Paper No. ________

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZTE (USA), Inc.

~~Google LLC~~ Petitioner

v.

Cywee Group Ltd.

(record) Patent Owner

~~IPR2018~~IPR201
9-~~01257~~00525
Patent No. 8,552,978

PETITION FOR INTER PARTES REVIEW UNDER 35 U.S.C. §§311-319 AND 37 C.F.R. §42.100 ET. SEQ

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Petitioner ZTE (USA), Inc. (“Petitioner” or “ZTE”) respectfully requests *inter partes* review under 35 U.S.C. §311 of claims 10 and 12 of U.S. Pat. No. 8,552,978 (“the ’978 patent”).

NOTICE OF LEAD AND BACKUP COUNSEL

Lead Counsel: James R. Sobieraj ~~Matthew A. Smith~~ (Reg. No. ~~49,003~~30,805); Tel: ~~202.669.6207~~312.321.4200

Backup Counsel: ~~Andrew S. Baluch~~Jon H. Beaupré (Reg. No. ~~57,503~~54,729); Tel: ~~847.863.1645~~734.302.6000

Backup Counsel: Yuezhong Feng ~~Christopher M. Colice~~ (Reg. No. ~~65,634~~58,657); Tel: 312.321.4200

Backup Counsel: Andrea L. Shoffstall (Reg. No. 75,426); Tel: 312.321.4200

~~617.947.7280.~~

Address of lead counsel: Brinks Gilson & Lione, NBC Tower, Suite 3600, 455 N. Cityfront Plaza Dr., Chicago, Illinois 60611-5599~~Smith Baluch LLP, 1100 Alma St., Ste 109, Menlo Park, CA 94025~~.

NOTICE OF THE REAL-PARTIES-IN-INTEREST

The real-parties-in-interest for this petition are ZTE Corporation and ZTE (USA), Inc~~Google LLC and Huawei Device USA, Inc., Huawei Device Co. Ltd., Huawei Technologies Co. Ltd., Huawei Device (Dongguan) Co. Ltd., Huawei~~

~~Investment & Holding Co. Ltd., Huawei Tech. Investment Co. Ltd., Huawei Device (Hong Kong) Co. Ltd~~.

NOTICE OF RELATED MATTERS

The ’978 patent is asserted in the following matters:

- *Cywee Group Ltd. v. Google, Inc.*, Case No. 1-18-cv-00571, (D. Del.);
- *Cywee Group Ltd. v. ZTE Corporation et al.*, Case No. 3-17-cv-02130, (S.D. Cal.);
- *Cywee Group Ltd. v. HTC Corporation et al.*, Case No. 2-17-cv-00932, (W.D. Wash.);
- *Cywee Group Ltd. v. Motorola Mobility LLC*, Case No. 1-17-cv-00780, (D. Del.);
- *Cywee Group Ltd. v. Huawei Technologies Co., Inc. et al.*, Case No. 2-17-cv-00495, (E.D. Tex.);
- *Cywee Group Ltd. v. LG Electronics, Inc. et al.*, Case No. 3-17-cv-01102, (S.D. Cal.);
- *Cywee Group Ltd. v. Samsung Electronics Co. Ltd. et al.*, Case No. 2-17-cv-00140, (E.D. Tex.);
- *Cywee Group Ltd. v. Apple Inc.*, Case No. 4-14-cv-01853, (N.D. Cal.);
- *Google LLC v. Cywee Group Ltd.*, IPR2018-01257; and

- *Samsung Electronics Co., Ltd. et al v. CyWee Group Ltd.*, IPR2019-00534 (filed concurrently with a motion for joinder to IPR2018-01257).

NOTICE OF SERVICE INFORMATION

Please address all correspondence to the lead counsel at the addresses shown above. Petitioner~~s~~ consents to electronic service by email at: ZTE_CyweeIPRs@brinksgilson.com; jsobieraj@brinksgilson.com, jbeaupre@brinksgilson.com, yfeng@brinksgilson.com, and ashoffstall@brinksgilson.com.~~smith@smithbaluch.com, baluch@smithbaluch.com,~~

GROUNDS FOR STANDING

Petitioner hereby certifies that the patent for which review is sought is available for *inter partes* review, and that the Petitioner is not barred or estopped from requesting an *inter partes* review on the grounds identified in the petition. ~~In particular,~~ This Petition is being submitted concurrently with a Motion for Joinder and Petitioner requests institution and joinder with *Google LLC v. Cywee Group Ltd.*, IPR2018-01257 ("the Google IPR"), which the Board instituted on December 11, 2018. ~~the~~ The district court suit against ~~Petitioner~~ Google LLC was served on April 19, 2018 (Ex. 1007), while the suit against certain Huawei entities was served on June 14, 2017 (Ex. 1008).

STATEMENT OF PRECISE RELIEF REQUESTED

Petitioner respectfully requests that claims 10 and 12 of the ’978 patent be canceled based on the following grounds:

Ground 1: Claims 10 and 12 are obvious over Zhang and Bachmann.

Ground 2: Claims 10 and 12 are obvious over Liberty and Bachmann.

THRESHOLD REQUIREMENT FOR INTER PARTES REVIEW

This petition presents “a reasonable likelihood that the Petitioner~~s~~ would prevail with respect to at least one of the claims challenged in the petition”, 35 U.S.C. §314(a), as shown in the Grounds explained below.

I. INTRODUCTION

The present petition is supported by the declaration of Prof. Majid Sarrafzadeh (Ex. 1002). Professor Sarrafzadeh holds the title of Distinguished Professor of Computer Science & Electrical Engineering at the University of California, Los Angeles. Professor Sarrafzadeh’s CV is included as Exhibit 1003.

The ’978 patent relates to 3D pointing devices. (Ex. 1001, Title). The ’978 patent describes the function of a 3D pointing device as “detecting motions of the device and translating the detected motions to a cursor display such as a cursor pointing on the screen…of a 2D display device….” (Ex. 1001, 1:31-33)(Ex. 1002, ¶26). For example, a 3D pointing device could be a kind of computer mouse that detects movements and rotations of the mouse in three dimensions, allowing the movements and rotations to be translated into actions on a computer. (Ex. 1001, 1:52-61)(Ex. 1002, ¶26). An example of such a device 110 (and a corresponding display 120) is shown in Fig. 1 of the ’978 patent, reproduced below:

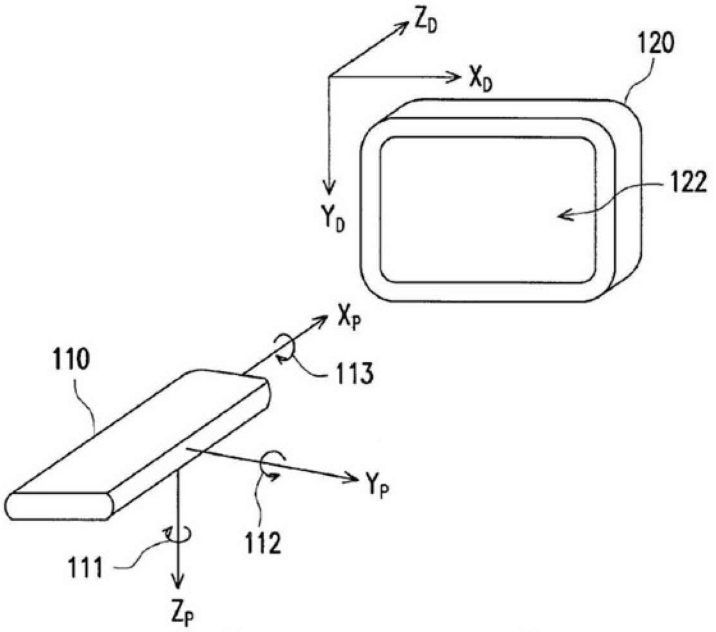

FIG. 1 (RELATED ART)

To keep track of the motions and rotations of a 3D pointing device, the ’978 patent proposes using three kinds of sensors: rotation sensors (for detecting the angular velocity of rotation), accelerometers (for detecting axial accelerations), and magnetometers (for detecting the local magnetic field). (Ex. 1001, Fig. 4)(Ex. 1002, ¶27). These sensors are mounted in or on the 3D pointing device, and provide information on the movements and rotations of the device. (Ex. 1002, ¶27).

The ’978 patent also purports to provide methods of using data output from the rotation sensors, accelerometers and magnetometers to calculate the orientation of the 3D pointing device. (Ex. 1001, 4:15-57)(Ex. 1002, ¶28). The “orientation” of the device (also called the “attitude” or “tilt” of the device) is the direction of the device, *e.g.* the angles between the device and the axes of any given coordinate system.[1] (Ex. 1001, 1:62-64)(Ex. 1002, ¶28). For example, Fig. 2 of the ’978 patent shows the same device 110 in a different “orientation”, having been rotated about the x-axis by 90 degrees:

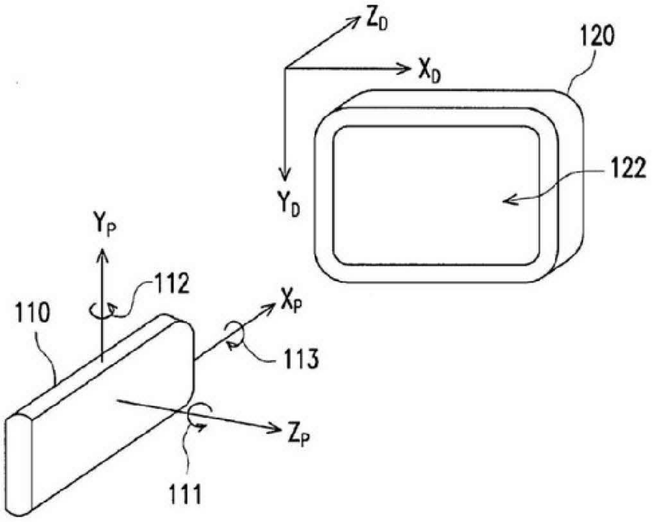

FIG. 2 (RELATED ART)

(Ex. 1001, 2:11-14)(Ex. 1002, ¶28).

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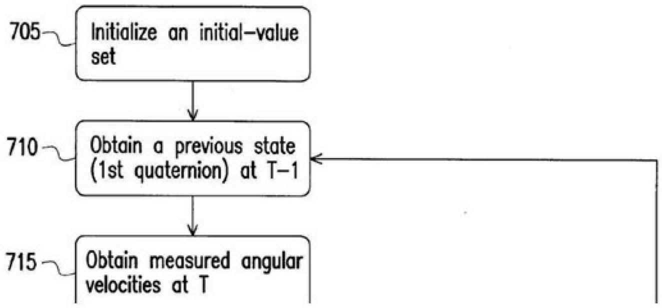
[1] Orientation may be expressed in a number of equivalent ways, such as with a quaternion. (Ex. 1002, ¶¶30-32).

While the ’978 patent acknowledges the existence of prior-art 3D pointers using sensors to detect and calculate orientation, the ’978 patent criticizes the specific devices mentioned as allegedly unable to calculate orientation accurately. (Ex. 1001, 2:41-3:52)(Ex. 1002, ¶33). The ’978 patent purports to provide a solution to the alleged deficiencies of the prior art, by using additional sensors and “compensating” the output of the sensors to improve the accuracy of the orientation calculation. (Ex. 1001, 1:22-27).

To “compensate” the output of the sensors, the ’978 patent discloses a mathematical method using quaternions. (Ex. 1001, 16:5 *et seq.*)(Ex. 1002, ¶34). As explained by Professor Sarrafzadeh, a “quaternion” is a way to represent an orientation (rotation angles) using a four-valued vector. (Ex. 1002, ¶¶30-32). Quaternion math operations (such as multiplication) are defined differently than for standard vectors, and can sometimes be used for efficient calculation of rotations. (Ex. 1002, ¶¶30-32).

A basic sketch of the ’978 patent method can be seen in Fig. 7, which is reproduced at right. The method



of Fig. 7 obtains measured angular velocities at step 715 (Ex. 1001, 16:27-30) and measured axial accelerations in step 725 (Ex. 1001, 16:60-64). The method then calculates a predicted set of axial accelerations at step 730. (Ex. 1001, 17:2-9). By comparing the actual and predicted accelerations (step 735), the method purports to improve the estimate of orientation (called the "updated state (3rd quaternion)" in box 735). (Ex. 1001, 18:25-55)(Ex. 1002, ¶34).

A. Prosecution History and Issued Claims

This petition challenges independent claim 10 and dependent claim 12. As originally filed, claim 10 (then numbered claim 12), read as follows:

> "12. A method for compensating rotations of a 3D pointing device, comprising:
>
> generating an orientation output associated with an orientation of the 3D pointing device associated with three coordinate axes of a global reference frame associated with Earth;

> generating a rotation output associated with a rotation of the 3D pointing device associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device; and
>
> using the orientation output and the rotation output to generate a transformed output associated with a fixed reference frame associated with a display device."

(Ex. 1009, p. 044-045). The claim was thus directed to generating a rotation output (*i.e.* output of rotation sensors), calculating orientation output, and then somehow "using" orientation output and rotation output to generate a "transformed output".

The Examiner initially rejected all original claims for double patenting, and as anticipated or obvious over U.S. Pat. Pub 2009/0262074 to Nasiri. (Ex. 1009, pp. 071-089). The applicants responded by requesting an interview. (Ex. 1009, pp. 060-066). In the interview request, the applicants' representative argued that Nasiri did not teach using a global reference frame associated with Earth, and that Nasiri "only briefly talks about 'magnetometers'" (Ex. 1009, pp. 060-066).

The applicants then submitted an amendment. (Ex. 1009, pp. 040-055). In the amendment, the applicants modified claim 12 to add several limitations. First, the applicants added language to claim 12 requiring generating signal sets associated with accelerometers and magnetometers. (Ex. 1009, pp. 044-045). Second, the applicants specified that the "orientation output" must be "based on the first signal set, the second signal set and the rotation output or based on the first signal set and the second signal set". (*Id.*). Third, the applicants specified that "the orientation output and the rotation output is generated by a nine-axis motion sensor module", and that a "resultant deviation including a plurality of deviation angles" must be obtained "using" a "plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set." (*Id.*).

Following the amendment, the Examiner allowed the claims without further comment. (Ex. 1009, pp. 024-027). As issued, independent claim 10 reads as follows:

> "10. A method for compensating rotations of a 3D pointing device, comprising:
>
> generating an orientation output associated with an orientation of the 3D pointing device associated with three coordinate axes of a global reference frame associated with Earth;
>
> generatinq [sic] a first signal set comprising axial accelerations associated with movements and rotations of the 3D pointing device in the spatial reference frame;
>
> generating a second signal set associated with Earth's magnetism;
>
> generating the orientation output based on the first signal set, the second signal set and the rotation output or based on the first signal set and the second signal set;
>
> generating a rotation output associated with a rotation of the 3D pointing device associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device; and

using the orientation output and the rotation output to generate a transformed output associated with a fixed reference frame associated with a display device, wherein the orientation output and the rotation output is generated by a nine-axis motion sensor module;

obtaining one or more resultant deviation including a plurality of deviation angles using a plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set."

II. CLAIM CONSTRUCTION

"A claim in an unexpired patent shall be given its broadest reasonable construction in light of the specification of the patent in which it appears". 37 C.F.R. §42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 195 L. Ed. 2d 423 (2016). For this proceeding, claim terms are presumed to take on their broadest reasonable ordinary meaning, which is explained in certain instances below. The constructions below are for the purpose of this petition only, and Petitioner reserves the right to change these constructions as appropriate in future proceedings. Petitioner also does not concede, by seeking this petition, that the challenged claims are of definite scope or properly described under 35 U.S.C. §112. Petitioner hereby discloses a recent claim construction order in *Cywee v. Motorola*, 17-cv-00780 (Ex. 1051), which does not construe any claim terms construed in this Petition.

A. Claim 10—"spatial reference frame" and similar terms

Claim 10 uses the phrases "spatial reference frame" and "spatial reference frame associated with the 3D pointing device". These phrases should be interpreted to mean "a reference frame associated with the 3D pointing device, which always has its origin at the same point in the device and in which the axes are always fixed with respect to the device". (Ex. 1002, ¶37).

The '978 patent states as follows concerning the spatial reference frame:

> "There are two reference frames, such as the **spatial pointer reference frame** and the display frame, associated with the pointing device 110 and the display device 120, respectively. The first reference frame or spatial pointer reference frame associated with the pointing device 110 is defined by the coordinate axes X_P, Y_P and Z_P as shown in FIG. 1."

(Ex. 1001, 1:39-1:45)(Emphasis added)(Ex. 1002, ¶40). Thus, the "spatial pointer reference frame" is shown by the coordinate axes X_P, Y_P and Z_P in Fig. 1. Figure 1 is reproduced here:

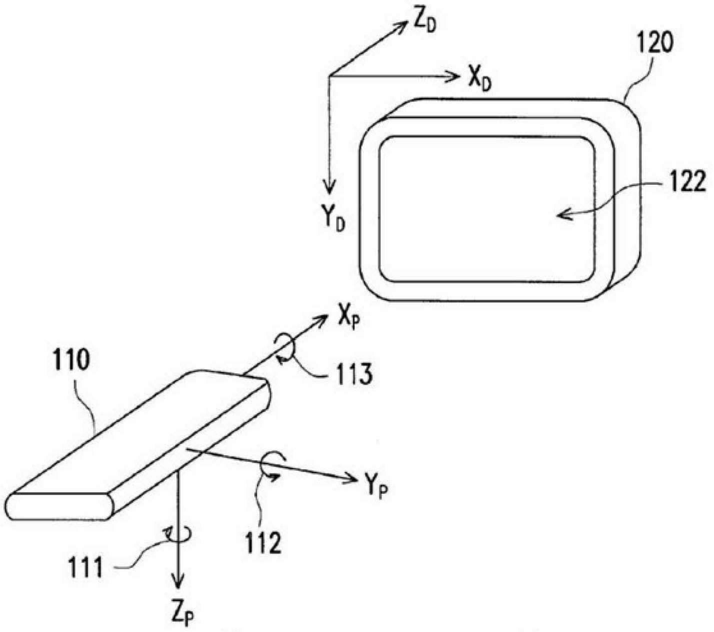


FIG. 1 (RELATED ART)

(Ex. 1002, ¶41). As can be seen from Fig. 1, the spatial pointer reference frame is a reference frame associated with the 3D pointing device, which has its origin at a point in the device. (Ex. 1002, ¶¶41-45).

Furthermore, as shown in Fig. 2, when the device is rotated, the axes X_P, Y_P and Z_P rotate with the device. (Ex. 1002, ¶¶45-46). Figure 2 is reproduced below, and shows a 90-degree roll of the device, with correspondingly rotated axes Y_P and Z_P:

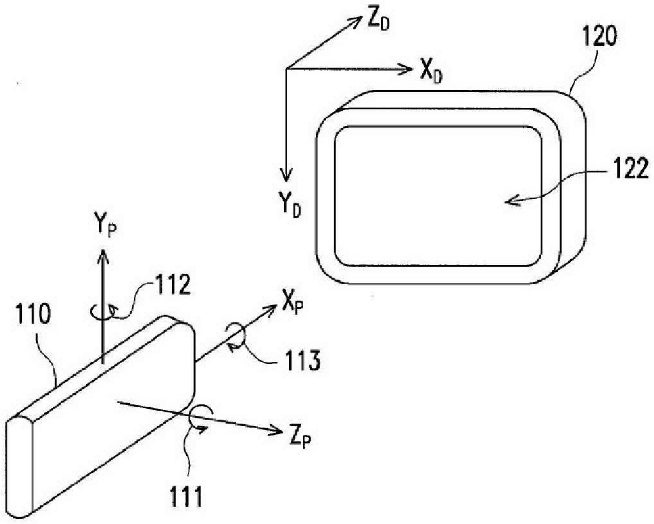


FIG. 2 (RELATED ART)

(Ex. 1002, ¶¶42-43). For that reason, in the spatial pointer reference frame, the origin and axes of the frame stay fixed with respect to the device. (Ex. 1002, ¶¶42-46). Note that the '978 patent treats each of the phrases "spatial reference frame" and "spatial pointer reference frame" as referring to a device-centered frame of reference analogous to the X_P, Y_P and Z_P axes. (Ex. 1001, 9:19-20, 1:39-47, 3:6-7)(Ex. 1002, ¶39-42). Because "spatial reference frame" already refers to a frame with its origin in the device, the longer phrase "spatial reference frame associated with the 3D pointing device" has the same meaning, as CyWee concedes. (Ex. 1002, ¶¶38-41; Ex. 1010, p. 2).

Thus, the phrases "spatial reference frame" and "spatial reference frame associated with the 3D pointing device" should both be interpreted to mean "a reference frame associated with the 3D pointing device, which always has its origin at the same point in the device and in which the axes are always fixed with respect to the device" (Ex. 1002, ¶¶37-47). Cywee agreed to these constructions during a co-pending litigation. (Ex. 1010, p. 2).

B. Claim 10—"rotation output"

Claim 10 uses the phrase "rotation output". In the specification, the '978 patent makes clear that the rotation output is the output of a rotation sensor (a sensor that detects rotation). For example, the '978 patent states:

> "The **rotation sensor generates a rotation output** associated with a rotation of the 3D pointing device associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device."

(Ex. 1001, 7:61-64)(Emphasis added)(Ex. 1002, ¶50).

Thus, "rotation output" should be interpreted in accordance with the specification as "output of a rotation sensor". (Ex. 1002, ¶¶48-52).

GROUNDS

Ground 1. Claims 10 and 12 are obvious over Zhang in view of Bachmann.

Claims 10 and 12 are unpatentable as obvious over U.S. Pat. App. Pub. 2004/0095317 ("Zhang")(Ex. 1005), in view of U.S. Pat. No. 7,089,148 ("Bachmann")(Ex. 1004).

Zhang was published on May 20, 2004, and is thus prior art under pre-AIA 35 U.S.C. §102(b). **Bachmann** issued on August 8, 2006, and is thus also prior art under pre-AIA 35 U.S.C. §102(b). Zhang and Bachmann are analogous art, because they are in the same field and reasonably related to the problems facing the named inventors, as shown by the discussion below.

Neither Zhang nor Bachmann are listed as prior art of record on the face of the '978 patent.

Overview of the Combination

Claim 10 is directed to a method for compensating rotations of a 3D pointing device. The combination of Zhang and Bachmann, broadly speaking, uses *Zhang's 3D pointing device* together with *Bachmann's extra sensors and method for compensating rotations*.

Zhang teaches a (sic) "a handheld pointing device" that is used for a "computer pointing control system". (Ex. 1005, Abstract)(Ex. 1002, ¶53). Such a computer pointing control system is shown, for example, in Fig. 2 of Zhang (reproduced below), where the handheld device (a 3D pointer) has reference numeral 100:

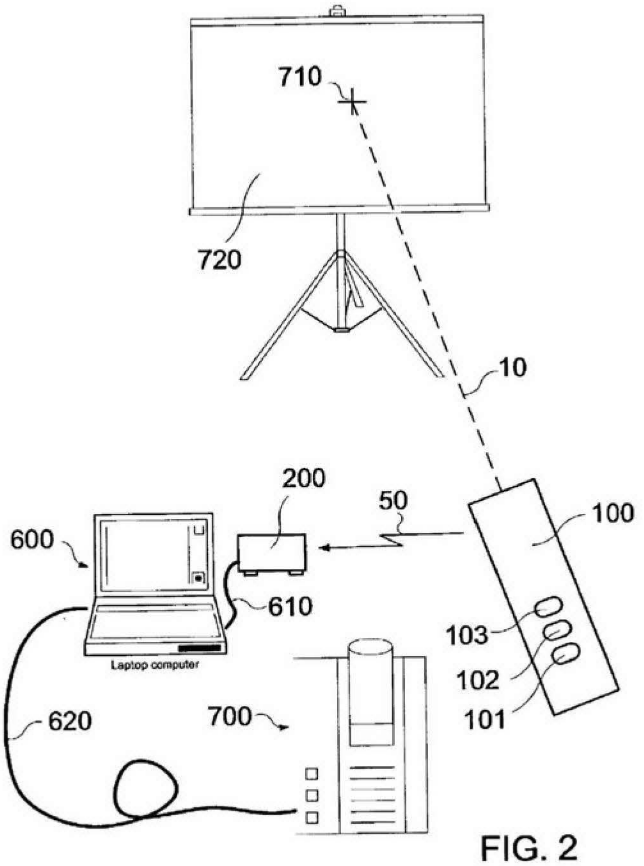


FIG. 2

Inside Zhang's device 100, there are several sensors that detect the orientation of the device. Zhang explains:

> "A universal pointing control system for televisions and computer displays is disclosed. The system is comprised of a remote handheld device, a display control unit and a command delivery unit. The remote handheld device includes **a set of orientation sensors that detect the device's current orientation**."

(Ex. 1005, ¶0008)(Emphasis added)(Ex. 1002, ¶54).

Zhang discloses that the device 100 has several different orientation sensors. The orientation sensors are arranged on a circuit board in the housing of the device, as shown in Fig. 3 of Zhang, reproduced at right. In Fig. 3, numeral 160 is the circuit board, while numerals 120 and 130 are sensors. (Ex. 1005, ¶0025)(Ex. 1002, ¶¶55-56). Numeral 120 is "a two-axis magnetic field sensor 120 [that] is used to detect the device's orientation relative to the direction of the earth's magnetic field 25." (Ex. 1005, ¶0026)(Ex. 1002, ¶¶57-58). Numeral 130 is an "accelerometer sensor 130 [that] contains two orthogonally arranged acceleration detectors." (Ex. 1005, ¶0027)(Ex. 1002, ¶¶57-58). Numeral 110 is a microcontroller for performing calculations. (Ex. 1005, ¶0025)(Ex. 1002, ¶59).

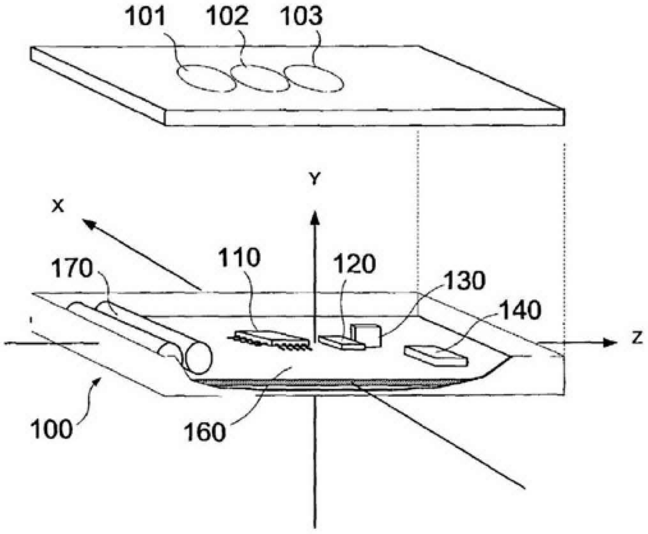


FIG. 3

A system diagram of Zhang's device 100 is shown in Fig. 5, reproduced below at right. (Ex. 1005, ¶0029)(Ex. 1002, ¶59). In Fig. 5, the two sets of two sensors (magnetometers 120 and accelerometers 130) are shown on the left side (the Petitioner has placed a red-dashed box around the numerals 120 and 130). These sensors output signals to circuits 111-112, 121-124 and 131-134. (Ex. 1005, ¶0029)(Ex. 1002, ¶60). These circuits condition the sensor output, convert it to digital format, and pass the digital data to the microcontroller (MCU) 110. (Ex. 1005, ¶0029)(Ex. 1002, ¶60). The MCU 110 determines the device's orientation, including azimuth and inclination angles (yaw and pitch). (Ex. 1005, ¶0029)(Ex. 1002, ¶60). These angles are shown in Figs. 4(a) and 4(b), reproduced below.

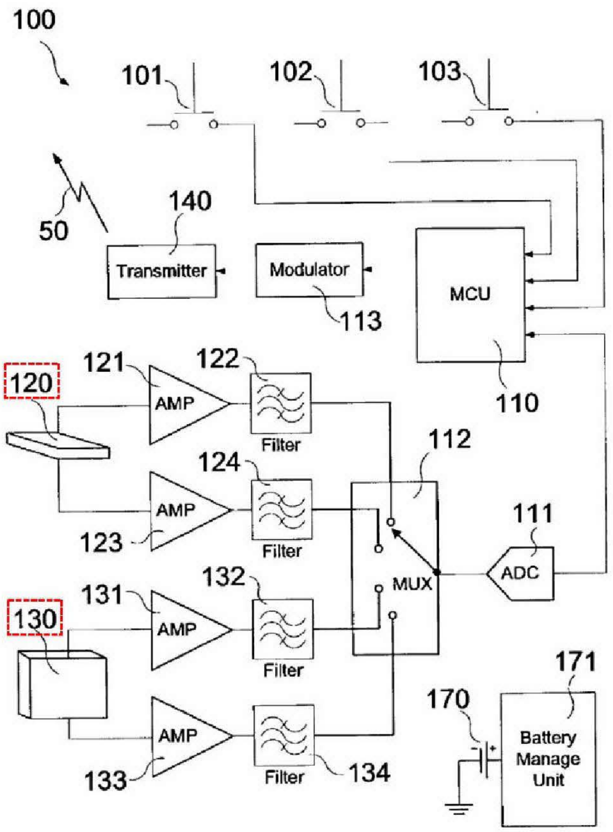


FIG. 5

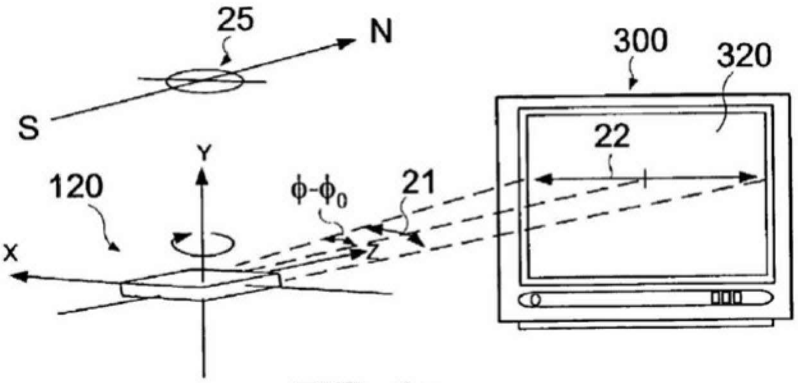


FIG. 4a

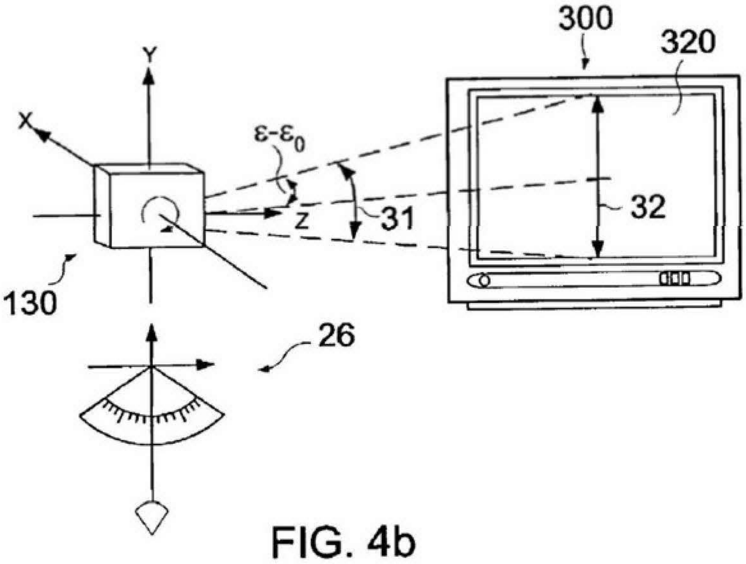


FIG. 4b

(Ex. 1002, ¶58). After Zhang's device calculates its own orientation, Zhang's system translates those angles into a display command (*e.g.* moving a cursor), by translating the angles into screen coordinates. (Ex. 1005, ¶¶0024, 0030)(Ex. 1002, ¶60).

Zhang's primary embodiment has a four-axis sensor module (compared to the "nine-axis sensor module" required by claim 10). Zhang explains that more sensors can be used, and that different kinds of sensors can be used. For example, Zhang states that gyro sensors (angular rate sensors that measure "rotation output") could be used:

> "The orientation sensors' mechanisms are shown in FIGS. 4a and 4b. The orientation sensor demonstrated in FIG. 4a is a magnetic field sensor, whereas the one in FIG. 4b is an accelerometer sensor. **However, the orientation detection may not be limited to these types of sensors**. **Other sensors, for example, a gyro sensor**, **can also be used** in the pointing control system."

(Ex. 1005, ¶0026)(Emphasis added)(Ex. 1002, ¶61). Zhang also mentions that accelerometers, magnetometers and gyro (angular rate) sensors can be used in combination. (Ex. 1005, ¶¶0006, 0026, claim 2)(Ex. 1002, ¶62).

Bachmann, in turn, provides an example of a nine-axis sensor system that combines accelerometers, magnetometers and angular rate detectors (*e.g.* gyroscopes), as suggested by Zhang. Bachmann, for example, states:

> "In another sensor embodiment, the **magnetometers** and **accelerometers** are supplemented with **angular rate detectors** configured to detect the angular velocity of the sensor (comprising so-called Magnetic, Angular Rate, Gravity (MARG) sensors). Each MARG sensor contains angular rate detectors, accelerometers, and magnetometers."

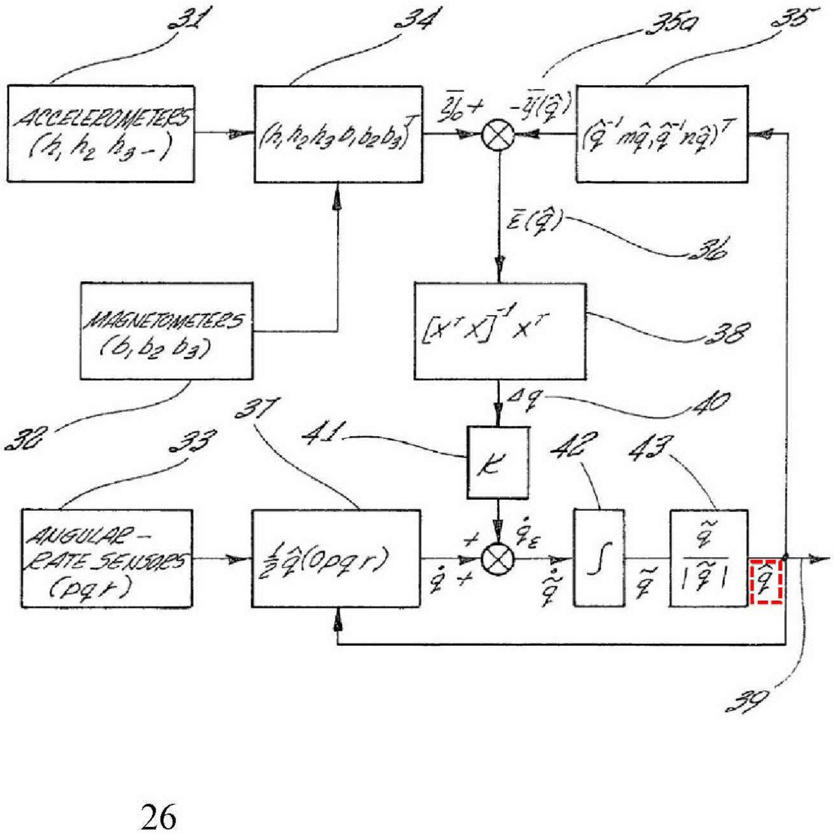
(Ex. 1004, 7:34-41)(Emphasis added)(Ex. 1002, ¶64). In Bachmann's system, each type of sensor is a three-axis sensor, making the entire system (3 sensor types x 3 axes per type) a nine-axis system. (Ex. 1002, ¶65).

Bachmann teaches combining sensor data using an attitude estimation *filter* to produce an estimate of the orientation of a tracked object. Bachmann explains:

> "[T]he filter inputs are from a **three-axis accelerometer** (h_1 h_2 h_3) 31, a **three-axis magnetometer** (b_1 b_2 b_3) 32, and a **three-axis angular rate sensor** (p, q, r) 33. Its output is a quaternion representation of the **orientation of the tracked object** $\hat{q}$ 39."

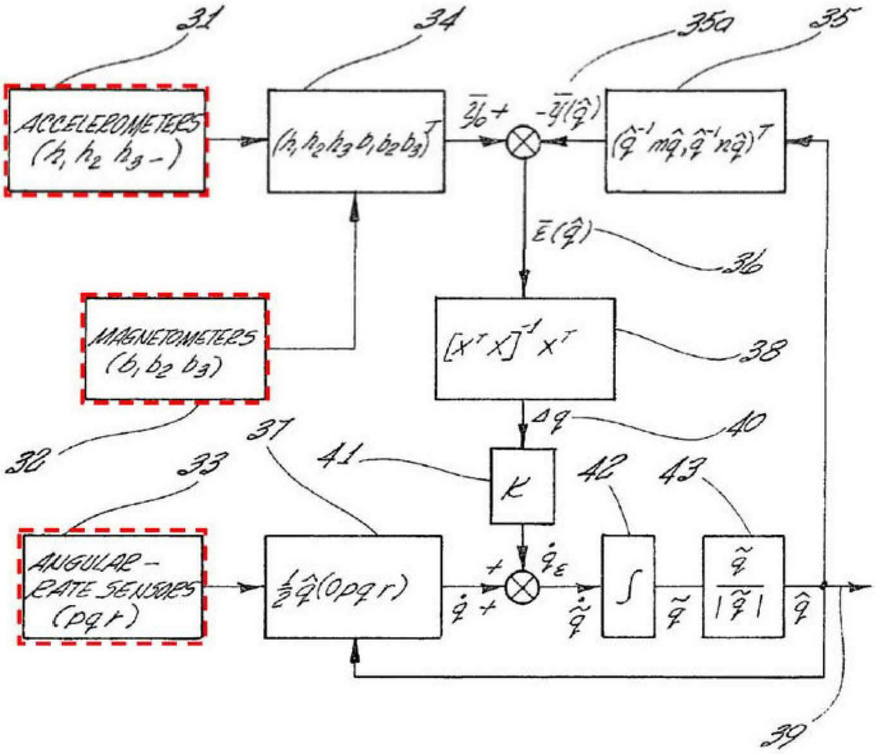
(Ex. 1004, 10:10-14)(Emphasis added)(Ex. 1002, ¶66). Bachmann thus takes the output of accelerometer, magnetometer and angular rate sensors, and uses these sensor outputs to calculate an orientation of a tracked device. (Ex. 1002, ¶67).

To calculate the orientation from sensor inputs, Bachman uses a filter. Bachmann's filter mirrors the claimed calculations of the '978 patent. (Ex. 1002, ¶68). A control diagram of Bachmann's filter process is shown in Fig. 3, reproduced at right, where the Petitioner has drawn a red-dashed box around the **output**, $\hat{q}$, in the lower right.



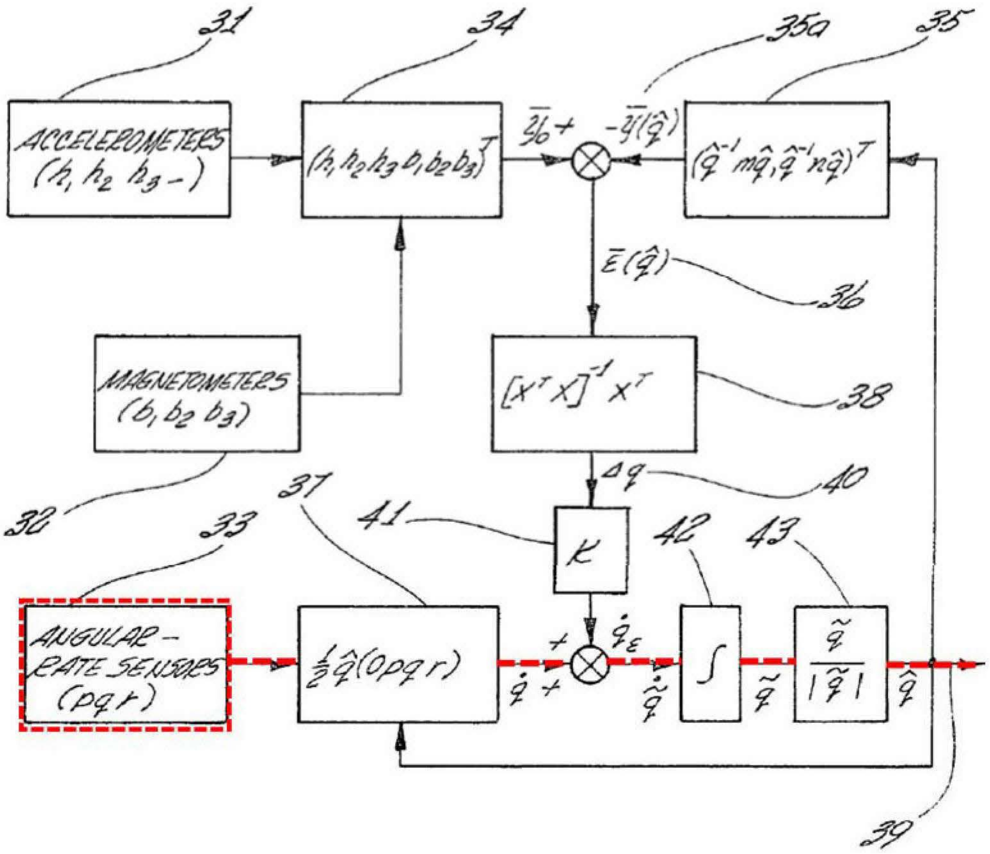
(Ex. 1004, Fig. 3)(Ex. 1002, ¶68). The output q̂ is a quaternion representing the orientation of the tracked object in space. (Ex. 1004, 10:10-14)(Ex. 1002, ¶68).

Bachmann's filter as shown in Fig. 3 receives inputs from three sets of sensors (accelerometers, magnetometers and angular-rate sensors) marked 31, 32 and 33, on the left side of Fig. 3. These sensors are shown in red-dashed boxes, below:



(Ex. 1002, ¶69).

The output of the angular rate sensors (33) is used to calculate the orientation of the device q̂. The calculation is shown in the boxes along the red-dashed line that has been added to the lower portion of Fig. 3, below:



(Ex. 1002, ¶70). In the figure, the output of the angular rate sensors (33) is a set of measured angular rates of rotation (p, q, r) about three axes. (Ex. 1004, 10:10-14)(Ex. 1002, ¶70). These rates are converted, in box 37, to a rate quaternion $\dot{q}$. (Ex. 1004, 10:15-36)(Ex. 1002, ¶70). To the rate quaternion $\dot{q}$ is added a correction factor $\dot{q}_\varepsilon$ (which will be explained below), to yield a corrected rate quaternion $\dot{\tilde{q}}$. (Ex. 1004, 10:15-65)(Ex. 1002, ¶¶70-74). The corrected rate quaternion $\dot{\tilde{q}}$ is then integrated in box 42 and normalized to a unit length in box 43, to yield the orientation quaternion at the output, $\hat{q}$. (Ex. 1004, 10:15-65)(Ex. 1002, ¶¶70-74).

Bachmann's filter shown in Fig. 3 takes advantage of extra sensor measurements from the accelerometers and magnetometers via the previously-mentioned correction factor, $\dot{q}_\varepsilon$. Bachmann calculates this correction factor $\dot{q}_\varepsilon$ in steps 34-41 of Fig. 3. There, Bachmann first obtains *actual* sensor measurements from the accelerometers[2] (31) and magnetometers (32), forming a six-valued measurement vector (h_1 h_2 h_3 b_1 b_2 b_3), as shown in box 34. (Ex. 1004, 10:10-14, 3:13-17, 8:47-51)(Ex. 1002, ¶72). These six measurement values include three measurements of acceleration along the X, Y and Z axes of the sensors, and three measurements for magnetism, also along the X, Y and Z axes of the sensors. (*Id.*). The six actual measurements are then compared to six predicted measurements found in the vector $\bar{y}(\hat{q})$, by subtracting the predicted measurements $\bar{y}(\hat{q})$ from the actual measurements (h_1 h_2 h_3 b_1 b_2 b_3). (Ex. 1004, 8:63-9:18, 17:12-22)(Ex. 1002, ¶72). This forms a six-valued error vector $\bar{\varepsilon}(\hat{q})$, numbered 36. (Ex. 1004, 17:12-22, 9:9-14)(Ex. 1002, ¶72).

The six-valued error vector $\bar{\varepsilon}(\hat{q})$ is essentially a measure of how actual accelerometer and magnetometer measurements differ from what the filter predicts those measurements should be based on the angular rate sensor output. (Ex. 1004, 17:12-22, 9:9-14)(Ex. 1002, ¶73). The difference $\bar{\varepsilon}(\hat{q})$ is utilized in boxes 38 and 41.

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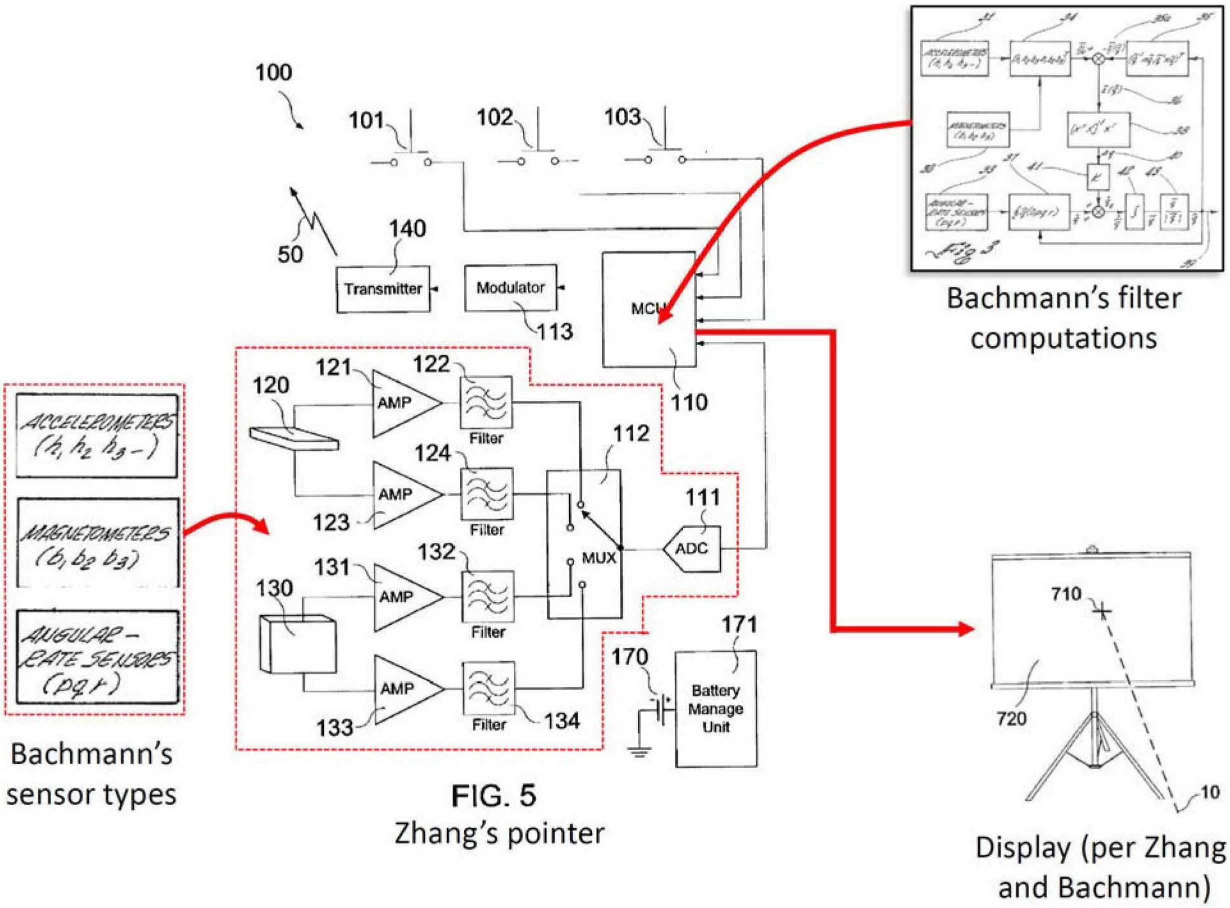
[2] The accelerometer measurements are first low-pass filtered to remove sudden accelerations. (Ex. 1004, 8:12-20)(Ex. 1002, ¶125).

There, the filter selects a correction factor $\dot{q}_{\varepsilon}$ that will minimize $\overline{\varepsilon}(\hat{q})$. (Ex. 1004, 9:9-35)(Ex. 1002, ¶73). That is, the filter will choose a correction factor $\dot{q}_{\varepsilon}$ that, when added to $\dot{q}$, will minimize the difference between the actual measurements (h_1 h_2 h_3 b_1 b_2 b_3) and the predicted measurements for those same values. (Ex. 1004, 9:9-35)(Ex. 1002, ¶73). This has the effect of compensating the orientation output of the filter, $\hat{q}$. (Ex. 1002, ¶73).

The combination proposes using the 3D pointer of Zhang (modified to include additional sensors), together with Bachmann's filter process to calculate a device orientation. Once a device orientation has been calculated, it can be converted to the coordinate system of a display device, as disclosed in both Zhang and Bachmann. The combination can be illustrated with the Figure below, created by the Petitioner, showing the relevant modifications to the Zhang pointer (adding sensors and using Bachmann's filter calculations):



(Ex. 1002, ¶93).

Rationale for the Combination

It would have been obvious to a person of skill in the relevant timeframe[3] to use Zhang's 3D pointer with Bachmann's sensors and filter calculations. As

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[3] The first provisional application in the chain of applications leading to the '978 patent was filed on January 6, 2010. Petitioner disagrees that this is the proper priority date, and notes that subsequent applications were continuations-in-part applications but for purposes of this Petition assumes that this date applies.

discussed above in the Overview section beginning on page 23, Zhang expressly states that additional sensors can be used, and in particular, that “gyro” (angular rate) sensors can be used. (Ex. 1005, ¶¶0006, 0025, 0026, claim 2)(Ex. 1002, ¶¶61-63, 94). Thus, it would have been obvious to add sensors to Zhang, including the angular rate sensors of Bachmann, based on Zhang’s express suggestion. Furthermore, a person of ordinary skill would have understood that additional sensors, and additional types of sensors, would have yielded at least two benefits. (Ex. 1002, ¶95). First, additional sensors (in particular sensor axes) and additional sensor types would have allowed the device to detect different modes of movement, for example a roll angle, thus better allowing the device to translate user movements to display operations. (Ex. 1002, ¶94). Second, additional sensor axes and sensor types would have increased the overdetermination (the amount of information beyond that necessary to determine orientation), which in turn would have enabled better error and noise control. (Ex. 1002, ¶94).

Bachmann’s nine-axis sensors were also well-known in the art in the relevant timeframe. Bachmann, which issued in 2006, states that magnetic, angular rate and gravitational (acceleration) sensors were known in the art as MARG sensors, were already commercially available, and could be integrated in a known fashion. Bachmann states:

> "One example of a suitable sensor device is an analog MARG sensor. In one embodiment such a sensor measures 10.1x5.5x2.5 cm. The analog output of the sensor is connected to a breakout header via a thin VGA monitor cable. Output range is 0-5 vdc. The power requirement of the sensors is 12 vdc at approximately 50 milliamperes. The primary sensing components are a triaxial accelerometer (e.g. a Model No. CXL04M3 manufactured by Crossbow, Inc.), a 3-axis magnetometer (e.g., Model No. HMC2003 from Honeywell), and three miniature angular rate detectors mounted in an orthogonal configuration (e.g., Tokin CG-16D series sensors available from Tokin American, Inc.). The individual components can be integrated using a single integrated circuit board with the accelerometers mounted separately. Rate sensor output voltage is amplified by a factor of five and filtered to attenuate rate sensor oscillator noise. **Such MARG sensors can be obtained from McKinney Technology of Prunedale, Calif**. **Software or hardware biasing can be used to successfully integrate the signal from the angular rate detectors with the rest of the system**."

(Ex. 1004, 14:37-57)(Emphasis added)(Ex. 1002, ¶96). Bachmann further states that its sensors and filter are applicable to hand-held devices (like Zhang's):

> "By mounting a plurality of sensors on a body, the posture of the body can be determined and tracked. **Sensors constructed in accordance with the principles of the present invention can be used to track motion and orientation of simple rigid bodies** as long as they are made of non-magnetic materials. Examples include,

> but are not limited to **hand-held devices**, swords, pistols, or simulated weapons."

(Ex. 1004, 13:42-48)(Emphasis added)(Ex. 1002, ¶97). There was thus significant motivation to use known nine-axis MARG sensors to improve the measurement capabilities of the Zhang hand-held pointer, as suggested by Zhang and Bachmann. (Ex. 1002, ¶¶95-98).

In using Bachmann's suggested MARG sensors, it would have been obvious to use Bachmann's quaternion-based filter techniques (as illustrated, for example, in Fig. 3 of Bachmann), because those filter techniques were adapted directly to MARG sensors. (Ex. 1004, 7:18-45)(Ex. 1002, ¶99). In particular, Bachmann teaches that its filter techniques using quaternion calculations are superior to filters that (internally) use spatial (*e.g.* Euler) angle calculations, because the quaternion-based techniques are computationally more efficient and avoid singularities that might otherwise occur at certain sensor orientations. (Ex. 1004, 5:33-7:31)(Ex. 1002, ¶99). This yields a highly advantageous orientation calculation. Bachmann states:

> "The principles of the present invention use magnetometer and accelerometer input subject to filtering to track body posture. In one implementation, Euler angles and their related coordinate transform matrices are used to calculate body orientation. Although computationally intensive, embodiments of the present invention can use Euler angle calculations to track body orientation. Additionally, angular velocity information can be used to correct for time lag

> errors. However, other embodiments of the present invention present a **particularly advantageous approach** for achieving body tracking using quaternion mathematics. **Such embodiments eliminate the Euler angle singularity problem, and reduce the computational complexity of the invention**."

(Ex. 1004, 7:4-17)(Emphasis added)(Ex. 1002, ¶99). Thus, a person of ordinary skill would have used Bachmann's improved quaternion-based filter (as illustrated in Fig. 3) with the sensors for which it was designed, based on Bachmann's express recommendation. (Ex. 1002, ¶100).

The combination is also, separately, supported by the rationales discussed in *KSR Int'l Co. v. Teleflex, Inc.*, 580 U.S. 398 (2007). There, the Supreme Court held (*e.g.*) that "[t]he combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *Id.* at 416. Furthermore, "if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill." *Id.* at 417.

In the present case, Zhang's device has a housing, sensors and a software for using sensor output to calculate the orientation of the device. (Ex. 1002, ¶101). Bachmann has the same, but uses additional sensors and a modified calculation. (Ex. 1002, ¶101). Bachmann's sensors were well-known and available on the commercial market, while Bachmann's calculations were known at least as soon as Bachmann's specification published. (Ex. 1002, ¶¶96, 101). These functional blocks (sensors and calculations) could have been substituted for the same functional blocks in Zhang requiring only ordinary skill to implement (as discussed in the next section). (Ex. 1002, ¶101). There would have been no unexpected results—only the *expected* improvement promised by Bachmann. (Ex. 1002, ¶101). The combination is thus further supported by *KSR*.

Finally, it would have been obvious to use the orientation calculated by Bachmann's filter to calculate coordinates that can be used on a display device. (Ex. 1002, ¶102). This is the intended use of Zhang's 3D pointer—to translate human movements while holding the pointer into commands that can be executed on-screen, such as movements of a cursor. (Ex. 1002, ¶102). For example, Zhang states:

> "The CPU in the display control unit interprets the direction information, sends the pointer move command to the computer's peripheral port, and instructs the computer to move the pointer 710 on screen to the aimed place. This is analogous to moving the pointer by moving a regular computer mouse device, except that the moving information is in absolute coordinates instead of relative steps."

(Ex. 1005, ¶0024)(Ex. 1002, ¶102). To do this, Zhang's system performs a transformation of device orientation from a device-centered frame of reference to a frame of reference associated with a display. Zhang explains:

> "The CPU compares **the device's azimuth and inclination angle data with the reference angles**, which are sampled and stored in the memory module 270 during the calibration procedure. The difference angles calculated are **translated into screen coordinates** and the target device is instructed to move the pointer to the new location."

(Ex. 1005, ¶0030)(Emphasis added)(Ex. 1002, ¶103). Bachmann likewise discloses that its orientation output can be used with a display.

> "The system can further include a display for displaying the position and orientation of the body with respect to a synthetic environment."

(Ex. 1004, 4:26-28)(Ex. 1002, ¶104). A person of skill in the art would have understood a display with a "synthetic environment" to have a fixed reference frame associated with a display device, so that images controlled by a pointer can be displayed on screen, as shown conceptually in Fig. 4 of Bachmann, reproduced below:

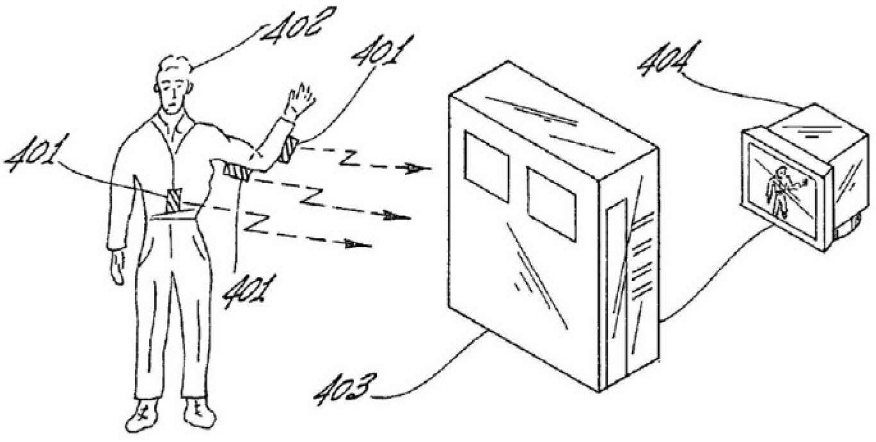


Fig 4

(Ex. 1002, ¶104). As shown in Fig. 4, sensors 401 located on a human body allow the image of a body to be displayed on a display screen 404, in display screen coordinates. (Ex. 1004, 13:64-14:29)(Ex. 1002, ¶105). Thus, Zhang expressly discloses the transformation of orientation to a display frame of reference, and Bachmann suggests transforming orientation output in a way that can be reproduced on a display device. (Ex. 1002, ¶¶102-105).

Ability to Implement and Reasonable Expectation of Success

A person of skill in the art in the relevant timeframe would have been able to implement the combination and would have had a reasonable expectation of success. (Ex. 1002, ¶¶106-110). As discussed above, sensors of the type described by Bachmann were widely available on the commercial market. (Ex. 1002, ¶106). A person of ordinary skill would have been able to integrate these sensors into Zhang's device using standard conditioning circuits, samplers and analog-to-digital converters, making adjustments as necessary. (Ex. 1002, ¶106).

Bachmann's filter calculations, in turn, could have been executed in software predictably and using only ordinary skill. Both Zhang and Bachmann teach implementing orientation calculations on computer chips, for example Zhang's MCU 110 (Ex. 1005, ¶0029) or Bachmann's CPU 403 (Ex. 1004, 13:64-14:29). (Ex. 1002, ¶107). In the relevant timeframe, microprocessors and microcontrollers with sufficient power to implement Bachmann's filter would have been readily available. (Ex. 1002, ¶107). A person of skill likewise would have expected success performing a transformation of Bachmann's orientation output into the frame of reference of a display device. (Ex. 1002, ¶108).

The '978 patent itself, for example, reports no difficulty in constructing appropriate circuits to use sensor output, nor in implementing the relevant mathematics in appropriate software. (Ex. 1002, ¶109). In fact, the '978 patent does not explain how to implement its sensor within appropriate circuits or its mathematics within appropriate software in any detail, thereby admitting for the purposes of assessing obviousness that such details were within ordinary skill. (Ex. 1002, ¶109). *See In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 2004)("[T]he Board's observation that appellant did not provide the type of detail in his specification that he now argues is necessary in prior art references supports the Board's finding that one skilled in the art would have known how to implement the features of the references….”).

A person of ordinary skill therefore would have been able to implement the combination and would have had a reasonable expectation of success.

Graham Factors

The **level of ordinary skill** in the art corresponds to a person with an undergraduate degree in computer science, electrical engineering, mechanical engineering, or other related technical field, and knowledge of sensor systems. (Ex. 1002, ¶25). The prior art also reflects the level of ordinary skill. (Ex. 1002, ¶26)

The **scope and content of the prior art** are discussed throughout the ground.

The **differences between the prior art and the claims** are discussed in the "Overview of the Combination" and in the claim mapping, below.

Petitioner is not aware of any **secondary considerations** that would make an inference of non-obviousness more likely.

Claim Mapping

The elements of claims 10 and 12 are mapped to the combination of Zhang and Bachmann in the following section, where the relevant claim language is provided in bold-italic font, and the mapping in the text that follows each claim element. In claim 10, lettering has been added to each element (*e.g.* [10b]) to assist the discussion of the issues. The discussion in the claim mapping section supplements the discussion of the ground above, and the two should be read together.

Claim 10

"10[a]. A method for compensating rotations of a 3D pointing device, comprising:"

As discussed above in the Overview of the Ground, Zhang discloses a **3D pointing device**. (Ex. 1005, Title, Abstract)(Ex. 1002, ¶112). An example of the 3D pointing device is shown as device 100 in Fig. 2 of Zhang, reproduced at right. (Ex. 1002, 112).

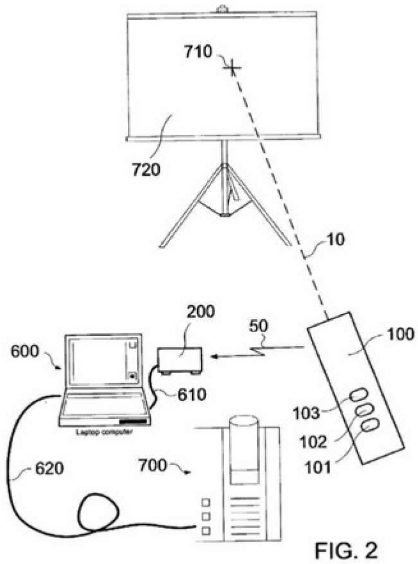


FIG. 2

Zhang states:

> "The object of the present invention is to provide a low-cost, practical, **universal pointing device** to control home entertainment systems and computer systems using spatial orientation sensor technologies."

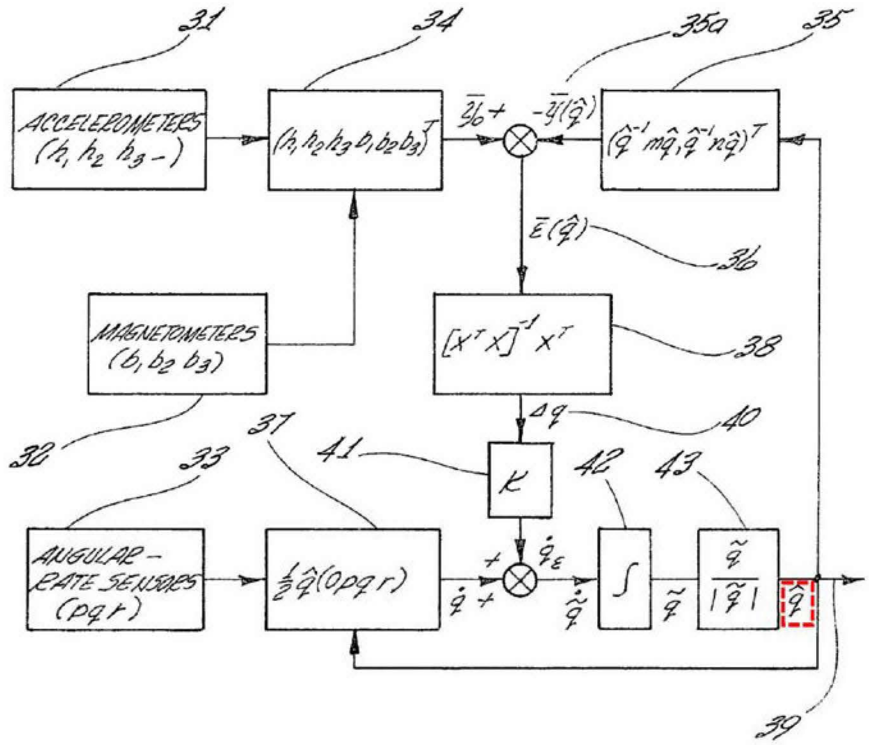
(Ex. 1005, ¶0007)(Ex. 1002, ¶112).

Zhang's pointer is a "**3D** pointer" because it can be moved in a user's hand in 3D space, and its orientation will be tracked "in three-dimensional space". (Ex. 1005, claim 2, ¶0021, ¶0008)(Ex. 1002, ¶113). As discussed above, it would further have been obvious to use Zhang with three sets of three types of sensors (rotational velocity, axial acceleration and magnetism) to improve the determination of orientation in **three-dimensional** space. (Ex. 1002, ¶114).

The combination discloses a **method of compensating rotations** of the device, as described in steps [10b]-[10h], below. (Ex. 1002, ¶114).

> ***"[10b] generating an orientation output associated with an orientation of the 3D pointing device associated with three coordinate axes of a global reference frame associated with Earth;"***

The combination of Zhang and Bachmann uses Bachmann's attitude estimation filter to generate an orientation quaternion. (Ex. 1002, ¶115)(Ex. 1004, 7:59-61). The orientation quaternion, called q̂, is the required **orientation output**. (Ex. 1002, ¶115). The orientation output of the filter (q̂) is shown in the lower right of Fig. 3 of Bachmann, which is reproduced below with the output q̂ shown in an added red-dashed box.



(Ex. 1002, ¶115).

The orientation quaternion is **associated with an orientation of the 3D pointing device**, because it describes the orientation of the 3D pointing device. Bachmann explains:

> "[T]he filter inputs are from a three-axis accelerometer (h_1, h_2, h_3) 31, a three-axis magnetometer (b_1, b_2, b_3) 32, and a three-axis angular rate sensor (p, q, r) 33. Its **output is a quaternion representation of the orientation of the tracked object $\hat{q}$** 39."

(Ex. 1004, 10:10-14)(Emphasis added)(Ex. 1002, ¶116). In the combination, the "tracked object" is Zhang's 3D pointer, as explained above in the Overview of the Combination, beginning on page 19. (Ex. 1002, ¶117).

The orientation output $\hat{q}$ is **associated with three coordinate axes of a global reference frame associated with Earth**. (Ex. 1002, ¶118). Specifically, $\hat{q}$ is a quaternion describing orientation of the tracked body, by describing the rotation between a sensor frame of reference to a "flat Earth" or "Earth-fixed" coordinate system, in which the angles roll, pitch (elevation) and yaw (azimuth) describe orientation. (Ex. 1002, ¶¶118, 122).

This can be seen directly from Bachmann. As stated in Bachmann, the output $\hat{q}$ represents the *orientation* of a tracked object. (Ex. 1002, ¶119). The "orientation" of a tracked object, according to Bachmann, is often described using the same Euler angles that are described in the '978 patent, associated with an Earth-associated coordinate system. Bachmann states:

> "A conventional way of describing the **orientation of a rigid body** uses '**Euler angles**' to describe the orientation of a rigid body in three dimensions. Euler angles describe the orientation of a rigid body using three rotations about specified axes. **One commonly used reference coordinate system is the local 'flat Earth' system**. Such reference systems use an arbitrarily selected origin on the surface of the earth with respect to coordinate axes X, Y, and Z. By convention, the X-direction corresponds to local north, the Y- direction corresponds to local east, and the Z-direction corresponds to down as depicted in FIG. 2(a)."

(Ex. 1004, 5:50-61)(Emphasis added)(Ex. 1002, ¶119). The Earth-associated coordinate system is shown in Fig. 2(a) of Bachmann, reproduced below at right. (Ex. 1002, ¶120). Bachmann states that the angles shown in Fig. 2(a), specifically Θ, Φ, and φ, correspond to the elevation (pitch), roll and azimuth (yaw), respectively about the X, Y and Z axes. These are the **three coordinate axes**. (Ex. 1004, 6:1-10)(Ex. 1002, ¶120).

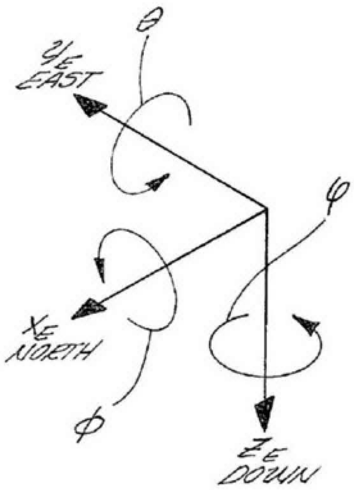


Fig 2(a)

Bachmann also states, however, that the use of Euler angles is computationally expensive and can result in singularities. (Ex. 1004, 6:25-7:3)(Ex. 1002, ¶121). For that reason, Bachmann states that orientation can be presented as a quaternion. (Ex. 1004, 7:18-31)(Ex. 1002, ¶121). The quaternion still represents the Euler angles and is still **associated with three coordinate axes of a global reference frame associated with Earth**. (Ex. 1002, ¶121). The fact that $\hat{q}$ is a quaternion representing the angles between the sensor frame to the earth-fixed frame of reference can be seen directly from equation (7) of Bachmann ($h=\hat{q}^{-1}m\hat{q}$). (Ex. 1002, ¶121). Equation (7) uses the orientation quaternion $\hat{q}$ in inverse fashion to transform the vector m to the vector h. This transformation is one "from the earth fixed frame to the sensor frame". (Ex. 1004, 8:63-67). Because $\hat{q}$ is used in inverse fashion to transform a vector from the earth fixed frame to the sensor frame, $\hat{q}$ itself (if *not* used in inverse fashion) represents a rotation in the opposite direction: from the sensor frame to the earth fixed frame. (Ex. 1004, 8:63-67)(Ex. 1002, ¶121). As explained by Professor Sarrafzadeh, the quaternion is simply an alternate expression of the Euler angles. (Ex. 1002, ¶¶121, 30-32).

The use of a quaternion to describe orientation falls within the scope of claim 10 as an "orientation output", at least because dependent claim 12 expressly states that "the orientation output is a rotation matrix, a **quaternion**, a rotation vector, or comprises three orientation angles." (Ex. 1001, claim 12)(Emphasis added)(Ex. 1002, ¶121). *See Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 910 (Fed. Cir. 2004)(Presence of a limitation in a dependent claim creates presumption that the independent claim is broader than the limitation in the dependent claim).

"[10c] generating a first signal set comprising axial accelerations associated with movements and rotations of the 3D pointing device in the spatial reference frame;"

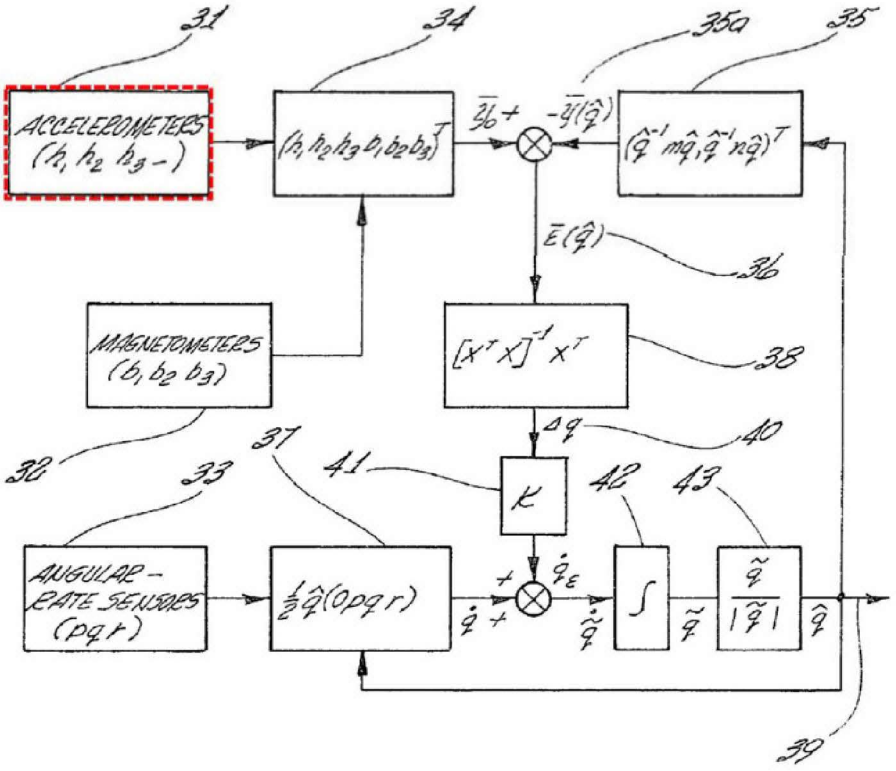
The combination of Zhang and Bachmann would use a set of three axial acceleration sensors. (Ex. 1002, ¶123). The sensors **generate a first signal set** designated $\vec{a}_{measured}$ in Bachmann. Bachmann explains as follows:

> "In one embodiment, a three-axis accelerometer can be used to measure total acceleration (forced linear acceleration and gravitational reaction force) $\vec{a}_{measured}$ as over a fixed time period."

(Ex. 1004, 8:12-16)(Ex. 1002, ¶123). The total acceleration is expressed in Bachmann in equation (1) reproduced here:

$$\vec{a}_{measured} = \vec{a} + \vec{g} \tag{1}$$

The signals $\vec{a}_{measured}$ are low-pass filtered to remove fast accelerations to form a vector h, which is shown in Fig. 3 of Bachmann. (Ex. 1004, 8:13-42)(Ex. 1002, ¶¶124-125). Figure 3 is reproduced below with a red box around the accelerometers and their output signals (h1, h2, h3)(which are filtered versions of $\vec{a}_{measured}$):



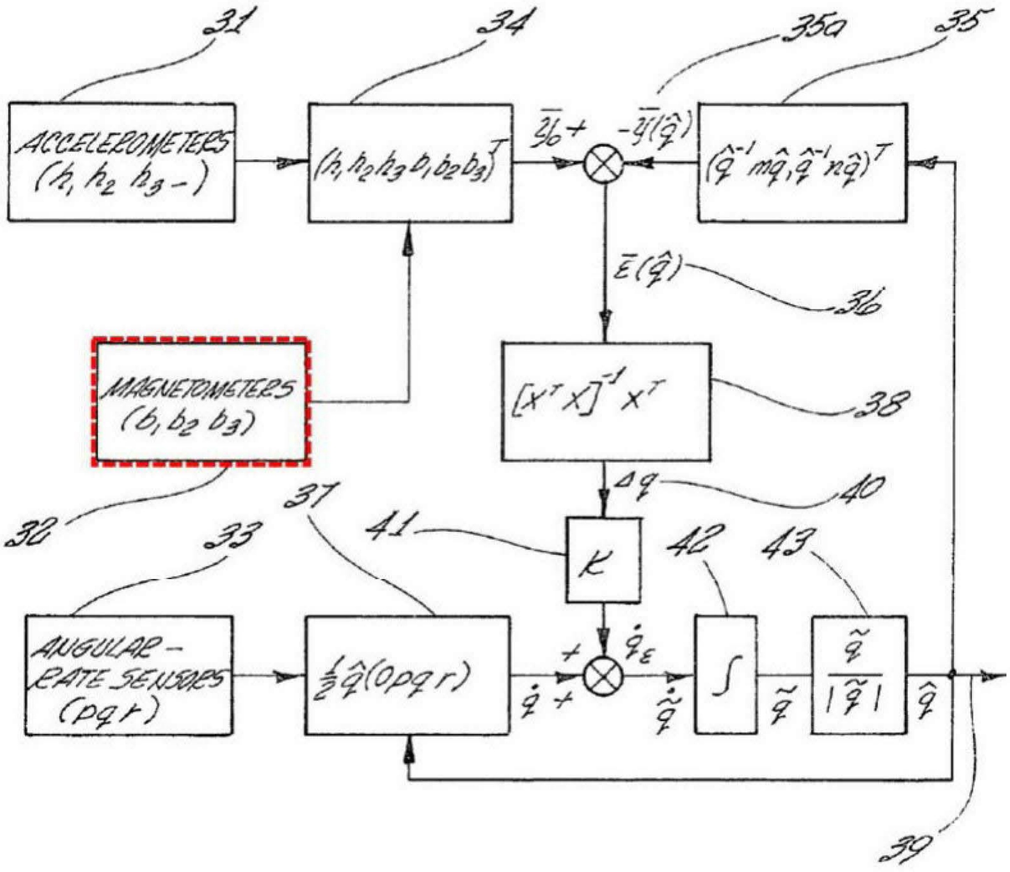
(Ex. 1002, ¶125).

The accelerometer measurements generate a signal set $\vec{a}_{measured}$ that **comprises axial accelerations associated with movements and rotations of the 3D pointing device**, because (as shown in the block quote above) the signals $\vec{a}_{measured}$ comprise forced linear acceleration. (Ex. 1004, 8:12-16) (Ex. 1002, ¶126). These forced linear accelerations are accelerations that the device experiences due to movement and rotation. (Ex. 1002, ¶126). In addition, the gravitational accelerations are also accelerations that the 3D pointing device experiences due to movements and rotations, as rotation of the device will alter the linear acceleration along each axis, Ax, ~~Az~~AY, Az. (Ex. 1002, ¶125).

The accelerations are **in the spatial reference frame**, because the sensors are mounted to the pointer, and the orientation of the sensors (and thus their axes of sensing) move and rotate with the movements and rotations of the pointer. (Ex. 1002, ¶127). This fact can also be seen directly from equation (7) of Bachmann ($h=\hat{q}^{-1}m\hat{q}$). (Ex. 1002, ¶¶122, 127). Equation (7) uses the orientation quaternion $\hat{q}$ to transform the vector m—which represents gravity in earth-fixed coordinates of Fig. 2(a)—to the vector h, which is just a filtered version of the first signal set $\vec{a}_{measured}$. (Ex. 1004, 8:63-67)(Ex. 1002, ¶¶122, 127). The transformation causes m to be converted "from the earth fixed frame to the sensor frame" (Ex. 1004, 8:63-67), and further demonstrates that the resulting filtered accelerometer output h is in the pointer frame of reference. (Ex. 1002, ¶¶122, 127). The pointer frame of reference, in turn, is the **spatial reference frame** required by the claim. (Ex. 1001, 5:60-64, 6:10-13)(Ex. 1002, ¶¶122, 127).

"[10d] generating a second signal set associated with Earth's magnetism;"

The combination of Zhang and Bachmann would use a set of three magnetometers. (Ex. 1002, ¶128). The magnetometers generate **a second signal set** designated (b_1, b_2, b_3) in Bachmann. These signals are shown in Fig. 3 of Bachmann, reproduced below with a red-dashed box around the magnetometers and their output signals (b_1, b_2, b_3):



(Ex. 1002, ¶128). Bachmann explains:

> "The magnetometers measure and return the direction of the local magnetic field vector (the unit vector b) 32."

(Ex. 1004, 7:63-65)(Ex. 1002, ¶129). As further explained in Bachmann, the local magnetic field vector is **associated with Earth's magnetism**:

> "An embodiment of the present invention makes use of the fact that a local magnetic field vector and local gravity vector can be defined. FIG. 1 is a simplified figurative illustration of the surface of the earth 10 showing a local gravity vectors 11 and **a local magnetic field vector 13. In general, for any object positioned on the earth 10**, the gravity vectors always points to the earth's center of mass, which

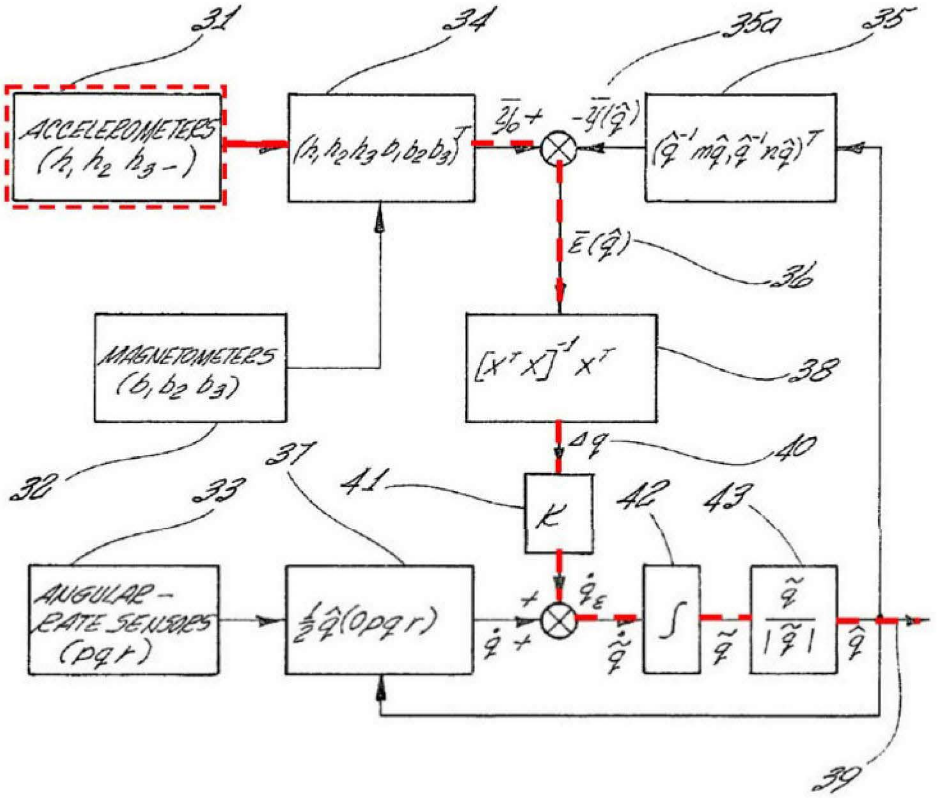
> may be defined as "down". This phenomenon is simply illustrated in FIG. 1. Additionally, **the magnetic field vector 13 always points to magnetic north.**"

(Ex. 1004, 5:11-20)(Emphasis added)(Ex. 1002, ¶129).

> ***"[10e] generating the orientation output based on the first signal set, the second signal set and the rotation output or based on the first signal set and the second signal set;"***

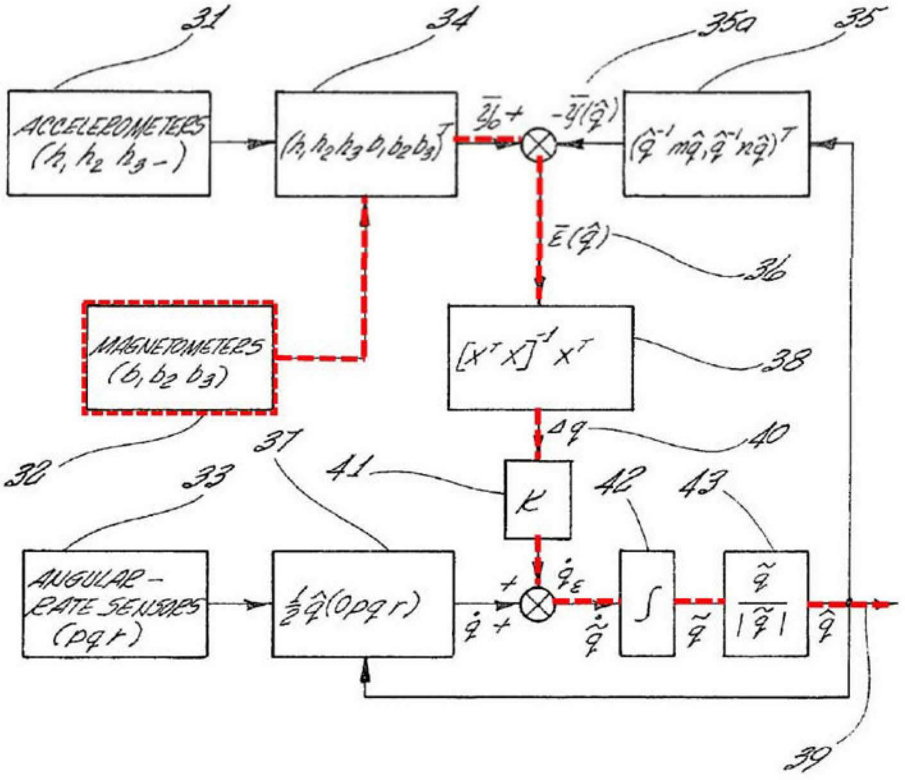
As explained above in the Overview of the Combination, beginning on page 19, Bachmann generates the orientation output $\hat{q}$ both **based on the first signal set, the second signal set** and **the rotation output,** because each of these signal sets are used in calculating $\hat{q}$. (Ex. 1002, ¶130).

The orientation output $\hat{q}$ is **based on the first signal set** ($\vec{a}_{measured}$). The first signal set $\vec{a}_{measured}$, once acquired, is filtered to yield $h=(h_1, h_2, h_3)$. (Ex. 1004, 8:63-67)(Ex. 1002, ¶131). This vector h is then compared to predicted measurements $\bar{y}(\hat{q})$, and used to generate a correction ($\dot{q}_\varepsilon$) that is added to rate quaternion ($\dot{q}$). (Ex. 1004, 9:9-35, 10:15-65)(Ex. 1002, ¶131). The corrected rate quaternion is then integrated and normalized to yield the orientation output, $\hat{q}$. (Ex. 1004, 10:15-65)(Ex. 1002, ¶131). The path in Fig. 3 from the accelerometers to the orientation output $\hat{q}$ is shown by the added red-dashed lines in Fig. 3, below:



(Ex. 1002, ¶131).

The orientation output $\hat{q}$ is also **based on the second signal set** (b_1, b_2, b_3)(produced by the magnetometers). The second signal set is, like the filtered first signal set, compared to predicted measurements $\bar{y}(\hat{q})$, and used to generate a correction ($\dot{q}_\varepsilon$) that is added to rate quaternion ($\dot{q}$). (Ex. 1004, 9:9-35, 10:15-11:12)(Ex. 1002, ¶132). The corrected rotational velocity is then integrated and normalized to yield the orientation output, $\hat{q}$. (Ex. 1002, ¶132). The path in Fig. 3 from the magnetometers to the orientation output $\hat{q}$ is shown by the added red lines in Fig. 3, below:



(Ex. 1002, ¶132).

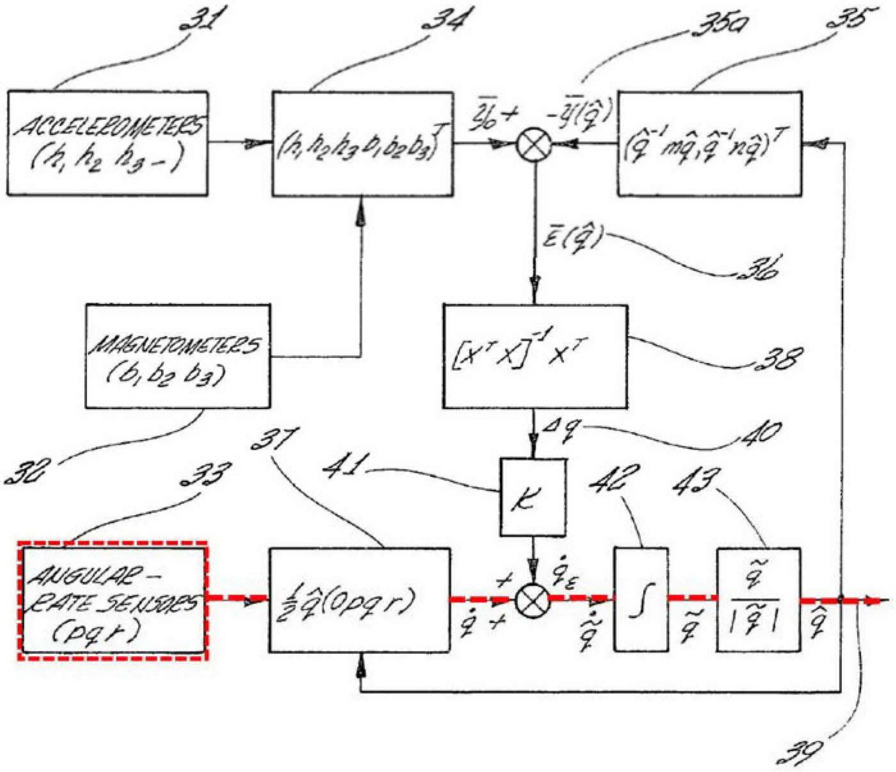
The orientation output q̂ is also **based on the rotation output**. (Ex. 1002, ¶133). "The rotation output" is not previously mentioned in the claims, but is simply the angular velocity output of rotational sensors. *See* §II.B, above, as well as the discussion under element [10f], below. Bachmann uses "angular rate" sensors to output an angular rate vector (p, q, r), as shown in box 33 of Fig. 3. (Ex. 1004, 9:50-10:65)(Ex. 1002, ¶133). Bachmann explains:

> "FIG. 3 depicts the inputs from sensor embodiments that include **angular velocity (rate) detectors 33**. Interpreted in this way, such a filtering embodiment measures angular rate information 33, and uses measurements of local magnetic field 32 and local gravity 31 to correct the angular rate information or integrated angular rate

information."

(Ex. 1004, 9:52-58)(Emphasis added)(Ex. 1002, ¶133). The "angular velocity (rate)" of angular rate sensors 33, shown as (p, q, r) in Fig. 3 of Bachmann, is the **rotation output** required by the claim. (Ex. 1004, 10:10-14)(Ex. 1002, ¶134).

This rotation output (p, q, r) is converted to the rate quaternion $\dot{q}$. (Ex. 1004, 10:15-45)(Ex. 1002, ¶135). The rate quaternion $\dot{q}$, in turn, is then corrected using $\dot{q}_\varepsilon$ (as described above), and used to generate the orientation output $\hat{q}$. (Ex. 1004, 10:37-11:20)(Ex. 1002, ¶135). The path in Fig. 3 from the rotational velocity sensors to the orientation output $\hat{q}$ is shown by the added red-dashed lines in Fig. 3, below:



(Ex. 1002, ¶135).

In this way, the orientation output $\hat{q}$ is both (1) **based on the first signal set, the second signal set and the rotation output** and is also (2) **based on the first signal set and the second signal set**. (Ex. 1002, ¶136).

> ***"[10f] generating a rotation output associated with a rotation of the 3D pointing device associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device;"***

As discussed immediately above, Bachmann uses angular velocity (rate) detectors 33 to **generate a rotation output** (p, q, r). This initial rotation output (p, q, r), which is shown in box 33 of Fig. 3 of Bachmann, is **associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device**. Specifically, the angular rate sensor is a "**three-axis** angular rate sensor". Ex. 1004, 10:12)(Emphasis added)(Ex. 1002, ¶138). The axes are the three **coordinate axes of the spatial reference frame of the pointer**. (Ex. 1002, ¶138). This is because the angular rate sensors are fixed to the tracked object, and their axes of measurement change when the tracked object is rotated. (Ex. 1002, ¶138). As Bachmann states, referring to equation (11), the angular rates are "measured in the sensor reference frame." (Ex. 1004, 10:17-30)(Ex. 1002, ¶138). The "sensor reference frame" in Bachmann is the "spatial reference frame of the pointer" in the '978 patent. (Ex. 1002, ¶138).

Each of p, q, and r represent an angular velocity around a particular **axis**. For example, q is the pitch rate. (Ex. 1004, 10:30-32)(Ex. 1002, ¶139). A person of ordinary skill would have understood that p is the roll rate, while r is the yaw rate within the sensor frame of reference. (Ex. 1002, ¶139).

> ***"[10g] and using the orientation output and the rotation output to generate a transformed output associated with a fixed reference frame associated with a display device, wherein the orientation output and the rotation output is generated by a nine-axis motion sensor module;"***

As discussed above under limitations [10e] and [10f], the Bachmann system generates an **orientation output** $\hat{q}$ and a **rotation output** (p, q, r). In the combination, these outputs are **generated by a nine-axis motion sensor module**, specifically, the module containing the Bachmann filter, which has "a three-axis accelerometer (h_1, h_2, h_3) 31, a three-axis magnetometer (b_1, b_2, b_3) 32, and a three-axis angular rate sensor (p, q, r) 33." (Ex. 1004, 10:10-14)(Ex. 1002, ¶140). Three sensor types times three axes each yields a nine-axis module. (Ex. 1002, ¶140).

As discussed above beginning with the Overview of the Combination and Rationale for the Combination sections, it would have been obvious to generate a **transformed output associated with a fixed reference frame associated with a display device.** Bachmann suggests that its orientation output be transformed to the coordinate system of a display device (*e.g.* in connection with Fig. 4). Zhang, in turn, expressly discloses such a transformation:

"The CPU compares t**he device's azimuth and inclination angle**

> **data with the reference angles**, which are sampled and stored in the memory module 270 during the calibration procedure. The difference angles calculated are **translated into screen coordinates** and the target device is instructed to move the pointer to the new location."

(Ex. 1005, ¶0030)(Emphasis added)(Ex. 1002, ¶141).

For the reasons discussed above under "Rationale for the Combination", beginning on page 30, it would have been obvious to **use the orientation output and the rotation output for this transformation**. The orientation output $\hat{q}$ tracks the orientation of Zhang's pointing device. To implement Zhang's suggestion that difference angles are translated to screen coordinates, a person of ordinary skill would have found it obvious to use the available estimate of orientation—the **orientation output** $\hat{q}$— to obtain difference angles to translate. (Ex. 1002, ¶142).

The combination of Zhang and Bachmann would also **use the rotation output** in the transformation in two ways. First, because the orientation output $\hat{q}$ itself is based on the rotation output (as discussed above under element [10e]), the transformation to display coordinates based on $\hat{q}$ would necessarily **use the rotation output**. (Ex. 1002, ¶143). Second, it would have been obvious to transform not only orientation $\hat{q}$, but also an estimate of angular velocity (*e.g.* $\dot{q}$) into display coordinates. This would have allowed the display pointer in Zhang's system to be more smoothly and consistently rendered during rotation of the pointing device. (Ex. 1002, ¶143).

> ***"[10h] obtaining one or more resultant deviation including a plurality of deviation angles using a plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set."***

It would have been obvious to obtain **a resultant deviation including a plurality of deviation angles** from the orientation output $\hat{q}$ of Bachmann. (Ex. 1002, ¶144). The orientation output $\hat{q}$ is in quaternion form, which is an alternate representation of orientation using Euler angles (deviation angles).[4] While Bachmann uses quaternions for computational advantage, once the computations of the filter process were complete, it would have been obvious to convert the orientation output quaternion, $\hat{q}$, to Euler angles. (Ex. 1002, ¶144). Bachmann expressly states that:

> "**A conventional way** of describing the orientation of a rigid body uses '**Euler angles**' to describe the orientation of a rigid body in three dimensions. Euler angles describe the orientation of a rigid body using three rotations about specified axes."

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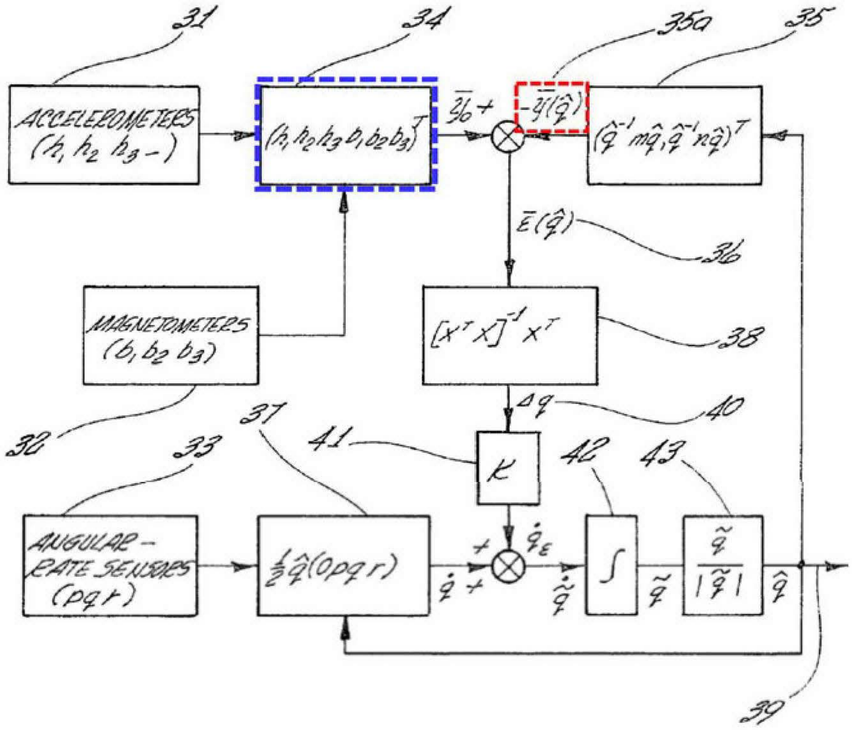
[4] For purposes of this Petition, Petitioner applies Patent Owner's interpretation of "resulting deviation" as indicated by Patent Owner's infringement contentions in the related litigations. (Ex. 1011, p. 16). Petitioner does not concede that Patent Owner's interpretation is the proper construction in district court under the *Phillips* standard.

(Ex. 1004, 5:50-55)(Ex. 1002, ¶144). It would have been obvious to convert the orientation output quaternion, $\hat{q}$, into the "conventional" form of Euler angles (roll, pitch and yaw), which are more intuitive to human users. (Ex. 1002, ¶145). The equations for such a transformation were widely known in the art. (Ex. 1002, ¶145).

The orientation output $\hat{q}$, from which deviation angle would be obtained, is calculated **using a plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set.** Specifically, as discussed above under element [10e], Bachmann teaches obtaining a second signal set (b_1, b_2, b_3), which are **a plurality of magnetisms Mx, My, Mz**. (Ex. 1002, ¶146). Bachmann also teaches using **a plurality of predicted magnetism[s] Mx', My' and Mz'.** The measured magnetisms are shown in box 34 (as b_1 b_2 b_3) of Fig. 3, below, with an added blue-dashed box, while the predicted magnetisms are part of the vector $\bar{y}(\hat{q})$, highlighted by the added red-dashed box:



(Ex. 1002, ¶146). Bachmann explains that $\bar{y}(\hat{q})$ is a "computed measurement vector" containing both predicted accelerations (h_1, h_2, h_3) and predicted magnetisms (b_1, b_2, b_3):

> "Combining the vector parts of Eq. (7) yields a single 6x1 **computed measurement vector** $\bar{y}(\hat{q})$ 35a, wherein: [¶] $y(\hat{q})=[h_1\ h_2\ h_3\ b_1\ b_2\ b_3]^T$ (8) [¶] and wherein the values for $h_1\ h_2\ h_3\ b_1\ b_2\ b_3$ are generated by mapping m and n through as an estimated orientation quaternion."

(Ex. 1004, 9:1-8)(Emphasis added)(Ex. 1002, ¶147). The (b_1, b_2, b_3) portion of the computed measurement vector is the **predicted magnetism Mx', My' and Mz'**. The predicted magnetisms are associated with the **X, Y and Z axes** in the spatial pointer reference frame because (1) they are mapped from magnetic quaternion n=[0 n1 n2 n3] in the earth-fixed frame to (b_1, b_2, b_3) in the sensor frame using the orientation quaternion $\hat{q}$; and (2) they will be matched with actual measurements from the **three-axis** magnetometers. (Ex. 1004, 8:57-9:17)(Ex. 1002, ¶148).

Bachmann further discloses that the measured and predicted magnetisms are **used to form the orientation output** (which is, in turn, used to form deviation angles). Specifically, Bachmann compares the measured and predicted magnetisms to generate an error value ($\varepsilon(\hat{q})$), that is used to optimize a correction $\dot{q}_\varepsilon$ for the angular rate $\dot{q}$, and thus also for the orientation output $\hat{q}$. Bachmann states:

> "Again, **a 6x1 measurement vector** y_0 34 in sensor coordinates **is produced** (Eqn. (4)). Again, in accordance with Eq. (7), Eq. (5), and Eq. (6) are approximations mapped from the earth fixed frame to the body frame through quaternion multiplication 35. **And a 6x1 computed measurement vector** $\bar{y}(\hat{q})$ 35a is generated. As previously described, the difference between the measurement vector y_0 and the computed measurement vector $\bar{y}(\hat{q})$ is the error vector $\bar{\varepsilon}(\hat{q})$ 36 and the square of the filter modeling error is termed the criterion function. The error vector is then minimized….[A]s previously explained with respect to Eqns (9) and (10) a Gauss- Newton iteration 38 is performed to **correct a measured rate quaternion** (See, FIG. 3, 36)."

(Ex. 1004, 9:64-10:45)(Emphasis added)(Ex. 1002, ¶149). Thus, the combination using Bachmann's filter **obtains one or more resultant deviation including a plurality of deviation angles using a plurality of measured magnetisms Mx, My,**

Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set. (Ex. 1002, ¶150).

Claim 12

"12. The method of claim 10, wherein the orientation output is a rotation matrix, a quaternion, a rotation vector, or comprises three orientation angles."

As discussed above under claim 10, element [10b], the orientation output is the **quaternion** q̂. (Ex. 1004, 10:12-14)(Ex. 1002, ¶151).

Ground 2. Claims 10 and 12 are unpatentable over Liberty in view of Bachmann.

Claims 10 and 12 are unpatentable as obvious over U.S. Pat. 7,158,118 ("Liberty")(Ex. 1006), in view of U.S. Pat. No. 7,089,148 ("Bachmann")(Ex. 1004).

Liberty issued on January 2, 2007, and is thus prior art under pre-AIA 35 U.S.C. §102(b). Liberty is also Admitted Prior Art. (Ex. 1001, 2:25-26). **Bachmann** issued on August 8, 2006, and is thus also prior art under pre-AIA 35 U.S.C. §102(b). Liberty and Bachmann are analogous art, because they are in the same field and reasonably related to the problems facing the named inventors, as shown by the discussion herein.

Bachmann is not listed as prior art of record on the face of the '978 patent. Liberty is discussed in the Background of the '978 patent specification. (Ex. 1001, 2:26, *et seq.*).

Overview of the Combination

Claim 10 is directed to a method for compensating rotations of a 3D pointing device. The combination of Liberty and Bachmann uses *Liberty's 3D pointing device* together with *Bachmann's extra sensors and method for compensating rotations*.

Liberty teaches that—like the '978 patent—its invention:

> "relates generally to handheld, pointing devices and, more specifically to three-dimensional (hereinafter **"3D") pointing devices** and techniques for tilt compensation and improved usability associated therewith."

(Ex. 1006, 1:31-34)(Emphasis added)(Ex. 1002, ¶75).

An embodiment of the Liberty 3D pointing device (400) is shown together with a display (408) in Fig. 3, reproduced below:

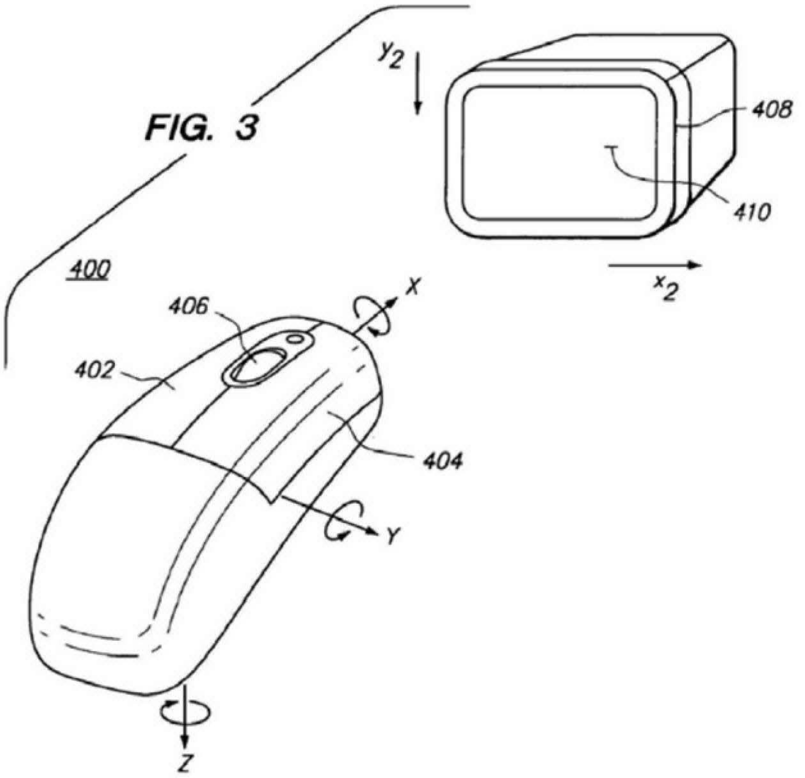


FIG. 3

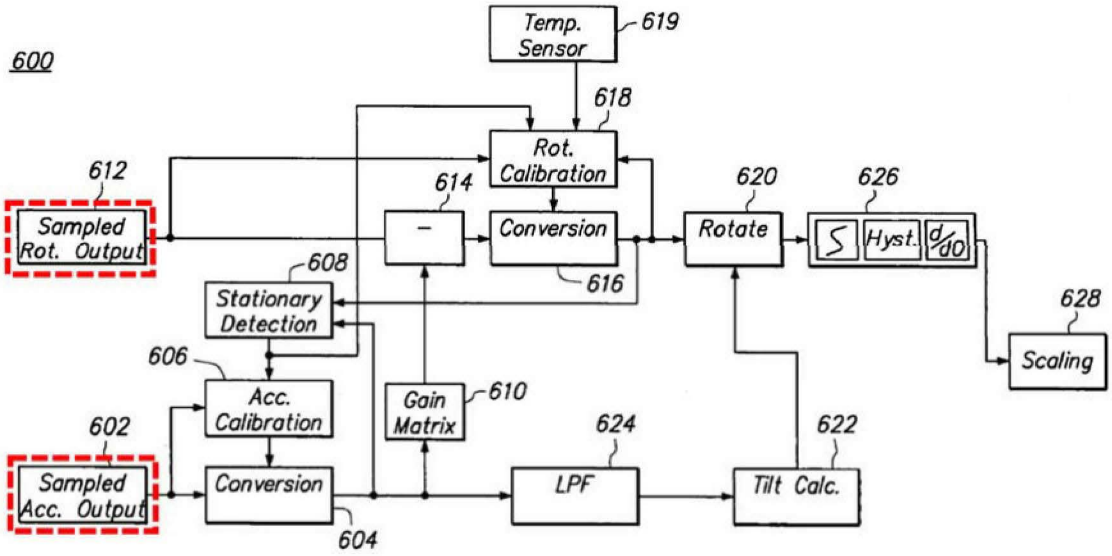
With respect to Fig. 3, Liberty explains:

> “An exemplary **3D pointing device 400** is depicted in FIG. 3. Therein, **user movement of the 3D pointing can be defined, for example, in terms of a combination of x-axis attitude (roll), y-axis elevation (pitch) and/or z-axis heading (yaw)** motion of the 3D pointing device 400. In addition, some exemplary embodiments of the present invention can also measure linear movement of the 3D pointing device 400 along the x, y, and z axes to generate cursor movement or other user interface commands.”

(Ex. 1006, 7:19-27)(Emphasis added)(Ex. 1002, ¶¶76-77).

To track user movements in three dimensions, Liberty uses a sensor module within the pointing device 400. (Ex. 1006, 7:57-8:20)(Ex. 1002, ¶¶79-86). The sensor module contains rotation sensors and axial accelerometers. (*Id.*). One arrangement of the sensor system is shown in Fig. 5, reproduced below, with red-dashed boxes added on the left side to show the sensor outputs (602 and 612):

FIG. 5



(Ex. 1002, ¶82).

Liberty explains that, once the device 400 obtains sensor output, the device 400 will perform calculations on the output. (Ex. 1006, 8:37-50)(Ex. 1002, ¶80). The calculations compensate for errors in the sensor data or stemming from the device construction, and for user factors. In Liberty's words:

> "[V]arious measurements and calculations are performed by the handheld device 400 which are used to adjust the outputs of one or more of the sensors 502, 504 and 506 and/or as part of the input used by a processor to determine an appropriate output for the user interface based on the outputs of the sensors 502, 504 and 506. These measurements and calculations are used to compensate for factors

> which fall broadly into two categories: (1) factors which are intrinsic to the 3D pointing device 400, e.g., errors associated with the particular sensors 502, 504 and 506 used in the device 400 or the way in which the sensors are mounted in the device 400 and (2) factors which are not intrinsic to the 3D pointing device 400, but are instead associated with the manner in which a user is using the 3D pointing device 400…."

(Ex. 1006, 8:37-50)(Ex. 1002, ¶80). During these calculations, Liberty determines the "tilt" (*i.e.* orientation) of the device. (Ex. 1006, 11:16-12:53)(Ex. 1002, ¶84). Liberty does this to compensate for tilt during movement of the device. As Liberty explains:

> "In order to provide an interface which is transparent to the user in terms of how the 3D pointing device 400 is held, **tilt compensation** according to exemplary embodiments of the present invention **translates the readings output from rotational sensors 502 and 504** back into the inertial frame of reference as part of processing the readings from these sensors **into information indicative of rotational motion of the 3D pointing device 400**. According to exemplary embodiments of the present invention, returning to FIG. 5, **this can be accomplished by determining the tilt of the 3D pointing device 400** using the inputs y and z received from accelerometer 506 at function 622."

(Ex. 1006, 12:13-26)(Emphasis added)(Ex. 1002, ¶84).

Finally, Liberty teaches translating the information obtained from the sensors into another frame of reference, for example, the coordinates associated with a display screen. Liberty explains:

> "[E]xemplary embodiments of the present invention process movement data received from sensor(s) in the 3D pointing device to **convert this data from the frame of reference of the 3D pointing device's body into another frame of reference**, **e.g., the user's frame of reference**. In the exemplary application of a 3D pointing device used to control a user interface displayed on a screen, e.g., a television, **the user's frame of reference might be a coordinate system associated with the television screen**."

(Ex. 1006, 16:21-29)(Emphasis added)(Ex. 1002, ¶85).

Liberty's primary embodiment has a five-axis sensor module (compared to the "nine-axis sensor module" required by claim 10). Liberty expressly states, however, that more sensors can be used, and that *different kinds* of sensors can be used. For example, Liberty explains with respect to Fig. 9 that:

> "**A variety of different sensors could be employed** as long as they measure motion with respect to the body of the device. Exemplary sensors include **accelerometers, rotational sensors, gyroscopes, magnetometers** and cameras."

(Ex. 1006, 18:30-33)(Emphasis added)(Ex. 1002, ¶86). Liberty reinforces this point several times in the specification (Ex. 1006, 16:38-44, 19:62-20:13)—although the discussion of Liberty in the '978 patent omits this point. (Ex. 1002, ¶¶86-87).

Liberty also suggests that different calculation algorithms can be used, stating:

> "Additional stability can be provided by constant field vectors including gravity and the earth's magnetic field and combined with the results above. The combination can be achieved using several numerical and filtering methods including, but not limited to, Kalman filtering."

(Ex. 1006, 18:24-29)(Ex. 1002, ¶88).

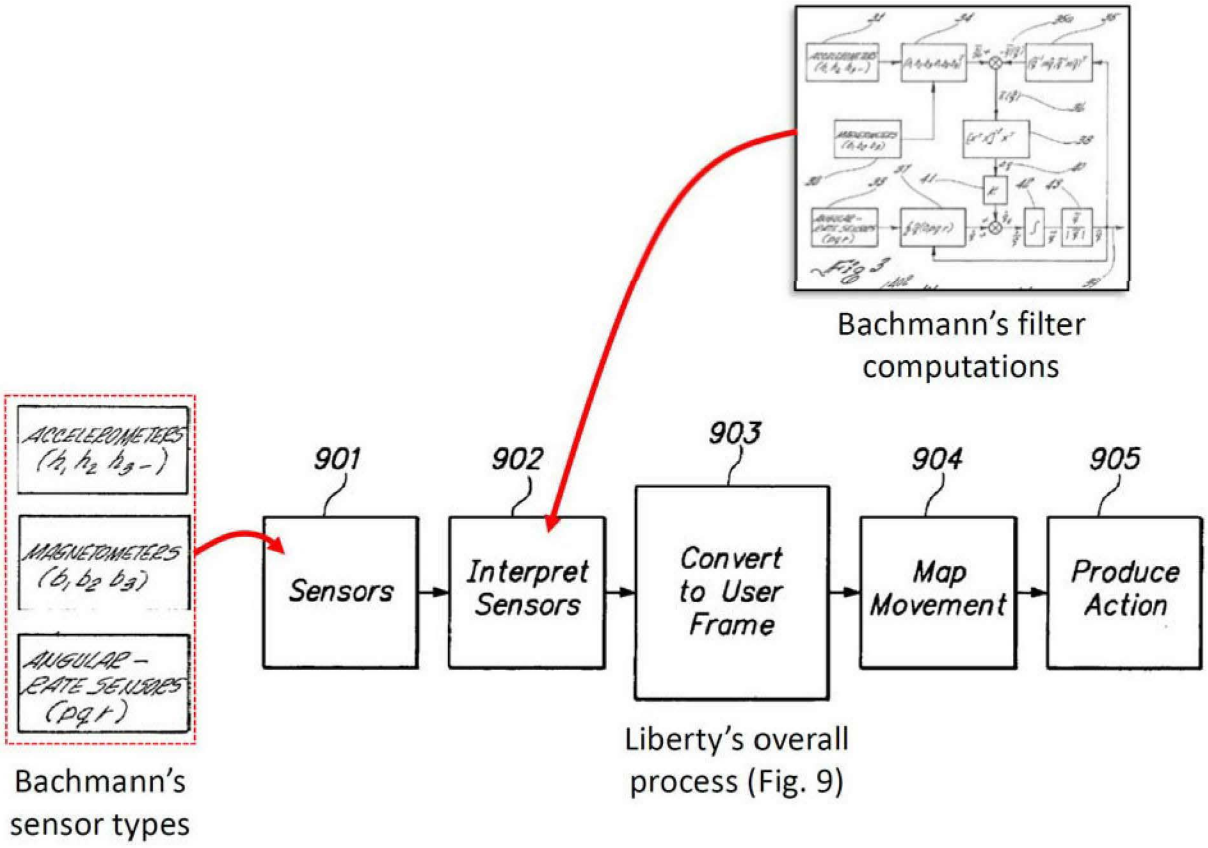
Bachmann, in turn, provides an example of a nine-axis sensor system that combines accelerometers, magnetometers and angular velocity sensors, as suggested by Liberty. Bachmann, for example, states:

> "In another sensor embodiment, the **magnetometers** and **accelerometers** are supplemented with **angular rate detectors** configured to detect the angular velocity of the sensor (comprising so-called Magnetic, Angular Rate, Gravity (MARG) sensors). Each MARG sensor contains angular rate detectors, accelerometers, and magnetometers."

(Ex. 1004, 7:34-40)(Emphasis added)(Ex. 1002, ¶156). In Bachmann's system, each type of sensor is a three-axis sensor, making the entire system (3 sensor types x 3 axes per type) a nine-axis system. (Ex. 1002, ¶156).

Bachmann likewise corresponds to Liberty's suggestion of using "filtering" by combining sensor data using an attitude estimation *filter* to produce an estimate of the attitude (also known as the "orientation") of a tracked object. Bachmann's filter is discussed above in Ground 1, beginning on page 24. That discussion applies here in the same way. (Ex. 1002, ¶156).

The combination thus proposes using the 3D pointer of Liberty (modified to include additional sensors), together with Bachmann's filter process to calculate a device orientation. Once a device orientation has been calculated, it can be converted to the coordinate system of a display device, as disclosed in both Liberty and Bachmann. The combination can be illustrated with the Figure below, created by the Petitioner, showing the relevant modifications to the Liberty pointer. In the Figure, which is based on Fig. 9 of Liberty, Bachmann's sensors are used, while Bachmann's filter calculations are added to help interpret the sensor output. The output is then converted to display coordinates as Liberty describes, making any adjustments necessary to use new sensor types and information. (Ex. 1002, ¶¶157-158).



(Ex. 1002, ¶¶157-158).

Rationale for the Combination

It would have been obvious to a person of skill in the relevant timeframe to use Liberty's 3D pointer with Bachmann's sensors and filter calculations. (Ex. 1002, ¶159). As discussed above in the Overview section beginning on page 61, Liberty expressly states that additional sensors can be used, and in particular, that magnetometer sensors can be used. (Ex. 1006, 16:38-44, 18:29-33, 19:62-20:12)(Ex. 1002, ¶159). Thus, it would have been obvious to add sensors to Liberty, including the additional sensors of Bachmann, based on Liberty's express suggestion. (Ex. 1002, ¶159). Furthermore, a person of ordinary skill would have understood that additional sensors, and additional types of sensors, would have yielded at least two benefits. (Ex. 1002, ¶160). First, additional sensors (in particular sensor axes) and additional sensor types would have allowed the device to detect different modes of movement, for example a roll angle, thus better allowing the device to translate user movements to display operations. (Ex. 1002, ¶160). Second, additional sensor axes and sensor types would have increased the overdetermination (the amount of information beyond that necessary to determine orientation), which in turn would have enabled better error and noise control. (Ex. 1002, ¶160).

Bachmann's nine-axis sensors were also well-known in the art in the relevant timeframe. Bachmann, which issued in 2006, states that magnetic, angular rate and gravitational (acceleration) sensors were known in the art as MARG sensors, and were already commercially available, and could be integrated in a known fashion. (Ex. 1004, 14:37-57)(Ex. 1002, ¶161). Bachmann further states that its sensors and filter are applicable to hand-held devices (like Liberty's). (Ex. 1004, 13:42-48)(Ex. 1002, ¶161). There was thus significant motivation to use known nine-axis MARG sensors to improve the measurement capabilities of the Liberty 3D pointer, as suggested by Liberty and Bachmann. (Ex. 1002, ¶161).

In using Bachmann's suggested MARG sensors, it would have been obvious to use Bachmann's quaternion-based filter techniques (as illustrated, for example, in

Fig. 3 of Bachmann), because those filter techniques were adapted directly to MARG sensors. (Ex. 1004, 7:18-45)(Ex. 1002, ¶162). In particular, Bachmann teaches that its filter techniques using quaternion calculations are superior to filters that (internally) use spatial (*e.g.* Euler) angle calculations, because the quaternion-based techniques are computationally more efficient and avoid singularities that might otherwise occur at certain sensor orientations. (Ex. 1004, 5:33-7:31)(Ex. 1002, ¶162). This yields a highly advantageous orientation calculation. (Ex. 1004, 7:4-17)(Ex. 1002, ¶162). Thus, a person of ordinary skill would have used Bachmann's improved quaternion-based filter (as illustrated in Fig. 3, e.g.) with the sensors for which it was designed, based on Bachmann's express recommendation. (Ex. 1002, ¶163).

The combination is also, separately, supported by the rationales discussed in *KSR Int'l Co. v. Teleflex, Inc.*, 580 U.S. 398 (2007). There, the Supreme Court held (e.g.) that "[t]he combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *Id.* at 416. Furthermore, "if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill." *Id.* at 417.

In the present case, Liberty's device has a housing, sensors and a software for using sensor output to calculate the orientation of the device. (Ex. 1002, ¶164). Bachmann has the same, but uses different sensors and a modified calculation. (Ex. 1002, ¶164). Bachmann's sensors were well-known and available on the commercial market, while Bachmann's calculations were known at least as soon as Bachmann's specification published. (Ex. 1002, ¶164). These functional blocks (sensors and calculations) could have been substituted for the equivalent functional blocks in Liberty requiring only ordinary skill to implement (as discussed in the next section). (Ex. 1002, ¶164). There would have been no unexpected results—only the *expected* improvement promised by Bachmann. (Ex. 1002, ¶164). The combination is thus further supported by *KSR*.

Finally, it would have been obvious to use the orientation calculated by Bachmann's filter to calculate coordinates that can be used on a display device. (Ex. 1002, ¶165). This is the intended use of Liberty's 3D pointer—to translate human movements while holding the pointer into commands that can be executed on-screen, such as movements of a cursor. For example, Liberty states:

> "[E]xemplary embodiments of the present invention process movement data received from sensor(s) in the 3D pointing device to convert this data from the frame of reference of the 3D pointing device's body into another frame of reference, e.g., the user's frame of reference. In the exemplary application of a 3D pointing device

> used to control a user interface displayed on a screen, e.g., a television, the user's frame of reference might be a coordinate system associated with the television screen."

(Ex. 1006, 16:21-29)(Ex. 1002, ¶166). To do this, Liberty's system performs a transformation of device orientation from a device-centered frame of reference to a frame of reference associated with a display. (Ex. 1006, 16:21-19:22)(Ex. 1002, ¶166). Liberty states that the transformation can occur for all three dimensions of translational and rotational motion, with considerable flexibility in the translated quantities and the frames of reference between which the translations are performed:

> "[T]ransformations according to the present invention can be performed to transform the sensed motion in **all three dimensions**, for **translational motion and rotational motion** or any subset thereof, from the perspective of either the input side of the motion equation or the output side. Additionally, **the selection of the frame of reference into which the sensed motion is mapped or transformed can be made in a number of different ways**. One example provided above shows the second frame of reference being a user's frame of reference associated with **the tilt of the device**, however **many other variations are possible**.

(Ex. 1006, 19:31-41)(Emphasis added)(*see also* 19:23-20:12)(Ex. 1002, ¶167). Liberty further notes that the transformation can be combined with any other data necessary to track the movement of the device for any particular application:

> "[I]t will be appreciated that the present invention describes various techniques for mapping sensed motion of a handheld device from one frame of reference (e.g., a body frame of reference) to another frame of reference (e.g., a user's frame of reference). **These mappings can be independent from other mappings associated with the use of the handheld device, e.g., the mapping of sensed motion to cursor movement or can be combined therewith**."

(Ex. 1006, 23:31)(Emphasis added)(Ex. 1002, ¶168).

Bachmann likewise discloses that its orientation output can be used with a display:

> "The system can further include a display for displaying the position and orientation of the body with respect to a synthetic environment."

(Ex. 1004, 4:26-28)(Ex. 1002, ¶169). A person of skill in the art would have understood a display with a "synthetic environment" to have a fixed reference frame associated with a display device, so that images controlled by a pointer can be displayed on screen, as shown conceptually in Fig. 4 of Bachmann, reproduced below:

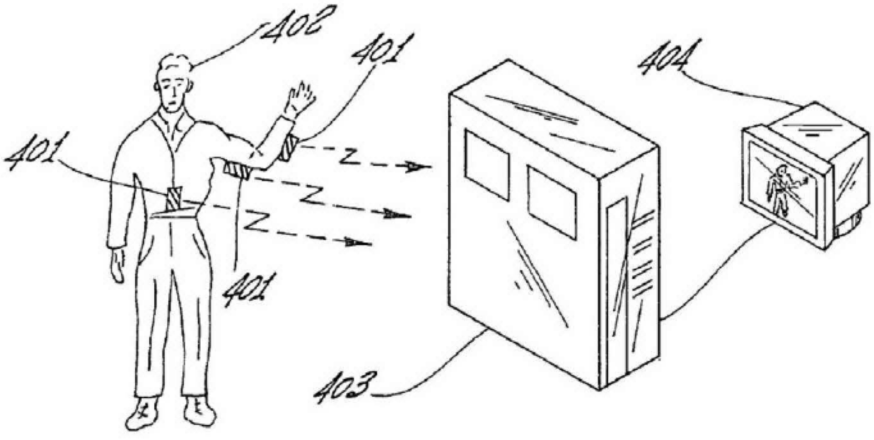


Fig 4

(Ex. 1002, ¶169). As shown in Fig. 4, sensors 401 located on a human body allow the image of a body to be displayed on a display screen 404, in display screen coordinates. (Ex. 1004, 13:64-14:29)(Ex. 1002, ¶169). Thus, Liberty expressly discloses the transformation of orientation to a display frame of reference, and Bachmann suggests transforming orientation output in a way that can be reproduced on a display device. (Ex. 1002, ¶169).

Ability to Implement and Reasonable Expectation of Success

A person of skill in the art in the relevant timeframe would have been able to implement the combination and would have had a reasonable expectation of success. (Ex. 1002, ¶170). As discussed above, sensors of the type described by Bachmann were widely available on the commercial market. A person of ordinary skill would have been able to integrate these sensors into Liberty's device using standard conditioning circuits, samplers and analog-to-digital converters, making adjustments as necessary. (Ex. 1002, ¶170). For example, a person of ordinary skill would have been able to integrate Bachmann's filter process with signal conditioning and correction described, *e.g.*, in reference to Fig. 5 of Liberty as needed, taking into account the needs of any particular display application. (Ex. 1002, ¶170).

Bachmann's filter calculations, in turn, could have been executed in software predictably and using only ordinary skill. Both Liberty and Bachmann teach implementing orientation calculations on computer chips, for example Liberty's processor (Ex. 1006, 8:35-43) or Bachmann's CPU 403 (Ex. 1004, 13:64-14:29). (Ex. 1002, ¶170). In the relevant timeframe, microprocessors and microcontrollers with sufficient power to implement Bachmann's filter would have been readily available. (Ex. 1002, ¶170). A person of skill likewise would have expected success performing a transformation of Bachmann's orientation output into the frame of reference of a display device. (Ex. 1002, ¶170).

The '978 patent itself, for example, reports no difficulty in constructing appropriate circuits to use sensor output, nor in implementing the relevant mathematics in appropriate software. (Ex. 1002, ¶170). In fact, the '978 patent does not explain how to implement its sensor within appropriate circuits or its mathematics within appropriate software in any detail, thereby admitting for the purposes of assessing obviousness that such details were within ordinary skill. (Ex. 1002, ¶170). *See In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 2004).

A person of ordinary skill therefore would have been able to implement the combination and would have had a reasonable expectation of success. (Ex. 1002, ¶170).

Difference Between the Combination and Prior Discussion of Liberty

As noted above, the ’978 patent criticizes the Liberty patent in the specification. (Ex. 1001, 2:25, *et seq.*). Specifically, the ’978 patent states that Liberty’s “5-axis motion sensor” suffers from limitations in properly determining the orientation of the device. (Ex. 1001, 2:41-3:52).[5]

The ’978 patent, however, does not contemplate the possibility (expressly suggested in Liberty) of extending Liberty’s sensor system, and in particular to using a well-known nine-axis system as taught by Bachmann. The Liberty-Bachmann combination uses the same sensor combinations disclosed in the ’978 patent, and has never been examined by the Office.

Graham Factors

The **level of ordinary skill** in the art is discussed above on page 39.

The **scope and content of the prior art** are discussed throughout the present ground.

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[5] It is not clear whether the entire discussion in 2:41-3:52 is directed to Liberty ’118, or other prior art.

The **differences between the prior art and the claims** are discussed in the "Overview of the Combination" and in the claim mapping, below.

Petitioner is not aware of any **secondary considerations** that would make an inference of non-obviousness more likely.

Claim Mapping

The elements of claims 10 and 12 are mapped to the combination of Liberty and Bachmann in the following section, where the relevant claim language is provided in bold-italic font, and the mapping in the text that follows each claim element. In claim 10, lettering has been added to each element (*e.g.* [10b]) to assist the discussion of the issues. The discussion in the claim mapping section supplements the discussion of the ground above, and the two should be read together.

Claim 10

"10[a]. A method for compensating rotations of a 3D pointing device, comprising:"

As discussed above in the Overview of the Ground, Liberty discloses a **3D pointing device**. (Ex. 1006, Title, Abstract)(Ex. 1002, ¶172). An example of the 3D pointing device (400) is shown as device 400 in Fig. 3 of Liberty, reproduced at right. (Ex. 1006, 7:19-31)(Ex. 1002, ¶172).

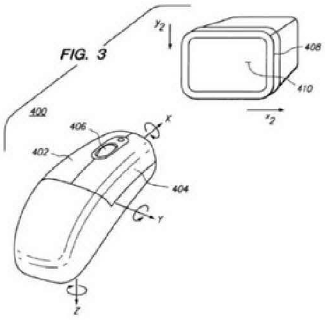
FIG. 3

Liberty states:

"The present invention relates generally to handheld, pointing

> devices and, more specifically to three-dimensional (hereinafter **"3D") pointing devices** and techniques for tilt compensation and improved usability associated therewith."

(Ex. 1006, 1:31-34)(Ex. 1002, ¶173).

Liberty's pointer is a "**3D** pointer" because it can be moved in a user's hand in 3D space. (Ex. 1006, 4:48-55, 3:51-65)(Ex. 1002, ¶174). As discussed above, it would further have been obvious to use Liberty with three sets of three types of sensors (rotational velocity, axial acceleration and magnetism) to improve the determination of orientation in **three-dimensional** space. (Ex. 1002, ¶174).

The combination discloses a **method of compensating rotations** of the device, as described in steps [10b]-[10h], below. (Ex. 1002, ¶175).

> ***"[10b] generating an orientation output associated with an orientation of the 3D pointing device associated with three coordinate axes of a global reference frame associated with Earth;"***
>
> ***"[10c] generating a first signal set comprising axial accelerations associated with movements and rotations of the 3D pointing device in the spatial reference frame;"***
>
> ***"[10d] generating a second signal set associated with Earth's magnetism;"***
>
> ***"[10e] generating the orientation output based on the first signal set, the second signal set and the rotation output or based on the first signal set and the second signal set;"***
>
> ***"[10f] generating a rotation output associated with a rotation of the 3D pointing device associated with three coordinate axes of a spatial reference frame associated with the 3D pointing device;"***

The combination of Liberty and Bachmann teaches elements [10b] - [10f] based on Bachmann's disclosure, in the same manner described under Ground 1, elements [10b] - [10f]. (Ex. 1002, ¶176). Thus, the discussion under Ground 1 is applied in the same manner for these elements. (Ex. 1002, ¶¶176-180).

> ***"[10g] and using the orientation output and the rotation output to generate a transformed output associated with a fixed reference frame associated with a display device, wherein the orientation output and the rotation output is generated by a nine-axis motion sensor module;"***

As discussed above under limitations [10e] and [10f], the Bachmann system generates an **orientation output** $\hat{q}$ and a **rotation output** (p, q, r). In the combination, these outputs are **generated by a nine-axis motion sensor module**, specifically, the module containing the Bachmann filter, which has "a three-axis accelerometer (h_1, h_2, h_3) 31, a three-axis magnetometer (b_1, b_2, b_3) 32, and a three-axis angular rate sensor (p, q, r) 33." (Ex. 1004, 10:10-14)(Ex. 1002, ¶181). Three sensor types times three axes each yields a nine-axis module. (Ex. 1002, ¶181).

As discussed above beginning with the Overview of the Combination and Rationale for the Combination sections, it would have been obvious to generate a **transformed output associated with a fixed reference frame associated with a display device.** Bachmann suggests that its orientation output be transformed to the coordinate system of a display device (*e.g.* in connection with Fig. 4). Liberty, in turn, expressly discloses such a transformation:

> "[E]xemplary embodiments of the present invention process movement data received from sensor(s) in the 3D pointing device to **convert this data from the frame of reference of the 3D pointing device's body into another frame of reference**, **e.g., the user's frame of reference**. In the exemplary application of a 3D pointing device used to control a user interface displayed on a screen, e.g., a television, **the user's frame of reference might be a coordinate system associated with the television screen**."

(Ex. 1006, 16:21-29)(Emphasis added)(Ex. 1002, ¶181).

For the reasons discussed above under "Rationale for the Combination", beginning on page 68, it would have been obvious to **use the orientation output and the rotation output for this transformation**. The orientation output q̂ tracks the orientation of Liberty's pointing device. To implement Liberty's translation of data concerning device motion into screen coordinates, a person of ordinary skill would have found it obvious to use the available estimate of orientation ("tilt" in Liberty's language)—the **orientation output** q̂. (Ex. 1002, ¶182). Liberty enhances this suggestion by explaining that rotations from one frame of reference to another can be performed using quaternion multiplication. (Ex. 1006, 17:19-47)(Ex. 1002, ¶182).

The combination of Liberty and Bachmann would also **use the rotation output** in the transformation in two ways. First, because the orientation output q̂ itself is based on the rotation output (as discussed above under element [10e]), the transformation to display coordinates based on $\hat{q}$ would necessarily **use the rotation output**. (Ex. 1002, ¶183). Second, it would have been obvious to transform not only orientation $\hat{q}$, but also an estimate of angular velocity (*e.g.* $\dot{q}$) into display coordinates. This would have allowed the display pointer in Liberty's system to be more smoothly and consistently rendered during rotation of the pointing device. (Ex. 1002, ¶183).

> ***"[10h] obtaining one or more resultant deviation including a plurality of deviation angles using a plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set."***

It would have been obvious to obtain **a resultant deviation including a plurality of deviation angles** from the orientation output $\hat{q}$ of Bachmann. (Ex. 1002, ¶184). The orientation output $\hat{q}$ is in quaternion form, which is an alternate representation of orientation using Euler angles (deviation angles). As Liberty states:

> "**Q is the normalized rotation quaternion** that represents the rotation from the body frame to the user frame. Since the rotation quaternion to rotate from the user frame to the body frame is Q*, we could replace Q with R* where R is the rotation from the user frame to the body frame. **Note that Q can be represented in a number of equivalent forms including Euler angles** and the direction cosine matrix (DCM), and the above equations may vary slightly in their equivalent forms based upon different representations of Q."

(Ex. 1006, 17:37-44)(Emphasis added)(*see also* Ex. 1006, 16:54-56)(Ex. 1002, 184).

While Bachmann uses quaternions for computational advantage, once the computations of the filter process were complete, it would have been obvious to convert the orientation output quaternion, q̂, to Euler angles. (Ex. 1002, ¶185). Bachmann expressly states that:

> "A conventional way of describing the orientation of a rigid body uses 'Euler angles' to describe the orientation of a rigid body in three dimensions. Euler angles describe the orientation of a rigid body using three rotations about specified axes."

(Ex. 1004, 5:50-55)(Ex. 1002, ¶185). It would have been obvious to convert the orientation output quaternion, q̂, into the "conventional" form of Euler angles (roll, pitch and yaw), which are more intuitive to human users, based on the express teaching in Liberty that such angles are equivalent representations of orientation. (Ex. 1006, 16:54-56, 17:37-44)(Ex. 1002, ¶185). The equations for such a transformation were widely known in the art. (Ex. 1002, ¶185).

The combination using Bachmann's filter also **obtains one or more resultant deviation including a plurality of deviation angles using a plurality of measured magnetisms Mx, My, Mz and a plurality of predicted magnetism Mx', My' and Mz' for the second signal set.** This is explained above under Ground 1, element [10h], and that discussion is equally applicable here. (Ex. 1002, ¶185).

Claim 12

"12. The method of claim 10, wherein the orientation output is a rotation matrix, a quaternion, a rotation vector, or comprises three orientation angles."

The combination of Liberty and Bachmann would generate an orientation output in the form of a quaternion. The discussion under Ground 1, claim 12 is equally applicable here. (Ex. 1002, ¶186).

I. CONCLUSION

Petitioner respectfully requests that claims 10 and 12 of the '978 patent be canceled. The Petition Fee of $30,500 required by 37 C.F.R. §§ 42.15(a) is paid concurrently with the filing of this Petition by Deposit Account 23-1925. Petitioner authorizes charge of any additional necessary fees to Deposit Acct. 23-1925.

Date: ~~June 14~~January 10, 201~~8~~9	/~~MatthewA.Smith~~James R. Sobieraj/(RN ~~49,003~~30,805) ~~Matthew A. Smith~~ ~~SMITH BALUCH LLP~~ ~~1100 Alma St., Ste 109~~ ~~Menlo Park, CA (202) 669-6207~~ ~~smith@smithbaluch.com~~James R. Sobieraj Brinks Gilson & Lione 455 N. Cityfront Plaza, Suite 3600 Chicago, IL 60611 jsobieraj@brinksgilson.com *Counsel for Petitioner ~~Google LLC~~ZTE (USA), Inc.*

CERTIFICATE OF SERVICE

The undersigned hereby certifies that the foregoing petition for *inter partes* review, together with all exhibits and other documents filed therewith, was served today by Federal Express on the Patent Owner's counsel of record at the United States Patent & Trademark Office having the following address:

DING YU TAN
8819 Purdy Crescent Trail
Richmond TX 77406

Date: ~~June14~~January 10, ~~2018~~2019 /~~Matthew A. Smith~~James R. Sobieraj/

(RN ~~49,003~~30,805)

CERTIFICATE OF WORD COUNT

The undersigned hereby certifies that the foregoing petition for *inter partes* review contains ~~13,948~~13,999 words according to the word processing program used to prepare it.

Date: January 10, 2019 /James R. Sobieraj/ (RN 30,805)

~~Date: June14,2018 /Matthew A. Smith/ (RN 49,003)~~