UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS INC.
Petitioner

v.

CYWEE GROUP LTD.
Patent Owner

Case IPR2019-00559
Patent No. 8,441,438

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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1004	U.S. Pat. No. 7,089,148 (“**Bachmann**”).
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1006	U.S. Pat. 7,158,118 (“**Liberty**”).
1007	Return of Service for *Cywee Group Ltd. v. Google, Inc.*, Case No. 1-18-cv-00571, (D. Del.).
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1012	Institution Decision for IPR2018-01258 (paper 7).

LG Electronics Inc. ("Petitioner") respectfully requests *inter partes* review under 35 U.S.C. § 311 of claims 1 and 3-5 of U.S. Pat. No. 8,411,438. This Petition is being submitted concurrently with a Motion for Joinder. Specifically, Petitioner requests institution and joinder with *Google LLC v. Cywee Group Ltd.*, IPR2018-01258 ("the Google IPR" or "the Google proceeding"), which the Board instituted on December 11, 2018. This Petition is substantially identical to the Petition in the Google IPR; it contains the same grounds (based on the same prior art combinations and supporting evidence) against the same claims. Petitioner authorizes the Office to charge Account No. 50-0310 for fees set forth in 37.C.F.R. § 42.15(a), and further authorizes payment of additional fees to be charged to that Account.

NOTICE OF LEAD AND BACKUP COUNSEL

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NOTICE OF THE REAL-PARTIES-IN-INTEREST

The real-parties-in-interest are LG Electronics Inc., and LG Electronics U.S.A., Inc.[1] Petitioner further identifies as real-parties-in-interest the parties identified in IPR2018-01258 (to which this petition seeks joinder): Google LLC, 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 '438 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.);

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[1] LG Electronics MobileComm U.S.A., Inc. merged into and is now part of LG Electronics U.S.A., Inc.

- *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.).

Also, as noted above, the '438 patent has been challenged in the Google IPR Proceeding. Petitioner is concurrently filing a motion to join this proceeding. The '438 patent is also at issue in *ZTE (USA) Inc. et al. v. Cywee Group Ltd.*, IPR2019-00143, and in *Samsung Electronics Co., Ltd. et al v. CyWee Group Ltd.*, IPR2019-00535. Petitioner is also concurrently filing a petition challenging claims 10 and 12 of U.S. Patent No. 8,552,978 (IPR2019-00560) along with a motion to join *Google LLC v. Cywee Group Ltd.*, IPR2018-01257, which the Board instituted on December 11, 2018.

NOTICE OF SERVICE INFORMATION

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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, *inter partes* review IPR2018-01258 was instituted on December 11, 2018 (Ex. 1012) and this petition is accompanied by a request for joinder in that review, pursuant to 37 CFR § 42.122(b).

STATEMENT OF PRECISE RELIEF REQUESTED

Petitioner respectfully requests that claims 1 and 3-5 of the '438 patent be canceled based on the following Ground.

Ground 1: Claims 1 and 3-5 are obvious over Zhang in view of Bachmann.

THRESHOLD REQUIREMENT FOR INTER PARTES REVIEW

This petition presents "a reasonable likelihood that the Petitioners 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 Ground 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 '438 patent relates to 3D pointing devices. (Ex. 1001, Title). The '438 patent describes the function of a 3D pointing device as allowing a user to "perform control actions and movements utilizing the pointing device for certain purposes including entertainment such as playing a video game, on the display device ... through the aforementioned pointer on the screen". (Ex. 1001, 1:48-51)(Ex. 1002, ¶25). 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, 1:32-34)(Ex. 1002, ¶25). An example of such a device 110 (and a corresponding display 120) is shown in Fig. 1 of the '438 patent, reproduced below:

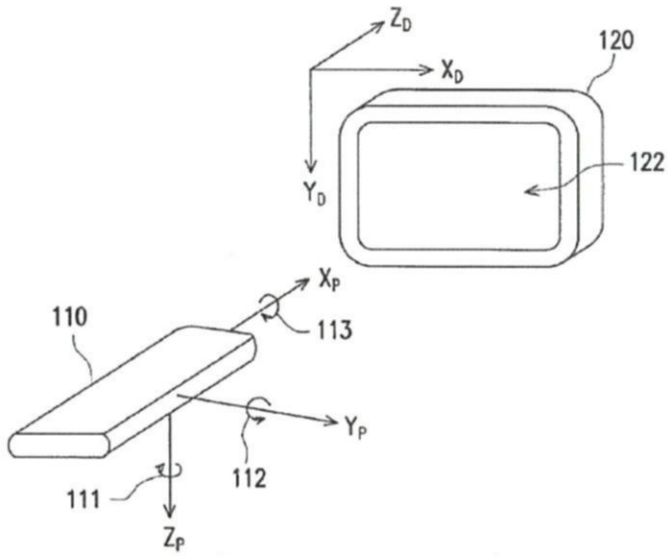

FIG. 1 (RELATED ART)

To keep track of the motions and rotations of a 3D pointing device, the '438 patent proposes using two kinds of sensors: rotation sensors (for detecting the angular velocity of rotation) and accelerometers (for detecting axial accelerations). (Ex. 1001, Fig. 4)(Ex. 1002, ¶26). These sensors are mounted in or on the 3D pointing device, and provide information on the movements and rotations of the device. (Ex. 1002, ¶26).

The '438 patent also purports to provide methods of using data output from the rotation sensors and accelerometers to calculate the orientation of the 3D pointing device. (Ex. 1001, 4:6-19)(Ex. 1002, (¶27). 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.[2] (Ex. 1001, 1:58-2:2)(Ex. 1002, ¶27). For example, Fig. 2 of the '438 patent shows the same device 110 in a different "orientation", having been rotated about the x-axis by 90 degrees:

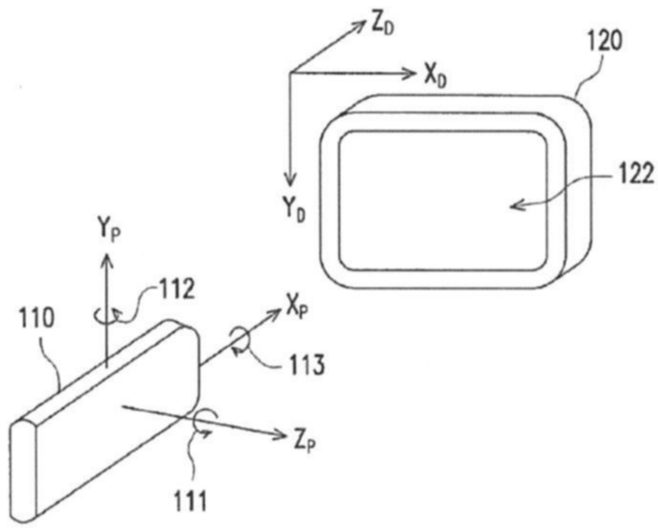

FIG. 2 (RELATED ART)

(Ex. 1001, 2:7-10)(Ex. 1002, ¶27).

While the '438 patent acknowledges the existence of prior-art 3D pointers using sensors to detect and calculate orientation, the '438 patent criticizes the specific devices mentioned as allegedly unable to calculate orientation accurately.

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[2] Orientation may be expressed in a number of equivalent ways, such as with a quaternion. (Ex. 1002, ¶¶28-31).

(Ex. 1001, 2:22-3:51)(Ex. 1002, ¶32). The '438 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, 1:21-26).

To "compensate" the output of the sensors, the '438 patent discloses a mathematical method using quaternions. (Ex. 1001, 10:42 *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, ¶34). 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 a '438 patent method is shown in Fig. 7, which is reproduced at right. The method of Fig. 7 obtains measured angular velocities at step 715 (Ex. 1001, 12:31-35) and measured axial accelerations in step 725 (Ex. 1001, 12:64-13:1). The method then calculates a *predicted* set of axial accelerations at step 730. (Ex. 1001, 13:1-11). By comparing the actual and predicted accelerations (step 735), the method purports to improve the estimate of orientation (in this case called the "updated state (3rd quaternion)" in box 735). (Ex. 1001, 13:25-49)(Ex. 1002, ¶¶33-34).

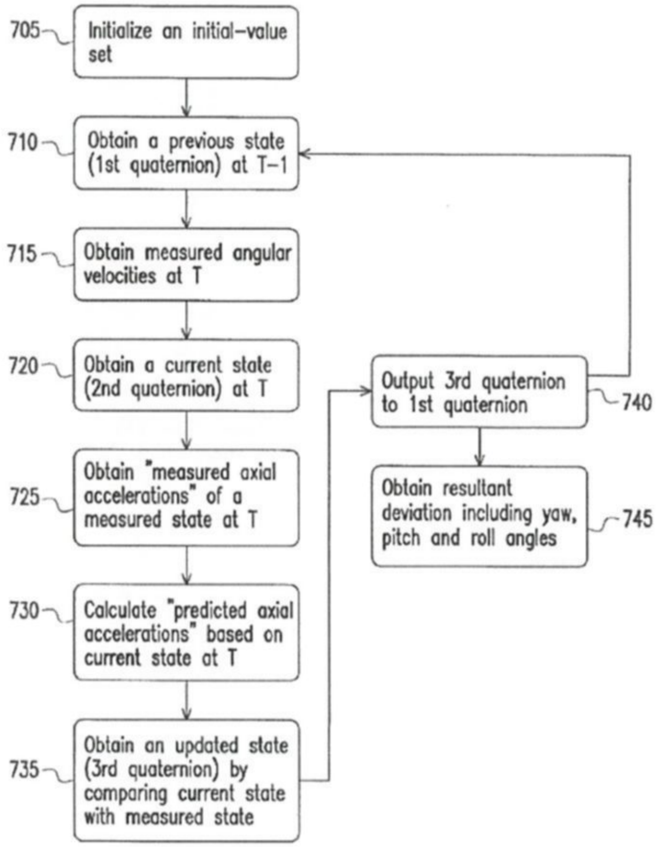


FIG. 7

A. Prosecution History and Issued Claims

This petition challenges independent claim 1 and dependent claims 3-5. As originally filed, claim 1 read as follows (with terms that will be discussed below in bold):

"1. A three-dimensional (3D) pointing device subject to movements and rotations in dynamic environments, comprising:

a housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame; a printed circuit board (PCB) enclosed by the housing; a six-axis motion sensor module attached to the PCB,

comprising a rotation sensor for detecting and generating a **first signal set comprising angular velocities ω_x, ω_y, ω_z** associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,

an accelerometer for detecting and generating a **second signal set comprising axial accelerations A_x, A_y, A_z** associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame; and

a processing and transmitting module, comprising a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof and a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit,

communicating with the six-axis motion sensor module to **calculate a resulting deviation comprising resultant angles** in said spatial pointer reference frame by **utilizing a comparison to compare the first signal set with the second signal set** whereby said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments."

(Ex. 1009, p. 223). Broadly speaking, original claim 1 was directed to a 3D pointing device that measured angular velocities (a first signal set) and axial accelerations (a second signal set), and used a "comparison to compare the first signal set with the second signal set" to obtain deviation angles (*i.e.* the device's orientation).

The Examiner rejected all claims in two different office actions. (Ex. 1009, pp. 134-148 and 066-091). In response to the second rejection, the applicants modified claim 1 to limit the claimed "comparison". Specifically, the applicants added the following limitation:

> "wherein the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set; wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set."

(Ex. 1009, p. 050).

Following this amendment, the Examiner issued an Interview Summary, indicating agreement that "the pending claims would be in condition for allowance if the limitation 'without using any derivatives of the measured angular velocities ω_x, ω_y, ω_z' was inserted into each of the independent claims." (Ex. 1009, p. 030). The Examiner entered the amendment, and allowed the claims. (Ex. 1009, pp. 029-042).

As issued, independent claim 1 reads as follows:

"1. A three-dimensional (3D) pointing device subject to movements and rotations in dynamic environments, comprising:

a housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame; a printed circuit board (PCB) enclosed by the housing; a six-axis motion sensor module attached to the PCB, comprising a rotation sensor for detecting and generating a first signal set comprising angular velocities ω_x, ω_y, ω_z, associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,

an accelerometer for detecting and generating a second signal set comprising axial accelerations Ax, Ay, Az associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame; and

a processing and transmitting module, comprising a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof and a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit,

communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame by utilizing a comparison to compare the first signal set with the second signal set whereby said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments, wherein the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set; wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set without using any derivatives of the first signal set."

II. CLAIM CONSTRUCTION

In the interest of filing a substantially identical petition to that of IPR2018-01258 (to which this petition seeks joinder), Petitioner proposes identical constructions to those proposed by original petitioner Google. However, recognizing that the Board has construed the terms in instituting IPR2018-01258, Petitioner consents to the Board's constructions therein.

Moreover, while the claim construction standard has changed from BRI to *Phillips* for petitions filed after November 13, 2018, the Board should apply the BRI standard to the instant petition because Petitioner is simply seeking joinder as a co-petitioner to the Google proceeding. If the Board deems that its rule(s) require application of the *Phillips* standard to this petition, Petitioner seeks waiver of such rule(s) pursuant to 37 C.F.R. § 42.5(b). Alternatively, even if the *Phillips* standard is deemed to apply to this petition, Petitioner submits that the Board's constructions should be the same and would apply in the same manner in all aspects of the petition and decision instituting IPR2018-01258.

"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.

A. Claim 1—"Comparison"

Claims 1 uses the term "comparison" in the phrase:

> "communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame by utilizing a **comparison** to compare the first signal set with the second signal set whereby said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments, wherein the comparison utilized by the processing and transmitting module further comprises an update program...."

The specification describes the term "comparison" as follows:

> "The term of '**comparison**' of the present invention may generally refer to the calculating and obtaining of the actual deviation angles of the 3D pointing device 110 with respect to the first reference frame or spatial pointing frame X_P Y_P Z_P utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors."

(Ex. 1001, 2:26-32)(Emphasis added). This passage indicates that a "comparison" is "calculating and obtaining" orientation using signals from different motion sensors, whether or not any "comparison" of those signals—as that word is normally understood—is made. These calculations ultimately result in deviation angles with respect to the first reference frame or spatial pointing frame and utilize sensor signals in a way that reduces noise.

For that reason, for the purposes of this petition, the term "comparison" should be construed to mean "performing calculations based on sensor signals to obtain the orientation of the device with respect to the spatial pointing frame in a way that reduces the effect of sensor noise." (Ex. 1002, ¶¶37-39).

B. Claim 1—"spatial pointer reference frame"

Claim 1 uses the phrase "spatial pointer reference frame". This phrase 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, ¶¶40-49). CyWee agreed to this construction during a co-pending litigation. (Ex. 1010, p. 2).

The '438 patent states as follows concerning the spatial pointer 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, 1:35-1:41)(Emphasis added)(Ex. 1002, ¶41). 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:

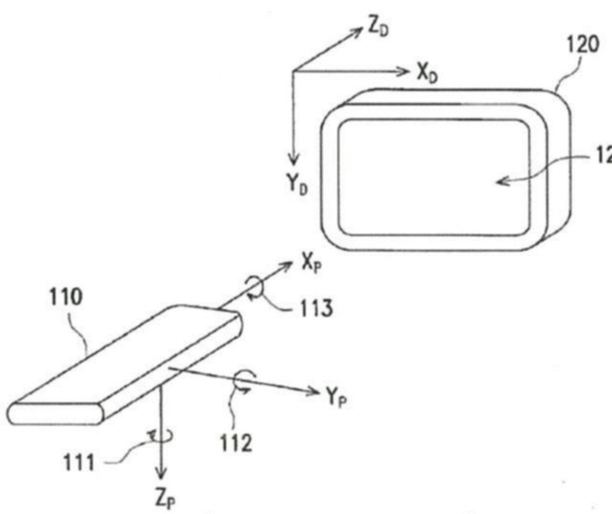


FIG. 1 (RELATED ART)

(Ex. 1002, ¶43). 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, ¶43).

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, ¶44). Figure 2 is reproduced below, and shows a 90-degree roll of the device, with correspondingly rotated axes Y_P and Z_P:

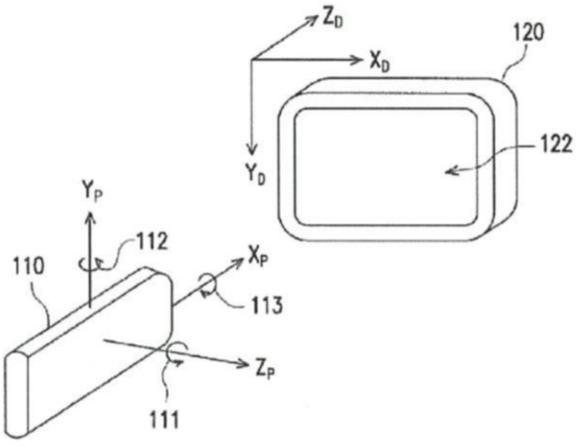


FIG. 2 (RELATED ART)

(Ex. 1002, ¶¶44-45). 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, ¶¶4548).Thus, the phrase "spatial pointer reference frame" 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, ¶¶40-49).

Ground 1. Claims 1 and 3-5 are obvious over Zhang in view of Bachmann.

Claims 1 and 3-5 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 '438 patent.

Overview of the Combination

Independent claim 1 is directed to a 3D pointing device 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 handheld pointing device" that is used for a "computer pointing control system". (Ex. 1005, Abstract)(Ex. 1002, ¶50). Such a computer pointing control system is shown, for example, in Fig. 2 of Zhang (reproduced at right), where the handheld device (a 3D pointer) has reference numeral 100. (Ex. 1002, ¶51).

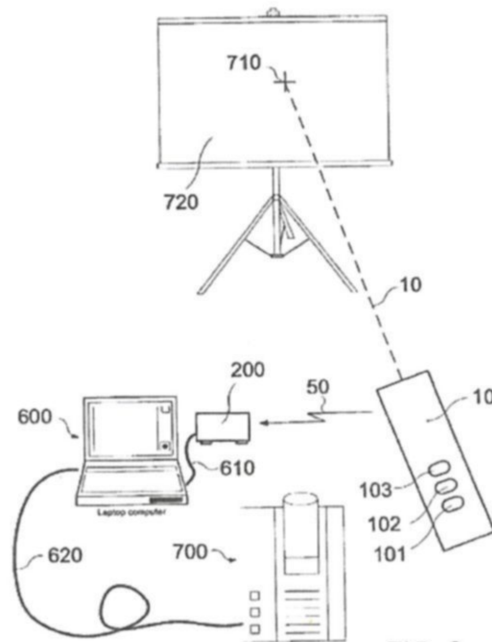


FIG. 2

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, ¶51).

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, ¶53). 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, ¶¶53-56). Numeral 130 is an "accelerometer sensor 130 [that] contains two orthogonally arranged acceleration detectors." (Ex. 1005, ¶0027)(Ex. 1002, ¶¶53-56). Numeral 110 is a microcontroller for performing calculations. (Ex. 1005, ¶0025)(Ex. 1002, ¶¶53-56).

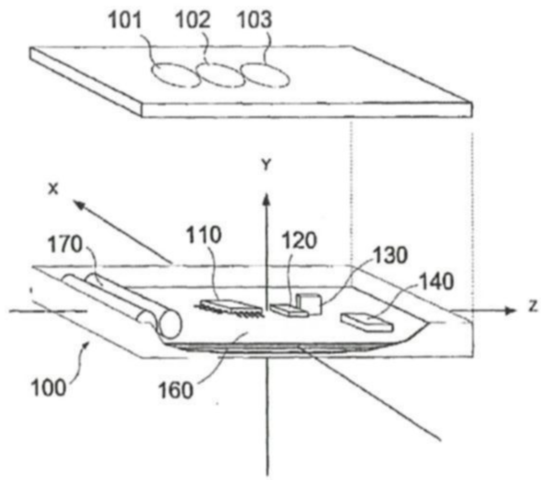


FIG. 3

A system diagram of Zhang's device 100 is shown in Fig. 5, reproduced below at right. (Ex. 1005, ¶0029)(Ex. 1002, ¶¶56-57). In Fig. 5, the two sets of two sensors (magnetometers 120 and accelerometers 130) are shown on the left side (the Petitioner has place 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, ¶56-57). 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, ¶56-57). The MCU 110 determines the device's orientation, including azimuth and inclination angles (yaw and pitch). (Ex. 1005, ¶0029)(Ex. 1002, ¶56-57). These angles are shown in Fig. 4(a) and 4(b), reproduced below.

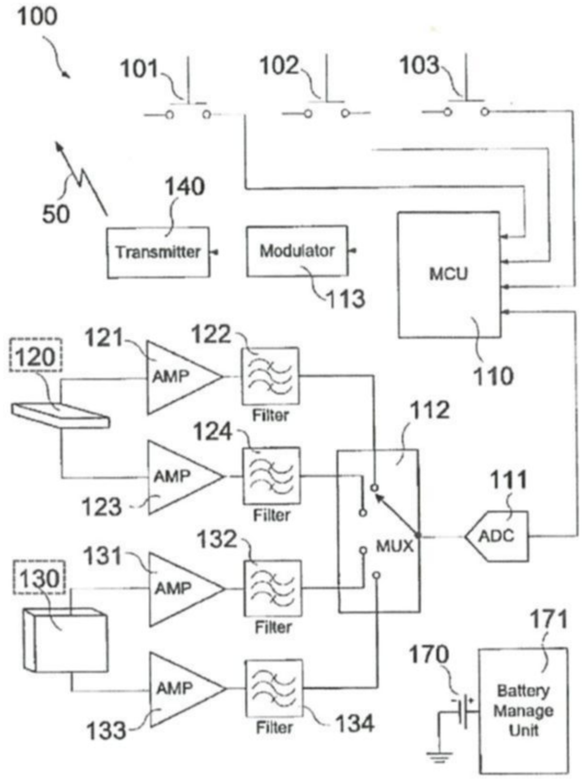


FIG. 5

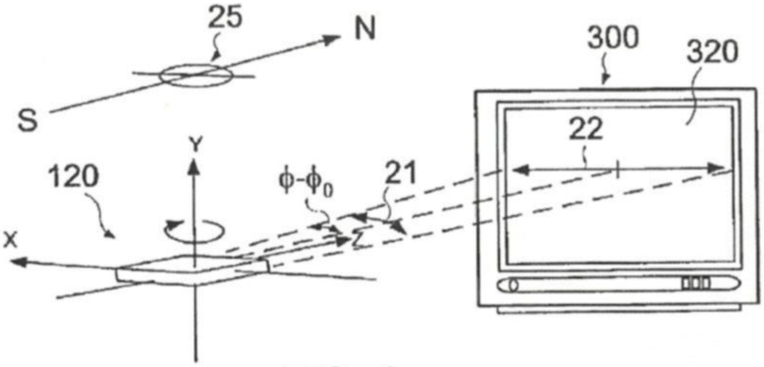


FIG. 4a

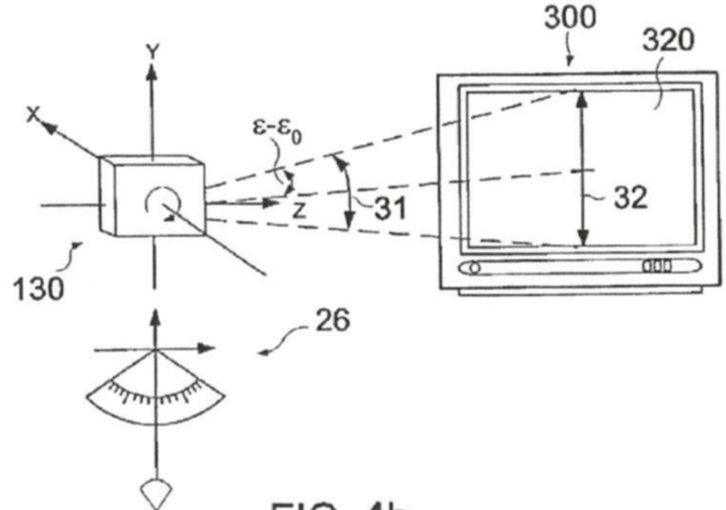


FIG. 4b

(Ex. 1002, ¶55). 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, ¶55-57).

Zhang's primary embodiment has a four-axis sensor module (compared to the "six-axis sensor module" required by claim 1). However, 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) 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, ¶58). Zhang also mentions that accelerometers, magnetometers and gyro (angular rate) sensors can be used in combination. (Ex. 1005, ¶¶0006, 0026, claim 2)(Ex. 1002, ¶¶58-60).

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."

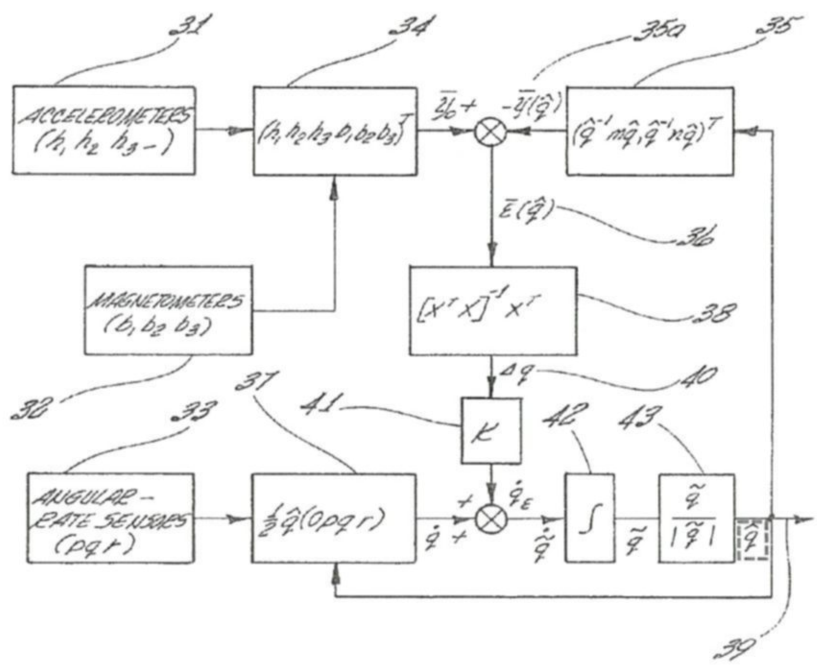
(Ex. 1004, 7:34-40)(Emphasis added)(Ex. 1002, ¶61). In Bachmann's system, each type of sensor is a three-axis sensor, making the entire system (3 sensor types x 3 axes per type) a nine-axis system. (Ex. 1002, ¶62).

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."

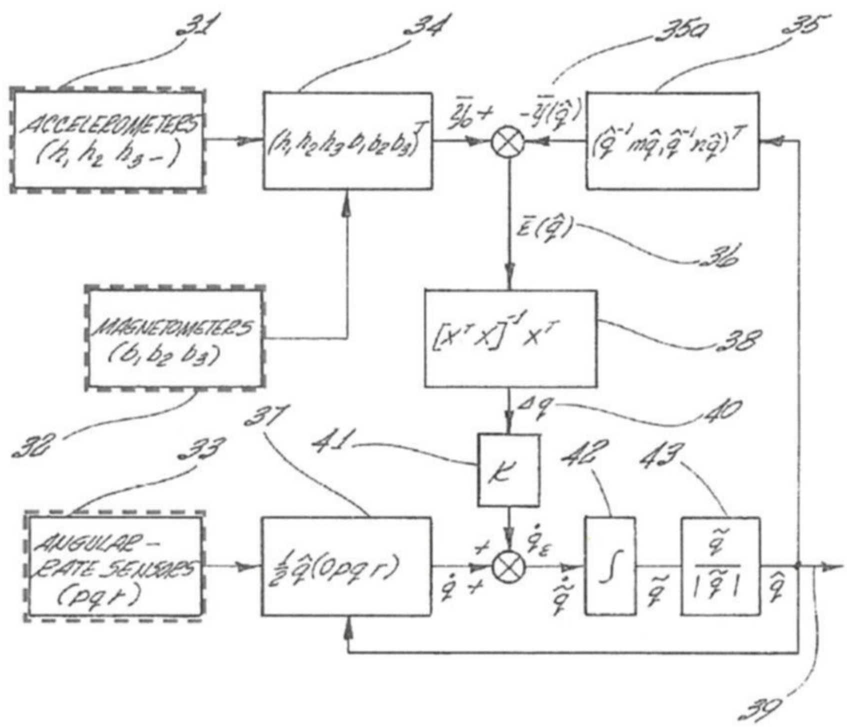
(Ex. 1004, 10:10-14)(Emphasis added)(Ex. 1002, ¶63). Bachmann thus takes the output of the accelerometer, magnetometer and angular rate sensors, and uses these sensor outputs to calculate an orientation of a tracked device. (Ex. 1002, ¶64).

To calculate the orientation from sensor inputs, Bachman uses a filter. Bachmann's filter employs the claimed calculations of the '438 patent. (Ex. 1002, ¶65). 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.



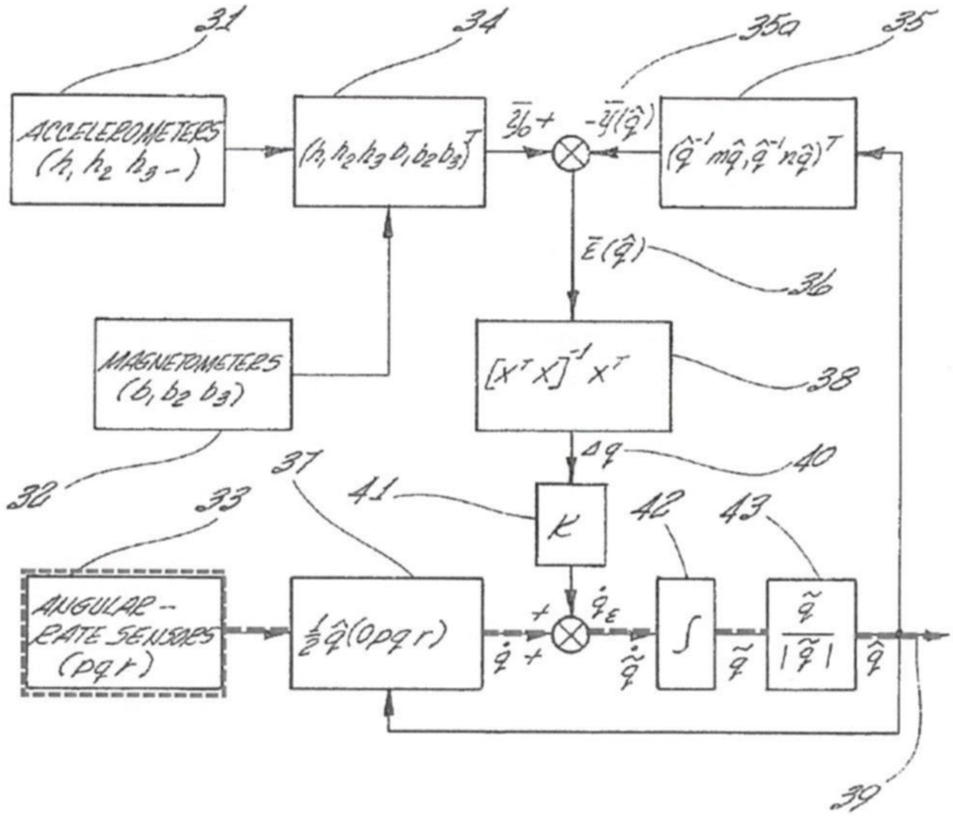
(Ex. 1004, Fig. 3)(Ex. 1002, ¶65). The output q̂ is a quaternion representing the orientation of the tracked object in space. (Ex. 1004, 10:10-14)(Ex. 1002, ¶65).

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. (Ex. 1004, 10:10-14)(Ex. 1002, ¶66). These sensors are shown in red-dashed boxes, below:



(Ex. 1002, ¶66).

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, ¶¶67-68). 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, ¶¶67-68). These rates are converted, in box 37, to a rate quaternion $\dot{q}$. (Ex. 1004, 10:15-36)(Ex. 1002, ¶¶67-68). 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, 10:38-65)(Ex. 1002, ¶¶67-68). 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, ¶¶67-68).

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[3] (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, ¶¶68-69). 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 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, 9:9-17, 17:12-22)(Ex. 1002, ¶¶68-69). This forms a six-valued error vector $\bar{\varepsilon}(\hat{q})$ numbered 36. (Ex. 1004, 9:9-17, 17: 12-22)(Ex. 1002, ¶¶68-69).

The six-valued error vector $\bar{\varepsilon}(\hat{q})$ is essentially a measure of how actual accelerometer and magnetometer measurements differ from the what the filter predicts those measurements should be, based on the angular rate sensor output. (Ex.

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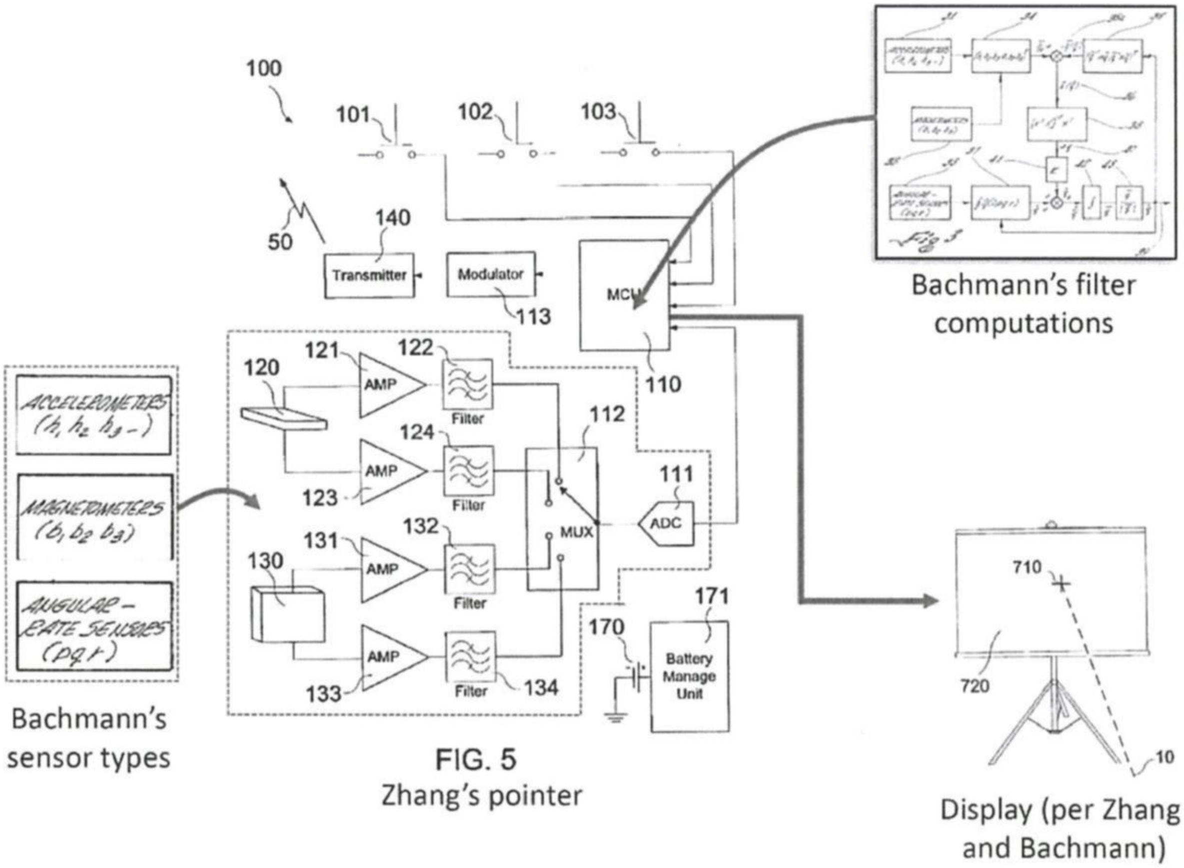
[3] The accelerometer measurements are first low-pass filtered to remove sudden accelerations. (Ex. 1004, 8:12-20)(Ex. 1002, ¶109).

1004, 17:12-22, 9:9-14)(Ex. 1002, ¶70). The error vector $\overline{\varepsilon}(\hat{q})$ is utilized in boxes 38 and 41. There, the filter selects a correction factor $\dot{q}_{\varepsilon}$ that will minimize $\overline{\varepsilon}(\hat{q})$. (Ex. 1004, 9:9-35)(Ex. 1002, ¶70). 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, ¶70). This has the effect of compensating the orientation output of the filter, $\hat{q}$. (Ex. 1002, ¶71).

The present 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 a deviation expressed as Euler angles (yaw, pitch, and roll), as disclosed in both Zhang and Bachmann, which can be used for a display. 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, ¶74).

Rationale for the Combination

It would have been obvious to a person of skill in the relevant timeframe[4] to use Zhang's 3D pointer with Bachmann's sensors and filter calculations. As

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[4] The first provisional application in the chain of applications leading to the '438 patent was filed on January 6, 2010. Petitioner assumes for the purpose of this proceeding that this date applies.

discussed above in the Overview section (beginning on page 22), 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, ¶75). 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, ¶76). 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, ¶76). Second, additional sensor axes and sensor types would have increased the overdetermination (the amount information beyond that necessary to determine orientation), which in turn would have enabled better error and noise control. (Ex. 1002, ¶76).

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, ¶77). 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, ¶78). 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, ¶79).

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, ¶80). 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, ¶80). 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, ¶80). 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, ¶81).

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, ¶82). Bachmann has the same, but uses additional sensors and a modified calculation. (Ex. 1002, ¶82). 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, ¶82). 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, ¶82). There would have been no unexpected results—only the *expected* improvement promised by Bachmann. (Ex. 1002, ¶82). 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 a resulting deviation using Euler angles (yaw, pitch and roll). In general, Zhang teaches outputting data to be used in an application, such as on a display device. (Ex. 1002, ¶83). 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, ¶82). To do this, Zhang's system calculates "difference angles", including the azimuth (yaw) and inclination (pitch) angles. Zhang states:

> "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, ¶84). Zhang further discloses that the **roll angle** can be calculated:

> "The sensor 120 detects the device's **yaw** (azimuth) angle and sensor 130 detects device's **pitch** (inclination) angle. Additional sensors (not show in the picture) could be used to detect device's **roll** angle which may provide an additional dimension of control. A microcontroller 110 provides computation power for calculating and encoding the orientation signal output from the orientation sensors."

(Ex. 1005, ¶0025)(Emphasis added)(Ex. 1002, ¶123).

Bachmann likewise discloses that its orientation output can be expressed as Euler angles, which were known to be the "conventional" way to express orientation:

> "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)(Emphasis added)(Ex. 1002, ¶121). It would thus 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, ¶¶83-86, 121-125). The equations for such a transformation were widely known in the art. (Ex. 1002, ¶123).

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, ¶¶87-89). 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 Zhang's device using standard conditioning circuits, samplers and analog-to-digital converters, making adjustments as necessary. (Ex. 1002, ¶¶87-89).

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, ¶¶87-89). In the relevant timeframe, microprocessors and microcontrollers with sufficient power to implement Bachmann's filter would have been readily available. (Ex. 1002, ¶¶87-89). A person of skill likewise would have expected success performing a transformation of Bachmann's orientation output into Euler angles to express a deviation, because the calculations were well-known and that was the conventional form of such output. (Ex. 1002, ¶¶87-89).

The '438 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, ¶¶87-89). In fact, the '438 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, ¶¶87-89). *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.

<u>*Graham* Factors</u>

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.

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 1 and 3-5 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 1, lettering has been added to each element (*e.g.* [1b]) 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 1

"1[a]. A three-dimensional (3D) pointing device subject to movements and rotations in dynamic environments, comprising:"

As discussed above in the Overview of the Ground, Zhang discloses a **3D pointing device.** (Ex. 1005, Title, Abstract)(Ex. 1002, ¶93). An example of the 3D pointing device is shown as device 100 in Fig. 2 of Zhang, reproduced at right. (Ex. 1002, ¶93).

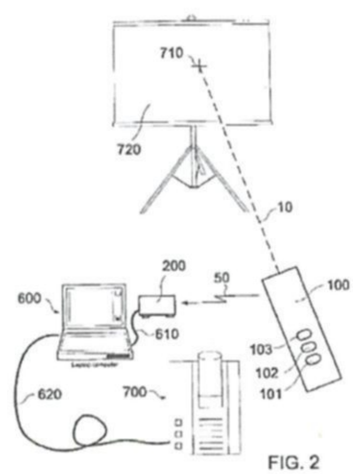


FIG. 2

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."

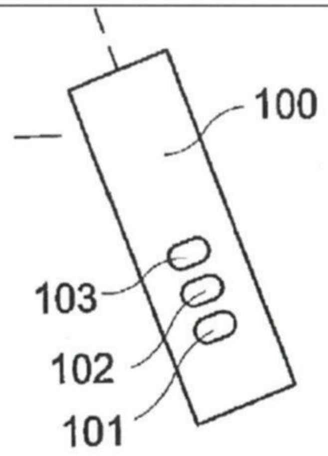
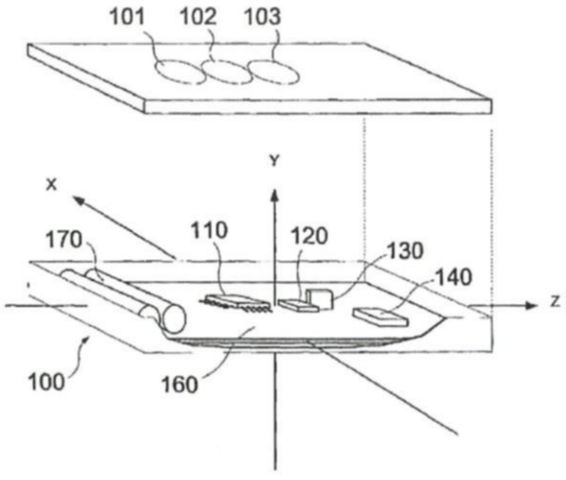
(Ex. 1005, ¶0007)(Ex. 1002, ¶94).

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, ¶95). 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, ¶95).

The Zhang pointing device is **subject to movements and rotations in dynamic environments.** (Ex. 1005, ¶¶0026-0027)(Ex. 1002, ¶96). For example, Zhang discloses that a user can use the Zhang pointing device to control a presentation by both rotating the device and by moving it horizontally and vertically. *(Id.)*.

"[1b] a housing associated with said movements and rotations of the 3D pointing device in a spatial pointer reference frame;"

Zhang teaches that its pointing device has a **housing**. The housing is shown in Figs. 1-3 of Zhang. Device 100 as shown in Fig. 2 of Zhang and device 100 as shown in Fig. 3 of Zhang are reproduced side-by-side below:

	 FIG. 3
Device 100 in Fig. 2	**Device 100 in Fig. 3**

(Ex. 1002, ¶97). In each case, the housing is visible as the external surface of the device. Zhang explains that "FIG. 3 exposes the components inside of the handheld pointing device." (Ex. 1005, ¶0025 and 0012). In Fig. 3, the housing is visible as the top lid (not numbered, but comprising buttons 101, 102 and 103) and the bottom box (also not numbered), which holds the printed circuit board 160. (Ex. 1005, ¶0025)(Ex. 1002, ¶98). A person of skill would have understood these pieces to comprise a housing, because they are shown as contiguous in Figs. 1 and 2, and because the text corresponding to Fig. 3 indicates that other components are found "inside of the handheld pointing device". (Ex. 1005, ¶0025)(Ex. 1002, ¶98).

The housing is **associated with movements and rotations of the 3D pointing device in a spatial pointer reference frame**, because the user moves the pointer, including its housing, to issue commands to a computer or display device. (Ex. 1002, ¶99). The spatial pointer reference frame moves with the pointer, and is shown, for example, by the X, Y and Z axes in Fig. 3. (Ex. 1002, ¶99).

"[1c] a printed circuit board (PCB) enclosed by the housing;"

Zhang discloses a printed circuit board (PCB) enclosed by the housing. As shown in Fig. 3, the housing encloses a PCB 160. (Ex. 1005, ¶0025)(Ex. 1002, ¶100). Zhang states:

> "FIG. 3 exposes the components **inside of the handheld pointing device.** On the top face of the device are buttons 101, 102, and 103 for collecting user selection activities. A set of orientation sensors 120 and 130 mounted on the **print circuit board 160** detect device's orientation changes. Note that the sensors are mounted orthogonally to each other."

(Ex. 1005, ¶0025)(Emphasis added)(Ex. 1002, ¶100). A person of ordinary skill would have understood the "print circuit board" to which components can be mounted as a "printed circuit board" or "PCB". (Ex. 1002, ¶101).

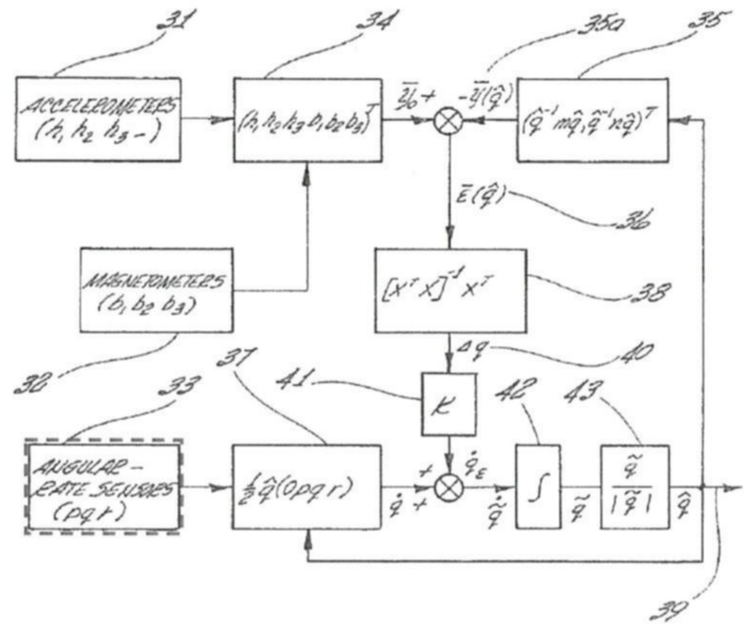
> ***"[1d] a six-axis motion sensor module attached to the PCB, comprising a rotation sensor for detecting and generating a first signal set comprising angular velocities $\Omega_x, \Omega_y, \Omega_z$, associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,"***

Zhang discloses a **motion-sensor module attached to the PCB.** As noted above, Zhang states:

> "A **set of orientation sensors 120 and 130 mounted on the print circuit board 160** detect device's orientation changes. Note that the sensors are mounted orthogonally to each other."

(Ex. 1005, ¶0025)(Ex. 1002, ¶102). As noted above, the combination uses Bachmann's sensors with Zhang's pointer. Bachmann's sensors include **three sensors to measure angular velocities (angular rates) $\Omega_x, \Omega_y, \Omega_z$, three sensors to measure axial accelerations Ax, Ay, Az,** and three sensors to measure magnetism b_1, b_2 and b_3. (Ex. 1004, 10:10-14)(Ex. 1002, ¶¶103-105). Thus, Bachmann teaches a sensor module with at least **six axes** (X, Y and Z axes for each of two of Bachmann's sensor types). (Ex. 1002, ¶¶103-105). Bachmann contains a six-axis sensor module in the form of the three angular velocity sensors and three axial acceleration sensors. (Ex. 1002, ¶¶103-105).

Bachmann's sensor module generates a first **set of signals (p, q, r) comprising angular velocities $\boldsymbol{\Omega_x, \Omega_y, \Omega_z}$.** (Ex. 1004, 10:10-14)(Ex. 1002, ¶104).



Specifically, Bachmann uses angular velocity (rate) detectors 33 to **generate a first set of signals** (p, q, r). This first set of signals (p, q, r), which is shown in box 33 of Fig. 3 of Bachmann (outlined in a red-dashed box, at right), is **associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame.** Specifically, the angular rate sensor is a **"three-axis** angular rate sensor". (Ex. 1004, 10:12)(Emphasis added)(Ex. 1002, ¶104). The axes are the three **coordinate axes of the spatial reference frame of the pointer.** (Ex. 1002, ¶¶105-106). This is because the angular rate sensors are fixed to the tracked object, and thus the origin and the axes of measurement move and rotate with the tracked object (Ex. 1002, ¶105), and remain fixed with respect to the tracked object. (Ex. 1002, ¶105). As Bachmann states, referring to equation (11), the angular rates are "measured in the sensor reference frame." (Ex. 1004, 10:17-30)(Ex. 1002, ¶105).

The "sensor reference frame" in Bachmann is the "spatial pointer reference frame" in the '438 patent. (Ex. 1002, ¶¶105-106).

It would have been **obvious to mount all of Bachmann's sensors on Zhang's PCB**. First, Zhang expressly states that its sensors are mounted on the printed circuit board 160. (Ex. 1005, ¶0025)(Ex. 1002, ¶107). As shown in Fig. 3 of Zhang, the PCB 160 takes up the entire inner area of pointing device, and thus Bachmann's sensors would obviously need to be placed on the PCB 160. (Ex. 1002, ¶107). Zhang also states that the sensors are mounted orthogonally to each other. (*Id.*). Bachmann's sensors sense along orthogonal axes X, Y, and Z, and would thus also be mounted orthogonally. Given Zhang's express suggestion that sensors be mounted on the PCB (Ex. 1005, ¶0025), the similarity in the needed orthogonal mounting techniques, and the fact that components were typically mounted to circuit boards in the relevant time frame, a person of ordinary skill would have found it obvious to mount **Bachmann's sensors on Zhang's PCB**. (Ex. 1002, ¶107).

> ***"[1e] an accelerometer for detecting and generating a second signal set comprising axial accelerations Ax, Ay, Az associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame;"***

The combination of Zhang and Bachmann would use an **accelerometer** having a set of **three axial acceleration sensors**. (Ex. 1002, ¶108). The sensors

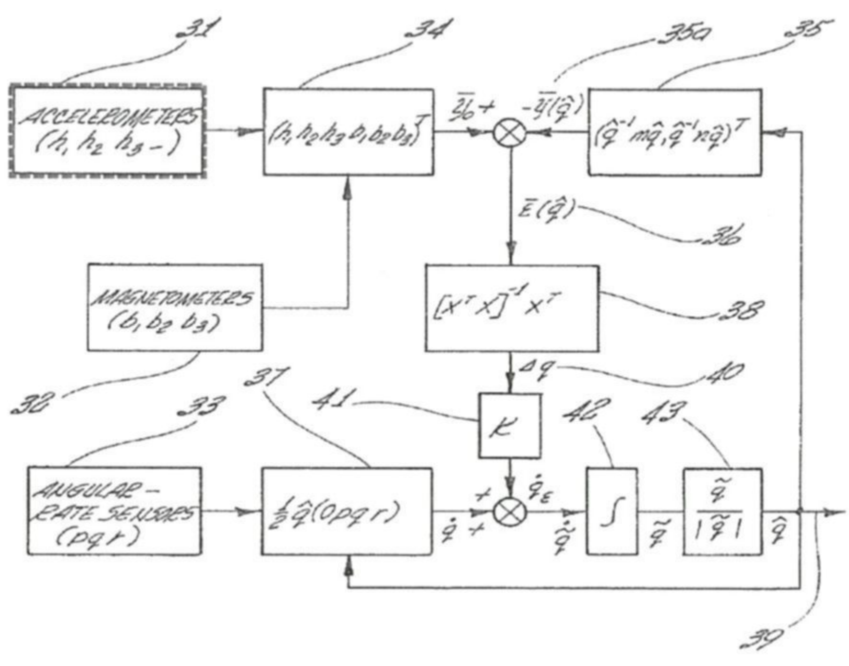
generate a second signal set designated $\overrightarrow{a}_{measured}$ in Bachmann. Bachmann explains as follows:

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

(Ex. 1004, 8:12-16)(Emphasis added)(Ex. 1002, ¶108). The total acceleration is expressed in Bachmann in equation (1) reproduced here:

$$\overrightarrow{a}_{measured} = \overrightarrow{a} + \overrightarrow{g} \quad (1)$$

The signals $\overrightarrow{a}_{measured}$ 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, ¶109). Figure 3 is reproduced below with a red box around the accelerometers and their output signals (h_1, h_2, h_3) (which are filtered versions of $\overrightarrow{a}_{measured}$):



(Ex. 1002, ¶110).

The accelerometer measurements generate a signal set $\overrightarrow{a}_{measured}$ (broken down after filtering as h_1, h_2, and h_3 for the X, Y, and Z axes) that **comprise axial accelerations Ax, Ay, Az associated with said movements and rotations of the 3D pointing device in the spatial pointer reference frame,** because (as shown in the block quote above) the signals $\overrightarrow{a}_{measured}$ comprise forced linear acceleration. (Ex. 1004, 8:12-16) (Ex. 1002, ¶111). These forced linear accelerations are accelerations that the **3D pointing device** experiences due to **movements and rotations**. (Ex. 1002, ¶111). 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, Ay, Az. (Ex. 1002, ¶111).

The accelerations are **in the spatial pointer 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, ¶112). Accordingly, they are measured in the spatial pointer reference frame. (Ex. 1002, ¶112). This fact can also be seen directly from equation (7) of Bachmann ($h = \hat{q}^{-1}m\hat{q}$). (Ex. 1002, ¶112). 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 second signal set $\overrightarrow{a}_{measured}$. (Ex. 1004, 8:63-67)(Ex. 1002, ¶112). The transformation causes m to be converted to the frame of reference of the pointer, and further demonstrates that the resulting filtered accelerometer output h is in the pointer frame of reference. (Ex. 1002, ¶112). The pointer frame of reference, in turn, is the **spatial pointer reference frame** required by the claim. (Ex. 1001, 5:60-64, 6:10-13)(Ex. 1002, ¶112).

> ***"[1f] and a processing and transmitting module, comprising a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof and a computing processor for receiving and calculating said first and second signal sets from the data transmitting unit,"***

Zhang includes **a processing and transmitting module**. The processing and transmitting module is shown in the system diagram of Fig. 5 of Zhang, reproduced below with a red-dashed boundary drawn around the components in the processing and transmitting module:

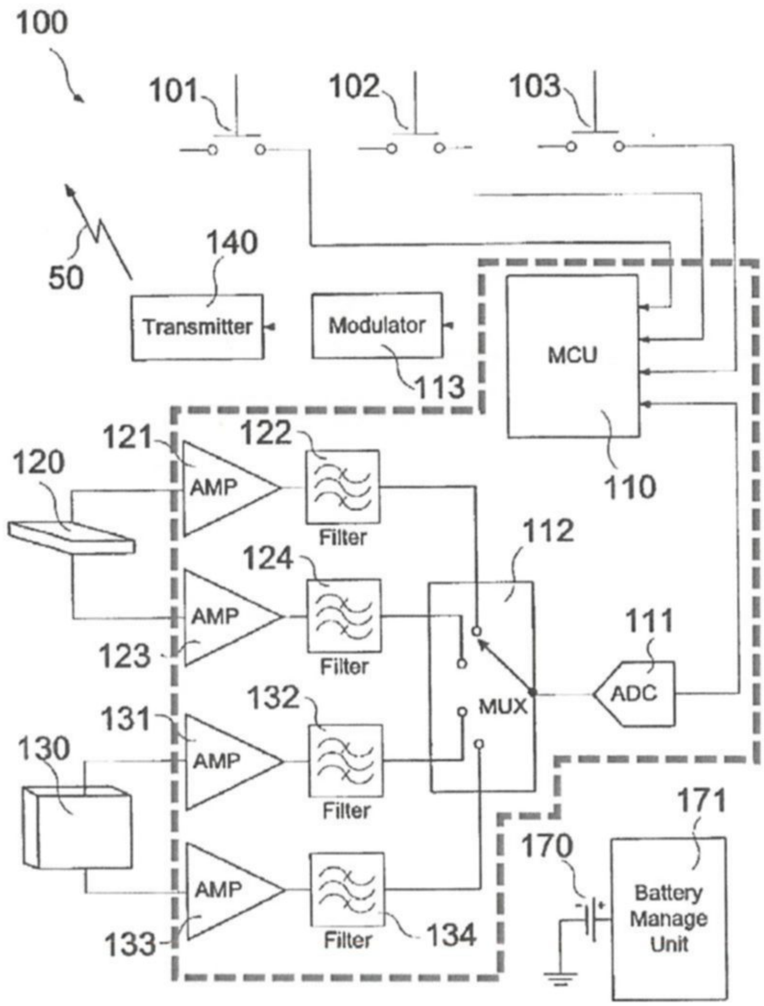


FIG. 5

(Ex. 1005, ¶0029)(Ex. 1002, ¶113).

The processing and transmitting module includes **a data transmitting unit electrically connected to the six-axis motion sensor module for transmitting said first and second signal sets thereof**. The data transmitting unit is shown in the blue-dashed outline in Fig. 5, reproduced again below:

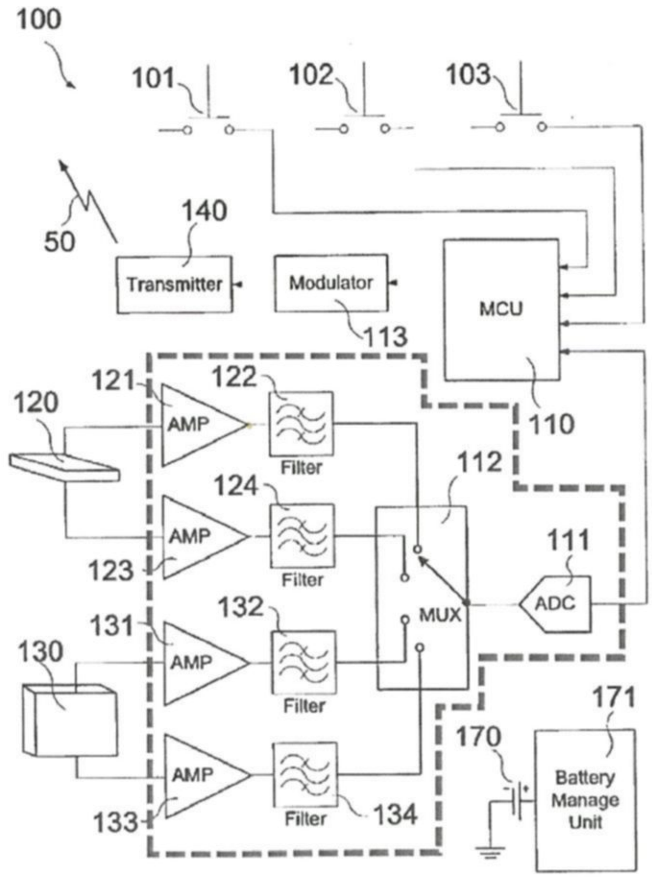
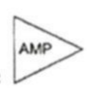


FIG. 5

(Ex. 1005, ¶0029)(Ex. 1002, ¶114). As can be seen from the Figure, the data transmitting unit includes amplifiers, filters, a multiplexer and an analog-to-digital converter. (Ex. 1005, ¶0029)(Ex. 1002, ¶115). The data transmitting unit is **electrically connected to the six-axis motion sensor module** by the lines between the sensors and the amplifiers (shown by the 

symbol) on the left side of the Figure. (Ex. 1005, ¶0029)(Ex. 1002, ¶115). In the combination, the sensors would be those of Bachmann, and the circuit would be modified accordingly (to have nine input paths, for example). (Ex. 1002, ¶¶115-116).

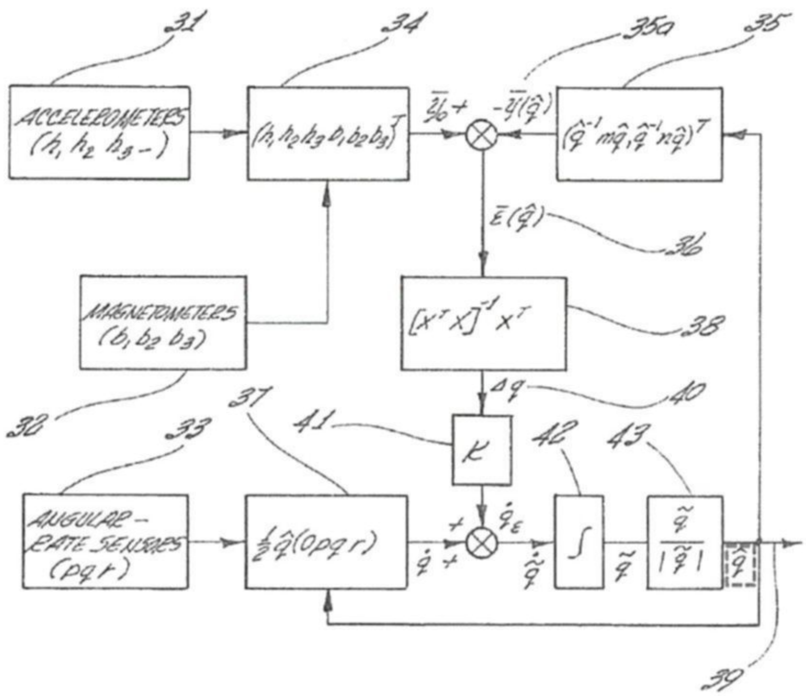
The data transmitting unit is furthermore **for transmitting said first and second signal sets thereof** because, once the signals have been conditioned and converted to digital, they are transferred to MCU 110. (Ex. 1005, ¶0029)(Ex. 1002, ¶115). The MCU 110, in turn, is the **computing processor for receiving and calculating said first and second signal sets from the data transmitting unit**. (Ex. 1005, ¶0029)(Ex. 1002, ¶117). Specifically, the MCU 110 receives the first and second signal sets from the data transmitting unit, and performs calculations on them. (Ex. 1005, ¶0029)(Ex. 1002, ¶118). In the combination, the calculations include the calculations according to Bachmann's filter. (Ex. 1002, ¶118).

"[1g] communicating with the six-axis motion sensor module to calculate a resulting deviation comprising resultant angles in said spatial pointer reference frame"

As discussed under element [1f], above, the MCU 110 of Zhang communicates with the six-axis motion sensor module by obtaining data from the sensors. (Ex. 1005, ¶0025)(Ex. 1002, ¶119). In the combination, it is obvious that the processor chip used would communicate in a like manner with the sensors taught by Bachmann. (Ex. 1002, ¶119).

In the combination, the processor (*e.g.* MCU 110 of Zhang or the processor 403 of Bachmann) also **calculates a resulting deviation comprising resultant angles in said spatial pointer reference frame**. In the '438 patent, a "deviation" is equivalent to an "orientation" and may comprise the angles specified by the claim. (Ex. 1001, 1:58-61, 14:47-55).

The combination renders obvious calculating a deviation comprising the requisite angles in two ways. First, Bachmann teaches, as described above in the Overview section beginning on page 23, a filter that outputs an "orientation of the tracked object", q̂. (Ex. 1004, 10:10-14)(Ex. 1002, ¶120). The orientation output q̂ is shown in the lower-right corner of Fig. 3 of Bachmann, reproduced below with a red-dashed box around it:



(Ex. 1002, ¶120). The orientation output $\hat{q}$ is a quaternion that represents a deviation (or rotation)[5] about the sensor-based coordinate axes. (Ex. 1002, ¶’1’). The sensor-based coordinate system is the **spatial reference frame** required by the claim. (Ex. 1001, 5:60-64, 6:10-13)(Ex. 1002, ¶121). Because the orientation output $\hat{q}$ is a quaternion representing the deviation necessary to go from the sensor frame to the earth-fixed frame of reference (Ex. 1004, 8:63-67)(Ex. 1002, ¶122), it represents the device’s orientation, and can be considered the deviation required by the claims.[6] (Ex. 1002, ¶122). The three deviation angles are simply expressed in the equivalent mathematical form of the quaternion. (Ex. 1002, ¶122).

The fact that $\hat{q}$ is a quaternion representing the deviation (rotations) between the sensor frame and 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

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[5] As Prof. Sarrafzadeh explains, a quaternion can be conceived of as describing a rotation about three coordinate axes. (Ex. 1002, ¶¶29-32).

[6] 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. 9). Petitioner does not concede that Patent Owner’s interpretation is the proper construction in district court under the *Phillips* standard.

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. 1002, ¶121). The sensor frame, in turn, is the **spatial reference frame** required by the claim. (Ex. 1001, 5:60-64, 6:10-13)(Ex. 1002, ¶121).

Second, the combination also renders obvious **calculating a resulting deviation comprising resultant angles** from the orientation output $\hat{q}$ of Bachmann 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, ¶¶122-126). 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)(Emphasis added)(Ex. 1002, ¶122). 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,

¶123). The equations for such a transformation were widely known in the art. (Ex. 1002, ¶123).

Such a transformation would also have been obvious because the Euler angles are used by Zhang. Specifically, Zhang uses sensor output to determine yaw and pitch, and expressly suggests determining the roll angle:

> "The sensor 120 detects the device's yaw (azimuth) angle and sensor 130 detects device's **pitch** (inclination) angle. Additional sensors (not show in the picture) could be used to detect device's **roll** angle which may provide an additional dimension of control. A microcontroller 110 provides computation power for calculating and encoding the orientation signal output from the orientation sensors."

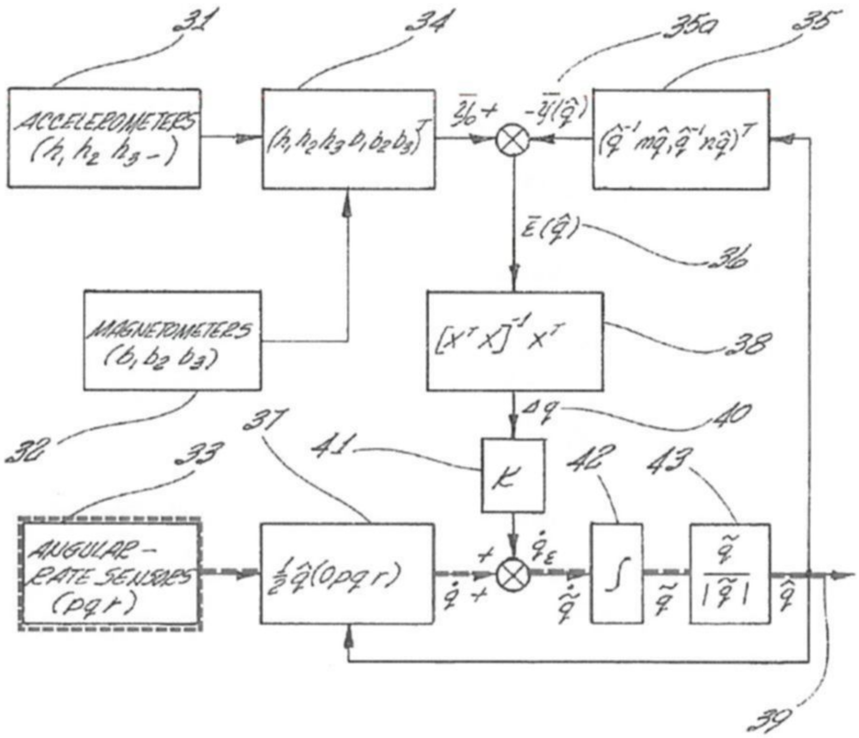
(Ex. 1005, ¶0025)(Emphasis added)(Ex. 1002, ¶124).

Because Zhang's output is in Euler angles, and because Bachmann outputs a quaternion equivalent to Euler angles, it would have been obvious to calculate the Euler angles (using well-known methods) equivalent to Bachmann's orientation output $\hat{q}$ to meet Zhang's output requirements and to make the orientation output more intuitive to human users. (Ex. 1002, ¶125). These Euler angles represent **a resultant deviation including a plurality of deviation angles.**

The orientation output quaternion $\hat{q}$ represents a deviation (*i.e.* a set of angles or a rotation) *from* the spatial pointer reference frame *to* the earth-fixed frame. (Ex. 1002, ¶126). Therefore, the Euler angles equivalent to the orientation output quaternion $\hat{q}$ represent the angles between the spatial pointer reference frame and the earth-fixed frame. Thus, the equivalent Euler angles are **in said spatial pointer reference frame,** because they represent the angles between the axes of the spatial pointer reference frame and the corresponding axes of the earth-fixed frame. (Ex. 1002, ¶¶121-126).

> ***"[1h] by utilizing a comparison to compare the first signal set with the second signal set whereby said resultant angles in the spatial pointer reference frame of the resulting deviation of the six-axis motion sensor module of the 3D pointing device are obtained under said dynamic environments, wherein the comparison utilized by the processing and transmitting module further comprises an update program to obtain an updated state based on a previous state associated with said first signal set and a measured state associated with said second signal set;"***

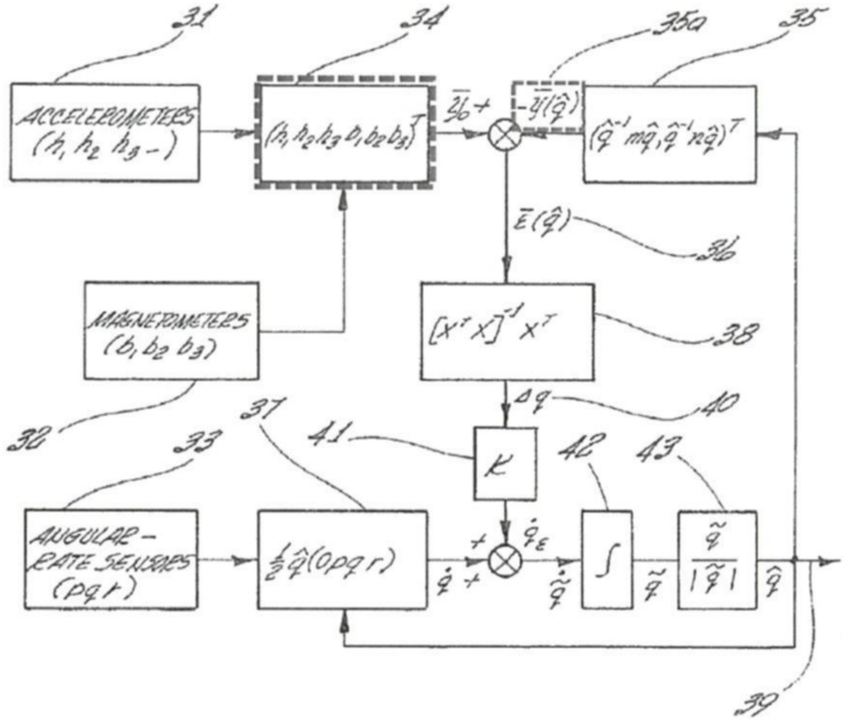
Bachmann **utilizes a comparison to compare the first signal set with the second signal set** to obtain the resulting deviation. (Ex. 1002, ¶127). As explained in the Overview section (beginning on page 23), Bachmann's filter calculates the orientation output quaternion $\hat{q}$ by integrating and normalizing the angular rate quaternion $\dot{q}$, which is shown by the pathway highlighted with a red-dashed line in Fig. 3, below:

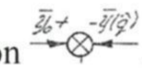


(Ex. 1002, ¶127). In the figure, the output of the angular rate sensors (33, lower left) is a set of measured angular rates of rotation (p, q, r) about three axes (*i.e.* the first signal set). (Ex. 1004, 10:10-14)(Ex. 1002, ¶128). These rates are converted, in box 31, to a rate quaternion $\dot{q}$. (Ex. 1004, 10:15-36)(Ex. 1002, ¶128). To the rate quaternion q is added a correction factor $\dot{q}_\varepsilon$, to yield a corrected rate quaternion $\dot{\tilde{q}}$. (Ex. 1004, 10:38-65)(Ex. 1002, ¶128). 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, ¶128).

The claimed **comparison** happens in forming the 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[7] (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, ¶¶129-130). These six measurement values include three measurements of acceleration along the X, Y and Z axes of the sensors (*i.e.* the second signal set), 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** 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, 9:9-17, 17:12-22)(Ex. 1002, ¶¶129-130). In Fig. 3, below, the actual measurements are shown in a blue-dashed box, while the predicted measurement vector $\bar{y}(\hat{q})$ is shown in a red-dashed box.

[7] The accelerometer measurements are first low-pass filtered to remove sudden accelerations. (Ex. 1004, 8:12-20)(Ex. 1002, ¶111).



Subtracting predicted measurements from actual measurements (i.e. "comparing" them) forms a six-valued error vector $\bar{\varepsilon}(\hat{q})$, numbered 36 in Fig. 3. (Ex. 1004, 17:12-22, 9:9-14)(Ex. 1002, ¶131). The comparison happens in Fig. 3 above directly between the blue and red-dashed boxes at the junction . (Ex. 1002, ¶131). The error vector $\bar{\varepsilon}(\hat{q})$ is utilized in boxes 38 and 41 to select a correction factor $\dot{q}_{\varepsilon}$ that will minimize $\bar{\varepsilon}(\hat{q})$. (Ex. 1004, 9:9-35)(Ex. 1002, ¶131). 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, ¶131). This has the effect of compensating the orientation output of the filter, $\hat{q}$. (Ex. 1002, ¶131).

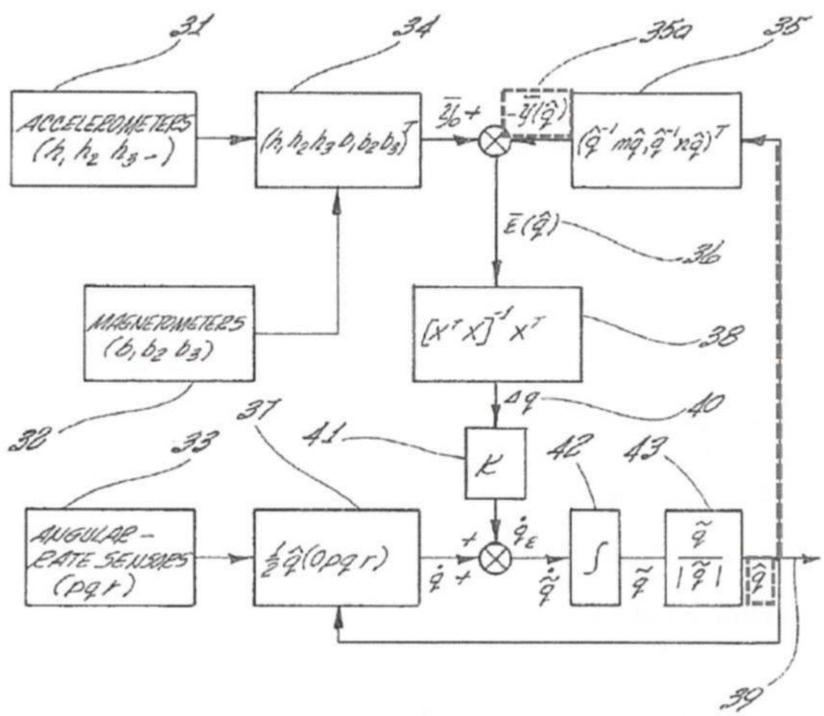
The process described above is a "**comparison**" as construed above (*see* §II.A, above) because it is used while **calculating and obtaining** the orientation output quaternion $\hat{q}$, which is in turn used to calculate **the deviation angles with respect to the spatial pointer frame**. (Ex. 1002, ¶132). The calculation also **utilizes signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors**. Specifically, the calculation of the correction factor $\dot{q}_{\varepsilon}$ uses signals from six sensor axes, the accelerometers (*i.e.* the second signal set) and angular rate sensors (*i.e.* the first signal set), and reduces errors associated with the sensors. As Bachmann explains:

> "[I]n normal operating environment, **the output 33 of angular rate detectors tends to drift over time**. Thus, rate detector data 33 can be used to determine orientation only for relatively short periods of time unless this **orientation is continuously corrected using 'complementary' data from additional sensors** (here, accelerometer 31 and magnetometer 32). Thus, as 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, 10:36-45)(Emphasis added)(see *also* Ex. 1004, 9:1-48)(Ex. 1002, ¶132).

In the combination, the filter of Bachmann would be implemented in software running on a processor (such as Zhang's MCU 110 or Bachmann's processor 403), and would thus constitute an **update program.** (Ex. 1002, ¶133). The processor (and thus the update program) is part of the processing **and transmitting module,** as explained above under element [1f]. (Ex. 1002, ¶133). The **updated state** is a new value of the orientation output quaternion $\hat{q}$. (Ex. 1004, 10:10-14)(Ex. 1002, ¶133).

The updated state is **based on a previous state**, because the correction factor $\dot{q}_\varepsilon$ is calculated using predicted measurements $\bar{y}(\hat{q})$, which in turn uses the prior orientation output quaternion $\hat{q}$ (*i.e.* **the previous state**). (Ex. 1004, 11:12-20 and Equation (8), 3:42-46). This is shown by the added red-dashed line in Fig. 3, below:



(Ex. 1002, ¶134). As can be seen in box 35 (and equation (7)) of Bachmann, the prior orientation output quaternion $\hat{q}$ is used to calculate predicted measurements $\bar{y}(\hat{q})$. (Ex. 1002, ¶134).

The **previous state** (*i.e.* prior orientation output quaternion $\hat{q}$) **is associated with said first signal set.** The first signal set, as explained above under element [1d], constitutes the signals (p, q, r) comprising angular velocities $\Omega_x, \Omega_y, \Omega_z$. These first signals are used to calculate each output $\hat{q}$ (as explained above) and are therefore a part of each orientation output quaternion $\hat{q}$. (Ex. 1002, ¶136).

The measured state is **associated with said second signal set**. The "measured state" of the claims comprises both the filtered actual measurements (h_1 h_2 h_3 b_1 b_2 b_3) and the predicted measurements $\bar{y}(\hat{q})$. (Ex. 1002, ¶137). The second signal set, as explained above under element [1e], comprises axial accelerations Ax, Ay, Az. (Ex. 1002, ¶137). The **measured state is associated with said second signal set** because the *actual* measurements contain accelerations (h_1, h_2, h_3). The *predicted* measurement vector also contains predicted accelerations (h_1, h_2, h_3), as shown in equation 8 of Bachmann, reproduced below:

$$y(\hat{q}) = [h_1 h_2 h_3 b_1 b_2 b_3]^T \quad (8)$$

(Ex. 1004, 8:63-9:48)(Ex. 1002, ¶137).

> ***"[1i] wherein the measured state includes a measurement of said second signal set and a predicted measurement obtained based on the first signal set without using any derivatives of the first signal set."***

As explained above under element [1h], the measured state (h_1 h_2 h_3 b_1 b_2 b_3) includes actual **measurements of the second signal set** (*i.e.* measured accelerations), in (h_1, h_2, h_3). The measured state also includes **predicted measurements of the second signal set** (*i.e.* predicted accelerations) in the vector $\bar{y}(\hat{q})$. (Ex. 1004, 8:63-9:48)(Ex. 1002, ¶¶138-140). This vector is shown in Equation (8) of Bachmann, reproduced below, where the predicted accelerations are visible as h_1 h_2 h_3.

$$y(\hat{q}) = [h_1 h_2 h_3 b_1 b_2 b_3]^T \tag{8}$$

The predicted measurements of the second signal set are **obtained based on the first signal set without using any derivatives of the first signal set**. Specifically, the predicted measurement vector $\bar{y}(\hat{q})$ is obtained by transforming the magnetic field vector n and the gravity vector m, using the prior orientation output quaternion $\hat{q}$. This is shown in the two equations labeled (7) in Bachmann, reproduced below:

$$h = \hat{q}^{-1} m \hat{q} \quad b = \hat{q}^{-1} n \hat{q} \tag{7}$$

(Ex. 1004, 8:52-67)(Ex. 1002, ¶139). The resulting vectors h and b are combined to form the computed (predicted) measurement vector $\bar{y}(\hat{q})$. (Ex. 1004, 9:1-8)(Ex. 1002, ¶140).

Equations (7) (and thus $\bar{y}(\hat{q})$) are **based on the first signal set** (*i.e.* angular velocities), because equations (7) use $\hat{q}$. The output $\hat{q}$, in turn, is integrated from the output of the angular rate sensors 33 (*i.e.* the first signal set), as discussed above under element [1h]. (Ex. 1002, ¶141).

The **predicted measurements also do not use any derivatives of the first signal set**. Specifically, the components of equation (7) do not use any derivatives of the first signal set (*i.e.* derivatives of angular velocities). The gravity vector m and the magnetic vector n are simple vectors describing directions, and do not contain any derivatives of the angular velocities. (Ex. 1004, 8:52-62)(Ex. 1002, ¶142). The prior orientation output quaternion $\hat{q}$, in turn, is a normalized *integral* (the opposite of a derivative) of the corrected rate quaternion $\dot{\hat{q}}$. (Ex. 1004, 10:15-65)(Ex. 1002, ¶142). The corrected rate quaternion $\dot{\hat{q}}$ itself is formed by adding two components: the rate quaternion q and the correction factor $\dot{q}_{\varepsilon}$. (Ex. 1004, Fig. 3, 10:46-11:26)(Ex. 1002, ¶142). The rate quaternion $\dot{q}$ is simply a quaternion representation of the angular velocities, not a derivative of the angular velocities. (Ex. 1004, Fig. 3, 10:46-11:26)(Ex. 1002, ¶142).

The correction factor $\dot{q}_{\varepsilon}$ is formed using a matrix X, which uses derivatives. (Ex. 1004, 10:46-65)(Ex. 1002, ¶143). However, these derivatives are the partial derivatives of the acceleration and magnetism with respect to changes in orientation, not derivatives of the first signal set (angular acceleration). (Ex. 1004, 10:46-65)(Ex. 1002, ¶143). Furthermore, the output value $\hat{q}$ is an integrated value of angular velocity, meaning any derivative operator applied to it would simply result in angular velocity, not the derivative of angular velocity. (Ex. 1002, ¶143).

Claim 3

"3. The 3D pointing device of claim 1, wherein the PCB enclosed by the housing comprises at least one substrate having a first longitudinal side configured to be substantially parallel to a longitudinal surface of the housing."

Zhang's PCB enclosed by the housing has a **substrate having a first longitudinal side configured to be substantially parallel to a longitudinal surface of the housing.** This is shown in Fig. 3, below, where the Petitioner has drawn dashed-red lines along two edges of the PCB substrate that are parallel to the a longitudinal surface of the housing:

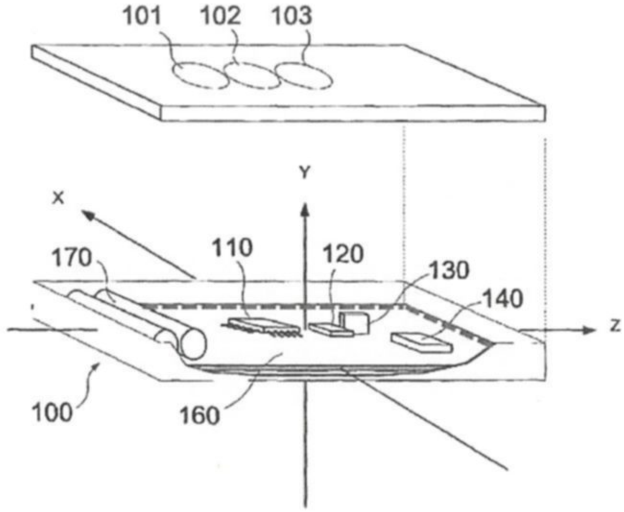


FIG. 3

(Ex. 1002, ¶¶144-145). One of the sides (*e.g.* the long one) is a "longitudinal side". (Ex. 1002, ¶¶144-145).

In addition, a person of ordinary skill would have found it obvious that fitting the PCB to the shape of the housing along the edges would have maximized the available area of the PCB, thereby allowing more components to be connected to the PCB. (Ex. 1002, ¶¶144-145).

Claim 4

"4. The 3D pointing device of claim 1, wherein the spatial pointer reference frame is a reference frame in three dimensions; and wherein said resultant angles of the resulting deviation includes yaw, pitch and roll angles about each of three orthogonal coordinate axes of the spatial pointer reference frame."

Both Zhang and Bachmann disclose that the spatial pointer reference frame is a frame in three dimensions. For example, Zhang discloses in connection with Fig. 3 (below at right) a pointer having **three axes**, x, y, and z, as shown in the figure.

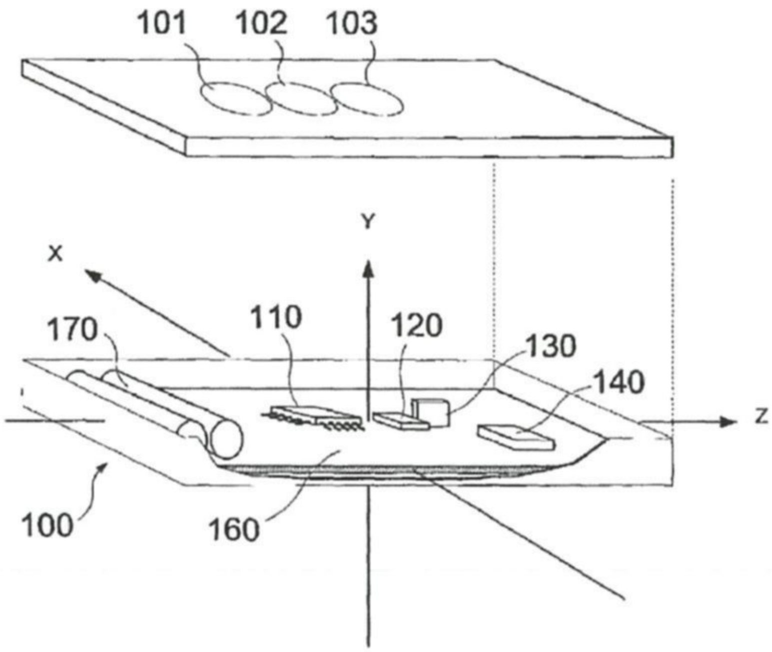
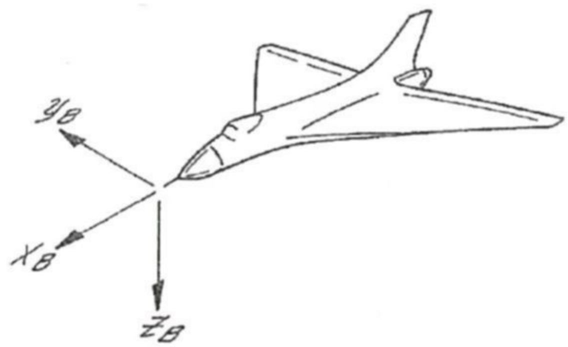


FIG. 3

(Ex. 1002, ¶¶146-149). Zhang states that its device calculates the yaw and pitch of the device, and suggests calculating the roll. (Ex. 1005, ¶0025)(Ex. 1002, ¶¶146-149).

Bachmann likewise discloses a "body coordinate system" with **orthogonal X-Y-Z** axes, equivalent to the claimed **spatial pointer reference frame**. (Ex. 1004, 5:49-6:10)(Ex. 1002, ¶¶146-149). This coordinate system is shown in Fig. 2(b) of Bachmann, reproduced below:



Bachmann states:

> "[I]t is important to specify a **body coordinate system** which is attached to the body being tracked. FIG. 2(b) depicts such a system. This is also an X-Y-Z system with X pointing 'out of the nose' in a positive direction, Y out the right side, and Z down. The subscript 'E' designates earth reference coordinates (X_E, Y_E, Z_E) and the subscript 'B' designates body reference coordinates (X_B, Y_B, Z_B)."

(Ex. 1004, 5:61-67)(Emphasis added)(Ex. 1002, ¶¶146-149).

As discussed above under claim 1, element [1g], the **resultant angles would be yaw, pitch and roll angles**. (Ex. 1002, ¶¶146-149).

Claim 5

> ***"5. The 3D pointing device of claim 1, wherein the data transmitting unit of the processing and transmitting module is attached to the PCB enclosed by the housing and transmits said first and second signal of the six-axis motion sensor module to the computing processor via electronic connections on the PCB."***

It would have been obvious to have the data transmitting unit of the processing and transmitting module attached to the PCB and transmitting the first and second signal sets to the processor via electronic connections on the PCB. As can be seen from Fig. 3 of Zhang, both the sensors and the processor are connected to the PCB 160, which takes up the entire internal area of the device 100. (Ex. 1004, Fig. 3)(Ex. 1002, ¶¶150-153). Thus, there is no room for an additional PCB. (Ex. 1002, ¶¶150-153). As explained above under claim 1, element [1f], the data transmitting unit is *functionally* between the sensors (*e.g.* 120 and 130) and the processor (*e.g.* 110), and must be electrically connected to the sensors and the processor. (Ex. 1002, ¶¶150-153). For these reasons, it would have been obvious to also attach the data transmitting unit to the same PCB, and to use the PCB traces (electronic connections on the PCB) in a known fashion to form the required connections. (Ex. 1002, ¶¶150-153). This would have been considered superior to adding a second PCB, for which the person of skill would have needed to find additional space and create longer board-to-board connections. (Ex. 1002, ¶¶150-153).

III. CONCLUSION

Petitioner respectfully requests that claims 1 and 3-5 of the '438 patent be canceled.

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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 by Federal Express on January 10, 2019, on the Patent Owner's counsel of record at the United States Patent & Trademark Office having the following address:

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Richmond TX 77406

Date: January 10, 2019

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CERTIFICATE OF WORD COUNT

The undersigned hereby certifies that the foregoing petition for *inter partes* review contains 11,337 words according to the word processing program used to prepare it.

Date: January 10, 2019

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