UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Samsung Electronics Co., Ltd.
Petitioner

v.

CM HK LIMITED
Patent Owner

Patent No. 10,852,846

PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,852,846

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Ex. 1008	U.S. Patent No. 8,462,109 to Nasiri ("Nasiri")
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I. INTRODUCTION

Samsung Electronics Co., Ltd. ("Petitioner") respectfully requests *inter partes* review of claims 1, 3, 7, and 9 (the "challenged claims") of U.S. Patent No. 10,852,846 (the "'846 patent") (Ex. 1001) assigned to CM HK Limited ("Patent Owner").

II. MANDATORY NOTICES

Real Parties-in-Interest: Pursuant to 37 C.F.R. § 42.8(b)(1), Petitioner identifies the following as the real parties-in-interest: Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, "Samsung") are the real parties-in-interest.

Related Matters: The '846 patent is asserted in the following civil actions (collectively, "the co-pending litigations"): *CM HK Ltd. v. Samsung Electronics Co., Ltd.*, No. 2:24-cv-00880-JRG (E.D. Tex.), and *Samsung Electronics Co. Ltd. v. CM HK, Ltd.*, No. 4:24-cv-06567-JST (N.D. Cal.). The '846 patent issued from U.S. Patent Application No. 15/611,970 ("the '970 Application"). The '970 Application is a continuation-in-part of U.S. Patent Application No. 12/943,934 (Ex. 1001, Cover), which issued as U.S. Patent No. 8,441,438 ("the '438 patent") (Ex. 1009). U.S. Patent No. 8,552,978 ("the '978 patent") (Ex. 1010) is in the same family as the '438 patent. (*Id.*, Cover.)

The '438 patent was at issue in *ZTE (USA), Inc. v. CyWee Group Ltd.*, IPR2019-00143. The PTAB issued a final written decision invalidating the challenged claims of the '438 patent and denying Patent Owner's Motion to Amend in *Google LLC v. CyWee Group Ltd.*, No. IPR2018-01258, Paper 86 (PTAB Jan. 9, 2020) (Ex. 1011), and in *ZTE (USA), Inc. and LG Electronics Inc. v. CyWee Group Ltd.*, No. IPR2018-00143, Paper 87 (PTAB Feb. 17, 2021) (Ex. 1012). The PTAB issued a final written decision invalidating the challenged claims of the '978 patent and denying Patent Owner's Motion to Amend in *Google LLC, et al v. CyWee Group Ltd.*, No. IPR2018-01257, Paper 87 (PTAB Jan. 9, 2020) (Ex. 1013).

Counsel and Service Information: Lead counsel is Naveen Modi (Reg. No. 46,224). Backup counsel are Chetan Bansal (Reg. No. 81,590) and Robert Laurenzi (Reg. No. 45,557). Service information is Paul Hastings LLP, 2050 M Street NW, Washington, D.C. 20036, Tel.: 202.551.1700, Fax: 202.551.1705, email: PH-Samsung-CMHK-IPR@paulhastings.com. Petitioner consents to electronic service.

III. PAYMENT OF FEES UNDER 37 C.F.R. §§ 42.15 AND 42.103

The PTO is authorized to charge any fees due during this proceeding to Deposit Account No. 50-2613.

IV. GROUNDS FOR STANDING

Petitioner certifies under 37 C.F.R. § 42.104(a) that the '846 patent is available for review and Petitioner is not barred or estopped from requesting review on the grounds identified herein.

V. PRECISE RELIEF REQUESTED AND GROUNDS RAISED

Petitioner respectfully requests review of claims 1, 3, 7 and 9 of the '846 patent and cancellation of these claims as unpatentable. The challenged claims should be found unpatentable on the following grounds:

Ground 1: Claims 1, 3, 7, and 9 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as rendered obvious by WO 2009/156499 to Bassompiere *et al.*("Bassompiere") (Ex. 1005). A certified translation of Bassompiere is attached as Exhibit 1006.

Ground 2: Claims 1 and 3 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as rendered obvious by Bassompiere in combination with U.S. Patent No. 8,462,109 to Nasiri ("Nasiri") (Ex. 1008).

The '846 patent has a filing date of June 2, 2017, and claims priority through multiple continuation and continuation-in-part applications to Application No. 12/943,934, which issued as the '438 patent, and was filed on November 11, 2010. The '846 patent also claims the benefit of Provisional Application No. 61/292,558

("the provisional '558 application") (Ex. 1014), filed on January 6, 2010.[1] Bassompiere published on December 30, 2009, and is therefore prior art to the challenged claims under pre-AIA 35 U.S.C. § 102(a). Nasiri was filed on June 16, 2009, and issued on June 11, 2013, and is therefore prior art to the challenged claims under pre-AIA 35 U.S.C. § 102(e).

A U.S. equivalent of Bassompiere (U.S. Patent Publication No. 2011/0199298) and a patent application publication related to Nasiri (U.S. Patent Publication No. 2009/0262074) were considered by the Patent Office during prosecution of the '846 patent. (Ex. 1001, p. 2.) Neither Bassompiere nor Nasiri were raised by the Examiner in any rejection.[2] Moreover, Nasiri is merely being relied upon as a secondary reference in conjunction with other references. Thus, a discretionary denial under 35 U.S.C. § 325(d) is not appropriate.

VI. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art at the time of the alleged invention of the '846 patent ("POSA") would have had an undergraduate degree in electrical

[1] As explained below in Section X, the challenged claims of the '846 patent are not entitled to the filing date of the provisional '558 application. (*Infra* Section X.)

[2] In IPR2019-00143, Petitioner argued that Nasiri rendered obvious (in combination with other references) certain proposed claim amendments made by Patent Owner.

engineering, computer engineering, computer science, physics or a related field along with two years of work experience in the field of sensors (such as accelerometers, gyroscopes and magnetometers), sensor fusion algorithms, including Kalman filters, quaternion mathematics, and mobile computing technologies. (Ex. 1002, ¶¶17-18.)[3] More education can supplement practical experience and vice versa. (*Id*.)

VII. OVERVIEW OF THE '846 PATENT AND THE PRIOR ART

A. THE '846 PATENT

The '846 patent relates to a three-dimensional (3D) pointing device that is subject to movement and rotation and that has sensor modules allowing the device to "obtain actual resulting deviation angles in [a] spatial reference frame and under dynamic environments." (Ex. 1001, 1:23–40; Ex. 1002, ¶¶31-38.) The '846 patent acknowledges that 3D pointing devices were known in the prior art, as shown in Figure 1, reproduced below:

[3] Petitioner submits herewith the declaration of Majid Sarrafzadeh, Ph.D. (Ex. 1002), an expert in the field of the '846 patent. (*Id.*; Ex. 1003.)

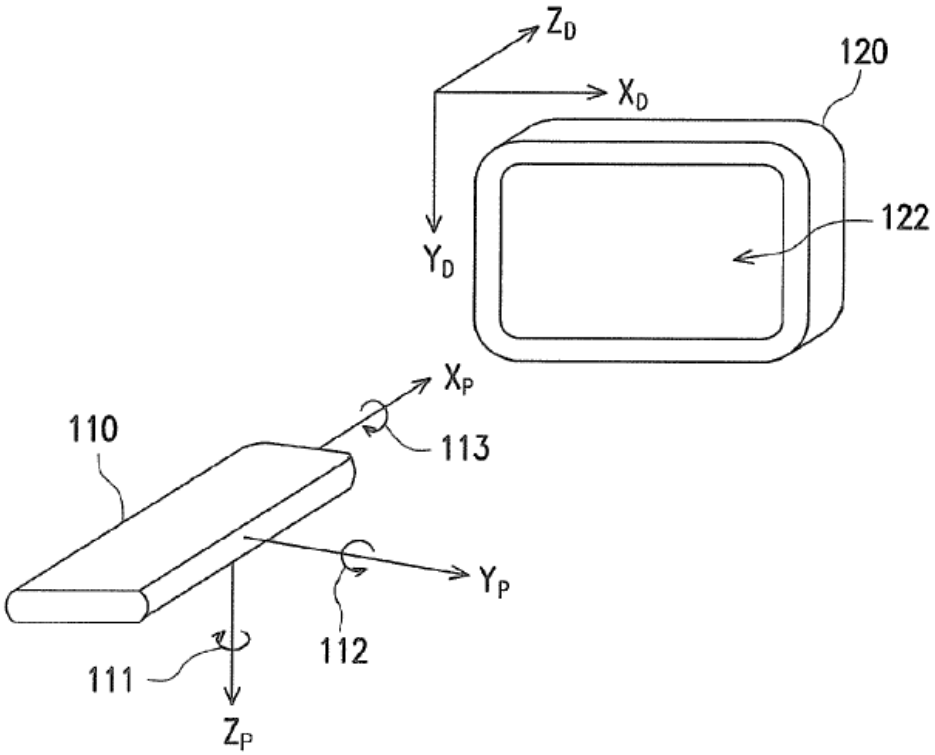


FIG. 1 (RELATED ART)

(Ex. 1001, FIG. 1.)

As shown in Figure 1, a user may point a 3D pointing device 110 at a screen 122 of a display device 120. (*Id.*, 1:35–40.) Figure 1 shows sets of axes representing two different reference frames: a "spatial pointer reference frame" associated with pointing device 110, and a "display frame" associated with display device 120. (*Id.*, 1:45–48.) The spatial pointer reference frame is defined by coordinate axes X_P, Y_P, and Z_P and, as shown in Figure 1 and Figure 2, always has its origin at the same point in the device and axes fixed with respect to the device. (*Id.*, 1:48–51, 2:19–22.) The system keeps track of the "orientation" of pointing device 110 by measuring three deviation angles: yaw angle 111 representing the device's rotation

about axis Z_P, pitch angle 112 representing its rotation about axis Y_P, and roll angle 113 representing its rotation about axis X_P. (*Id.*, 2:2-14.) The system may then perform "mapping" by translating the deviation angles in the spatial pointer reference frame to a corresponding movement of the pointer on screen 122. (*Id.*, 2:44–48; *see also id.*, 2:15–48, describing prior art examples of mapping; Ex. 1002, ¶32.)

Figure 5 illustrates an embodiment of the purported invention where an "electronic device 500" includes a first part 560 and a second part 570. (Ex. 1001, 11:44–46.) As shown in Figure 5, the first part 560 (which is a pointer device) and the second part 570 are not physically connected, and need not be in the same housing. (*Id*., 11:46–60.)

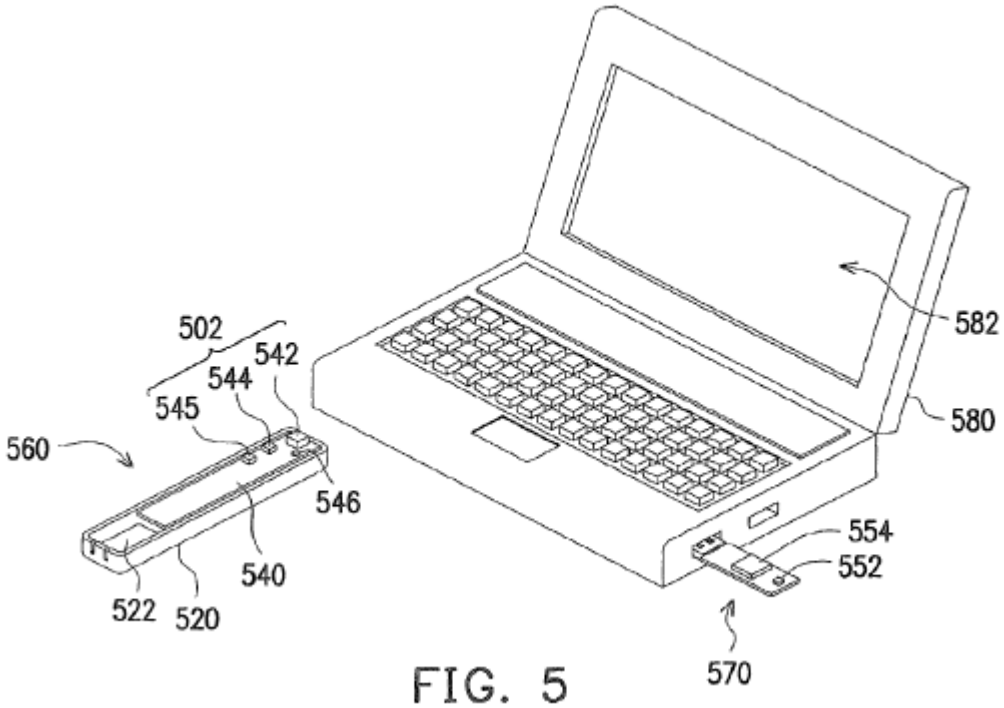


FIG. 5

(*Id*., FIG. 5.) The first part 560 includes a nine-axis motion sensor module 503 comprising a rotation sensor 542, an accelerometer 544, and a magnetometer 545. (*Id*., 11:44–60.) An algorithm is used to map movements of the first part 560 to movements on screen 582 of a notebook computer 580 coupled to the second part 570. (*Id.*, 12:17–13:3; Ex. 1002, ¶33.)

One such algorithm is described with reference to Figure 7. As explained below, this algorithm uses the measured angular velocities and accelerometer readings of the motion sensor module.

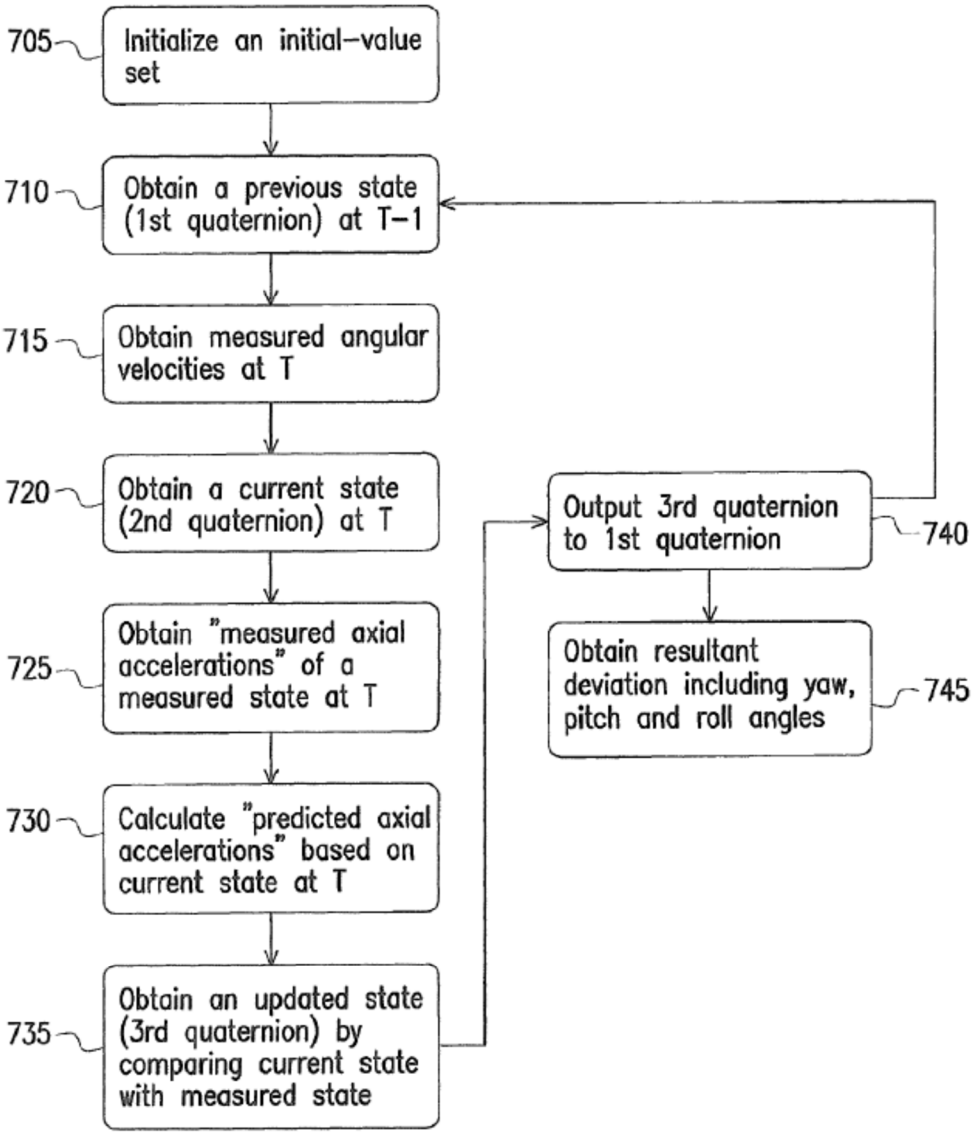


FIG. 7

(Ex. 1001, FIG. 7.) Figure 7 depicts a method of calculating deviation angles of a 3D pointing device's spatial pointer reference frame. (*Id*., 13:62–14:2.) The method starts with either initializing a new state or "obtaining a previous state of the nine-axis motion sensor module (. . . steps 705, 710)." (*Id.,* 14:24–34.) This state is in

the form of "a first quaternion[4] inducing values associated with at least previous angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a previous time T−1." (*Id.*, 14:34–39; Ex. 1002, ¶34.)

The method proceeds by "obtaining measured angular velocities ω_x, ω_y, ω_z gained from the motion sensor signals of the nine-axis motion sensor module at a current time T (. . . steps 715, 720)," to form a second quaternion of the "current state" with respect to current time T. (Ex. 1001, 14:39–44, 16:31–39.) According to the '846 patent, one way to convert ω_x, ω_y, ω_z into the "second quaternion" is by using the equation below.

$$\begin{bmatrix} \dot{q}_0 \\ \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 0 & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & 0 & \omega_z & -\omega_y \\ \omega_y & -\omega_z & 0 & \omega_x \\ \omega_z & \omega_y & -\omega_x & 0 \end{bmatrix} \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{bmatrix}$$

[4] Quaternions are known four-dimensional extensions of complex numbers that have the unique property of maintaining rotational relationships with relatively limited computational complexity. (Ex. 1002 ¶¶24, 34, fn. 2.) The '846 patent acknowledges that Euler angles can be used and defined from a quaternion. (Ex. 1001, 15:48–50 ("It can be understood that one may make reference to Euler Angles for definition on quaternion.").)

(*Id*., 16:46–53 (equation 1).) Equation 1 is a differential equation with respect to the "first quaternion" ($q0$, $q1$, $q2$, $q3$), and the '846 patent suggests solving it using a data conversion utility. (*Id.*, 16:39–61; Ex. 1002, ¶35.)

The method in Figure 7 then obtains the "measured state" of the motion sensor module in steps 725 and 730. (Ex, 1001, 16:62–66.) This measured state has two parts: a set of "measured axial accelerations Ax, Ay, Az" obtained from the accelerometer signals (step 725), and "predicted axial accelerations Ax', Ay', Az'," which are calculated based on the measured angular velocities (step 730). (*Id.*, 16:65–17:14.) The predicted axial accelerations in step 730 are "calculated based on the . . . current state or second quaternion in relation to the measured angular velocities thereof." (*Id.*,17:11–14.) The '846 patent provides the following equations for calculating each of Ax', Ay', Az', which the '846 characterizes as a "conversion utility":

$$2(q_1\, q_3 - q_0\, q_2) = Ax'$$

$$2(q_2\, q_3 + q_0\, q_1) = Ay'$$

$$q_0{}^2 - q_1{}^2 - q_2{}^2 + q_3{}^2 = Az'$$

(*Id.*, 17:17–28, Equations 2–4; Ex. 1002, ¶36.)

Next, in step 735, the process obtains a "third quaternion," representing an "updated state," by comparing the current state with the measured state. (Ex. 1001, 14:52–55, 14:63–15:15.) It does this by using a "comparison model" involving

equations 5–11. (*Id.*, 17:34–38; *see also id.,* 17:29–18:38.) In testimony that the PTAB found persuasive concerning the related '438 patent, which has the same Figure 7 and same relevant equations, Patent Owner's expert "characterize[d] equations 5–10 [of the '846 patent] as extended Kalman Filter ["EKF"] equations, ***which were known in the art***, and describes equation 11 as an error minimization." (Ex. 1012 at 11 (emphasis added); Ex. 1002, ¶37.)

Next, "to provide a continuous loop," the method in step 740 outputs and substitutes the third quaternion (updated state) into the first quaternion (previous state) (step 710). (Ex. 1001, 14:63–15:4.) Ultimately, in step 745, the method uses the third quaternion to generate a "resulting deviation," in terms of yaw, pitch, and roll angles, with respect to the axes of the spatial pointer reference frame. (*Id.*, 15:55–63, 19:16–52.) According to the '846 patent, these resulting deviation angles are used to map locations from 3D space to corresponding locations that indicate where the device is pointing on a 2D display device. (*Id.*, 11:27–40, 20:5–29, FIGS. 8 (Step 750), 9; Ex. 1002, ¶38.)

As explained below, none of these features, nor any limitations recited in the challenged claims, is novel or non-obvious. (*Infra* Section IX; Ex.1002, ¶¶19-30, 43-93, App. [1.pre]-9[b].[5])

B. PROSECUTION HISTORY

The '846 patent claims issued after Patent Owner amended the claims to overcome various rejections. (Ex. 1004, 194–208, 247–262.) During prosecution, Patent Owner made several remarks to distinguish the claims over the prior art. (*Id.*, 254–262.) More specifically, Patent Owner amended the claims over U.S. Patent No. 7,089,148 to Bachmann *et al.*, which was the principal reference on which claims of the related '438 patent and '978 patents were invalidated in IPR2018-01258, IPR2018-00143 and IPR2018-01257. In the amendments, Patent Owner added language to make clear the purported invention of the '846 patent uses different quaternions "with respective time frame differences between axial accelerations and angular velocities, as the input of respective computation blocks in the same round of the loop computation." (*Id.*, 256.) To that end, Patent Owner amended the independent claims such that the predicted axials accelerations were

[5] Citation to "App." refers to the Appendix attached with Dr. Sarrafzadeh's declaration.

determined "without using the measured axial accelerations corresponding to time T." (*Id.*, 254-255, 258.)

C. BASSOMPIERE

Bassompiere discloses a three-dimensional pointing device system "for pointing by a user at a mobile element in a plane surface." (Ex. 1006, 4:1–12, FIGS. 1, 2.) As shown in Figure 1, the pointer "has the shape and appearance of a television remote control, i.e., it is of elongate form, able to be held in the user's hand." (*Id.*, 8:25–27.) "The pointer is associated with a mobile element able to move in a plane surface, for example, a screen or a writing surface. The displacements of this mobile element are controlled by the displacements of the pointer." (*Id*., 9:1–4, FIG. 2.) The pointer, reproduced below, includes an angular velocity sensor 20 and a linear acceleration sensor 30.

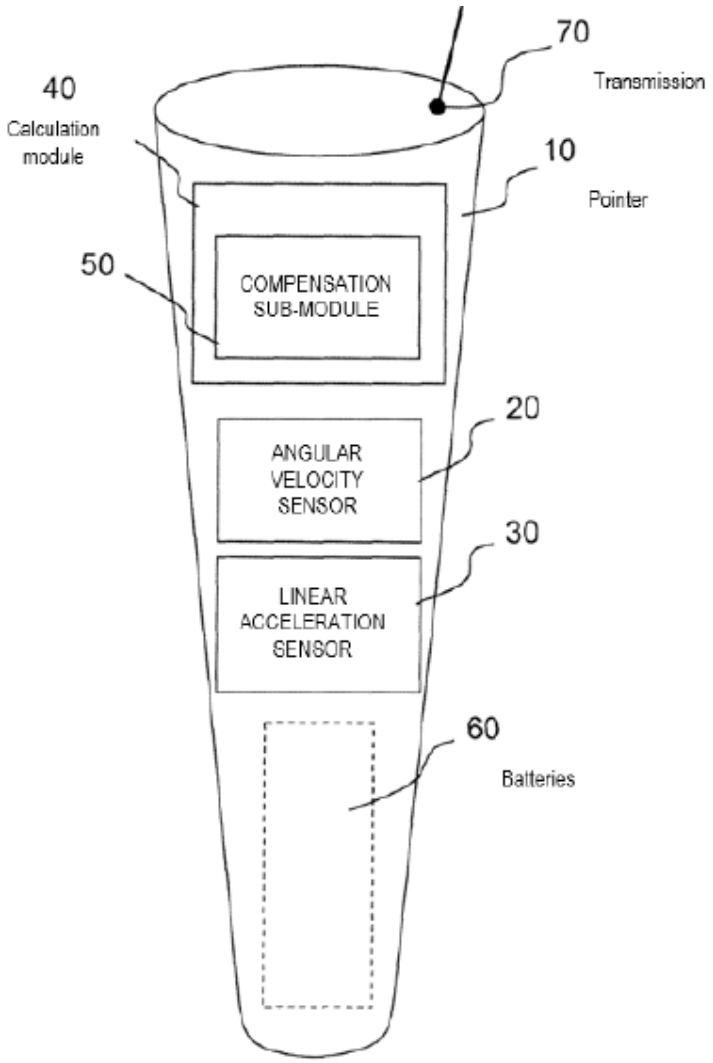


FIG.1

(*Id*., FIG. 1, 9:24–26, 10:14–17.) The pointer in use with a display is also illustrated in Figure 2, reproduced below.

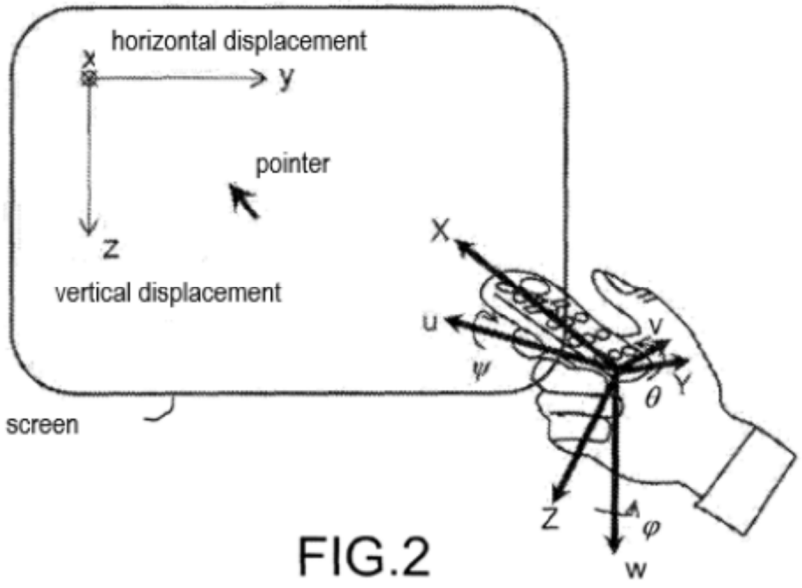


FIG.2

(*Id*., FIG. 2; Ex. 1002, ¶44.)

The accelerometer (i.e., sensor 30) and gyroscope (i.e., sensor 20) "respectively return measurements noted (a_X,a_Y,a_Z) and (ω_y, ω_z,) in the frame of reference (XYZ) of the pointing device." (Ex. 1006, 12:14–15.) These measurements are used to estimate pitch and roll angles (θ and ψ) of the pointer through a sensor fusion algorithm, namely, an extended Kalman filter (EKF). (*Id*., 13:15–32; *see also id.*, 18:15-19:12; Ex. 1002, ¶45.)

The process of Bassompiere operates in two steps: "a step 1 of estimating the angles θ and ψ of pitch and of roll by an EKF and a step 2 of computing the angular rate components ω_v, ω_w, related to the displacement of the mobile element with respect to the frame of reference of the user." (Ex. 1006, 15:3–7; Ex. 1002, ¶47.)

To estimate the pitch angle θ and roll angle ψ by an EKF, Bassompiere defines the angles θ and ψ as a state vector. (Ex. 1006, 17:5–6 ("the state vector chosen to solve the problem is: x=[θ ψ]. Where θ and ψ are respectively the pitch and roll angles.").) The state vector, at sampling step k, i.e., $\hat{x}_k$, is calculated using the following EKF equation.

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} a_{X,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(*Id*., 19:8–9 (equation 23); *see also id.*, 5:4–6, 29:2–5 (claim 10).) In this equation, $\hat{x}_k^-$ is an "a priori estimation of the state vector" (*id.*, 19:1–3, *see also id.*, 4:24–25, 28:11 (claim 7)) at present time k. As seen in equation 21 below, Bassompiere represents $\hat{x}_k^-$ as the estimated pitch and roll angles $\begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix}$. Specifically, the state vector ($\hat{x}_k^-$) is calculated by adding the pitch and roll angles from the previous iteration k-1 of the EKF, i.e., $\begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix}$, to the current gyroscope readings $\left(\omega_x \,.\, \omega_y^{\square}, \omega_z^{\square}\right)$, multiplied by a sampling period T_e, using the following equation:

$$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$$

(*Id*., 19:3 (equation 21); *see also id.*, 4:18–19, 7:1; Ex. 1002, ¶¶48-49.)

Next, Bassompiere determines the estimated acceleration ($\hat{y}_k^-$), at time step k, based on the *a priori* estimation of the state vector, i.e., $\hat{x}_k^-$ or $\begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix}$.

$$\hat{y}_k^- = \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix}$$

(Ex. 1006, 19:1–5 (equation 22); *see also id.*, 28:15–17; Ex. 1002, ¶50.)

The estimated acceleration is compared against the accelerometer readings (y= $[a_x\ a_y\ a_z]$) at time step k and added to the *a priori* estimate of the state vector ($\hat{x}_k^-$) to yield the roll and pitch angles:

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} \alpha_{x,k} \\ \alpha_{y,k} \\ \alpha_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(Ex. 1006, 19:8–9 (equation 23); *see also id.*, 5:4–6, 19:3, 4:18–19, 7:1; Ex. 1002, ¶51.)

While the state vector in equations 21 and 23 is represented in Euler angle form, Bassompiere discloses a first variation of this embodiment in which the state vector (x) is a "quaternion." (Ex. 1001, 20:10–19; *see also id.*, 6:3–4, 27:11–14 (claim 1), 30:1–3 (claim 13).) In this variation, "the angles of torsion θ and ψ" are replaced by a "quaternion formulation of the same torsion." (*Id.*, 20:10-11.) Dr. Sarrafzadeh explains this variation in detail. (Ex. 1002, ¶¶55-79.) Bassompiere acknowledges the benefits of using, and instructs the reader to use, quaternions over Euler angles for performing sensor fusion:

> A first variant embodiment consists in replacing the angles of torsion θ and ψ by a quaternion formulation of the same

> torsion. This variant exhibits the advantage of avoiding the computations of the sines and cosines of the pitch and roll angles that are greedy in terms of computational power.

(Ex. 1006, 20:10–14.)[6]

For ease of reference and understanding, replacing $\hat{x}_k^-$ in equation 23 for the *a priori* estimate of the state vector and replacing $\hat{y}_k^-$ with the equation for determining the predicted acceleration, yields the following equation:

$$\hat{x}_k = \begin{pmatrix} \hat{\Theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix} + K_k \left(\begin{bmatrix} \alpha_{x,k} \\ \alpha_{y,k} \\ \alpha_{z,k} \end{bmatrix} - \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix} \right)$$

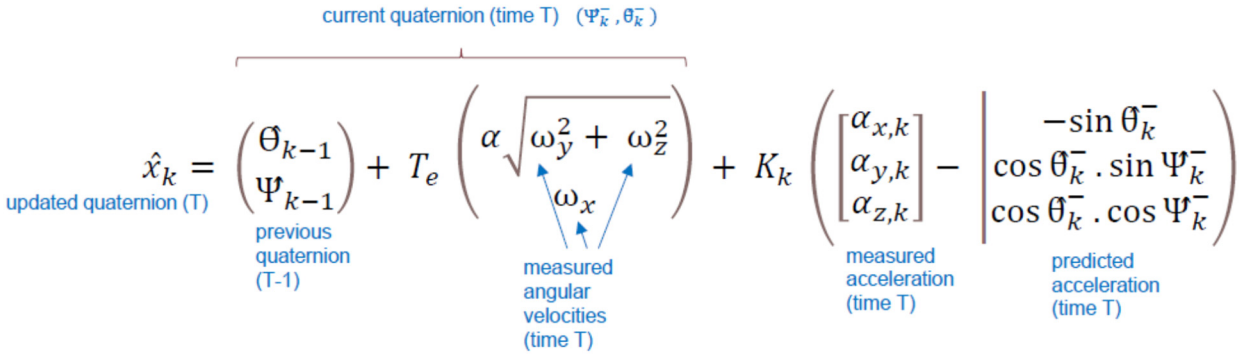
(Ex. 1002, ¶52.) The above equation shows that the EKF of Bassompiere determines $\hat{x}_k$ based on the pitch and roll angles from the previous iteration k-1, i.e., $\begin{pmatrix} \hat{\Theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix}$, the gyroscope readings of the present iteration $\left(\omega_x . \omega_y^{\square} , \omega_z^{\square}\right)$ and the difference

[6] Bassompiere also provides the well-known equations for converting between quaternions and Euler angles. (Ex. 1006, 20:13–16; Ex. 1002, ¶57.) It also describes known quaternion operations, such as how to calculate the conjugate of a quaternion. (Ex. 1006, 21:4–7; Ex. 1002, ¶57.)

between the accelerometer readings at present time k ($a_{x,k}$, $a_{y,k}$, $a_{z,k}$) and the predicted

$$\text{acceleration} \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix}.$$

With respect to the language of the '846 patent, and as will be fully described in Section IX, the above equation can be understood to determine $\hat{x}_k$ (referred to in the '846 patent variously as the "**updated state**" or "**third quaternion**" or "**updated quaternion**") as follows.



(Ex. 1002, ¶53.)

Step 2 of Bassompiere's process computes the angular rate components ω_v, ω_w, related to the displacement of the pointer device with respect to the frame of reference of the user (u, v, w). (*See* Ex. 1006, 11:18–20, 11:26–30.) Bassompiere teaches that the components ω_v and ω_w of the angular rate in the reference frame of the user are computed through the following formulae:

$$\omega_v = \cos\hat{\Psi} . \omega_y - \sin\hat{\Psi} . \omega_z$$

$$\omega_w = -\sin\hat{\theta}\,.\,\omega_x + \cos\hat{\theta}\,.\sin\hat{\Psi}\,.\,\omega_y + \cos\hat{\theta}\,.\cos\hat{\Psi}\,.\,\omega_z$$

(*Id*., 19:10–11; *see also id.*, 5:7–9, 29:6–9 (claim 11).)

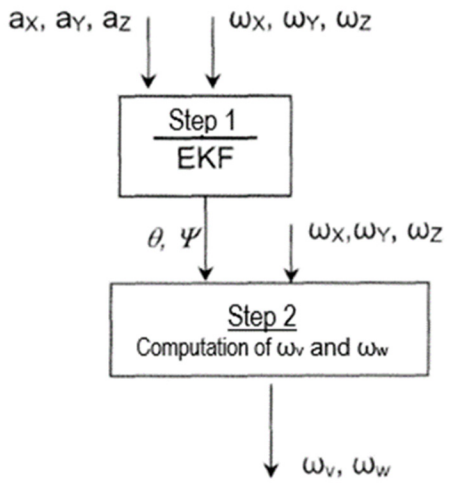


FIG.6

(*Id*., FIG. 6.) Specifically, ω_v and ω_w provide "information on the horizontal displacements (rotation about the axis ω represented by ω_w) and vertical displacements (rotation about the axis v represented by ω_v) and therefore the displacement of the mobile element on the screen (d_y and d_z)." (*Id*., 11:25–12:9; Ex. 1002, ¶54.)

Bassompiere is analogous art to the '846 patent. The '846 patent's field of endeavor is the fusing of data from small microsensor, like MEMS gyrometers and accelerators, in order to provide orientation of a device in three dimensional space. The orientation data is then used to present some kind of content on a screen that can be changed depending on, and subject to, the orientation. (*See, e.g.*, Ex. 1001,

Abstract, 5:27-61, FIGS. 1, 2.) As described above, Bassompiere too describes a device with sensors producing orientation data that is corrected using a sensor fusion algorithm so to allow presentation of two dimensional data on a screen based on the 3D orientation of the device.

VIII. CLAIM CONSTRUCTION

For IPR proceedings, the Board applies the claim construction standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (*en banc*). *See* 83 Fed. Reg. 51,340-59 (Oct. 11, 2018). Under *Phillips*, claim terms are typically given their ordinary and customary meanings, as would have been understood by a POSA, at the time of the invention, having taken into consideration the language of the claims, the specification, and the prosecution history of record. *Phillips*, 415 F.3d at 1313; *see also id.*, 1312–16. Other than the "spatial reference frame" term identified below, the Board need not construe any other claim terms as the claims are unpatentable under any reasonable construction. *Toyota Motor Corp. v. Cellport Systems, Inc.*, IPR2015-00633, Paper No. 11 at 16 (P.T.A.B. Aug. 14, 2015).[7]

[7] Petitioner reserves all rights to raise claim construction and other arguments in other venues. Specifically, Petitioner is not conceding that each claim satisfies all statutory requirements, nor waiving any arguments concerning claim scope or grounds that can only be raised in district court.

A. "spatial reference frame"

Claims 1 and 7 use the phrase "spatial reference frame." In IPR2018-01257, which concerned the related '978 patent, the Board determined that the term "spatial reference frame" should be interpreted as "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. 1013 at 46.) The '978 patent is a "continuation-in-part" of U.S. Patent Application No. 13/072,794 ("the '794 Application") whereas the '846 patent is a "continuation" of the '794 Application. The relevant disclosures of the '978 and '846 patents are the same; the '978 patent adds new figures 13 and 14 with associated description. Thus, the construction of "spatial reference frame" for the '978 patent should also apply to the '687 patent. (Ex. 1002, ¶¶39-40.)

Here, claims 1 and 7 do not recite the term "3D pointing device." Thus, the Board's construction in IPR2018-01257 should be modified to recite "a" 3D pointing device as opposed to "the" 3D pointing device. That is, "spatial reference frame" should be interpreted as "reference frame associated with ***a*** 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" (emphasis added). The Board and Petitioner's construction is the correct construction in view of the specification.

The '846 patent explains that the "spatial reference frame" refers to a 3-axis reference frame of a 3D pointing device. (*See, e.g.*, Ex. 1001, 9:5-17, 9:49-65, FIGS. 1-4.) "The spatial reference frame is analogous to the reference frame $X_P Y_P Z_P$ also shown in FIG. 1 and FIG. 2." (*Id.*, 9:5-17.) In particular, the "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." (*Id.*, 1:45–51.)

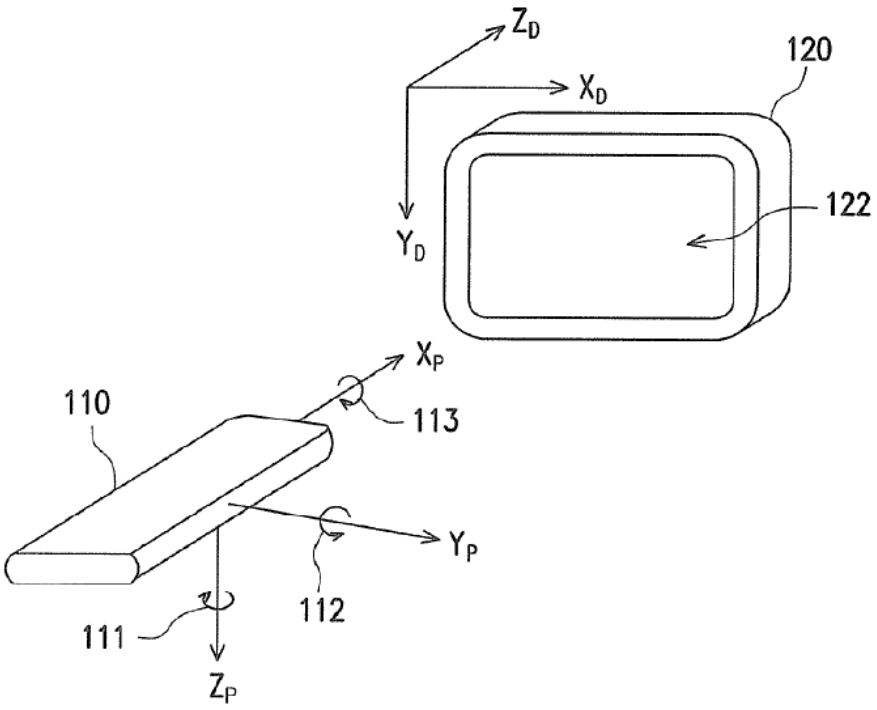


FIG. 1 (RELATED ART)

(*Id.*, FIG. 1, Ex. 1002, ¶41.)

Thus, the "spatial pointer reference frame" is shown by the coordinate axes X_P, Y_P and Z_P in Figure 1. (Ex. 1001, FIG. 1; Ex. 1002, ¶42.) As shown in Figure 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. 1001, FIG. 1; Ex. 1002, ¶¶42.) Furthermore, as shown in Figure 2, when the device is rotated, the axes X_P, Y_P and Z_P rotate with the device. (Ex. 1001, FIG. 2; Ex. 1002, ¶42.) The rotation of the device in Figure 2 shows a 90-degree roll of the device, with correspondingly rotated axes Y_P and Z_P. (Ex. 1001, FIG. 2; Ex. 1002, ¶¶42.) 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.)

Petitioner's proposed construction is also consistent with the claims.

IX. DETAILED EXPLANATION OF GROUNDS

As detailed below, each of the challenged claims is unpatentable.

A. Ground 1: Bassompiere Renders Obvious Claims 1, 3, 7, and 9

1. Claim 1

i) [1.pre] "1. An electronic device subject to movements and rotations in dynamic environments, comprising:"

To the extent the preamble of claim 1 is limiting, Bassompiere discloses the limitations therein. (Ex. 1002, ¶44, App. [1.pre].) Bassompiere discloses "a device for pointing by a user at a mobile element in a plane surface." (Ex. 1006, 4:1–12, 8:24-25, FIGS. 1, 2.) As shown in Figure 1, the pointer "has the shape and appearance of a television remote control, i.e., it is of elongate form, able to be held in the user's hand." (*Id.*, 8:25–27, FIG. 1.) The pointer includes a gyroscope (20)

and accelerometer (30). (*Id.*, FIG. 1.) Figure 2 illustrates a system ("**electronic device**"), which includes a pointer and a screen.[8]

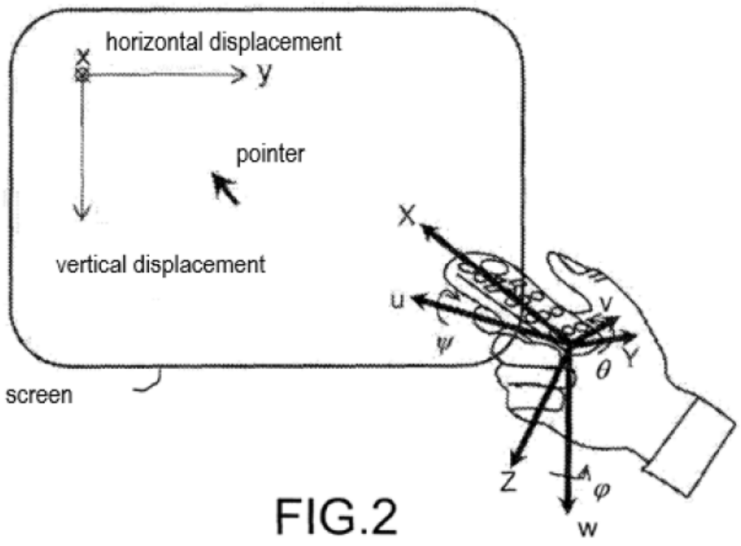


FIG.2

(*Id*., FIG, 2.)

The electronic device of Figure 1 and Figure 2 is "**subject to movements and rotations in dynamic environments**" because the hand holding the pointer is moving, which movement is displayed on the screen. (*Id*., 8:14–16 ("Figure 2 illustrates the definition of the various reference frames in which are computed the displacements of a pointer and of a cursor on a screen in an embodiment of the invention."), 9:23-26, 10:14-16; *see also infra* Section IX.A.1.iii (describing various

[8] Claim language is bolded and underlined in the analysis of the prior art.

sensors for sensing movement and rotation of the pointer); *see also supra* Section VII.C.)

ii) [1.a] "a display device associated with a display reference frame;"

Bassompiere discloses this limitation. (Ex. 1002, ¶91, App. [1.a].) Figure 2 (reproduced below) shows a screen ("**display device**") upon which the three-dimensional movements of the pointer are displayed in two dimensions (y, z) on a screen ("**associated with a display reference frame**").

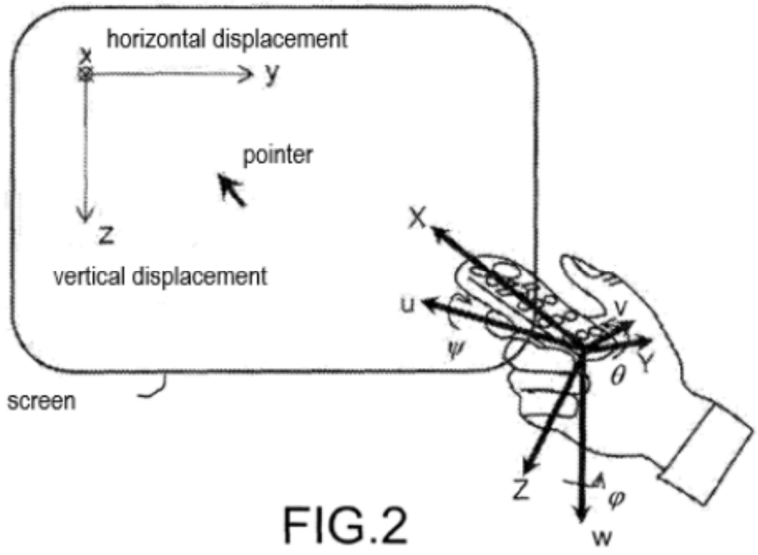


FIG.2

(Ex. 1006, FIG. 2; *see also id.*, 8:14–16.) Bassompiere states that "the pointer is associated with a mobile element able to move in a plane surface, for example, a screen or a writing surface. The displacements of this mobile element are controlled by the displacements of the pointer." (*Id.*, 9:1–4.)

iii) [1.b] "a motion sensor module comprising a rotation sensor and an accelerometer, the rotation sensor

> **having sensor circuitry configured to generate measured angular velocities and the accelerometer having circuitry configured to generate measured axial accelerations, with both the rotation sensor and the accelerometer being associated with the movements and the rotations of the electronic device in a spatial reference frame; and:"** [9]

Bassompiere discloses this limitation. (Ex. 1002, ¶44-46, App. [1.b].) Bassompiere discloses that the pointer has an angular velocity sensor 20 ("**rotation sensor**") and a linear acceleration sensor 30 ("**accelerometer**"). (Ex. 1006, 9:24–25, 10:17–21, FIG. 1.)

[9] The term "motion sensor module" does not invoke 35 U.S.C. ¶ 112(f) because the claim itself recites sufficient structure (e.g., rotation sensor and accelerometer). Even if the term invokes §112(f), the corresponding structure in the specification is a "Micro Electro - Mechanical - System (MEMS) type of sensor" or equivalents thereof. (Ex. 1001, 10:23–43.)

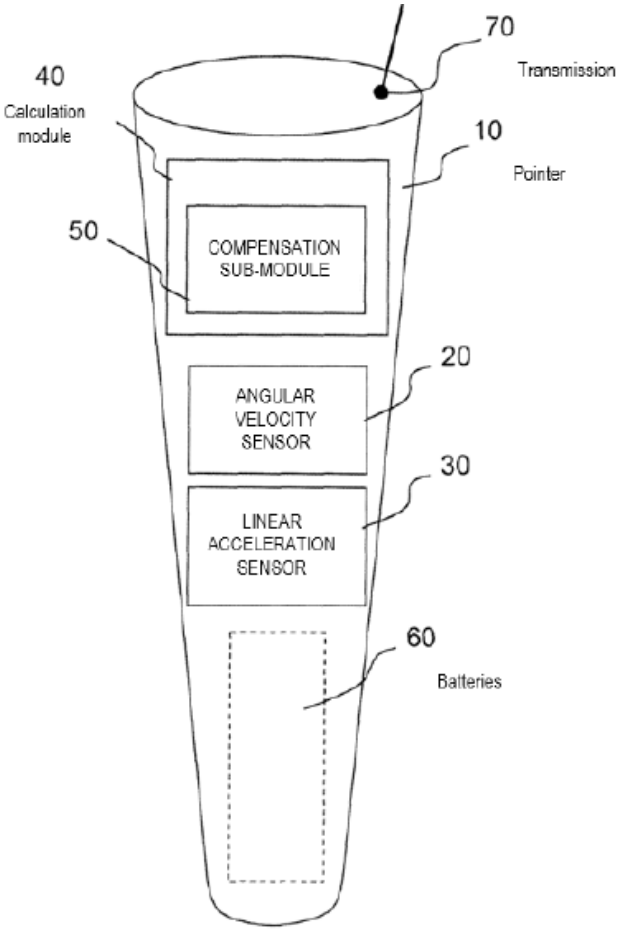


FIG.1

(*Id*., FIG. 1.)

Bassompiere explains that the angular velocity sensor 20 (also referred to as a "gyrometer") (*id.*, 9:25–29) has "**sensor circuitry configured to generate measured angular velocities**":

> angular velocity sensors 20 have the function of measuring the rotations of the pointer in relation to two or three axes. These sensors will preferably be gyrometers. It may be a two-axis gyrometer or a three-axis gyrometer. . . . It is, for example, possible to use the gyrometers

> provided by Analog Devices with the reference ADXRS300. But any sensor capable of measuring angular rates or velocities is usable.

(*Id*., 9:23–30.) Linear acceleration sensor 30 has "**circuitry configured to generate measured axial accelerations**." (*Id*., 10:14–17 ("The compensation sub-module recovers as input the outputs from a second sensor 30 which measures the linear accelerations of the pointer ax, ay, az. Preferably, the sensor 30 is a three-axis accelerometer.").)

The gyroscope and accelerometer are part of the same "**motion sensor module**." (*Id.*, 10:17–21 ("the sensors 20 and 30 are both produced by MEMS (Micro Electro Mechanical Systems) technology, **optionally within one and the same circuit** (for example, reference accelerometer ADXL103 from Analog Devices, LIS302DL from Thomson, reference gyrometer MLX90609 from Melixis, ADXRS300 from Analog Devices).") (emphasis added).) Moreover, the "motion sensor module" is a MEMS sensor, satisfying the structure of the term if it invokes §112(f). (*Id*., 10:17–21.)

The rotation sensor 20 and the accelerometer 30 are associated with the "**movements and the rotations of the electronic device in a spatial reference frame**," i.e., the reference frame XYZ of the pointer 10. (*Id.*, 10:21–22 ("the MEMS module will be situated near the center of gravity **of the pointing device.**"); *see also id.*, 12:14–15 ("The accelerometric and gyrometric sensors respectively **return**

measurements noted (a_X,a_Y,a_Z) and (ω_x . ω_y) in the frame of reference (XYZ) of the pointing device.") (emphasis added). Bassompiere further describes the accelerometer 30:

> at least one second sensor (30) for measuring the **linear movements** of said device along said two axes (Y, Z) and a third orthogonal axis (X), a module (40) for calculating the displacements (y, z) to be imparted to the mobile element in the plane surface as a function of **the displacements (X, Y, Z) of the pointer** in space

(*Id.*, 27:4-8 (emphases added).)

As discussed *supra* Section VIII.A, "spatial reference frame" means "a reference frame associated with a 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." As shown in Figure 2 of Bassompiere, the reference frame XYZ of the pointing device has a fixed point of origin where the X, Y, and Z axes meet. Moreover, the X, Y, and Z axes are fixed with respect to the pointer device, as evident from Figure 2. Indeed, the XYZ frame is the "reference frame of the [pointer]" and thus, would be expected to be fixed with respect to the pointer device. (Ex. 1006, 10:32-11:1.) Further, Bassompiere states that the accelerometer and gyroscopes respectively return "measurements noted (a_X,a_Y,a_Z) and (ω_x . ω_y) in the frame of reference (XYZ) of the pointing device." (*Id.*, 12:14–15.) The

"**movements and the rotations of the electronic device**" are therefore "**in a spatial reference frame**."

iv) [1.c] "a computing processor having processor circuitry configured to calculate a resulting deviation comprising resultant angles associated with the movements and the rotations of the electronic device in the spatial reference frame by:"

Bassompiere discloses this limitation. (Ex. 1002, ¶¶47, 54, App. [1.c].) As shown in FIG. 1, pointer 10 includes a compensation sub-module 50, which is a microprocessor that is programmed to determine how the pointer orientation has changed, and is therefore a "**computing processor**." Specifically, compensation sub-module 50 comprises a "microprocessor" that "compensate[es] for the **torsion imparted to the pointer** by the user." (Ex. 1006, 9:15–20 (emphases added).) The "the torsion compensation operation is performed in two steps, a step 1 of estimating the angles θ and ψ of pitch and of roll by an EKF and a step 2 of computing the angular rate components ω_v, ω_w, related to the displacement of the mobile element with respect to the frame of reference of the user." (*Id*., 15:3–7; *see also id.*, 4:11–21.) Thus, the compensation sub-module 50 calculates angles θ and ψ of pitch and of roll, respectively.

The angles θ and ψ are "**a resulting deviation comprising resultant angles associated with the movements and the rotations of the electronic device in the spatial reference frame"** because they represent the deviation in angular terms of

the pointing device's reference frame (XYZ) from a reference frame (*uvw*) of the user's limb, as the user moves and rotates the pointing device. (*Id*., FIG. 2, FIG. 3, 10:30–11:6, 11:31–12:9.) For example, when the two reference frames are aligned, "the pitch and roll angles are zero." (*Id*., 11:21–24.) A non-zero "roll and/or pitch angle[]" indicates that the "reference frames (uvw) and (XYZ) are not aligned." (*Id*., 11:31–12:9.) Calculating roll and pitch angles thus allows correlating angular velocities determined in the XYZ reference frame to the uvw reference frame, which allows calculating "the displacement of the mobile element on the screen (d_y and d_z)." (*Id*., 11:25–12:9.)

v) [1.d] "providing a previous quaternion corresponding to time T−1 based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T−1;"

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶48, 49, 52, 53, 65-71, App. [1.d].) Claim elements [1.d] through [1.h] describe the calculations performed for one loop, i.e., the present loop at time T, of the EKF algorithm described in the '846 patent. (*See infra* Section IX.A.1.vi-ix.) The output of the loop is a quaternion, and related angular deviations, that describe how the electronic device is oriented in three-dimensional space. The output of any given loop at time T-1 becomes the input of the next loop, i.e., the present loop, at time T, as the previous quaternion. (Ex. 1002, App. 1[d].)

Claim element [1.d] is the first step in the loop (at present time T), and begins by referencing the "**previous quaternion**," i.e., the output of the previous loop's operation (at time T-1), which provides the orientation of the electronic device at time T-1. (*Id.*)

Bassompiere discloses or suggests limitation [1.d]. (*Id.*, ¶¶48, 49, 52, 53, 65-71, App. [1.d].) To estimate the pitch angle θ and roll angle ψ by an EKF, Bassompiere defines the angles θ and ψ as a state vector. (Ex. 1006, 17:5–6 ("the state vector chosen to solve the problem is: x=[θ ψ]. Where θ and ψ are respectively the pitch and roll angles."); *see also id.*, 28:3–5.) In particular, Bassompiere discloses using the state vector $\hat{x}_{k-1}^{-}$ from the previous iteration k-1[10] (represented by the pitch and roll angles from the previous iteration $\begin{pmatrix}\hat{\theta}_{k-1}\\ \hat{\psi}_{k-1}\end{pmatrix}$) ("**providing a previous quaternion corresponding to time T-1**") to calculate an estimate of the state vector in the current loop at time k, as seen in equation 21 (reproduced below). (*Id.*, 19:1–3; *see also id.*, 4:20–26, 28:9–13.)

[10] Bassompiere describes operations in the present loop with the time index "k," rather than the time index of "T" or "t", and describes operation in the preceding past loop as "k-1" instead of "T-1" or "t-1". A POSA would understand k and T or t to be equivalent for purposes of the present analysis. (Ex. 1002, App, fn. 4.)

$$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$$

(*Id.*, 19:1-3 (equation 21) (emphasis added).)

As shown in equation 21 above, the state vectors $\hat{x}_k^-$ and $\hat{x}_{k-1}^-$ include the pitch and roll angles in Euler angle form. (Ex. 1002, ¶¶48, 55.) But Bassompiere explains that the state vector can instead be a quaternion:

> A first variant embodiment consists in replacing the angles of torsion θ and ψ by a quaternion formulation of the same torsion. This variant exhibits the advantage of avoiding the computations of the sines and cosines of the pitch and roll angles that are greedy in terms of computational power.

(Ex. 1006, 20:10–19; *see also id.*, 27:13–14 (claim 1) ("its state vector comprises at least one torsion representation chosen from the group Euler angles, quaternions").) Indeed, the benefits of using quaternions over Euler angles was well-known. (*See* Ex. 1007, 269-270 ("For modeling the rotational motion, quaternions are used rather than direction cosines and Euler angles because the quaternion representation does not have a problem with singularities; handles normalization better; and exchanges the bulky trigonometry of Euler angles with multiplication and addition . . . .").)

Thus, a POSA would have been motivated to modify equation 21 to include quaternions instead of Euler angles. (Ex. 1002, ¶¶48, 55-71.) In such a modification,

the state vectors the state vectors $\hat{x}_k^-$ and $\hat{x}_{k-1}^-$ would have been represented using quaternions. (*Id*.) A POSA would have a reasonable expectation of success in using quaternions (as opposed to Euler angles) because quaternions had been successfully used by persons of skill in the art with sensor fusion algorithms, such as extended Kalman filters, to achieve computations efficiencies in real time applications with gyroscope and accelerometers. (*Id*., ¶¶56-71.) (*See, e.g.,* Ex. 1007, 268-270.) In fact, Patent Owner's expert in IPR proceedings for the related '438 patent and '978 patent admitted that quaternions "would be known to someone of ordinary skill in the art." (Ex. 1013, 44.) The PTAB consequently found that "knowledge of quaternion mathematics [was] within the level of ordinary skill." (*Id.*, 44–45.)

Furthermore, Bassompiere uses a quaternion formulation to obtain a current quaternion based on a previous quaternion and the current angular velocities. (Ex. 1002, ¶¶66-71.) Specifically, Bassompiere discloses utilizing a previous quaternion (q_o, q_1, q_2, q_3) in conjunction with the angular velocities from the current time to estimate a state vector at the current time, i.e., $\dot{q}$ ("**current quaternion**"). (Ex. 1006, 20:10-25 (equation 26); *see also id.*, 6:3-8, 30:1-5.)

$$\dot{q} = \frac{1}{2} \begin{vmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{vmatrix} \otimes \begin{vmatrix} 0 \\ \omega_x \\ \omega_y \\ \omega_z \end{vmatrix} ;$$

(*Id*., 20:10–25 (equation 26).) A POSA would have understood that equation 26 is a quaternion form representation of equation 21. (Ex. 1002, ¶¶66-69, App. [1.d].) This is explained further below with reference to claim element [1.e]. (*See infra* Section IX.A.1.vi.)

Because each loop of the EKF uses measured acceleration at time T (s*ee infra* Section IX.A.1.viii) and measured angular velocities at time T (*see infra* Section IX.A.1.vi), the previous quaternion of the next loop is "**based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T−1**".

vi) [1.e] "converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations without using the measured axial accelerations corresponding to time T;"

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶49-50, 52-53, 66-71, App. [1.e].) The *a priori* estimate of the state vector, $\hat{x}_k^-$ ("**current quaternion**"), is calculated by adding the pitch and roll angles from the previous iteration k-1, i.e., $\begin{pmatrix}\hat{\theta}_{k-1}\\ \hat{\psi}_{k-1}\end{pmatrix}$ ("**based on the previous quaternion**"), to the gyroscope readings (ω_X, ω_Y and ω_Z) ("**converting the measured angular velocities corresponding to time T**") multiplied by a sampling period T_e as follows:

$$\hat{x}_k^- = \begin{pmatrix}\hat{\theta}_k^-\\ \hat{\psi}_k^-\end{pmatrix} = \begin{pmatrix}\hat{\theta}_{k-1}\\ \hat{\psi}_{k-1}\end{pmatrix} + T_e \begin{pmatrix}\alpha\sqrt{\omega_y^2 + \omega_z^2}\\ \omega_x\end{pmatrix}$$

(Ex. 1006, 19:3 (equation 21); *see also id.*, 4:23-26, 28:13.) As evident from the equation above, this conversion of measured angular velocities to a current quaternion does not require the use of measured acceleration at time k ("**without using the measured axial accelerations corresponding to time T**").

While equation 21 above utilizes Euler angles to represent the state vector, it would have been obvious to use quaternions in place of Euler angles, as discussed above in Section IX.A.1.v. One way of utilizing the current angular velocities and a previous quaternion (i.e., quaternion from the last loop) to estimate a current quaternion is set forth in Bassompiere in short-hand form in equation 26 (reproduced below).

$$\dot{q} = \frac{1}{2} \begin{vmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{vmatrix} \otimes \begin{vmatrix} 0 \\ \omega_x \\ \omega_y \\ \omega_z \end{vmatrix} ;$$

(*Id.*, 20:20-23 (equation 26); *see also id.*, 6:3–7, 30:1-5.) In the above equation, ω_X, ω_Y and ω_Z are the current angular angular velocities in three dimensions (X, Y, Z) in the sensor frame in the present loop of the EKF ("**measured angular velocities**

corresponding to time T").[11] The "**previous quaternion"** is represented by the vector q = (q0, q1, q2, q3). The solution to the differential equation is to "**convert the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion.**" The solution thus yields the "**current quaternion**." (Ex. 1002, ¶¶66-71.) Equation 1 of the challenged '846 patent is written in expanded form, but otherwise presents a similar equation for deriving the current quaternion from the previous quaternion using the measured angular velocities at time T:

$$\begin{bmatrix} \dot{q}_0 \\ \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 0 & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & 0 & \omega_z & -\omega_y \\ \omega_y & -\omega_z & 0 & \omega_x \\ \omega_z & \omega_y & -\omega_x & 0 \end{bmatrix} \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{bmatrix}$$

(Ex. 1001, equation 1, 16:45-54; Ex. 1002, ¶¶66-68, App. [1.e].)

Bassompiere determines an "*a priori* estimation of the [acceleration] measurement" ("**predicted axial accelerations")** based on the *a priori* estimation of the state vector ("**current quaternion"**). (Ex. 1006, 19:4–5; *see also id.*, 28:15–17; Ex. 1002, App. [1.e].) This *a priori* estimation of the [acceleration] measurement is taken in time step k and calculated as follows:

[11] Bassompiere also teaches the conversion of the gyroscope readings taken in only two directions (i.e., without ω_X). (*Id.*, 20:21–21:1.)

$$\hat{y}_k^- = \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix}$$

(Ex. 1006, 19:4–5 (equation 22); *see also id.*, 4:27-5:1, 28:15–17 (claim 8).) In the above equation, $\hat{x}_k^-$ ("**current quaternion**"), which as explained above was "**converted**" from "**measured angular velocities corresponding to time T based on the previous quaternion**," is used to determine the **predicted axial acceleration** $\hat{y}_k^-$. Readings from the current linear acceleration sensor 30 are not used in this calculation ("**without using measured axial accelerations corresponding to time T**").

Further, as noted above, Bassompiere teaches a POSA to substitute quaternions for Euler angles, such that the *a priori* estimation of the [acceleration] measurement $\hat{y}_k^-$ ("**predicted axial accelerations**") can be rendered from orientation in quaternion form as described by Bassompiere:

> A first variant embodiment consists in **replacing the angles of torsion θ and ψ** by a quaternion formulation of the same torsion. This variant exhibits the advantage of avoiding the computations of the sines and cosines of the pitch and roll angles that are greedy in terms of computational power.

(*Id*. 20:10–19 (emphasis added).)

To confirm that Bassompiere discloses the determination of predicted acceleration from quaternion form to a POSA, and that such a determination was well within the grasp of a POSA, Patent Owner admitted that the Equations 2 through 4 of the '846 patent, which show explicit quaternion-form calculations for determining predicted acceleration, were known in the art:

> Q. So Equation 2 is a calculation of a predicted acceleration along the x-axis?
>
> A. Yes.
>
> Q. And then Equation 3 is the predicted calculation acceleration along the y-axis?
>
> A. Uh-huh.
>
> Q. And then Equation 4 is a prediction of -- predicted acceleration along the z-axis?
>
> A. Yes.
>
> Q. Is what we've been talking about, are those well-known concepts, or were they well-known concepts at the time of the invention of the '438 patent? MR. RAFILSON: Objection. Form.
>
> A. The standard equations for -- the differential equation for the quaternion and the equations for computing these predicting accelerations are fairly well-known in the field.

(Ex. 1015, 58:3–22; *see generally id.*, 55:4–60:7 (testifying as to the related '438 patent).)

A person of ordinary skill in the art would know how to derive the predicted acceleration of Bassompiere in quaternion form using $\hat{x}_k^-$ in quaternion form, as the input. As explained by Dr. Sarrafzadeh in detail, the formulas for doing so were already known in the art (*e.g.*, in Ex. 1007, 270 (equation 13)) and could be readily derived using quaternion rotation, a basic mathematical operation used with quaternions. (Ex. 1002, ¶¶72-75.) That operation would yield the exact same formulas as Equations 2 through 4 in the challenged '846 patent:

$$\begin{bmatrix} 2(q_1q_3 + q_0q_2) \\ 2(q_2q_3 - q_0q_1) \\ q_0^2 - q_1^2 - q_2^2 + q_3^2 \end{bmatrix}$$

(*See* Ex. 1001, 17:20-26 (equations 2-4); Ex. 1002, ¶¶72-73, App [1.e].) As Dr. Sarrafzadeh explains, this derivation of the predicted axial acceleration in quaternion form is done using known quaternion relations with a gravity frame of reference and known quaternion mathematics. (*Id.*, ¶¶72-75.) In the above formula, q_o, q_1, q_2, and q_3 correspond to the quaternion equivalent of $\hat{x}_k^-$. (*Id.*, ¶¶72-73.)

vii) [1.f] "comparing the predicted axial accelerations, which are based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T, with the measured axial accelerations corresponding to time T to obtain a first comparison result;"

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶51, 76, 77, 79, App. [1.f].) This limitation is analyzed in two parts.

> (a) comparing the predicted axial accelerations, with the measured axial accelerations corresponding to time T to obtain a first comparison result;"

Bassompiere teaches the subtraction of $\hat{y}_k^-$ ("**predicted axial accelerations**") from $\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix}$ at time k ("**measured axial accelerations corresponding to time T"**), where the subtraction constitutes a "**comparison**" of predicted axial acceleration and measured axial accelerations at time T as part of the EKF process equation:

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(Ex. 1006, 19:8–9 (equation 23) (emphasis added); *see also id.*, 5:4–6, 29:10–14 (claim 10).) Bassompiere describes the comparing process as "the correction of the state estimated *a priori* at sampling step k." (*Id.*, 5:4–61; *see also id.*, 9:8–9.) In Bassompiere, the difference between the predicted axial accelerations and measured axials accelerations ("**first comparison result**") is multiplied by a gain (K_k), which is determined using equation 5 through 9 of Bassompiere. (*Id.*, 19:6–9, 16:10–17:4.) The gain acts as a correction that accounts for covariances of the modeling and measurement noise to determine which of the predicted axial accelerations (which

are derived from the measured angular velocities taken from the gyroscope reading) or the measured axials accelerations (which are read from the accelerometer) should be more trusted and to what degree. (*Id.*, 5:2–6, 13:20–32, 20:2–6, 28:18–29:9; Ex. 1002, App. [1.f].) This process of "comparison" is what the specification of the '846 patent describes as "utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors." (Ex. 1001, 2:37–43.)

Petitioner notes that Patent Owner has admitted that the EKF equations, like that disclosed in Bassompiere (*e.g.*, Ex. 1006, 16:10–17:4) and those discussed in the '846 patent (Ex. 1001, 17:52–18:33, equations 5–11) were "basic" and "standard":

> [Q.] So Equations 1 through 4 are sort of my process for getting current state and predicted accelerations, and then Equations 5 through 11 are the Kalman filter?
>
> [A.] those -- that piece right there will give you data that is necessary to put into Equations 5 through 11, which are the basic equations of the extended Kalman filter. . . . So those pieces, then, can be put into the, quote/unquote, main equations of the extended Kalman filter to get the comparison and to calculate the third quaternion, which essentially fuses all of these information together.
>
> Q. And that main equation is 5 through 11?
>
> A. Yeah. Standard --

Q. And that's just a framework?

A. Yes.

(Ex. 1015, 62:2–63:9 (testifying as to the same equations in the related '438 patent (Ex. 1009, 13:44–14:23)); Ex. 1002, App. [1.f].)

While Bassompiere's equation 23 involves Euler angles, a POSA would have found it obvious to utilize quaternions in place of Euler angles. This is explained further below in Section IX.A.1.viii (analysis for claim element [1.g]).

> (b) the predicted axial accelerations . . . are based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T

Bassompiere discloses that $\hat{y}_k^-$ ("**predicted axial accelerations**") is calculated using pitch and roll angles $\begin{pmatrix}\hat{\theta}_k^- \\ \hat{\psi}_k^-\end{pmatrix}$, which are derived using the previous quaternion $\begin{pmatrix}\hat{\theta}_{k-1} \\ \hat{\psi}_{k-1}\end{pmatrix}$ and the "**measured angular velocities corresponding to time T**." (Ex. 1006, equations 21-22; *see also supra* Section IX.A.1.vi.) But pitch and roll angles $\begin{pmatrix}\hat{\theta}_{k-1}^- \\ \hat{\psi}_{k-1}^-\end{pmatrix}$ is the output of the prior loop (k-1). (Ex. 1002, ¶¶41, 52; *see also supra* Section IX.A.1.v ("providing a previous quaternion corresponding to time T−1 based on the measured axial accelerations corresponding to time T−1").) And the output of the previous loop, i.e., the output pitch and role angles at time T-1, is calculated "**based on the measured axial accelerations corresponding to time**

T−1." (*See infra* Section IX.A.1.viii (explaining that equation 23 provides the output pitch and roll angles based on the measured accelerations during that loop).)

viii) [1.g] "obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result, which is based on the measured axial accelerations corresponding to time T−1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T, and using the updated quaternion as a next occurrence of the previous quaternion; and

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶51-53, 76-79, App. [1.g].) This limitation is analyzed in several parts.

(a) obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result

Bassompiere discloses this limitation. (*Id.*) Returning to equation 23, $\hat{x}_k$ is the "**updated quaternion**" in Euler angle form:

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(Ex. 1006, 19:8-9 (equation 23) (emphasis added); *see also id.*, 5:5-6, 28:9–13.) Bassompiere describes $\hat{x}_k$ ("**updated quaternion**") as the "correction of the *a priori* estimated state" (*Id.*, 19:8–9), which is calculated at time k as indicated by the subscript k ("**associated with time T**"). (*Id.*, 29:2–5 ("correction of the state estimated a priori **in the sampling step k** of the Kalman filter.") (emphasis added).)

Thus, solving the above equation gives the "**updated quaternion associated with time T**."

$\hat{x}_k$ ("**updated quaternion**") is "**based on the current quaternion**," $\hat{x}_k^-$, at least for the reason that the $\hat{x}_k^-$ ("**current quaternion**") is an explicit part of the equation for calculating $\hat{x}_k$ ("**current quaternion**"):

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(*Id*. 19:8–9 (equation 23) (emphasis added); *see also id.*, 29:2–5.)

$\hat{x}_k$ (the "**updated quaternion**") is also "**based on . . . the first comparison result**," (i.e., the difference between the measured axial acceleration $\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix}$ and the predicted acceleration $\hat{y}_k^-$) described in claim element [1.f] and shown in the EKF equations as highlighted below:

$$\hat{x}_k = \hat{x}_k^- + K_k \left(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^- \right)$$

(*Id*. 19:8–9 (equation 23) (emphasis added); *see also id.*, 5:5-6, 29:2–5; *see also supra* Section IX.A.1.vii.)

A POSA would have found it obvious to perform the calculations of equation 23 using quaternions instead of Euler angles. The '846 patent does not explain how quaternions would have been used to obtain an "updated quaternion." But Patent

Owner's expert has testified that equations 5-11 in the '846 patent correspond to step 735 (which is the step that obtains the "updated" quaternion) and were "known in the art." (Ex. 1012 at 11-12; Ex. 1002, ¶23, App. [1.g].)

As Dr. Sarrafzadeh explains, following Bassompiere's instruction to utilize quaternions instead of Euler angles, a person of ordinary skill in the art would have known that the above EKF equation for $\hat{x}_k$ (Ex. 1006, 19:9 (equation 23)) could be presented in quaternion form as:

$$\hat{\mathrm{q}}_k = \hat{\mathrm{q}}_{\bar{k}} \otimes (\mathrm{K}_k(\mathrm{z}_k - h(\hat{\mathrm{q}}_{\bar{k}})))$$

where $\hat{\mathrm{q}}_k$ is the updated quaternion, $\hat{\mathrm{q}}_{\bar{k}}$ is the current quaternion, and $\mathrm{z}_k - h(\hat{\mathrm{q}}_{\bar{k}})$ represents the difference or comparison between measured acceleration $\mathrm{z}_k(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix})$ and predicted acceleration in quaternion form $\begin{bmatrix} 2(q_1q_3 + q_0q_2) \\ 2(q_2q_3 - q_0q_1) \\ q_0^2 - q_1^2 - q_2^2 + q_3^2 \end{bmatrix}$. (Ex. 1002, ¶¶76-79; *see also supra* Section IX.A.1.vi (regarding predicted acceleration in quaternion form).) Dr. Sarrafzadeh explains that this is the same equation performing the same operation as Equation 23 of Bassompiere, except that it utilizes quaternions instead of Euler angles in the manner known by a person of ordinary skill in the art, just as Bassompiere recommends. (*Id*.)

Any person of skill in the art would appreciate and understand that for the dimensions of $\hat{\mathrm{q}}_{\bar{k}}$ and $\mathrm{z}_k - h(\hat{\mathrm{q}}_{\bar{k}})$ to match, the Kalman gain $\mathrm{K_k}$ must be a 4×3 matrix.

(*Id.*, ¶79.) In that way, the three-dimensional comparison of measured to predicted acceleration can be mapped to the four-dimensional current quaternion $\hat{q}_k^-$. To this end, Bassompiere provides that the Kalman gain is multidimensional. (Ex. 1006, 16:13–15 (equations 5–10 (referring to the Kalman gain as "G").) Consequently, $K_k\left(z_k - h(\hat{q}_k^-)\right)$ results in a four-dimensional vector that effectively represents a small rotation in quaternion space, just as $K_k\left(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix} - \hat{y}_k^-\right)$ represented a correction in Euler angle form. (Ex. 1002, ¶79.) The quaternion multiplication $\otimes$ of that error and the current quaternion $\hat{q}_k^-$ results in the updated quaternion $\hat{q}_k$. (*Id.*)

> (b) the first comparison result "is based on the measured axial accelerations corresponding to time T−1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T,"

The comparison result between the measured axial acceleration $\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix}$ and the predicted acceleration $\hat{y}_k^-$ utilizes the measured axial acceleration $\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix}$, which constitute "**measured axial accelerations corresponding to time T**." It also utilizes the predicted acceleration $\hat{y}_k^-$ that is calculated based on "**angular velocities corresponding to time T**." (*See supra* Section IX.A.1.vii.)

The predicted acceleration $\hat{y}_k^-$ is "**based on the measured axial accelerations corresponding to time T−1**." Specifically, $\hat{y}_k^-$ is calculated using the pitch and roll angles represented by $\hat{x}_k^-$:

$$\hat{y}_k^- = \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix}$$

(Ex. 1006, 19:4–5 (equation 22), 28:14–17 (claim 8).) But $\hat{x}_k^-$ is calculated with reference to the output of the previous loop (i.e., the **previous quaternion**) shown in yellow boxes as follows:

$\dot{q} = \frac{1}{2} \begin{vmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{vmatrix} \otimes \begin{vmatrix} 0 \\ \omega_x \\ \omega_y \\ \omega_z \end{vmatrix}$;	$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$
(*Id.*, 20:21 (equation 26) (emphasis added).)	(*Id.*, 19:3 (equation 21) (emphasis added).)

The **previous quaternion** at time T (k) is the **updated quaternion** $\hat{x}_k$ from the previous loop ("**corresponding to time T-1**"), which is based on the measured acceleration at time **T-1** in that loop. (*Id.*, 20:20–21 (equation 26), 19:3 (equation 21).) Thus, $\hat{y}_k^-$ is "**based on the measured axial accelerations corresponding to time T−1**." (Ex. 1002, App. [1.g].)

(c) using the updated quaternion as a next occurrence of the previous quaternion;

$\hat{x}_k$ ("**updated quaternion**") becomes the "**previous quaternion**," i.e., $\begin{matrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{matrix}$ or $\begin{matrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{matrix}$, in the "**next occurrence**" (next loop k) in the equations for determining the **current quaternion**:

$\dot{q} = \frac{1}{2} \begin{vmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{vmatrix} \otimes \begin{vmatrix} 0 \\ \omega_x \\ \omega_y \\ \omega_z \end{vmatrix}$ (Ex. 1006, 20:21 (equation 26) (emphasis added).)	$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$ (*Id.*, 19:3 (equation 21) (emphasis added).)

(Ex. 1002, App. [1.g].)

ix) [1.h] "providing the resulting deviation based on the updated quaternion;"

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶53-54, 80-85 App. [1.h].) Bassompiere teaches that after "step 1 of estimating the angles θ and ψ of pitch and of roll by an EKF . . . a step 2 of computing the angular rate components *ωv*, *ωw*, related **to the displacement of the mobile element with respect to the frame of reference of the user**" is performed. (Ex. 1006, 15:3–7 (emphasis added).) "Step two" is performed by using the pitch and roll angles of (θ, Ψ) from equation 23 to derive ω_v and ω_w as follows:

$$\begin{cases} \omega_v = cos\hat{\psi}.\omega_\gamma - sin\hat{\psi}.\omega_z \\ \omega_w = -sin\hat{\theta}.\omega_x + cos\hat{\theta}.sin\hat{\psi}.\omega_y + cos\hat{\theta}.cos\hat{\psi}.\omega_z \end{cases}$$

(Ex. 1006, 19:10–11 (equation 24); *see also id.*, 5:7-10, 29:6–9 (claim 11).) This is further illustrated in FIG. 6, where Bassompiere shows ω_v and ω_w as the output of a "step 2" process, where the input to the step 2 process includes the pitch and roll angles (θ ψ) and the output of the step 2 process is ω_v and ω_w calculated using Equation 24 above (using Euler angles).

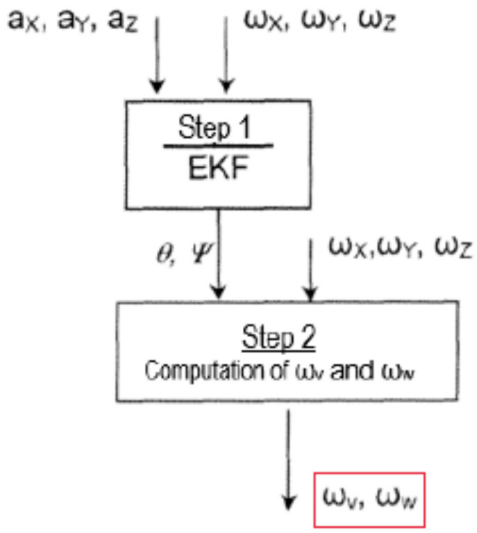


FIG.6

(*Id.*, 19:11; Ex. 1002, ¶54.)

Thus, a POSA would understand that if the output of Bassompiere's equation 23 is a quaternion representing the pitch and roll angles, such a quaternion would then be translated into pitch and roll angles in Euler angle format for use in equation 24. (Ex. 1002, ¶¶80-81.) For example, $\hat{x}_k$ ("**updated quaternion**") would be transformed to provide the pitch and roll angles ("**resulting deviation**") in Euler

angle form.[12] Indeed, $\hat{x}_k$is merely a state vector in terms of pitch and roll angles. (Ex. 1006, 19:1-3, 19:8-9; *see also id.*, FIG. 6 (output of step 1), 17:5–6 ("In a first embodiment, the state vector chosen to solve the problem is: **x=[θ ψ]. Where θ and ψ are respectively the pitch and roll angles.**") (emphasis added).) Thus, the providing of the pitch and roll angles as the output of the EKF is a "**providing** [of] **the resulting deviation based on the updated quaternion**." (Ex. 1002, ¶¶52-53, App. [1.h].)

The Board has previously determined in the proceedings for the related '438 patent, that it would have been obvious to a person of ordinary skill in the art to convert a quaternion into yaw, pitch and roll resultant Euler angles in the spatial reference frame because the equations for such a transformation were widely known in the art. (Ex. 1011, 49.) Dr. Sarrafzadeh explains the straight-forward known way of using quaternion and Euler angle rotation matrices to render the conversion formulas to move from quaternion to Euler angles. (Ex. 1002, ¶¶80-85.) Thus, to the extent the calculations for the Kalman filter process of Bassompiere is performed using quaternions, as opposed to Euler angles, it would have been obvious for a person of ordinary skill in the art to convert the quaternion output $\hat{x}_k$ ("**updated**

[12] As explained above with reference to limitation [1.c], the pitch and roll angles disclose the "**resulting deviation**." (*See supra* Section IX.A.1.iv.)

quaternion") into pitch and roll angles in Euler angle format, which provides "**the resulting deviation based on the updated quaternion**."

In fact, a POSA would have been motivated to convert equation 23's quaternion output into Euler angles because Euler angles are more intuitive, i.e., it is easier to understand and perceive the effect of an orientation change of an object in terms of Euler angles than quaternions. (Ex. 1007, 271 ("The quaternion states were also decomposed into the more intuitive representation of roll, pitch, and yaw in Fig. 5"); Ex. 1002, ¶82.) Furthermore, converting the quaternion output of equation 23 into Euler angles would have been one of two available choices for a POSA, and thus obvious. (Ex. 1002, ¶81.) *Uber Techs., Inc. v. X One, Inc.*, 957 F.3d 1334, 1339 (Fed. Cir. 2020) (holding that when there are "only two possible methods," the use of each method is obvious). A POSA can either convert equation 24 to use quaternions or they can convert the quaternion output of equation 23 into Euler angles, and use the Euler angles in equation 24. (Ex. 1002, ¶81.) A POSA would have been capable of computing ω_v and ω_w under either choice. (*Id.*)

x) [1.i] "wherein the current quaternion and the predicted axial accelerations are converted from the measured angular velocities corresponding to time T so that the first comparison result and the updated quaternion correspond to time T; and"

Bassompiere discloses or suggests this limitation. (Ex. 1002, ¶¶49-50, 52, App. [1.i].[13]) As explained in the analysis for claim [1.g] above, $\hat{x}_k^-$ ("**current quaternion**") is calculated from the reading of the gyroscope (ω_X, ω_Y and ω_Z) at time step k ("**converted from the measured angular velocities corresponding to time T"**):

$$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\Psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\Psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha\sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$$

(Ex. 1006, 19:1–3 (equation 21); *see also id.*, 28:13; *see also supra* Section IX.A.1.viii.)

As described in the analysis of claim element [1.e] above, $\hat{y}_k^-$ ("**predicted axial accelerations"**) is based on $\hat{x}_k^-$ ("**current quaternion**"):

$$\hat{y}_k^- = \begin{vmatrix} -\sin\hat{\theta}_k^- \\ \cos\hat{\theta}_k^- . \sin\hat{\Psi}_k^- \\ \cos\hat{\theta}_k^- . \cos\hat{\Psi}_k^- \end{vmatrix}$$

(*Id.*, 19:4–5 (equation 22); *see also id.*, 28:15–17 (claim 8); *see also supra* Section IX.A.1.vi.) Thus, $\hat{y}_k^-$ ("**predicted axial accelerations"**) is derived from the gyroscope readings of the measured angular velocity (ω_X, ω_Y and ω_Z) at time step k (**T**) ("**converted from the measured angular velocities corresponding to time**

[13] The analysis for claim [1.i] assumes that equations 21-23 use quaternions, instead of Euler angles.

T"). Therefore, "[t]**he first comparison result and the updated quaternion**" also "**correspond to time T.**" (Ex. 1006, 19:8-9 (equation 23).)

xi) [1.j] "wherein the processor circuitry is further configured to translate the resultant angles of the resulting deviation in the spatial reference frame into a real-time movement pattern in the display reference frame."

Bassompiere discloses this limitation. (Ex. 1002, ¶¶28-30, 44, App. [1.j].) The processor circuitry of Bassompiere (*see supra* Section IX.A.1.iv) is configured to translate the pitch and roll angles (θ ψ) ("**resultant angles of the resulting deviation in the spatial reference frame**"), which are output as the updated quaternion, $\hat{x}_k$, into a resultant deviation in the two-dimensional reference frame of the screen through use of the user reference frame (u, v, w). (*See supra* Section IX.A.1.ix.) For example, the pitch and roll angles allow correlating angular velocities determined in the XYZ reference frame to the uvw reference frame, which allows calculating "the displacement of the mobile element on the screen (d_y and d_z)" (**"real time movement patterns in the display reference frame"**). (Ex. 1006, 11:25–12:9.) Specifically, "ω_v and ω_w . . . give direct information on the horizontal displacements (rotation about the axis ω represented by ω_w) and vertical displacements (rotation about the axis v represented by ω_v) and therefore the displacement of the mobile element on the screen (d_y and d_z)." (*Id.*) Equation 24

discloses the calculation of ω_w and ω_v using the roll and pitch angles of the updated quaternion:

$$\begin{cases} \omega_v = cos\hat{\psi}.\omega_\gamma - sin\hat{\psi}.\omega_z \\ \omega_w = -sin\hat{\theta}.\omega_x + cos\hat{\theta}.sin\hat{\psi}.\omega_y + cos\hat{\theta}.cos\hat{\psi}.\omega_z \end{cases}$$

(*Id*., 19:10–11 (equation 24); *see also supra* Section IX.A.1.ix.)

2. Claim 3:

i) [3.pre] The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to:

The **computing processor** of the **electronic device** of Bassompiere (is responsible for **calculating the resulting deviation**. (*See supra* Section IX.A.1.iv. [14])

ii) [3.a] utilize a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T;

Bassompiere discloses the limitations therein. (Ex. 1002, ¶¶51, 76, 77, 79, App. [3.a].) As described in [1.f] above, the EKF of Bassompiere includes "**a first data association model**" in the form of the comparison by subtraction of $\hat{y}_k^-$

[14] The analysis for claim 3 assumes that equations 21-23 use quaternions, instead of Euler angles.

("**predicted axial acceleration**") with $\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix}$ ("**measured axial accelerations**") at time step k ("**corresponding to time T**"), which is then multiplied by the Kalman gain at time step k in the form of K_k:

$$\hat{x}_k = \hat{x}_k^- + K_k\left(\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix} - \hat{y}_k^-\right)$$

(Ex. 1006, 19:8–9 (equation 23) (emphasis added); *see also id.*, 5:4–6, 29:2–4 (claim 10); *see also supra* Section IX.A.1.vii.) The value of the Kalman gain determines the influence of the measured axial acceleration reading $\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix}$ ("**measured axial accelerations**") on $\hat{x}_k^-$ ("**current quaternion**"). In other words, the value of the compensation data association model (Kalman gain times the difference between the measured acceleration and predicted acceleration) determines that amount by which the $\hat{x}_k^-$ ("**current quaternion**") must be changed (compensated) to arrive at $\hat{x}_k$ ("**updated quaternion**"). That calculation is "**based on the measured axial accelerations corresponding to time T**" because the measured accelerometer values $\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix}$ taken at time k ("**measured axial accelerations corresponding to time T**") is part of the EKF equation that solves for $\hat{x}_k$ ("**updated quaternion**"). (Ex. 1002, ¶¶51, 77.)

iii) [3.b] and obtain the updated quaternion in response to determining that the compensation is needed.

Bassompiere discloses this limitation. (*Id.*, ¶¶51, 76, 77, 79, App. [3.b].), As explained in the analysis of [3.a], "**determining that the compensation is needed**" is performed by the EKF equation based on the comparison by subtraction of $\hat{y}_k^-$ ("**predicted axial acceleration**") with $\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix}$ ("**measured axial accelerations**") multiplied by the Kalman gain:

$$\hat{x}_k = \hat{x}_k^- + K_k\left(\begin{bmatrix}\alpha_{x,k}\\ \alpha_{y,k}\\ \alpha_{z,k}\end{bmatrix} - \hat{y}_k^-\right)$$

(Ex. 1006, 19:8–9 (equation 23) (emphasis added), *see also id.*, 5:4–6 , 29:1–4 (claim 10).) If that calculated value is anything other than 0, then $\hat{x}_k^-$ ("**current quaternion**") will be incremented or decremented ("**compensation**") thus adjusting $\hat{x}_k$ ("**obtain the updated quaternion**"). A determination is thus made that "**compensation is needed**." (Ex. 1002, App. [3.b].)

3. Claim 7:

i) [7.pre] "A method for determining movements and rotations in dynamic environments, comprising:"

Bassompiere discloses this limitation for the reasons discussed above with reference to limitation [1.b] and [1.c]. (Ex. 1002., App. [7.pre]; *see also supra* Sections IX.A.1.iii-iv.)

ii) [7.a] "generating, with a rotation sensor having sensor circuitry measured angular velocities;"

Bassompiere discloses this limitation for the reasons discussed above with reference to limitations [1.b]. (Ex. 1002, App. [7.a]; *see also supra* Section IX.A.1.iii.)

iii) [7.b] "generating, with an accelerometer having accelerometer circuitry measured axial accelerations;"

Bassompiere discloses this limitation for the reasons discussed above with reference to limitation [1.b]. (Ex. 1002, App. [7.b]; *see also supra* Section IX.A.1.iii.)

iv) [7.c] "calculating, with a computing processor having processor circuitry, a resulting deviation comprising resultant angles associated with the movements and the rotations in a spatial reference frame by:"

Bassompiere discloses this limitation for the reasons discussed above with reference to limitation [1.c]. (Ex. 1002, App. [7.c]; *see also supra* Section IX.A.1.iv.)

v) [7.d] "providing a previous quaternion corresponding to time T−1 based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T−1;"

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.d]. (Ex. 1002, App. [7.d]; *see also supra* Section IX.A.1.v.)

vi) [7.e] "converting the measured angular velocities corresponding to time T based on the previous quaternion into a current quaternion and predicted axial accelerations without using the measured axial accelerations corresponding to time T;"

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.e]. (Ex. 1002, App. [7.e]; *see also supra* Section IX.A.1.vi.)

vii) [7.f] "comparing the predicted axial accelerations, which are based on the measured axial accelerations corresponding to time T−1 and the measured angular velocities corresponding to time T, with the measured axial accelerations corresponding to time T to obtain a first comparison result;"

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.f]. (Ex. 1002, App. [7.f]; *see also supra* Section IX.A.1.vii.)

viii) [7.g] "obtaining an updated quaternion associated with time T based on the current quaternion and the comparison result, which is based on the measured axial accelerations corresponding to time T−1, measured axial accelerations corresponding to time T, and angular velocities corresponding to time T, and using the updated quaternion as a next occurrence of the previous quaternion; and"

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.g]. (Ex. 1002, App. [7.g]; *see also supra* Section IX.A.1.viii.)

ix) [7.h] "providing the resulting deviation based on the updated quaternion,

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.h]. (Ex. 1002, App. [7.h]; *see also supra* Section IX.A.1.ix.)

x) [7.i] wherein the current quaternion and the predicted axial accelerations are converted from the measured angular velocities corresponding to time T so that the comparison result and the updated quaternion correspond to time T; and"

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.i]. (Ex. 1002, App. [7.i]; *see also supra* Section IX.A.1.x.)

xi) [7.k] "translating the resultant angles of the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame associated with a display device."

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.j]. (Ex. 1002, App. [7.k]; *see also supra* Section IX.A.1.xi.)

4. Claim 9:

i) [9.pre] The method of claim 7, wherein calculating the resulting deviation further comprises:

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.c] and [3.pre]. (Ex. 1002, App. [9. pre] and [3.pre]; *see also supra* Section IX.A.2.i.)

ii) [9.a] utilizing a first data association model to determine whether compensation is needed to obtain the updated quaternion based on the measured axial accelerations corresponding to time T; and

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [3.a]. (Ex. 1002, App. [9.a]; *see also supra* Section IX.A.2.ii.)

iii) [9.b] obtaining the updated quaternion in response to determining that the compensation is needed.

Bassompiere discloses or suggests this limitation for the reasons discussed above with reference to limitation [3.b]. (Ex. 1002, App. [9.b]; *see also supra* Section IX.A.2.iii.)

B. Ground 2: Bassompiere and Nasiri Render Obvious Claims 1 and 3

Ground 2 incorporates the analysis of Ground 1 for claims 1 and 3. However, it includes additional analysis to address certain limitations of claim 1 based on Nasiri. Thus, except for the additional analysis below, Ground 2 is identical to Ground 1.

1. **"An electronic device subject to movements and rotations in dynamic environments, comprising: . . . a display device associated with a display reference frame; a motion sensor module comprising a rotation sensor and an accelerometer , . . . with both the rotation sensor and the accelerometer being associated with the movements and the rotations of the electronic device in a spatial reference frame"**

Petitioner analyzed claim 1 under the interpretation that the "**display device**" and a "**motion sensor module**" are not required to be in the same housing. This understanding is consistent with the '846 patent. (Ex. 1002, ¶86.) For example, Figure 5 illustrates an embodiment of the purported invention where an "electronic device 500" includes a first part 560 and a second part 570. (Ex. 1001, 11:44–46.) As shown in Figure 5, the first part 560 (which is a pointer device) and the second part 570 are not physically connected, and need not be in the same housing. (*Id*., 11:46–60.)

To the extent Patent Owner argues the "**electronic device**" must include both a "**display device**" and a "**motion sensor module**" in the same housing (e.g., claim elements [1.pre], [1.a], [1.b]), the claims would have been obvious based on Bassompiere in view of Nasiri. (Ex. 1002, ¶87.)

Nasiri discloses a mobile phone with a display screen, gyroscope, and accelerometer, all held in the same housing. (Ex. 1008, 8:21–49, 9:47–10:37, FIGS. 1, 2.) The mobile phone is shown below in Figures 1 and 2:

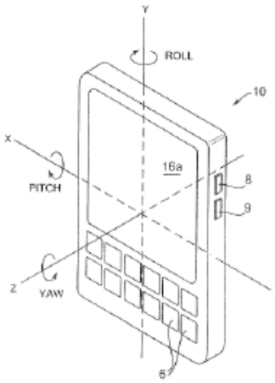


FIG. 1

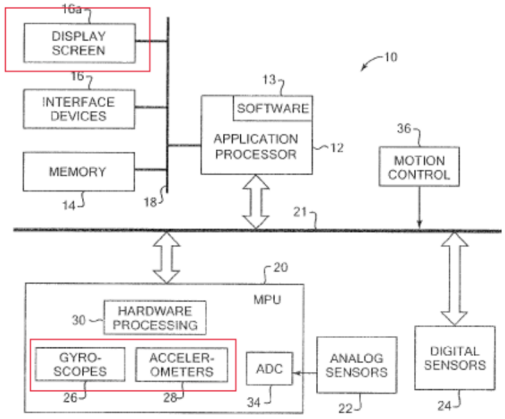


FIG. 2

(*Id.*, FIGS. 1, 2 (emphasis added).) Mobile phone 10 of Nasiri uses the output reading of its gyroscope and accelerometer in a sensor fusion algorithm (which, like the EKF of Bassompiere, predicts the acceleration, i.e., the gravity vector), to facilitate handheld gaming on the phone. (*Id.*, 10:46–53, 30:48–57.) Nasiri further describes the output of the gyroscope and accelerometer:

> [A] driving, flying, skiing, or other game involving steering could be controlled **using gyroscopes and accelerometers**. The **sensor fusion algorithm** that **combines gyroscopes and accelerometer** can output a **gravity vector** that determines which way the direction "down" **is**, relative to the device. By rotating the device relative to the gravity vector, **a steering motion can be used to control a game**.

(*Id.*, 30:48–54 (emphases added); *see also id.*,10:46-53, 14:49-57; Ex. 1002, ¶88)

Bassompiere, like Nasiri, teaches the use of gyroscopes and accelerometers to facilitate movement on a display for gaming:

> The user normally holds the pointer in his hand, although other modes of carriage may easily be envisaged depending on the application, . . . They may have diverse functions, notably: . . . **electronic games interface** where, depending on the **game**, the pointer may be an object manipulated by the user (golf club, tennis racket, bowling ball, hand- gun, hip gun or rifle, etc.)

(Ex. 1006, 1:3–26 (emphasis added).) As already discussed, Bassompiere also uses a sensor fusion algorithm (EKF) to combine gyroscope and accelerometer readings. (*See, e.g., supra* Sections IX.A.1.iii-v.) A POSA would have thus looked to combine Bassompiere and Nasiri. (Ex. 1002, ¶¶87-89.) As discussed above in Section VII.C, Bassompiere is analogous art to the '846 patent. Nasiri is also analogous art because it teaches a mobile device with gyrometer and accelerometer motion sensors (Ex. 1008, 30:48-54, FIGS. 1, 2) running a sensor fusion algorithm (*id.*) to facilitate display of an image on a two dimensional screen. (*Id.*, 30:48–54; *see also id.*,10:46-53, 14:49-57; Ex. 1002, ¶88.)

Having looked to both Nasiri and Bassompiere, a POSA would have recognized that an EKF, as disclosed in Bassompiere, could allow the playing of games in Nasiri's single handheld device that includes sensors and a display screen,

all in the same fixed body. (Ex. 1002, ¶89.) Bassompiere calls out gaming applications as one particularly suited to the device of Figure 5 that can be addressed by using a three-axis gyroscope instead of a two-axis gyroscope:

> The invention makes it possible to compute the displacement of the mobile element in a plane surface on the basis of the movements of the pointer for small values of the angle of pitch (less than 30°). **This condition is fulfilled in most pointing applications, except perhaps in games where the amplitude of displacement is particularly important**. The choice of a gyrometer with two measurements axes is a solution which is simpler and less expensive to implement than a solution based on a three-axis gyrometer. In this second solution, **the pointing device comprises**, for example, a three-axis MEMS accelerometer sensor 20 and a **three-axis gyrometer MEMS sensor 30** composed of three single-axis or of one single-axis and of one two-axes. The **third gyrometer axis makes it possible to circumvent the constraint on the value of the pitch angle**.

(Ex. 1006, 14:7–17 (emphasis added).) Moreover, Bassompiere's EKF sensor fusion algorithm has several advantages, including compensation of "tilt" or "torsion." (*Id.*, 2:16-22, 10:10-14, 13:15-14:2.) Thus, Bassompiere motivates a POSA to use its EKF process in a mobile phone gaming solution such as that of Nasiri. (Ex. 1002, ¶89.)

A POSA would have had a reasonable expectation of success in configuring the Bassompiere-Nasiri combined system to allow an EKF sensor fusion operation on a mobile device with sensors and a screen in the same housing, such as a mobile phone. (Ex. 1002, ¶¶90-93.) Making such a combination would have been within the skill of the POSA and would not have required much (if any) change to the underlying system configuration of Bassompiere. (*Id.*) Since Bassompiere already teaches the translation of angles from the reference frames of the pointer device and user to the display reference frame, it would have been within the knowledge of the POSA to perform a fixed transformation between the reference frame of the pointer with that of the display to accomplish the movement of images to the display moving with the sensors in the same housing. (*Id.*) Such a transformation would be simpler than that already described with respect to Bassompiere because the sensors and display would be in a fixed relation, meaning that there would be fewer axes of rotation involved. (*Id*.)

As shown in Figure 2 of Bassompiere, the device reference frame (X,Y,Z) can be transformed into display reference frame (x,y,z), where x=0, using transformation matrices to represent the relationship between the two frames of reference. (Ex. 1006, FIG. 2.) If the two frames of reference are connected to each other to force one frame of reference to move with the other frame of reference in some defined way, then instead of utilizing the (x,y,z) reference frame, a POSA would know to

utilize reference frame (X,Y,Z) and its determined relation to the display to create a transformation matrix specific to the now-fixed relationship. (Ex. 1002, ¶91.)

Bassompiere describes exactly this scenario with respect to the device depicted in Figure 5. (Ex. 1006, FIG. 5.) There, "the sensors are positioned in the upper part of the device, whose orientation is different from the lower part, held by the wearer," but the two positions are fixed by angle of pitch θ.

> [T]he sensor axes are defined by the reference frame (*X, Y, Z*). When the carrier of the device performs a rotation about the axis w, the gyrometer, located in the inclined part of the device, detects a rotation around the axes *X* and *Z*, dependent on the angle of pitch θ. The determination of the angle θ coupled with the knowledge of the measurements of angular rate around the axes *X* and *Z* then makes it possible to deduce therefrom the angular rate/velocity about the axis w.

(*Id.*, 14:19–27, FIG. 5; Ex. 1002, ¶92.) Thus, a person of ordinary skill in the art could implement Bassompiere's EKF sensor fusion algorithm in a device where both the sensors and the display screen are fixed in the same housing. (Ex. 1002, ¶92.)

As further evidence that person of ordinary skill in the art would be able to apply the teachings of Bassompiere to the mobile device of Nasiri having sensors and a display in the same housing, Patent Owner's expert testified in the IPR proceedings for the related '438 and '978 patents that a person of ordinary skill in

the art would be able to convert a three-dimensional orientation to a display screen of two dimensions even in the case where the display screen was part of the same handheld device:

> Q. And does the mapping or the ability of a person of ordinary skill in the art to do the mapping, does that depend on whether it's a built-in display or a display that is, say, somewhere across the room from the 3D pointing device?
>
> A. It does make a difference as to where the quote, unquote, display reference frame is. If it's coupled with the 3D -- by the handheld 3D pointing device versus some screen somewhere in some distance away, you have to understand the relationship between the two coordinate systems in order to properly perform the mapping.
>
> Q. So, would your answer be different than specifically to the question, did a person of ordinary skill in the art in the 2009 or earlier time frame have the ability to do that transformation, if it's a built-in display?
>
> A. A person of ordinary skill in the art would be able to do that.
>
> Q. Would it require a lot of experimentation?
>
> A. It's hard to say. I mean, there's various levels of skill in the art, so... I would say if that person was following

> proper procedure for how you do transformations from one coordinate system to another, then there wouldn't be a lot of experimentation needed.

(Ex. 1016, 49:22-50:23; Ex. 1002, ¶93.)

X. THE '846 PATENT IS NOT ENTITLED TO THE FILING DATE OF THE PROVISIONAL '558 APPLICATION

The '846 patent is not entitled to the January 6, 2010 filing date of the provisional '558 application.[15] The provisional '558 application does not provide written description support under 35 U.S.C. § 112 for several claim elements of the '846 patent. (Ex. 1002, ¶94.) The provisional '558 application makes no mention of, and presents no equations using, quaternions. All disclosures in the provisional '558 application are described with respect to only Euler angles. (Ex. 1002, ¶95.)

For example, the provisional '558 application discloses a:

> three-dimensional (3D) pointing device may refer to an input device applicable to be moved by a user in three or more dimensions in the space (e.g., air) in front of a screen (or monitor) to control a corresponding user interface by translating those motions done by the user with the 3D pointing device directly into commands acceptable by the

[15] In the co-pending litigation, Patent Owner confirmed that the '846 patent is entitled to a filing date of no earlier than November 11, 2010. (Ex. 1017 at 4.)

> user interface, for example, movement of a cursor on the screen.

(Ex. 1014, ¶0002.) To accomplish the translation of pointer movement to movement of a cursor on the screen, the provisional '558 application describes the 3D point device as including "an accelerometer (g-sensor) and a gyroscope, wherein the accelerometer is used to detect/measure the acceleration of the 3D pointing device in a specific direction(s) (e.g., the three axis directions), and the gyroscope is used to measure the rotation (e.g., the rotation rate) of the 3D pointing device." (*Id.*, ¶0003.) The provisional '558 application describes the rotations of the gyroscope as "tilt angles." (*Id*., ¶¶0010, 0011, 0028, 0029.) The provisional '558 application also refers to tilt angles as "rotation angles." (*Id.*, ¶0029 ("Referring to FIG. 2A, rotation (tilt) angles θx and θy may be calculated by *Ax* and *Ay* signals").) With respect to accelerometer data, the provisional '558 application similarly describes "tilt angles calculated from measuring results of an accelerometer." (*Id.*, ¶30.) The provisional '558 application never converts, or suggests conversion or use of, quaternions to represent the orientation of the pointer. (Ex. 1002, ¶95.)

Further, the provisional '558 application does not describe or suggest the use of quaternions for the sensor fusion algorithms that combine the sensor measurements. For example, the sensor fusion algorithm, described in Figures 5A

and 5B performs its calculations (represented in the boxes shown below) using Euler angles, not quaternions:

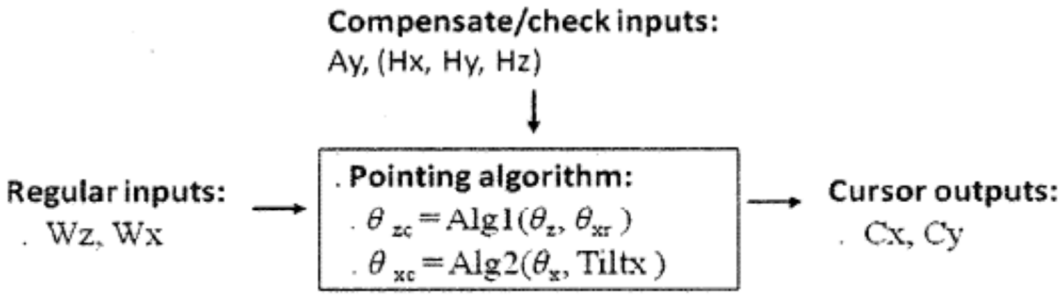


FIG. 5A

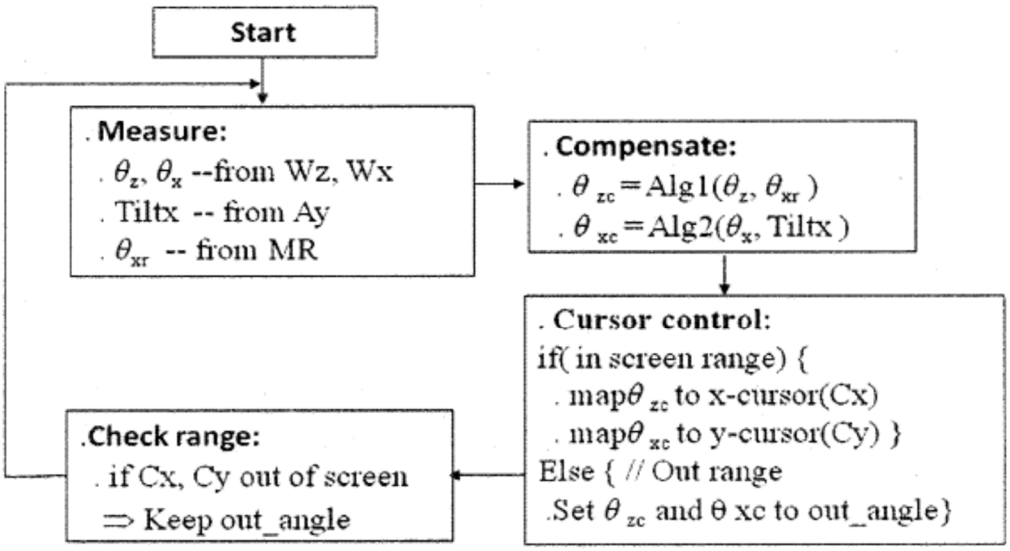


FIG. 5B

(Ex. 1014, FIGS. 5A, 5B; *see also id.*, ¶0040; Ex. 1002, ¶96.)

Therefore, the provisional '558 application lacks written description for at least claim elements [1.d], [1.e], [1.g], [3.a], [3.b], [7.d], [7.e], [7.g], [7.h], [7.j], [9.a],

and [9.b] insofar as the provisional '558 application lacks any description or suggestion to utilize quaternions.

Further, the provisional '558 application does not describe a comparison of a predicted axial accelerations and measured axial accelerations. For example, the provisional '558 application describes the algorithms of Figures 5A and 5B in only the most general terms as using "tilt measured by the accelerometer to compensate x-gyro drift and monitor cursor vertical range." (Ex. 1014, FIGS. 5A, 5B, ¶0040.) Nowhere in the specification or drawings does the provisional '558 application describe the details of that algorithm, let alone to the level that would indicate that predicted axial accelerations and measured axial accelerations should be compared. (Ex. 1002, ¶97.) Therefore, the provisional '558 application lacks written description for at least the "comparing" recitation of claim elements [1.f] and [7.f].

XI. CONCLUSION

Petitioner requests institution of IPR for claims 1, 3, 7, and 9 of the '846 patent based on the grounds specified in this petition.

Respectfully submitted,

Dated: May 20, 2025

By: /Naveen Modi/
Naveen Modi (Reg. No. 46,224)
Counsel for Petitioner

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,852,846 contains, as measured by the word-processing system used to prepare this paper, 12,680 words. This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Respectfully submitted,

Dated: May 20, 2025

By: /Naveen Modi/
Naveen Modi (Reg. No. 46,224)
Counsel for Petitioner

CERTIFICATE OF SERVICE

I hereby certify that on May 20, 2025, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 10,339,825 and supporting exhibits to be served via express mail on the Patent Owner at the following correspondence address of record as listed on PAIR:

McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE, Suite 530
Atlanta, GA 30339

Respectfully submitted,

Dated: May 20, 2025

By: /Naveen Modi/
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Counsel for Petitioner