

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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HTC CORPORATION, HTC AMERICA, INC., and  
VALVE CORPORATION,  
Petitioner,

v.

ELECTRONIC SCRIPTING PRODUCTS, INC.,  
Patent Owner.

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Case IPR2018-01032<sup>1</sup>  
Patent 8,553,935 B2

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Before ANDREI IANCU, *Director of the United States Patent and Trademark Office*, WILLIAM M. FINK, *Vice Chief Administrative Patent Judge*, and ROBERT J. WEINSCHENK, *Administrative Patent Judge*.

FINK, *Vice Chief Administrative Patent Judge*.

FINAL WRITTEN DECISION  
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

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<sup>1</sup> Valve Corporation filed a Petition in IPR2019-00074, and has been joined as a party to this proceeding.

## I. INTRODUCTION

HTC Corporation and HTC America, Inc. filed a Petition pursuant to 35 U.S.C. §§ 311–319 requesting an *inter partes* review of claims 1–21 of U.S. Patent No. 8,553,935 B2 (“the ’935 patent”). Paper 2 (“Pet.”). Electronic Scripting Products, Inc. (“Patent Owner”) filed a Preliminary Response. Paper 5 (“Prelim. Resp.”).

On September 13, 2018, we instituted trial. Paper 6 (“Inst. Dec.”). After institution, Patent Owner filed a Response. Paper 8 (“PO Resp.”).

On January 18, 2019, we granted Valve Corporation’s Motion for Joinder in *Valve Corp. v. Electronic Scripting Products*, Case IPR2019-00074 (PTAB filed Oct. 11, 2018). Paper 12, 10. In doing so, we joined Valve Corporation to this proceeding, resulting in HTC Corporation, HTC America, Inc., and Valve Corporation (collectively “Petitioner”) challenging the claims of the ’935 patent. *Id.*

Petitioner filed a Reply to Patent Owner’s Response. Paper 14 (“Reply”). Patent Owner filed a Sur-Reply. Paper 16 (“Sur-Reply”).

An oral hearing was held on June 4, 2019. A transcript of the hearing has been entered into the record. Paper 23 (“Tr.”).

This Final Written Decision (“Decision”) is issued pursuant to 35 U.S.C. § 318(a). For the reasons that follow, we conclude Petitioner has demonstrated, by a preponderance of the evidence, that claims 1–21 of the ’935 patent are unpatentable.

### A. Related Proceedings

The parties inform us that the ’935 patent and a related patent, U.S. Patent No. 9,235,934 B2 (Ex. 1002), are the subject of a patent infringement lawsuit in the U.S. District Court for the Northern District of California:

*Electronic Scripting Products, Inc. v. HTC America, Inc.*, No. 3:17-cv-05806-RS (N.D. Cal. filed Oct. 9, 2017). Pet. 1–2; Paper 4, 2; *see also* *Valve*, Case IPR2019-00074 (Paper 1, 1–2; Paper 6, 2). With respect to the '934 patent, we denied petitions for institution of *inter partes* review.

*B. The '935 Patent (Ex. 1001)*

The '935 patent relates to determining an absolute pose of a manipulated object in a real three-dimensional environment, particularly of a manipulated object used by humans to interface with the digital world. Ex. 1001, 1:24–28. An object's pose combines the three linear displacement coordinates (x, y, z) of any reference point on the object and the three orientation angles, also called the Euler angles ( $\phi$ ,  $\theta$ ,  $\psi$ ), that describe the object's pitch, yaw, and roll. *Id.* at 1:46–50.

According to the '935 patent, one-to-one motion mapping between space and cyberspace is not possible without the ability to digitize the absolute pose of a manipulated object with respect to a well-defined reference location in real space. Ex. 1001, 2:49–52. The disclosed invention optically infers the absolute pose of the manipulated object by relating Euler-rotated object coordinates describing the orientation of the object to world coordinates ( $X_o$ ,  $Y_o$ ,  $Z_o$ ). *Id.* at 11:43–47. More specifically, knowledge of the absolute positions of invariant features or beacons in world coordinates ( $X_o$ ,  $Y_o$ ,  $Z_o$ ) allows an optical measuring arrangement to describe the absolute pose of the object with absolute pose data expressed in parameters (x, y, z,  $\phi$ ,  $\theta$ ,  $\psi$ ) in Euler-rotated object coordinates within world coordinates ( $X_o$ ,  $Y_o$ ,  $Z_o$ ). *Id.* at 11:65–12:4.

Figure 21 of the '935 patent is reproduced below:

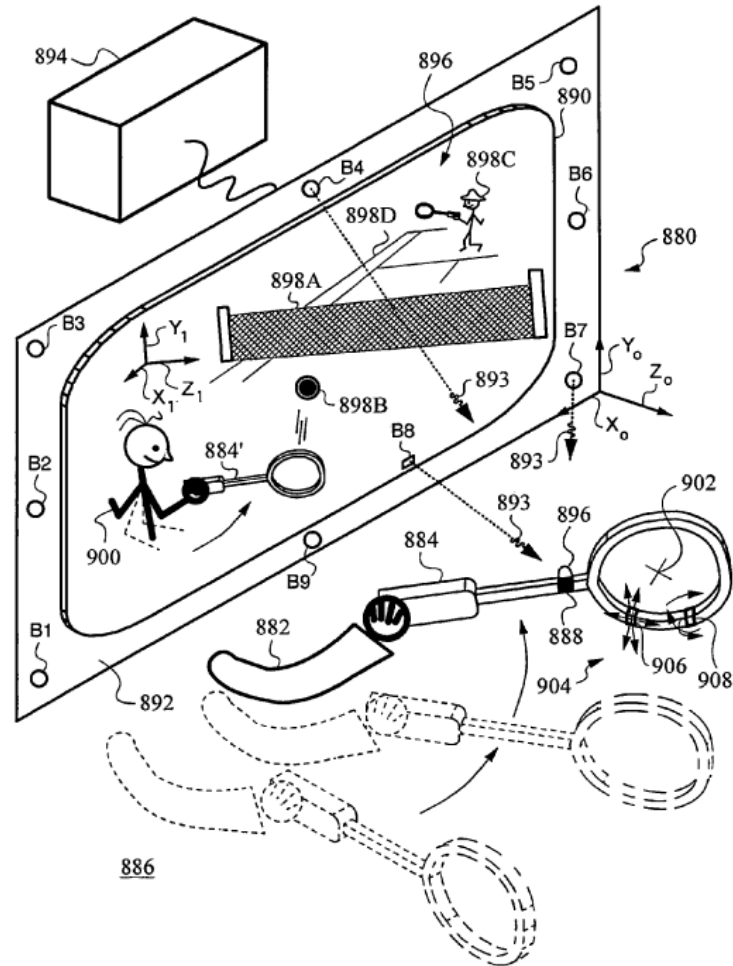


**FIG. 21**

Figure 21 illustrates a “cyber game” in which user or player 882 interacts with game application 880 by moving manipulated object 884, in this case a tennis racket, in real three-dimensional environment 886. Ex. 1001, 37:9–13. Visual tennis match elements 898A–D and image 884’ of tennis racket 884 held by user 882 are displayed on screen 890. *Id.* at 37:29–44. The display of image 884’ changes in response to the detected absolute pose of racket 884. *Id.* at 38:12–20.

The absolute pose of racket 884 is determined using on-board optical measuring arrangement 888 and auxiliary motion detection component 904.

Ex. 1001, 37:14–16, 37:65–66, 38:12–14. Optical measurement arrangement 888 infers absolute pose data ( $x, y, z, \phi, \theta, \psi$ ) of racket 884 by sensing light 893 emitted from beacons B1–B9 disposed on and around screen 890. *Id.* at 37:14–21, 37:61–64. Auxiliary motion detection component 904 is an inertial sensing device that includes three-axis gyroscope 908 for providing information about changes in orientation ( $\phi, \theta, \psi$ ) and three-axis accelerometer 906 for providing information about linear displacement ( $x, y, z$ ). *Id.* at 37:65–38:11.

The combination of absolute pose data ( $x, y, z, \phi, \theta, \psi$ ) and relative motion data is used by tennis game 880 as input for interacting with output 896. *Id.* at 38:12–14. Such absolute pose data and relative motion data can be combined using any suitable combination or data fusion techniques well-known in the art. *Id.* at 35:24–34; 44:51–55.

### *C. Illustrative Claim*

Of the challenged claims, claims 1 and 12 are independent. Claim 1 is illustrative of the claims at issue and is reproduced below:

1. A method for use with a system having a manipulated object, the method comprising:
  - a) accepting light data indicative of light detected by a photodetector mounted on-board said manipulated object from a first plurality of predetermined light sources having known locations in world coordinates;
  - b) accepting relative motion data from a relative motion sensor mounted on-board said manipulated object indicative of a change in an orientation of said manipulated object; and
  - c) determining the pose of said manipulated object based on said light data and said relative motion data, wherein

said pose is determined with respect to said world coordinates.

Ex. 1001, 51:13–26.

*D. Evidence of Record*

Petitioner relies on the following references and declaration (*see* Pet. 3):

| Reference or Declaration                                                                                                                                    | Exhibit No. |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Greg Welch, et al., <i>High-Performance Wide-Area Optical Tracking</i> , PRESENCE: TELEOPERATORS AND VIRTUAL ENVIRONMENTS, Feb. 2001, at 1 (“Welch-HiBall”) | Ex. 1004    |
| Greg Welch, et al., <i>Tracking: Beyond 15 Minutes of Thought</i> , SIGGRAPH 2001 Conference (Aug. 12, 2001) (“SIGGRAPH 2001”)                              | Ex. 1005    |
| Romanik, US 5,884,239, issued March 16, 1999.                                                                                                               | Ex. 1006    |

Petitioner relies on the declaration of Dr. Gregory Welch (Ex. 1003, “Welch Decl.”). Patent Owner relies on the declaration of Dr. Hector H. Gonzalez-Banos (Ex. 2001, “Gonzalez-Banos Decl.”).

*E. Asserted Grounds of Unpatentability*

Petitioner asserts that the challenged claims are unpatentable on the following grounds (*see* Pet. 23, 53):

| Claims Challenged  | Basis    | References                               |
|--------------------|----------|------------------------------------------|
| 1–6, 11–18, and 21 | § 103(a) | Welch-HiBall and SIGGRAPH 2001           |
| 7–11 and 19–21     | § 103(a) | Welch-HiBall, SIGGRAPH 2001, and Romanik |

II. ANALYSIS

*A. Level of Ordinary Skill in the Art*

Petitioner argues a person of ordinary skill in the art at the time of the invention would have had “at least a Master of Science or equivalent degree in electrical engineering or computer science, or alternatively a Bachelor of

Science or equivalent degree in electrical engineering or computer science, with approximately two years of experience in a field relating to image processing, robotics, virtual worlds, or sensor integration.” Pet. 13–14 (citing Welch Decl. ¶¶ 26–30). Petitioner further argues “[t]his definition is approximate and more experience may substitute for education or vice versa.” *Id.* at 14 (citing Welch Decl. ¶ 29).

Patent Owner does not provide its own explanation of the level of ordinary skill in the art. Patent Owner also does not oppose Petitioner’s proffered level of ordinary skill in the art. Upon consideration of the record, including the level of skill reflected by the cited references, Welch-HiBall and SIGGRAPH 2001, we agree with and therefore adopt Petitioner’s proposed definition for the level of ordinary skill in the art.

### *B. Claim Construction*

In an *inter partes* review filed prior to November 13, 2018, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b) (2017).<sup>2</sup> Under the broadest reasonable construction standard, claim terms are presumed to have their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *In re Translogic Tech., Inc.*, 504

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<sup>2</sup> The Petition in this proceeding was filed on May 10, 2018, prior to the effective date of the rule change that replaces the broadest reasonable interpretation standard with the federal court claim interpretation standard. *See Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board*, 83 Fed. Reg. 51340 (Oct. 11, 2018) (codified at 37 C.F.R. § 42.100(b) (2019)) (amending 37 C.F.R. § 42.100(b) effective Nov. 13, 2018).

F.3d 1249, 1257 (Fed. Cir. 2007). However, only terms that are in controversy need to be construed, and only to the extent necessary to resolve the controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

Petitioner proposes construction of the following claim terms: “photodetector,” “relative motion sensor,” “world coordinates,” and “a processor for determining the pose of said manipulated object based on said light data and said relative motion data.” Pet. 14–17. Patent Owner does not propose any separate claim construction or refute Petitioner’s constructions.

For purposes of institution, we determined it was unnecessary to construe any of these claim terms expressly to address the parties’ arguments. Inst. Dec. 6. Similarly, in view of the complete record, we find that it is unnecessary to provide a separate explicit claim construction to resolve the issues before us. Instead, to the extent the parties’ arguments are based on the scope of the claims, we resolve the disputed claim scope in the context of the parties’ arguments as set forth below.

### *C. Prior Art Status of the References*

Despite some disagreement regarding the priority date of the challenged claims (*see* Pet. 12–13; PO Resp. 24–25), neither party disputes that the references relied on by Petitioner in its patentability challenges qualify as prior art under 35 U.S.C. § 102(b) against even the earliest possible priority date of the claims of the ’935 patent.

Petitioner contends Welch-HiBall was published in the peer-reviewed journal “PRESENCE: TELEOPERATORS AND VIRTUAL ENVIRONMENTS” in February 2001, and, therefore, is prior art under 35 U.S.C. § 102(b).

Pet. 18–19. Petitioner provides evidence in support of Welch-HiBall’s public availability. *See id.* (citing Exs. 1019–1024; Welch Decl. ¶ 120). Patent Owner does not dispute these contentions. We agree that Welch-HiBall is prior art under 35 U.S.C. § 102(b).

Petitioner contends SIGGRAPH 2001 is a set of printed, bound course materials distributed to attendees of a course taught by Dr. Welch and colleagues on August 12, 2001, at a widely attended conference (called “SIGGRAPH”), and, therefore, is prior art under 35 U.S.C. § 102(b).

Pet. 19–21. Petitioner provides evidence in support of SIGGRAPH 2001’s availability, including Dr. Welch’s testimony regarding the distribution of the course materials at the conference. *See id.* (citing Exs. 1025–1029, 1036; Welch Decl. ¶¶ 104–108). Patent Owner does not dispute these contentions. In view of the evidence demonstrating the public availability of SIGGRAPH 2001, Petitioner has demonstrated persuasively that SIGGRAPH 2001 is prior art under 35 U.S.C. § 102(b).

*D. Obviousness of Claims 1–6, 11–18, and 21 over Welch-HiBall and SIGGRAPH 2001*

Petitioner contends the subject matter of claims 1–6, 11–18, and 21 would have been obvious over Welch-HiBall and SIGGRAPH 2001.

Pet. 23–52; Reply 1–17, 21–25. Petitioner relies on the declaration of Dr. Welch for support. *See* Welch Decl. ¶¶ 120–196. Patent Owner disputes Petitioner’s contentions, and relies on the declaration of Dr. Gonzalez-Banos for support. PO Resp. 4–24, 27–30; Sur-Reply 10–27; Gonzalez-Banos Decl. ¶¶ 4–9. We first summarize Welch-HiBall and SIGGRAPH 2001, and then address the parties’ contentions.

1. *Welch-HiBall (Ex. 1004)*

Welch-HiBall is an article titled “High-Performance Wide-Area Optical Tracking” that describes a system for head or hand tracking in virtual and augmented environments, referred to as a “HiBall Tracking System.” Ex. 1004 ¶¶ 1, 9. Figure 6 of Welch-HiBall is reproduced below:



Figure 6 depicts the HiBall Tracking System, which consists mainly of optical sensing units called HiBalls, infrared (“IR”) light-emitting diodes (“LEDs”) fixed on the ceiling, and a Ceiling-HiBall Interface Board (“CIB”) connected to a host computer. *Id.* ¶ 14. The CIB provides communication and synchronization between the host computer, HiBalls, and LEDs. *Id.* ¶ 23. In order to track the pose of the user, the HiBalls are attached to, for example, a head-worn display or user-held wand or drill. *Id.* ¶¶ 9, 50, 53, 64, Figs. 4, 13. The HiBalls observe sequentially-flashed LEDs on the ceiling using lateral-effect photodiode (“LEPD”) silicon photodetectors, which detect the centroid of the luminous flux incident on the detector. *Id.* ¶¶ 14–15, 17–18. The LEPD measurements are communicated to the CIB to generate pose estimates of the HiBalls using a Kalman-filter-based

prediction-correction approach known as single-constraint-at-a-time (“SCAAT”) tracking. *Id.* ¶¶ 8–9, 15, 19, 31.

Although the disclosed HiBall Tracking System is an optical system, Welch-HiBall discloses that “[r]ecently, inertial hybrid systems . . . have been gaining popularity . . . with the added benefit of reduced high-frequency noise and direct measurements of derivatives.” *Id.* ¶¶ 2, 4. The authors of Welch-HiBall indicate that they are pursuing an inertial/optical hybrid approach. *Id.* ¶ 67.

## 2. *SIGGRAPH 2001 (Ex. 1005)*

SIGGRAPH 2001 is a set of course materials distributed to attendees of a conference course titled “Tracking: Beyond 15 Minutes of Thought.” Ex. 1005, 1; *see* Pet. 19. SIGGRAPH 2001 describes methods for tracking a computer user’s real-world position and orientation, or pose, in virtual environment systems for the purpose of continually providing the user with two-dimensional computer generated images that match the user’s three-dimensional, real-world position and orientation. Ex. 1005, 9. The disclosed methods are applicable to head or hand tracking for interactive computer graphics. *Id.* at 71.

Tracking systems for interactive computer graphics have included mechanical, magnetic, acoustic, inertial, and optical technologies. *Id.* at 9. According to SIGGRAPH 2001, “every type of sensor has fundamental limitations related to the associated physical medium,” and “no single medium or sensor type provides the necessary performance over the wide spectrum of temporal and spatial characteristics desired for many applications.” *Id.* at 56. Accordingly, SIGGRAPH 2001 discusses combining tracking technologies exhibiting “complementary behavior” into

“hybrid systems” such that “the complementary behavior of each system is leveraged to obtain more accurate and stable tracking information than either system alone.” *Id.* at 56–57.

SIGGRAPH 2001 discloses that “[o]ne of the most popular technologies (mediums) used to improve or augment the performance of other mediums is to incorporate accelerometers and gyros in some form of an inertial navigation system.” *Id.* at 56 (emphases omitted). One type of inertial hybrid system disclosed by SIGGRAPH 2001 is the inertial-optical system. *Id.* at 57.

Figure 4.1 of SIGGRAPH 2001 is reproduced below:

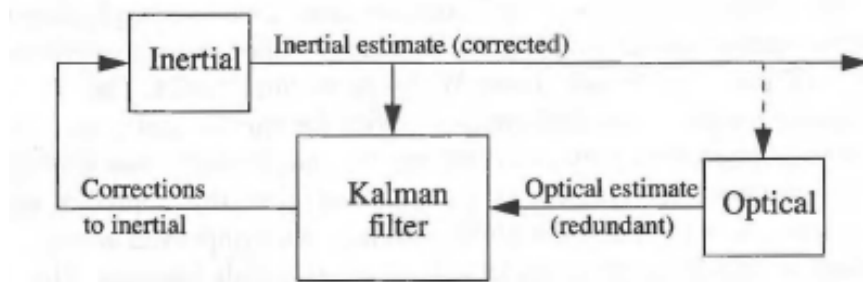


**Figure 4.1:** The Kalman filter used in an *indirect-feedback* configuration to optimally weight inertial and optical information.

Figure 4.1 illustrates an inertial-optical hybrid system that uses an indirect-feedback Kalman filter to combine information from inertial and optical sensors. *Id.* at 67. According to SIGGRAPH 2001, the Kalman filter is a well-known and often-used mathematical pose estimation tool. *Id.* at 66. “The basic idea is to use the Kalman filter to weight [sic] the different mediums most heavily in the circumstances where they each perform best, thus providing more accurate and stable estimates than a system based on any one medium alone.” *Id.* at 67.

3. *Independent Claim 1*

a. *Undisputed limitations*

Independent claim 1's preamble recites "[a] method for use with a system having a manipulated object." Ex. 1001, 51:13–14. Petitioner contends Welch-HiBall's "HiBall Tracking System" (or "HiBall System") is a system having a manipulated object such as "a handheld probe mounted on a drill to determine the pose of the drill." Pet. 35 (citing Ex. 1004 ¶¶ 50, 53, Figs. 13–14; Welch Decl. ¶¶ 144–146). For example, Petitioner refers to Figure 14 as depicting a "HiBall" attached to a drill. *Id.* Petitioner also contends SIGGRAPH 2001 suggests a manipulated object because it teaches tracking principles applicable to hand tracking. *Id.* (citing Welch Decl. ¶¶ 147–148).

Independent claim 1 also recites "a) accepting light data indicative of light detected by a photodetector mounted on-board said manipulated object from a first plurality of predetermined light sources having known locations in world coordinates" ("limitation 1(a)"). Ex. 1001, 51:15–18. According to Petitioner, the HiBall on-board a manipulated object (e.g., a drill) includes LEPDs, which detect light from a plurality of IR LEDs mounted on strips in the ceiling to generate and digitize data and transmit it via the CIB to a host computer. Pet. 35–36 (citing Ex. 1004 ¶¶ 10–12, 14–15; Welch Decl. ¶ 149). Welch-HiBall refers to this arrangement in which the sensors are on the moving object to be tracked and the landmarks are fixed as an "inside-looking-out" system as opposed to an "outside-looking-in" system in which the sensors are fixed and the landmarks are on the moving object. Ex. 1004 ¶¶ 10–12, Fig. 5. Petitioner contends the LEPDs in the HiBall are configured in different orientations to detect the x and y coordinates of the

centroid of the light beams hitting the sensor from the IR LEDs mounted in the ceiling. Pet. 36 (citing Ex. 1004 ¶¶ 16–19, Figs. 7–9). Petitioner contends the IR LEDs are light sources mounted in ceiling tiles at a “‘fixed-location’ and therefore have known locations in world coordinates.” *Id.* at 37 (citing Ex. 1004 ¶¶ 14, 20–22, Fig. 10). Petitioner also relies on SIGGRAPH 2001 as teaching “optical tracking systems relying on sensors mounted on-board a moving object and receiving light from external light sources, like those taught by Welch-HiBall.” *Id.* at 38 (citing Ex. 1005, 49–56).

Patent Owner does not dispute Petitioner’s analysis of independent claim 1’s preamble or limitation 1(a). We have considered Petitioner’s contentions and supporting evidence, and we find Petitioner meets its burden for these claim elements.

*b. Limitation 1(b)*

Independent claim 1 recites “b) accepting relative motion data from a relative motion sensor mounted on-board said manipulated object indicative of a change in an orientation of said manipulated object” (“limitation 1(b)”). Ex. 1001, 51:19–22. Petitioner relies on Welch-HiBall’s description of inertial tracking systems, which Petitioner contends are the “relative motion sensors” in the ’935 patent, as showing that such sensors are known in the art. Pet. 38 (citing Ex. 1004 ¶¶ 4, 35; Ex. 1001, 42:1–11). Petitioner also relies on Welch-HiBall’s discussion of the authors pursuing a “hybrid approach” referring to Dr. Welch’s 1995 paper entitled “Hybrid Self-Tracker: An Inertial/Optical Hybrid Three-Dimensional Tracking System” (Ex. 1012) as teaching combining the HiBall System’s optical

tracking with data from inertial sensors to provide more accurate pose estimation. Pet. 38 (citing Ex. 1004 ¶ 67).

Petitioner contends SIGGRAPH 2001 teaches inertial trackers including “accelerometers” and “gyroscopes” for pose determination (*id.* at 39 (citing Ex. 1005, 35–43)), and that such sensors “must be mounted ‘on-board’ the object being tracked” (*id.* (citing Ex. 1005, 25; Welch Decl. ¶ 185)). Petitioner further relies on SIGGRAPH 2001’s discussion of combining inertial tracking system data with optical data in a hybrid tracking system. *Id.* (citing Ex. 1005, 56–57). Patent Owner disputes these contentions, arguing that a gyroscope cannot be equated to limitation 1(b). PO Resp. 4–10.

According to Patent Owner, the relative motion sensor recited in limitation 1(b) does not need to be a gyroscope to produce relative motion data indicative of a change in an orientation of the manipulated object, as accelerometers can produce the same. *Id.* at 8–9; *see also id.* at 7 (“[A]ny sensor choice can be made to measure relative changes in orientation.”). Patent Owner also contends “the definition of how a gyroscope operates is not the ‘relative motion data’ of claim limitation 1(b).” *Id.* at 8. According to Patent Owner,

[i]t is thus NOT the selection of any particular inertial sensor, but a judicious selection of the subset of inertial data or, more broadly, a judicious selection of the subset of possible measurements of the motion of the manipulated object - namely changes in orientation - that are the gist of claim 1 limitation b). *Id.* at 9. The issue raised by Patent Owner is that, although the disclosed gyroscope *could* be a relative motion sensor (one of several possible choices), that alone is not sufficient for limitation 1(b). Rather, the gyroscope must be configured to measure “relative motion data” that is

“indicative of a change in orientation” to satisfy limitation 1(b), which, according to Patent Owner, has not been shown. We disagree.

As an initial matter, the evidence of record—including the ’935 patent and both declarants’ testimonies—conclusively establishes that a person of ordinary skill in the art would have understood a gyroscope could be used as a relative motion sensor that is indicative of a change in orientation. See, e.g., Ex. 1001, 42:4–8 (stating that relative motion sensor 1014 can include any suitable inertial sensing device, such as an accelerometer and gyroscope); Welch Decl. ¶ 90 (“The relative motion sensor may be an inertial sensing device such as a gyroscope or accelerometer.”); PO Resp. 8 (“[A] *gyroscope* is a type of sensor that inherently measures orientation, as taught by SIGGRAPH 2001 along with thousands of other references.”); Ex. 1048, 25:13–24 (admitting the inventors did not invent the “concept of a relative motion sensor for measuring changes in orientation” and that one way to measure such changes is using a gyroscope).

Furthermore, the evidence of record also establishes that a person of ordinary skill in the art would have used a gyroscope as a relative motion sensor that is indicative of a change in orientation. According to Dr. Welch, Petitioner’s declarant, the idea of using a relative motion sensor (“e.g. inertial or gyroscopic trackers”) and combining its output with optical data was well known in the art prior to the ’935 patent. Welch Decl. ¶ 121. Dr. Welch further testifies that “SIGGRAPH 2001 teaches the use of *relative motion sensors*, such as inertial trackers including accelerometers and gyroscopes.” *Id.* ¶ 157 (emphasis added).

We find this testimony to be supported by the evidence and therefore entitled to substantial weight. For example, the portions of SIGGRAPH

2001 cited by Dr. Welch teach using a gyroscope to determine orientation changes expressed as roll, pitch, and yaw. Ex. 1005, 35 (“Inertial trackers use . . . gyros to measure the orientation . . . 3D orientation in *roll, pitch, and yaw*.”), 37–38 (“If the [gyroscope’s] gimbals are constrained with springs, the rate of change of direction can be measured.”); Figure 3.7 (depicting “Rate gyroscopes for measuring rate of turn (left) and rate of roll (right)”); Reply 3–6. This evidence is inconsistent with Patent Owner’s contention that “nowhere in [the references] is there any terminology that even closely resembles the terms ‘relative orientation data’, ‘relative orientation motion’, ‘relative orientation’, ‘change in orientation’, etc.” Sur-Reply 21. Patent Owner’s declarant and the co-inventor of the ’935 patent, Dr.

Gonzalez-Banos, acknowledged that SIGGRAPH 2001 teaches a gyroscope for measuring change in orientation. Ex. 1048, 124:5–125:7 (“Q. And the data that is sensed from that angular rate by the micro-mechanical gyro [described on page 39 of SIGGRAPH 2001] is data that is indicative of a change in orientation of the micro-mechanical gyro? A. I agree.”). Based on the evidence before us, we find Petitioner has established persuasively that SIGGRAPH 2001 teaches use of a gyroscope for measuring relative motion data indicative a change of orientation of the manipulated object.

At the oral hearing, Patent Owner raised a variation on the above argument—contending that SIGGRAPH 2001’s gyroscope may not be providing relative motion data, because it is unclear whether the gyroscope is disregarding the gravity vector. *E.g.*, Tr. 21:22–22:20, 27:12–28:26, 47:15–21, 50:21–51:6, 53:6–19. This was the first time Patent Owner specifically mentioned that the effect of gravity or the “gravity vector” must

be removed for a gyroscope to teach relative motion data.<sup>3</sup> Patent Owner's declarant never mentions the gravity vector as an issue that should have been addressed by Petitioner.

Before addressing substantively this argument, we point out that oral argument is not itself evidence and, even if it were, it is not the proper forum for introducing new evidence or arguments in the proceeding. *See Office Trial Practice Guide*, 77 Fed. Reg. 48756, 48768 (Aug. 14, 2012) ("A party may rely upon evidence that has been previously submitted in the proceeding and may only present arguments relied upon in the papers previously submitted. No new evidence or arguments may be presented at the oral argument.").

Nonetheless, Petitioner's evidence addresses the gravity vector issue. For example, in describing the operation of gyroscopes used in inertial tracking (also called relative motion sensing in the '935 patent (Ex. 1001, 42:1–6)), Dr. Welch states:

Gyroscopes employ the principle of conservation of angular momentum. If torque is exerted on a spinning mass, its axis of rotation will precess at right angles to both itself and the axis of exerted torque. If the mass spins very fast, it will have a large angular momentum that will strongly resist changes in direction. For 3D orientation (roll, pitch and yaw), three rate gyroscopes are typically fitted to a platform with their axes mutually perpendicular. Two of the gyroscopes provide for horizontal stabilization of the platform--*an essential requirement to eliminate the influence of accelerations due to gravity*--while the third is responsible for the north-south alignment. Pitch, roll, and yaw are detected by the three gyroscope input axes. The

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<sup>3</sup> The only mention of gravity or gravity vector in Patent Owner's papers occurs in the Sur-Reply and, even then, only in discussing the human inner-ear as an analog to a gyroscope. *See* Sur-Reply 6–7.

gimbal deflection of each of the gyroscopes is converted into a signal.

Welch Decl. ¶ 54 (emphasis added). This testimony is nearly verbatim from SIGGRAPH 2001, which Dr. Welch authored. See Ex. 1005, 38. Finally, at the oral hearing, when asked about SIGGRAPH 2001's teaching of removing the influence of gravity, Patent Owner admitted that "[t]his has been known for a very long time." Tr. 50:21–23.

In another line of argument, Patent Owner contends Welch-HiBall and SIGGRAPH 2001 suggest relying primarily on the inertial measurement unit of the hybrid system, and using *all* relative motion data, not just the subset thereof indicative of a change in orientation. PO Resp. 7 ("The two references . . . teach to use ALL possible relative data coming from the inertials."), 14–22.

Claim limitation 1(b), however, is not limited solely to relative motion data indicative of a change in orientation. There is no language in limitation 1(b) to expressly limit it to only relative motion data indicative of a change in orientation. Indeed, we agree with Petitioner that interpreting the claim as so limited would be contrary to the specification of the '935 patent, which explains that the invention uses other types of relative motion data to determine pose. Reply 11–14 (citing Ex. 1001, 26:12–24, 38:2–11 ("[G]yroscope 908 provides information about changes in the orientation. . . . [A]ccelerometer 906 provides information about linear displacements."), 46:2–5, 47:42–49). Moreover, at the oral hearing, Patent Owner conceded that claim 1 does not exclude other types of relative data. Tr. 25:7–11 ("DIRECTOR IANCU: Okay. But if I have a device that accepts relative motion data indicative of the change in orientation and also in addition to that, it accepts relative data indicative of a change in position,

X, Y, Z, does that device meet the claim? MR. ALBOSZTA: Yes.”).

After considering the parties’ contentions and evidence, Petitioner shows persuasively that SIGGRAPH 2001 teaches a gyroscope configured as a relative motion sensor which provides relative motion data indicative of a change in orientation of the manipulated object, as recited in limitation 1(b). Petitioner has satisfied its burden to show that the proposed combination of Welch-HiBall and SIGGRAPH 2001 teaches limitation 1(b).

*c. Limitation 1(c)*

Independent claim 1 recites “c), determining the pose of said manipulated object based on said light data and said relative motion data, wherein said pose is determined with respect to said world coordinates” (“limitation 1(c)”). Petitioner contends Welch-HiBall teaches determining the pose for a manipulated object, i.e., a drill, using data from light sources. Pet. 39–40 (citing Ex. 1004 ¶¶ 8–9, 10–12, 15, 31–41). For example, Petitioner contends paragraphs 31–41 teach “recursive pose estimation.” *Id.* at 40. Petitioner also refers to its contentions regarding claim limitation 1(b) for Welch-HiBall’s suggestion to use inertial hybrid systems for obtaining relative motion data. *Id.*

The claim requires that the pose is “determined with respect to said world coordinates.” Petitioner contends Welch-HiBall teaches pose calculated to match a real-world object, and “also teaches measuring the position and orientation ‘of the HiBall in the world.’” *Id.* at 43–44 (citing, e.g., Ex. 1004 ¶¶ 6–9, 14–15, 38, 53–55). According to Petitioner, a person of ordinary skill in the art would have understood the prospective applications of the HiBall System, e.g., “track[ing] the pose of aircraft

manufacturing tools,” would necessarily require tracking world coordinates. *Id.* at 44 (citing Ex. 1004 ¶¶ 53–55; Welch Decl. ¶¶ 168–169).

Petitioner relies on SIGGRAPH 2001 as teaching a combined inertial-optical hybrid system to “produce higher performance across the range of movement from slow to fast than either system could produce alone.” Pet. 40 (citing Ex. 1005, 57). Petitioner contends SIGGRAPH 2001 teaches a Kalman filtering method for combining or fusing information from different systems by “weight[ing] the different mediums most heavily in the circumstances where they each perform best, thus providing more accurate and stable estimates than a system based on any one medium alone.” *Id.* (citing Ex. 1005, 67; Welch Decl. ¶ 160). Petitioner contends that both Welch-HiBall and SIGGRAPH 2001 teach using the SCAAT (“single-constraint-at-a-time”) algorithm, which can estimate pose from multiple light sources and relative motion data to calculate pose using the most available data. *Id.* at 41–42 (citing Ex. 1004 ¶¶ 31–41; Ex. 1005, 68–69; Welch Decl. ¶¶ 163–164).

Patent Owner contends limitation 1(c) recites “said relative motion data,” which refers to the relative motion data defined in preceding limitation 1(b), not just any relative motion data. PO Resp. 4, 11–12. According to Patent Owner, interpreting “said relative motion data” to be any relative motion data ignores the antecedent basis. *Id.* at 4–5, 11–13.

We agree with Patent Owner that “said relative motion data” derives antecedent basis from limitation 1(b), and, as such, “said relative motion data” must be indicative of a change in an orientation of the manipulated object, as recited in limitation 1(b). As set forth above, however, limitation 1(b) is not limited to only relative motion data indicative of a

change in orientation. Although limitation 1(b) requires this type of data, it does not exclude other types of relative motion data such as data indicative of a change of position. Reply 11–14. This is consistent with the plain language of the claim, which is open-ended, and the specification, as also set forth above.

Patent Owner further asserts Petitioner’s arguments for limitation 1(c) ignore the requirement of limitation 1(b) for relative motion data indicative of a change in orientation of the manipulated object. PO Resp. 5–6. We disagree. Petitioner’s arguments for limitation 1(c) reference its contentions for limitation 1(b), and refer to SIGGRAPH 2001’s inertial hybrid system. Pet. 38–40; Reply 6–7. Petitioner contends SIGGRAPH 2001 teaches that these systems leverage the peak performance of each type of system (i.e., optical and inertial) to produce higher performance across the range of movement from slow to fast than either system could produce alone. Pet. 40. Accordingly, we find that Petitioner accounts for the relative motion data indicative of a change in orientation recited in limitation 1(b) in arguing that the combined teachings of Welch-HiBall and SIGGRAPH 2001 would have resulted in the subject matter of limitation 1(c).

Patent Owner acknowledges that Welch-HiBall and SIGGRAPH 2001 teach combining inputs in a sensor fusion strategy, but argues the claimed invention is not about sensor fusion. Sur-Reply 4, 8–9, 11–20, 22. According to Patent Owner, the claimed invention is directed to a pose recovery process for tracking a manipulated object that is responsive to relative changes in orientation regardless of what type of sensor serves as the source for the relative orientation data. *Id.* at 15–16. Patent Owner also

argues “determining the pose,” as recited in limitation 1(c) does not connote sensor fusion. *Id.* at 18–20.

We agree with Patent Owner that limitation 1(c) does not require sensor fusion. The issue, however, is not whether limitation 1(c) requires sensor fusion, but rather whether SIGGRAPH 2001’s teaching of an inertial-optical hybrid system utilizing sensor fusion techniques to determine pose falls within the scope of limitation 1(c). As Patent Owner acknowledged at the oral hearing, the claims permit sensor fusion as a possible way to combine the data from the optical and inertial systems to practice the claim as long as the relative motion sensors are configured to provide relative data. Tr. 32:10–33:6. This is reflected by the specification, which explains that the invention “uses absolute data 1028 as well as relative motion data 1016, in accordance with *any suitable combination or data fusion technique that is efficient. Such sensor fusion and corresponding data fusion techniques are well known in the art.*” Ex. 1001, 44:51–55 (emphasis added).

After considering the parties’ evidence and arguments, we determine Petitioner has demonstrated that the combination of Welch-HiBall and SIGGRAPH 2001 teaches an inertial-optical hybrid system using data from the optical system and relative motion data from the inertial system indicative of a change in orientation to obtain pose. Pet. 40 (citing Ex. 1005, 57). SIGGRAPH 2001 further teaches using Kalman filtering to fuse information from the inertial and optical systems and achieve more accurate and stable estimates than a system using only one mode of sensing. *Id.* (citing Ex. 1005, 67). Accordingly, Dr. Welch’s testimony that Welch-HiBall and SIGGRAPH 2001 teach determining pose from data

captured simultaneously from multiple light sources and relative motion data (Welch Decl. ¶ 165) is supported by the evidence.

*d. Motivation to Combine*

Petitioner contends the ordinary artisan at the time of the invention would have been motivated to combine the teachings of Welch-HiBall and SIGGRAPH 2001. Pet. 30. Specifically, Petitioner relies on Welch-HiBall for its description of an optical-based system for determining pose from ceiling mounted LEDs and its suggestion to combine its optical-based system with hybrid sensing. *Id.* (citing Ex. 1004 ¶¶ 4, 35, 67). Acknowledging that Welch-HiBall does not describe specific operation of hybrid sensing systems, Petitioner relies on SIGGRAPH 2001’s discussion explaining “advantages of hybrid sensing that would lead a [person of ordinary skill in the art] at the time of the invention to combine a hybrid sensing system with inertial sensors as taught in SIGGRAPH 2001 with Welch-HiBall’s optical detection methods.” *Id.* at 30–31 (citing Welch Decl. ¶ 136). Based on the teachings and suggestions in Welch-HiBall and SIGGRAPH 2001, Petitioner contends a person of ordinary skill in the art would have combined the hybrid optical-inertial system taught by SIGGRAPH 2001 with the optical system taught by Welch-HiBall to “obtain more accurate and stable tracking information than either [an optical or inertial] system alone” could have provided. *Id.* at 33–34 (citing, e.g., Ex. 1004 ¶ 67; Ex. 1005, 57; Welch Decl. ¶ 139).

Patent Owner argues a person of ordinary skill in the art would not have combined the teachings of Welch-HiBall and SIGGRAPH 2001 to result in the claimed invention. PO Resp. 7, 14–22; Sur-Reply 8, 22–26; Gonzalez-Banos Decl. ¶¶ 4–9. First, according to Patent Owner,

Welch-HiBall and SIGGRAPH 2001 discuss hybrid systems in a very general manner, and the information presented is at an academic level to stimulate further work. PO Resp. 13–14; Sur-Reply 8. Patent Owner asserts that these general teachings are not direct instructions, suggestions, or ways to deploy hybrid systems and, therefore, are not instructive to a person of ordinary skill in the art. PO Resp. 14; Gonzalez-Banos Decl. ¶ 4.

Patent Owner similarly asserts that these general teachings are not implementable teachings that would have led a person of ordinary skill in the art to the claimed invention. *Id.* at 16–17. For example, Dr. Gonzalez-Banos testifies that the Kalman filtering approach would have required pre-filtering or sorting operations that would not have been obvious to a person of ordinary skill in the art. Gonzalez-Banos Decl. ¶ 6.

We have considered Petitioner’s evidence that a person of ordinary skill in the art would have had a reasonable expectation of success in combining the teachings of Welch-HiBall and SIGGRAPH 2001 to result in the claimed invention. Reply 14–16, 22–23. According to Dr. Welch, “SIGGRAPH 2001 specifically teaches how to fuse such data with data from inertial sensors to obtain a more accurate and precise combined pose estimate based on both types of data.” Welch Decl. ¶ 140. Dr. Welch also testifies that “a number of successful inertial-optical systems were developed by different teams and individuals prior to the alleged invention.” *Id.*

We have considered the conflicting testimony of the parties’ declarants and find that Dr. Welch’s testimony is entitled to more weight because it has greater support in the evidence of record. Dr. Welch’s testimony is consistent with the disclosures in SIGGRAPH 2001 providing specific teachings on how inertial data can be obtained and fused with

optical data using the indirect-feedback Kalman filtering approach and crediting this to others. Ex. 1005, 67 (citing to Maybeck, Peter S., *Stochastic Models, Estimation, and Control*, Vol. 1, Academic Press, Inc. (1979)), Fig. 4.1 (reproduced above) (depicting indirect-feedback Kalman filter)), 68 (describing previously implemented Kalman filter-based approaches to tracking using the SCAAT algorithm). Dr. Welch also relies on the '935 patent's specification, which itself suggests combining inertial and optical sensing using sensor fusion was well known in the art. See Welch Decl. ¶ 140 (citing Ex. 1001, 35:28–31 (“The combining of absolute and relative tracking data is sometimes referred to as ‘sensor fusion’ and is based on techniques that are well known in the art of robotics.”), 44:51–55 (“Such sensor fusion and corresponding data fusion techniques are well known in the art.”)). Finally, during his deposition, Dr. Gonzalez-Banos testified that the '935 patent did not need to go into “extreme mathematical detail” regarding “sensor fusion” because a person of ordinary skill in the art would have the necessary know-how. Ex. 1048, 112:4–19.

Patent Owner also argues the general disclosures of Welch-HiBall and SIGGRAPH 2001 would not motivate a person of ordinary skill in the art to use optics as the primary navigation mechanism and to thus use only partial data from the inertial system, namely the data indicative of a change in orientation. PO Resp. 7, 14. Patent Owner maintains Welch-HiBall and SIGGRAPH 2001 suggest the primary reliance in the disclosed hybrid systems should be on the inertial systems, and therefore teach away from having the optical system as the primary system and using only the subset of data from the inertial system that is indicative of a change in orientation. *Id.* at 14–15, 17–21; Gonzalez-Banos Decl. ¶ 4.

As an initial matter, these arguments are not commensurate with the scope of independent claim 1 for the reasons discussed above. Namely, we agree with Petitioner that independent claim 1 does not exclude other types of relative motion data. Reply 11–14. We further agree with Petitioner that independent claim 1 does not require the light data to have a higher priority than the relative motion data. *Id.* at 7–11. The claim simply requires accepting light data, accepting relative motion data indicative of a change of orientation, and determining pose based on the light data and the relative motion data. Finally, as to Patent Owner’s contention that Welch-HiBall and SIGGRAPH 2001 suggest the primary reliance in the disclosed hybrid systems should be on the inertial systems, and therefore teach away from having the optical system as the primary system, this in itself would not be “teaching away” because claim 1 does not require primary reliance on optical data. Moreover, SIGGRAPH 2001 provides reasons to create hybrid systems relying on primarily on either type of data depending on the motion. Reply 10 (citing Welch Decl. ¶ 163).

Patent Owner further argues that placing primary reliance on optical data and concentrating on changes in orientation from the inertial data would require undue experimentation:

[d]eriving any model, whether to be used with Kalman filtering or not, that from the very beginning places opticals or light data first and concentrates on only changes in orientation from the inertials would require undue experimentation by a [person of ordinary skill in the art] based on the combination of allegedly new prior art references SIGGRAPH 2001 and WELCH-HIBALL.

PO Resp. 18–19. For the reasons discussed above, however, we disagree. The evidence of record demonstrates that a person of ordinary skill would

have had reason and the necessary know-how to combine the optical data and relative motion data using the Kalman filter approach disclosed in SIGGRAPH 2001 to determine pose. That is all that claim limitation 1(c) requires.

Additionally, Patent Owner asserts the '935 patent provides a different motivation for combining optical and inertial data for determining pose—reducing the computation load of an on-board processor or computer. PO Resp. 21–22; Sur-Reply 25; Gonzalez-Banos Decl. ¶ 8. Petitioner is correct, however, that the reason for combining the references does not have to be the same as that contemplated by Patent Owner. Reply 13. Rather, any need or problem known in the field can provide a reason to combine the references. *See KSR Int'l v. Teleflex Inc.*, 550 U.S. 398, 420 (2007) (“The first error of the Court of Appeals in this case was to foreclose this reasoning by holding that courts and patent examiners should look only to the problem the patentee was trying to solve. . . . Under the correct analysis, any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.”).

Here, according to Petitioner, the motivation is supplied by the references themselves, which are closely related. Pet. 31. We agree. Welch-HiBall suggests an improvement by making its optical-only system a hybrid system to “obtain more accurate and stable tracking information than either [an optical or inertial] system alone” could have provided. *Id.* at 30, 34 (citing Ex. 1004 ¶ 67). SIGGRAPH 2001, also authored by Dr. Welch, teaches the advantages of hybrid optical-inertial systems. *Id.* at 30–31, 33–34 (citing Ex. 1005, 56–57). In view of the foregoing, Petitioner provides a

persuasive reason why a person of ordinary skill in the art would have combined the teachings of Welch-HiBall and SIGGRAPH 2001 to result in the claimed invention.

*e. Conclusion*

For the reasons set forth above, Petitioner shows persuasively each limitation of independent claim 1 in the combination of Welch-HiBall and SIGGRAPH 2001. Petitioner also articulates sufficient reasoning for why a person of ordinary skill would have combined the teachings of Welch-HiBall and SIGGRAPH 2001 in the manner set forth in the Petition. Accordingly, we find that Petitioner has shown, by a preponderance of the evidence, that independent claim 1 is unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall and SIGGRAPH 2001.

*4. Independent claim 12*

Independent claim 12 is directed to a system that recites substantially similar limitations to claim 1. *Compare* Ex. 1001, 51:13–26, *with id.* at 52:5–20. Petitioner relies on substantially the same evidence and analysis. Pet. 48–51; Welch Decl. ¶¶ 182–189. Patent Owner incorporates its arguments pertaining to independent claim 1. PO Resp. 22–23; Sur-Reply 20. For the reasons discussed above with respect to independent claim 1, we determine Petitioner shows, by a preponderance of the evidence, that independent claim 12 is unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall and SIGGRAPH 2001.

*5. Claims 2, 3, and 13–15*

Claim 2 requires the light sources of independent claim 1 to be arranged in a predetermined pattern. Ex. 1001, 51:27–28. Similarly, claims 13 and 14 require the known positions of light sources of independent

claim 12 to be in fixed position and to define a predetermined pattern, respectively. *Id.* at 52:21–24. Claim 3 requires the predetermined pattern of claim 2 to “comprise[] at least one member of the group consisting of linear patterns, non-linear patterns and asymmetric patterns.” *Id.* at 51:29–32. Claim 15, dependent from claim 14, recites a similar limitation. *Id.* at 52:25–28.

For these claims, Petitioner relies on Welch-HiBall’s description of strips of LED light sources in the ceiling arranged in a rectangular pattern. *See* Pet. 44–45, 51. Petitioner contends the light sources are in known, fixed positions (claim 13), the light sources define a predetermined pattern (claims 2 and 14), and the predetermined pattern is a linear pattern (claims 3 and 15). Pet. 44–45 (citing Ex. 1004 ¶¶ 20–22, Fig. 10; Welch Decl. ¶ 171), 51 (citing Welch Decl. ¶¶ 190–192).

Patent Owner does not argue that the arrangement of Welch-HiBall’s IR LEDs differs from the arrangements recited in claims 2, 13, and 14. Patent Owner contends that the “prior art only teaches a linear arrangement of IR LEDs mounted as an array in ceiling panels,” and that “WELCH-HIBALL does not suggest to a [person of ordinary skill in the art] asymmetric patterns or non-linear patterns.” PO Resp. 24. Moreover, with respect to claims 3 and 15, Patent Owner does not explain how these claims require light sources having linear, non-linear, *and* asymmetric patterns when the claims recite “at least one member of the group consisting of” the three listed patterns. *See Abbott Labs. v. Baxter Pharm. Prods., Inc.*, 334 F.3d 1274, 1280 (Fed. Cir. 2003) (“A Markush group is a listing of specified alternatives of a group in a patent claim, typically expressed in the form: a member selected from the group consisting of A, B, and C. . . . It is well

known that ‘members of the Markush group are . . . alternatively usable for the purposes of the invention.’” (quoting *In re Driscoll*, 562 F.2d 1245, 1249 (CCPA 1977))). We agree with Petitioner that, by acknowledging that the prior art discloses a linear arrangement of IR LEDs, Patent Owner concedes that the prior art discloses the subject matter of claims 3 and 15.

Reply 16–17.

After considering the parties’ arguments and evidence, we determine Petitioner shows, by a preponderance of the evidence, that claims 2, 3, and 13–15 are unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall and SIGGRAPH 2001.

6. *Claims 4–6, 11, 16–18, and 21*

Claims 4 and 16 require the light sources to comprise IR LEDs. Ex. 1001, 51:33–34, 52:29–30. As noted above, Petitioner contends the light sources in the HiBall System are IR LEDs. Pet. 45 (citing Ex. 1004 ¶¶ 5–8, 10, 14, 20–22), 52.

Claims 5 and 17 require the system to be coupled to a display for showing an image substantially defined by first and second orthogonal axes. Ex. 1001, 51:35–37, 52:31–33. Petitioner contends Welch-HiBall’s “head-worn display” and SIGGRAPH 2001’s virtual environment for providing a user with “two-dimensional computer-generated images” teach coupling to a display for showing an image in two dimensions, “i.e. first and second orthogonal axes.” Pet. 46 (citing Ex. 1004 ¶¶ 61, 64, Fig. 13; Ex. 1005, 9, 23, 78; Welch Decl. ¶ 175), 52.

Claims 6 and 18 require the pose to be defined by Euler angles ( $\phi$ ,  $\theta$ ,  $\psi$ ) or their mathematical equivalents. Ex. 1001, 51:38–40, 52:35–37. Petitioner contends both references provide pose in either Euler angles

(SIGGRAPH 2001) or their mathematical equivalents (Welch-HiBall’s “quaternion”). Pet. 46–48 (citing Ex. 1004 ¶ 38; Ex. 1005, 19–22; Welch Decl. ¶¶ 176–180), 52.

Claims 11 and 21 require the manipulated object to be selected from the group of “wands, remote controls, three-dimensional mice, game controls, gaming objects, jotting implements, surgical implements, three-dimensional digitizers, digitizing styli, hand-held tools and utensils.” Ex. 1001, 51:49–52:4, 52:44–49. Petitioner relies on Welch-HiBall’s description of the HiBall mounted on a drill, handheld probe, or handheld interaction device as satisfying this limitation. Pet. 48 (citing Ex. 1004 ¶¶ 50, 53–55, Figs. 13, 14).

Patent Owner does not present arguments for claims 4–6, 11, 16–18, and 21 apart from its arguments for independent claims 1 and 12. PO Resp. 23. After considering the parties’ arguments and evidence, we determine Petitioner shows, by a preponderance of the evidence, that claims 4–6, 11, 16–18, and 21 are unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall and SIGGRAPH 2001.

*E. Obviousness of Claims 7–11 and 19–21 over Welch-HiBall, SIGGRAPH 2001, and Romanik*

Petitioner contends that claims 7–11 and 19–21 are unpatentable as obvious over Welch-HiBall, SIGGRAPH 2001, and Romanik. Pet. 53–61. Petitioner relies on the declaration of Dr. Welch for support. See Welch Decl. ¶¶ 197–215. Patent Owner disputes Petitioner’s contentions. PO Resp. 25–26. We provide a brief description of Romanik before turning to the parties’ contentions.

1. *Romanik (Ex. 1006)*

Romanik relates to an optical system for monitoring the position and orientation of an object. Ex. 1006, 1:13–16. In the system of Romanik, the monitored object is a “hand-held stylus or controller” for manipulating a computer-generated view of an image. *Id.* at 3:54–56, 16:21–27.

Figure 8 of Romanik is reproduced below:

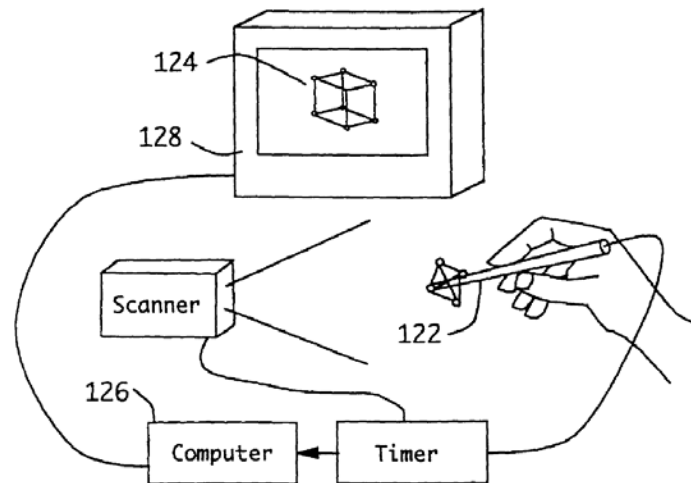


Figure 8

Figure 8 illustrates a system in which information on the position and orientation of stylus or controller 122 is used to determine the view of three-dimensional object 124 on display 128. *Id.* at 16:24–27. As shown in Figure 8, the system also includes an optical scanner and a timer (both unnumbered). Four light sensors (corresponding to light sensors 10, 12, 14, 16 in Figure 1, but not shown in Figure 8) are affixed to controller 122. *Id.* at [57], 7:11–14, Fig. 1. The scanner scans the area of controller 122 with light beams, and each of the light sensors produces a signal in response to a change in the intensity of light falling on that sensor. *Id.* at [57], 7:14–23. The timer records the times of position signals generated by the light sensors, as well as the timing of signals synchronized with specific points in

the scan. *Id.* at [57], 7:24–27, 7:56–58. Computer 126 calculates the position and orientation of stylus/controller 122 based on the times recorded by the timer and the coordinates of the light sensors. *Id.* at [57], 8:13–18. The information on the position and orientation of stylus/controller 122 is used by computer 126 to control the visual display of three-dimensional object 124 such that the visual display changes as the position and orientation of stylus/controller 122 changes. *Id.* at 16:23–29; *see also id.* at 16:15–20.

## 2. Claims 7 and 19

Claim 7 depends from claim 5. Ex. 1001, 51:41–42. Claim 5 recites “[t]he method of claim 1, wherein said system is coupled to a display that shows an image substantially defined by a first and second orthogonal axes.” *Id.* at 51:35–37. Claim 7 further requires the manipulated object be “configured to generate signals for rendering said display.” *Id.* at 51:41–42.

Similar to claim 5, Petitioner relies on Welch-HiBall as teaching a head-mounted display for displaying “on-screen representations based on the pose determined by the sensor, and the use of an optical sensing system attached to a hand-held tool, e.g. a pneumatic drill used in aircraft manufacturing, in order to track the pose of that tool.” Pet. 53 (citing Ex. 1004 ¶ 49, Fig. 13). Petitioner contends a person of ordinary skill in the art would have understood the most logical use of pose data would be to provide visual feedback of the pose data on the display, such as an on-screen representation of the tool being tracked, which is the actual use for which the HiBall System was intended. *Id.* (citing Welch Decl. ¶¶ 198–199; Ex. 1041).

Petitioner contends that, although Welch-HiBall does not *explicitly* describe pose data from a hand-held tool being translated onto a display, Romanik teaches this feature. *Id.* at 54 (citing Welch Decl. ¶¶ 200–201). Petitioner relies on Romanik as teaching an optical system for tracking the pose of an object having a plurality of light sensors mounted on the object. *Id.* at 54–55 (citing Ex. 1006, Abstract, Fig. 1). According to Petitioner, Romanik teaches an embodiment in which a “tracked object is a controller, and an output device can display a three-dimensional image 124 whose position and orientation on the display is calculated based on the position and orientation of the controller 122.” *Id.* at 55 (citing, e.g., Ex. 1006, 16:21–29, claim 15, Fig. 8). Petitioner contends Romanik teaches another embodiment in which the hand-held controller controls a cursor displayed on the screen. *Id.* at 56 (citing, e.g., Ex. 1006, 16:39–46, Fig. 10). Petitioner concludes that Romanik satisfies claim 7 because data from the controller, e.g., the stylus, is used to render the display as shown in Figures 8 and 10. *Id.* at 59 (citing, e.g., Ex. 1006, 16:21–29, 16:39–46, Figs. 8, 10; Welch Decl. ¶ 208).

Petitioner contends a person of ordinary skill in the art would have been motivated to combine Romanik with Welch-HiBall and SIGGRAPH 2001 because Welch-HiBall and SIGGRAPH 2001 teach methods for tracking pose of an object, such as a hand-held tool or hands, and Romanik teaches using the determined pose of a manipulated object to manipulate an on-screen object. Pet. 57 (citing Welch Decl. ¶ 205). Petitioner further contends such use of the output of the pose determination calculation to control a computer-generated object would improve the device taught by the combination of Welch-HiBall and SIGGRAPH 2001 by

providing a visual representation of the movement being tracked. *Id.* at 57–58. As evidence, Petitioner relies on Welch-HiBall’s teaching of using pose of a hand-held tool to provide “real-time feedback,” which Petitioner likens to the hand-held stylus taught by Romanik. *Id.* at 58 (citing Ex. 1004 ¶ 53; Ex. 1006, 16:21–29).

Patent Owner contends that Romanik cannot be easily integrated with optical-inertial systems as taught by Welch-HiBall and SIGGRAPH 2001 because Romanik teaches *both* the more conventional outside-in system and the less typical inside-out system, i.e., in which the sensors are on the manipulated object (*see* Welch Decl. ¶ 67). PO Resp. 26. Patent Owner further explains:

Conventionality is not to be construed as novelty under 35 U.S.C. §102. Because of a lack of small form factor CMOS cameras readily available at the time of filing of the ’219 patent the conventional solution to a [person of ordinary skill in the art] for tracking the motion of such a small hand-held tool as disclosed by ROMANIK would be the outside-in solution. WELCH-HIBALL and SIGGRAPH 2001 with ROMANIK thus do not meet the criteria for a motivated combination.

*Id.* Patent Owner’s contention, however, does not address Petitioner’s analysis and evidence.

As an initial matter, Petitioner relies on Romanik for “using the output of the pose determination calculation [of Welch-HiBall and SIGGRAPH 2001] to control a three-dimensional computer-generated object” (Pet. 57), not for “integrating” Romanik’s system in its entirety into the proposed Welch-HiBall-SIGGRAPH 2001 combination. *See In re Keller*, 642 F.2d 413, 425 (CCPA 1981) (“The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference.”).

Regardless, the portions of Romanik relied upon by Petitioner (i.e., Figs. 1, 8, and 10) teach an inside-out system where the sensors are attached to the manipulated object, similar to the system described in Welch-HiBall. For example, Petitioner characterizes Figure 1 of Romanik as having sensors 10, 12, 14, and 16 “so that the position and orientation of the device *on which the sensors are mounted* may be determined.” Pet. 55 (emphasis added). The description of Figure 1 confirms this understanding. See Ex. 1006, 7:10–14 (describing “four light sensors 10, 12, 14, and 16 affixed to an object (not shown)”). Similarly, when introducing Figure 8, where the manipulated object 122 is shown, Romanik states that the light sensors are mounted on a rigid frame, which “is then mounted to a handheld controller or helmet, depending on the application.” *Id.* at 15:60–64.

In view of the foregoing, Petitioner shows persuasively each limitation of claim 7 in Welch-HiBall, SIGGRAPH 2001, and Romanik. Petitioner also articulates sufficient reasoning for why a person of ordinary skill would have combined the teachings of Romanik, with the teachings of Welch-HiBall and SIGGRAPH 2001—two closely related references—in the manner set forth in the Petition to provide a visual representation of the movement being tracked. Petitioner shows, by a preponderance of the evidence, that claim 7 is unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall, SIGGRAPH 2001, and Romanik.

Claim 19 is similar to claim 7. Compare *id.* at 52:38–40, with *id.* at 51:41–42. Petitioner relies on its arguments for claim 7 for claim 19 and further argues Romanik’s computer includes a processor. Pet. 61 (citing Ex. 1006, 16:23–29, 41–16; Welch Decl. ¶ 213). Patent Owner does not present arguments for claim 19 apart from its arguments for claim 7.

PO Resp. 25–26. For the same reasons as claim 7, we determine Petitioner shows, by a preponderance of the evidence, that claim 19 is unpatentable under 35 U.S.C. § 103(a) over Welch-HiBall, SIGGRAPH 2001, and Romanik.

3. *Claims 8–11, 20, and 21*

Claim 8 depends from claim 7 and recites that the “rendering” limitation of claim 7 “comprises rearranging a visual element.” Ex. 1001, 51:43–44. Petitioner relies on the cursor of Romanik (Fig. 10) as the visual element that is rearranged as it is moved around. Pet. 59. Claim 9 requires that a “subset of said pose is used for rotating at least a portion of said image.” Ex. 1001, 51:45–46. Petitioner relies on Romanik as teaching that the hand-held controller may be used for “controlling the orientation of a three-dimensional computer-generated display.” Pet. 60 (citing Ex. 1006, 5:5–22, Fig. 8). Claim 10 requires that “at least a subset of said pose is used for rotating a visual element of said image.” Ex. 1001, 51:47–48. With respect to claim 10, Petitioner relies on its analysis of claim 9. Pet. 60. Claim 20 is similar to claim 10 (Ex. 1001, 52:40–42), and Petitioner relies on a similar analysis as provided for claim 10 (Pet. 61).

Claims 11 and 21 are discussed above with respect to the Welch-HiBall/SIGGRAPH 2001 combination. In addition to the evidence presented there, Petitioner also refers to Romanik’s teaching of the hand-held controller or stylus. Pet. 60–61 (citing Ex. 1006, 23–27, 41–46; Welch Decl. ¶¶ 212, 215).

Patent Owner does not present arguments for these claims apart from its arguments for claim 7. PO Resp. 25–26. We determine Petitioner shows, by a preponderance of the evidence, that claims 8–11, 20, and 21 are

unpatentable under 35 U.S.C. § 103(a) based on the combination of Welch-HiBall, SIGGRAPH 2001, and Romanik.

*F. Alleged Burden Shifting*

Patent Owner argues Petitioner improperly shifted its burden of proof to Patent Owner and the Board. PO Resp. 27–30. In particular, Patent Owner contends the lack of claim charts and the absence of alignment of evidence and arguments with the limitations of the challenged claims has effectively shifted the burden to the Patent Owner and placed the onus on the Board to map the evidence to the claims. *Id.* at 27.

We agree with Petitioner, however, that there is no requirement to use a claim chart format to map the claim limitations to the cited art. Reply 23–24. As discussed above, Petitioner provides an element-by-element claim mapping sufficient to carry its burden to show by a preponderance of the evidence that the challenged claims are unpatentable under 35 U.S.C. § 103(a).

III. CONCLUSION

We conclude Petitioner shows by a preponderance of the evidence that claims 1–21 of the '935 patent are unpatentable.<sup>4</sup>

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<sup>4</sup> Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

IV. IV. ORDER

In consideration of the foregoing, it is  
ORDERED that claims 1–21 of U.S. Patent No. 8,553,935 B2 (“the  
'935 patent”) have been shown to be unpatentable; and  
FURTHER ORDERED that parties to the proceeding seeking judicial  
review of this Final Written Decision must comply with the notice and  
service requirements of 37 C.F.R. § 90.2.

IPR2018-01032  
Patent 8,553,935 B2

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