted foreground components along with the merged background components of the scenes shown in Figures 1 and 6, respectively. *Id.*

Herbst states that its system allows for the determination of movable parts of a scene based on differencing with another scene. Ex. 1006, 7.

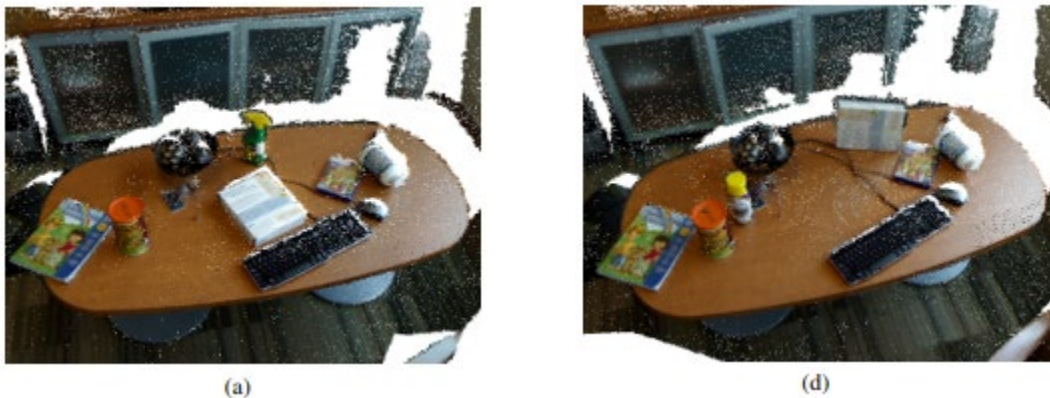
2. Analysis

Turning now to the claims, we address independent claims 1, 23, and 25 together. As discussed above, claims 23 and 25 recite similar limitations as claim 1. Petitioner relies primarily on its discussion of claim 1 for claims 23 and 25. Pet. 69–72. Accordingly, we focus on the language of claim 1. Our analysis of claim 1 applies to claims 23 and 25.

As with our analysis regarding obviousness over Newcombe and Hähnel, we address the recited step of determining a first excluded volume as well as the recited step of determining a second excluded volume.

a. Limitation 1c: determining a first excluded volume

Claim 1 recites “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.” For this limitation, Petitioner directs us to where Herbst teaches that “[t]he inputs to [its] system are two or more RGB-D videos representing separate visits to the same location.” Pet. 50 (quoting Ex. 1006, 2). Petitioner identifies Herbst’s tabletop scene in Figure 6(a) as a “first 3D representation” and Herbst’s tabletop scene in Figure 6(d) as a “second 3D representation.” *Id.* at 49–51. Petitioner also asserts that “the empty space shown in Figure 6(a) . . . [,] 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.* at 52. To illustrate, Figures 6(a) and 6(d) of Herbst are reproduced below.



Figures 6(a) and 6(d) show two scenes from a tabletop setting. Ex. 1006, 5–6.

Relying on the declaration testimony of Dr. Foroosh, Petitioner additionally asserts that “Herbst teaches the determination of an excluded volume using the probabilistic model,” which “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.” Pet. 51–52 (citing Ex. 1003 ¶¶ 262–266). Petitioner further points to where Herbst teaches that “[f]ollowing global registration, we convert points to surfels . . . to reduce map size and smooth evidence from multiple frames,” where “[e]ach 3-D point from each frame is assigned to a surfel.” *Id.* at 52 (quoting Ex. 1006, 2). In his declaration, Dr. Foroosh opines that an ordinarily skilled artisan “would understand that Herbst’s disclosure of the reduction of the size of the map (i.e. 3D representation) of the scanning visit, by assigning surfels to 3D points detected in frames of that scanning visit, is teaching that the empty space determined accordingly 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.” Ex. 1003 ¶ 264. Dr. Foroosh adds that an ordinarily skilled artisan “would further understand that the empty space for each scanning visit would constitute an excluded volume for the 3D representation of that scanning visit,” and “would therefore understand Herbst to teach that its probabilistic model is used to determine not only the location of surfaces but also the empty space in a location.” *Id.* ¶¶ 264–265.

Patent Owner responds that “Petitioner offers no explanation as to how Herbst discloses ‘determining’ . . . excluded volumes as a part of a method for detecting a movable object as is required by [c]laim 1.” Prelim. Resp. 37–38. As support, Patent Owner asserts that “Herbst seeks to determine the probability that a surfel has moved by determining ‘the difference between its measured depth and its expected depth value,’ as Dr. Foroosh recognizes.” *Id.* at 41 (quoting Ex. 1003 ¶ 270). Patent Owner further asserts that Petitioner “attempts to determine an excluded volume in

Herbst's disclosure by pointing out the existence of an 'empty space,'" but that Petitioner "does not explain how Herbst's technique involves determining the excluded volume of such empty space based on differences in depth as purportedly disclosed by Herbst." *Id.* at 38, 41.

We agree with Patent Owner. Neither Petitioner nor Dr. Foroosh sufficiently explains how Herbst's probabilistic model teaches "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," as recited in claim 1. For example, Petitioner merely asserts that "Herbst teaches the determination of an excluded volume using the probabilistic model disclosed." Pet. 51. Petitioner says nothing else about *determining* a first excluded volume. *See id.* at 51–53.

Dr. Foroosh opines that "Herbst's disclosure of the reduction of the size of the map (i.e. 3D representation) of the scanning visit, by assigning surfels to 3D points detected in frames of that scanning visit, is teaching that the empty space determined accordingly 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." Ex. 1003 ¶ 264. It is unclear how reducing the size of a map (3D representation) satisfies determining a first excluded volume in space. Dr. Foroosh says that "empty space [is] determined accordingly," but does not sufficiently explain any relationship between reducing the size of a map and determining a volume in space. *See id.* Although Dr. Foroosh points out that Herbst teaches reducing the size of the map by assigning surfels to 3D points, it is unclear how assigning surfels to 3D points satisfies determining a first excluded volume

in space. Dr. Foroosh does not sufficiently explain any relationship between assigning surfels to 3D points and determining a volume in space.

Even if we were to assume that empty space is determined by assigning surfels to 3D points, however, Dr. Foroosh testifies that the empty space “is excluded from the 3D surfel representation.” *See* Ex. 1003 ¶ 264. Claim 1 requires determining *for the first 3D representation* a first excluded volume where no surface can be present. It is unclear how determining empty space that is *excluded from the 3D surfel representation* satisfies determining a first excluded volume *for the first 3D representation*. Moreover, Dr. Foroosh’s testimony in this regard is inconsistent with Petitioner’s contention that “the empty space *shown* in Figure 6(a) . . . would constitute an excluded volume for the first 3D representation.” *See* Pet. 52 (emphasis added). Petitioner says that the empty space is *shown* in a representation, whereas Dr. Foroosh says that the empty space is *excluded* from the representation.

Regarding still Petitioner’s contention that “the empty space shown in Figure 6(a) . . . would constitute an excluded volume for the first 3D representation,” we note Herbst’s teaching that it “do[es] not show foreground components that are very small, of which there are . . . three in Fig. 6.” Ex. 1006, 5. It appears that the empty space shown in Figure 6(a) therefore includes space where a surface belonging to a very small foreground object *can* be present. Petitioner does not address this teaching in Herbst. *See* Pet. 51–53 (discussing limitation 1c). Accordingly, it is unclear how the empty space shown in Figure 6(a) where a very small object can be present satisfies a first excluded volume in *space where no surface can be present*.

In view of the foregoing, Petitioner has not sufficiently shown for purposes of this Decision that Herbst teaches the recited step of determining a first excluded volume.

b. Limitation 1d: determining a second excluded volume

Claim 1 further recites “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.” For this limitation, Petitioner cross-references its discussion of limitation 1c and relies on similar arguments presented for limitation 1c. Pet. 53–54. For example, Petitioner asserts that “Herbst’s teaching of a probabilistic model and excluded volume . . . necessarily applies equally to both the probabilistic model’s application to a first 3D representation and to a second 3D representation.” *Id.* at 53. Based on this reasoning, Petitioner further asserts that “the empty space shown in the figure [6(d) of Herbst] – 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.” *Id.*

Patent Owner makes the same arguments discussed above with respect to limitation 1c. Prelim. Resp. 35–42 (“Herbst does not disclose or suggest determining an excluded volume (Elements 1c and 1d).” (emphasis omitted)).

On this record, and for the reasons given above for limitation 1c, we are not persuaded that Petitioner has sufficiently shown for purposes of this Decision that Herbst teaches determining a second excluded volume. *See supra* Part III.C.2.a. In particular, we find that Petitioner does not

sufficiently explain how reducing the size of a map or assigning surfels to 3D points in Herbst teaches determining for the second 3D representation a second excluded volume in space where no surface can be present in both the first and second 3D representations shown in Figures 6(a) and 6(d) of Herbst. *Id.*

3. Summary

In view of the foregoing, we determine that Petitioner has not demonstrated a reasonable likelihood of showing that independent claims 1, 23, and 25 would have been obvious over Herbst. Claims 6–12, 15–17, 20–22, and 24 depend from claims 1 or 23. Petitioner’s contentions regarding these dependent claims rely on the same analysis for the limitations of claim 1 discussed above. *See* Pet. 58–72. Accordingly, we also determine that Petitioner has not demonstrated a reasonable likelihood of showing that dependent claims 6–12, 15–17, 20–22, and 24 would have been obvious over Herbst.

D. Remaining Grounds

Petitioner asserts two additional grounds. In particular, Petitioner asserts that claims 2–5, 18, and 19 would have been obvious over Newcombe, Hähnel, and McQueston. Pet. 47–48. Petitioner also asserts that claims 2–5, 18, and 19 would have been obvious over Herbst and McQueston. *Id.* at 72–73. Claims 2–5, 18, and 19 depend from claim 1. Petitioner’s contentions regarding these dependent claims rely on the same analysis for the limitations of claim 1 discussed above. *See* Pet. 47–48, 72–73. Accordingly, for the reasons given above, we determine that Petitioner

has not demonstrated a reasonable likelihood of showing that dependent claims 2–5, 18, and 19 would have been obvious over Newcombe, Hähnel, and McQueston, or that dependent claims 2–5, 18, and 19 would have been obvious over Herbst and McQueston. *See supra* Part III.B.2; Part III.C.2.

IV. CONCLUSION

For the foregoing reasons, Petitioner has not demonstrated on the record before us a reasonable likelihood that it would prevail in showing the unpatentability of any of the challenged claims of the '551 patent.⁷

V. ORDER

For the reasons given, it is

ORDERED that the Petition is *denied* and no trial is instituted.

⁷ Because we deny the Petition on the merits, we do not reach Patent Owner's request that we exercise our discretion to deny the Petition under 35 U.S.C. § 314(a) or 35 U.S.C. § 325(d). *See* Prelim. Resp. 46–51.

IPR2023-01313
Patent 9,629,551 B2

PETITIONER:

Douglas F. Stewart
Jeffrey E. Danley
Jared D. Schuettenhelm
Patrick Connolly
BRACEWELL LLP
doug.stewart@bracewell.com
jeff.danley@bracewell.com
jared.schuettenhelm@bracewell.com
patrick.connolly@bracewell.com

PATENT OWNER:

Todd R. Walters
Roger H. Lee
Mythili Markowski
Andrew R. Cheslock
BUCHANAN INGERSOLL & ROONEY PC
todd.walters@bipc.com
roger.lee@bipc.com
mythili.markowski@bipc.com
andrew.cheslock@bipc.com