

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. 11,698,687

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,698,687**

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I. INTRODUCTION

Samsung Electronics Co., Ltd. (“Petitioner”) respectfully requests *inter partes* review of claims 1-7, 12, 14, and 25 (the “challenged claims”) of U.S. Patent No. 11,698,687 (the “’687 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 ’687 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 ’687 patent issued from U.S. Patent Application No. 16/953771 (“the ’771 Application”). The ’771 Application is a continuation of U.S. Patent No. 10,852,846 (“the ’846 patent”), and 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 ’687 patent is related to U.S. Patent No. 10,852,846 (“the

'846 patent"). The '846 patent is asserted in the co-pending litigations. The '846 patent is currently at issue in IPR2025-01023, which was filed on May 20, 2025.

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 '687 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 1-7, 12, 14, and 25 of the '687 patent and cancellation of these claims as unpatentable. The challenged claims should be found unpatentable on the following grounds:

Ground 1: Claims 1-7, 12, 14 and 25 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as rendered obvious by WO 2009/156499 to Bassompierre *et al.* ("Bassompierre") (Ex. 1005). A certified translation of Bassompierre is attached as Exhibit 1006.

The '687 patent has a filing date of November 20, 2020, 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 '687 patent also claims the benefit of Provisional Application No. 61/292,558 ("the provisional '558 application") (Ex. 1014), filed on January 6, 2010.¹

¹ As explained below in Section X, the challenged claims of the '867 patent are not entitled to the filing date of the provisional '558 application. (*Infra* Section X.)

Bassompierre published on December 30, 2009, and is therefore prior art to the challenged claims under pre-AIA 35 U.S.C. § 102(a).

A U.S. equivalent of Bassompierre (U.S. Patent Publication No. 2011/0199298) was considered by the Patent Office during prosecution of the '687 patent. (Ex. 1001, 2.) Bassompierre was not raised by the Examiner in any rejection. Thus, a discretionary denial under 35 U.S.C. § 325(d) is not appropriate.

VI. LEVEL OF ORDINARY SKILL

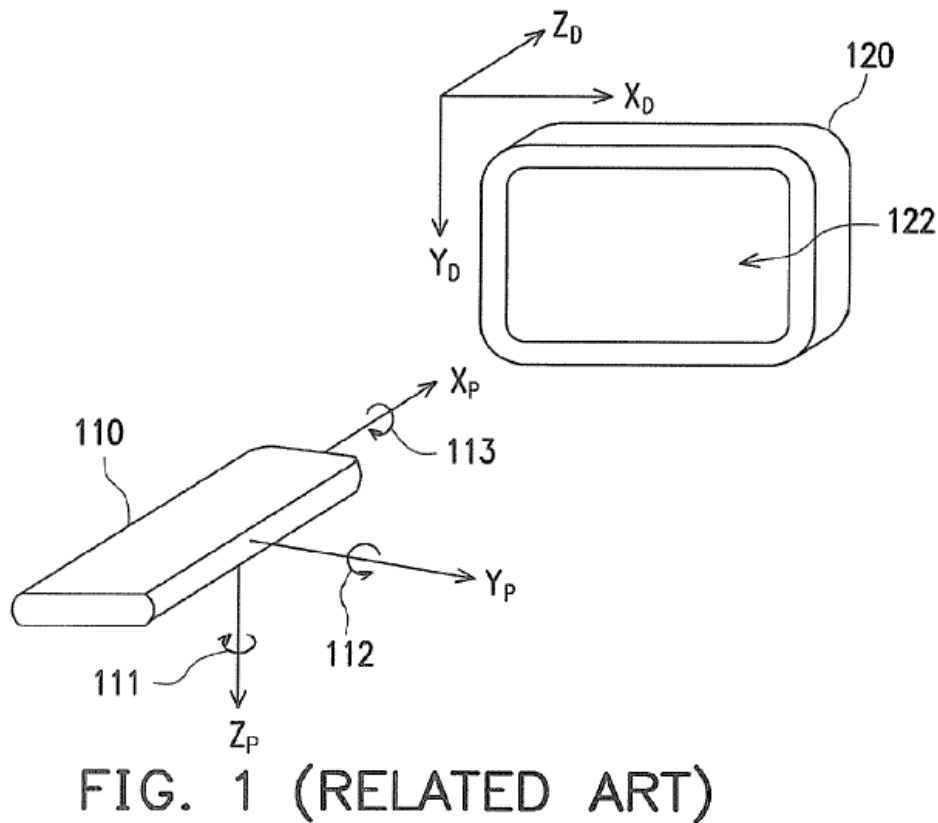
A person of ordinary skill in the art at the time of the alleged invention of the '687 patent ("POSA") would have had an undergraduate degree in electrical engineering, computer engineering, computer science, physics or a related field along with two years of work experience in the field of sensors (such as accelerometers, gyroscopes and magnetometers), sensor fusion algorithms, including Kalman filters, quaternion mathematics, and mobile computing technologies. (Ex. 1002, ¶¶17-18.)² More education can supplement practical experience and vice versa. (*Id.*)

² Petitioner submits herewith the declaration of Majid Sarrafzadeh, Ph.D. (Ex. 1002), an expert in the field of the '687 patent. (*Id.*, ¶¶ 2-10; Ex. 1003.)

VII. OVERVIEW OF THE '687 PATENT AND THE PRIOR ART

A. THE '687 PATENT

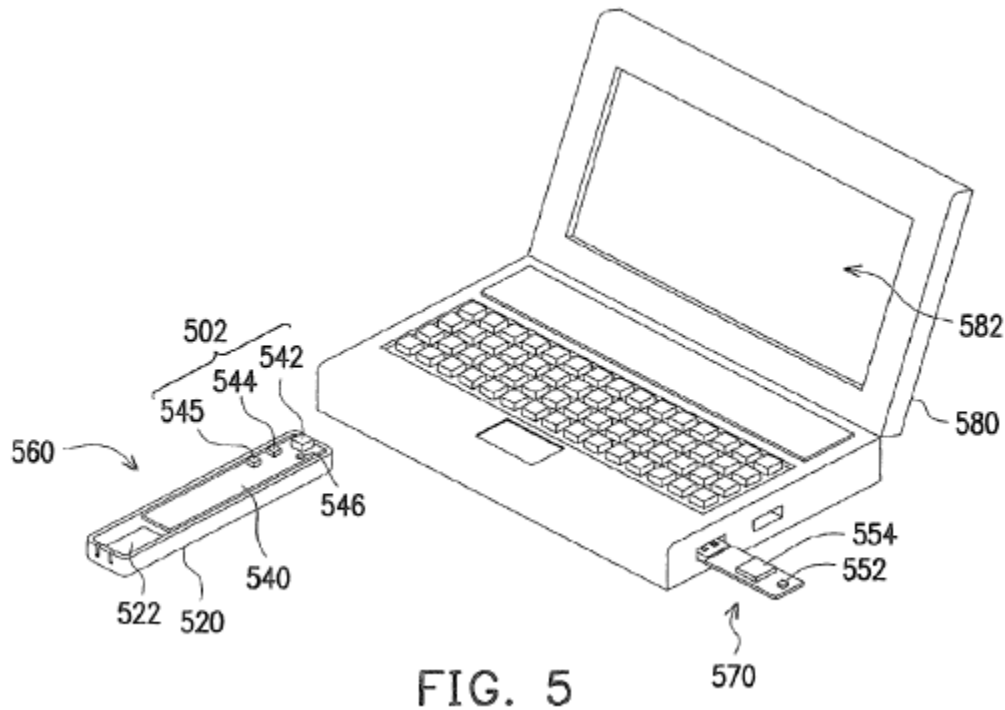
The '687 patent relates to a three-dimensional (3D) pointing device that is subject to movement and rotation and that has sensor modules allowing the device to “obtain actual resulting deviation angles in [a] spatial reference frame and under dynamic environments.” (Ex. 1001, 1:35–37; Ex. 1002, ¶31.) The '687 patent acknowledges that 3D pointing devices were known in the prior art, as shown in Figure 1, reproduced below:



(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. (Ex. 1001, 1:41–46.) 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.*, 1:51–54.) 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.*, 1:54–57, 2:25–28; Ex. 1002, ¶32.) 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 . (Ex. 1001, 2:8–20.) 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.*, 2:50–54; *see also id.*, 2:21–54, 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, 11:55–57.) 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.*, 11:57–12:4.)



(*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.*, 11:55–12:4.) 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.*, 12:28–13:14; 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.

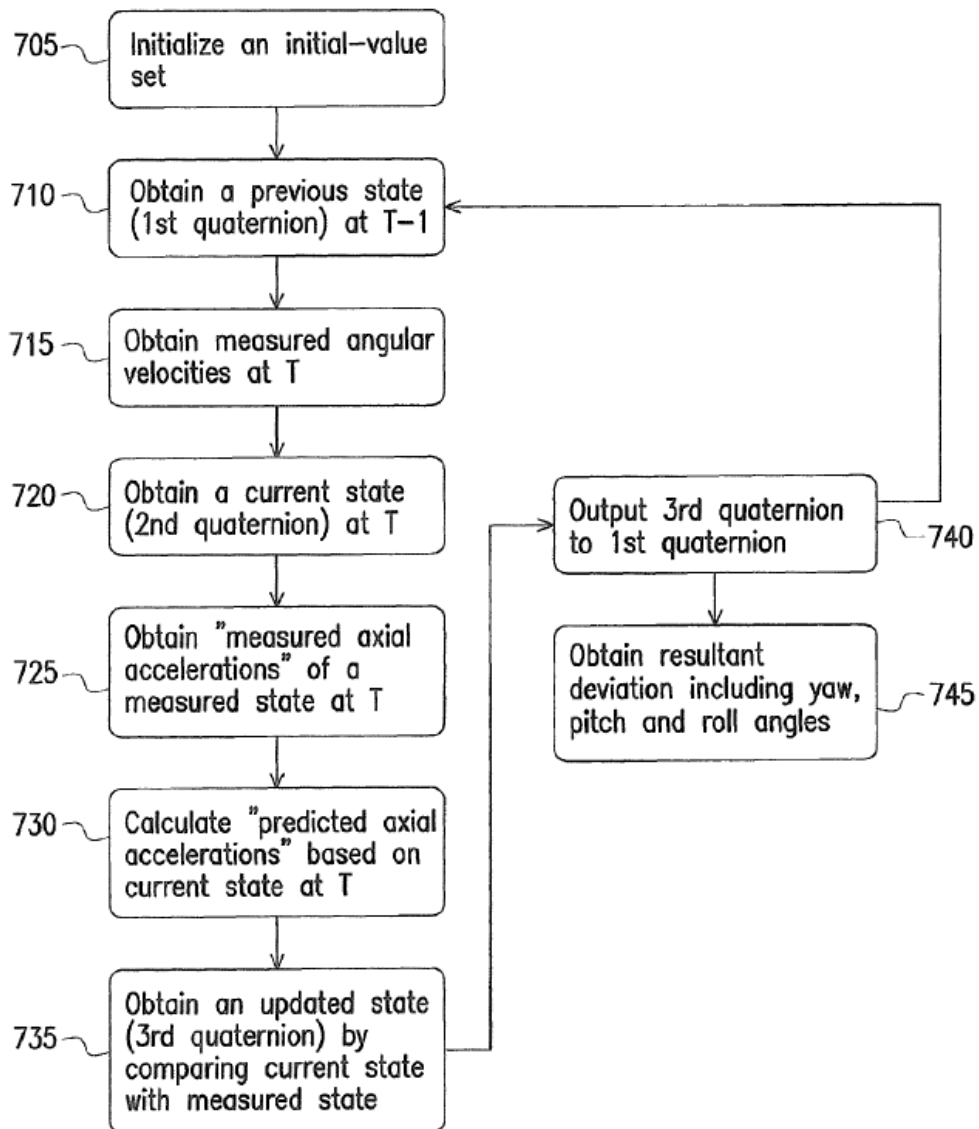


FIG. 7

(Ex. 1001, FIG. 7; Ex. 1002, ¶34.) Figure 7 depicts a method of calculating deviation angles of a 3D pointing device's spatial pointer reference frame. (Ex. 1001, 14:6–13.) 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.* at 14:35–45.)

This state is in the form of “a first quaternion³ 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.* at 14:45–50; 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, 14:50-55, 16:41-50.) According to the ’687 patent, one way to convert ω_x , ω_y , ω_z into the “second quaternion” is by using the equation below.

³ 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 ¶34, fn. 2.) The ’687 patent acknowledges that Euler angles can be used and defined from a quaternion. (Ex. 1001, 15:59–61 (“It can be understood that one may make reference to Euler Angles for definition on quaternion.”).)

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

(*Id.*, 16:56-63 (equation 1).) Equation 1 is a differential equation with respect to the “first quaternion” (q_0, q_1, q_2, q_3), and the ’687 patent suggests solving it using a data conversion utility. (*Id.*, 16:50–17:4; 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, 17:5–8; Ex. 1002, ¶36.) This measured state has two parts: a set of “measured axial accelerations A_x, A_y, A_z ” obtained from the accelerometer signals (step 725), and “predicted axial accelerations A_x', A_y', A_z' ,” which are calculated based on the measured angular velocities (step 730). (Ex. 1001, 17:8–17:24.) 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.*, 17:21–24.) The ’687 patent provides the following equations for calculating each of A_x', A_y', A_z' , which the ’687 characterizes as a “conversion utility”:

$$2(q_1 q_3 - q_0 q_2) = A_x'$$

$$2(q_2 q_3 + q_0 q_1) = A_y'$$

$$q_0^2 - q_1^2 - q_2^2 + q_3^2 = A_z'$$

(*Id.*, 17:27–37, 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, 14:63–66, 15:7–26.) It does this by using a “comparison model” involving equations 5–11. (*Id.*, 17:42–47; *see also id.*, 17:37–18:43; Ex. 1002, ¶37.) 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 as extended Kalman Filter [“EKF”] equations, ***which were known in the art***, and described 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, 15:7–15; Ex. 1002, ¶38.) 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. (Ex. 1001, 14:66–15:7, 19:21–57.) According to the ’687 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.*, 11:38–51, 20:10–35, 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, ¶43, App. [1.pre]-[25.b].⁴)

B. PROSECUTION HISTORY

The '687 patent claims issued after Patent Owner amended the claims to overcome various rejections. (Ex. 1004, 152-166, 348-364.) During prosecution, Patent Owner made several remarks to distinguish the claims over the prior art. (*Id.*, 152-166, 348-364, 430-433.) 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 arguments to overcome Bachman, Patent Owner described its invention as determining “predicted axial accelerations based on a previous quaternion” and then using “the predicted axial accelerations (not measured) and measured axial accelerations to obtain a first comparison result (error correction.)” (Ex. 1004, 148.) Patent Owner further argued over Bachmann:

⁴ The citation to “App.” refers to the Appendix attached with Dr. Sarrafzadeh’s declaration.

the recited feature of "obtaining predicted axial accelerations corresponding to time T based on the measured angular velocities corresponding to time T and the current quaternion" requires that "predicted axial accelerations corresponding to time T" be based on both "the measured angular velocities corresponding to time T" and "the current quaternion" (which also corresponds to time T). Stated differently, each of "the predicted axial accelerations", "the measured angular velocities" and "the current quaternion" recited in claim 1 are manifest in the same cycle - that is, each corresponds to time T. These relationships are not disclosed or suggested in Bachmann and the other references (either individually or in combination) are inadequate for remedying these deficiencies.

(*Id.*, 361.)

C. BASSOMPIERE

The '687 patent and Bassompierre have similar teachings. Both describe a pointing device with sensors for measuring angular velocity and axial acceleration. Both use a sensor fusion algorithm to process the velocity and acceleration measurements to arrive at the best estimate of the device's orientation in three-dimensional space. Like the '687 patent, Bassompierre translates that orientation to a two-dimensional representation on a display. (Ex. 1002, ¶46.)

Bassompierre 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; Ex. 1002, ¶44.) 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.” (Ex. 1006, 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.

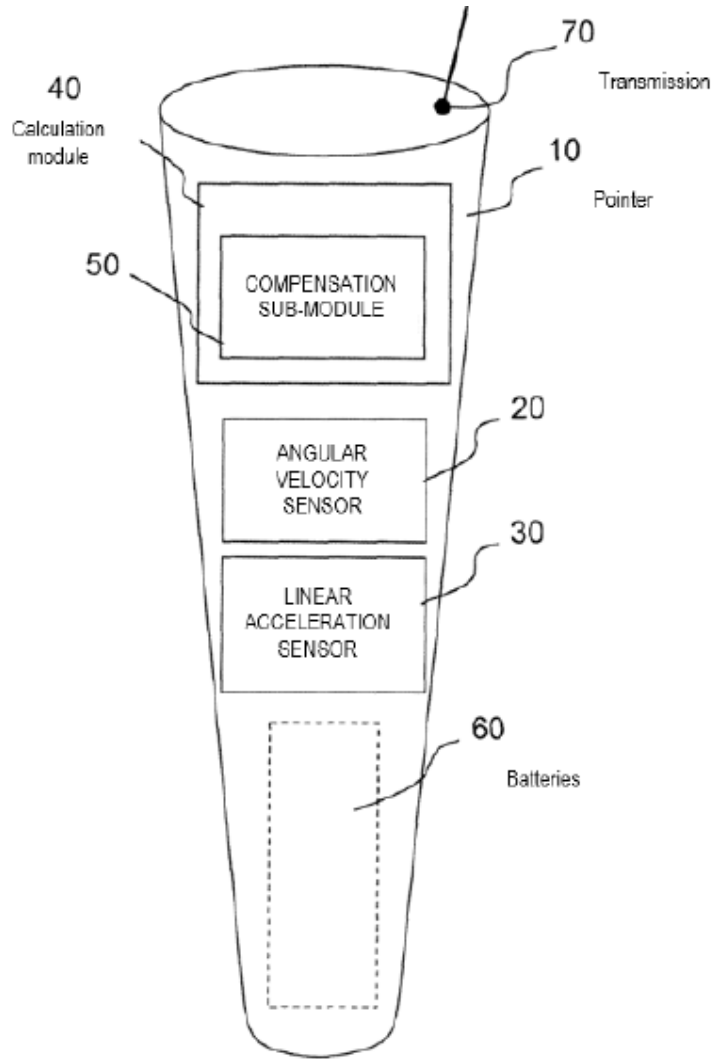


FIG.1

(*Id.*, FIG. 1, 9:24–26, 10:14–17; Ex. 1002, ¶44.) The pointer in use with a display is also illustrated in Figure 2, reproduced below.

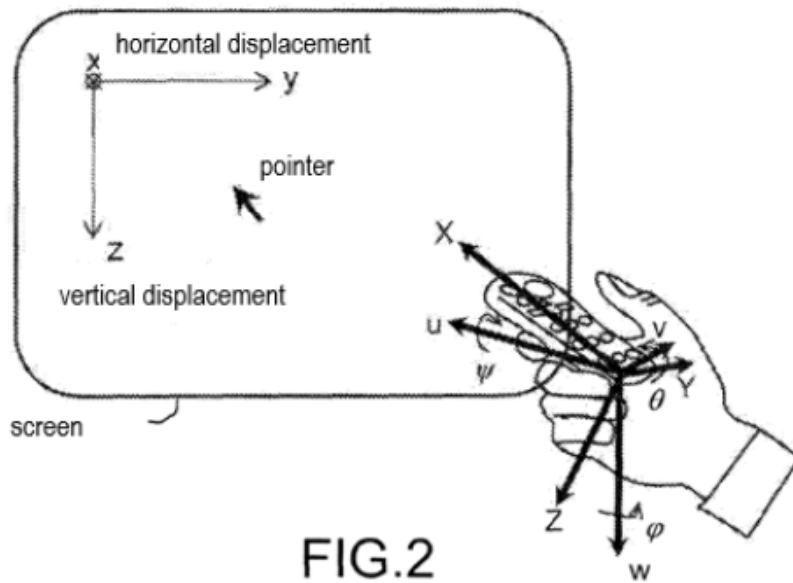


FIG.2

(*Id.*, FIG. 2.)

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 Bassompierre 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, Bassompierre defines the angles θ and ψ as a state vector. (Ex. 1006, 17:5–6 (“the state vector chosen to solve the problem is: $x=[\theta \ \psi]$. 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* 5:4–6, 29:2–5 (claim 10); Ex. 1002, ¶48.) In this equation, $\hat{x}_k^-$ is an “a priori estimate of the state vector” (Ex. 1006, 19:1–3, *see also id.*, 4:24–25, 28:11 (claim 7)) at present time k . As seen in equation 21 below, Bassompierre 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 $(\omega_x \cdot \omega_y^{\square}, \omega_z^{\square})$, 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, ¶49.)

Next, Bassompierre 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 $\begin{pmatrix} \hat{\theta}_k^- \\ \hat{\psi}_k^- \end{pmatrix}$.

$$\hat{y}_k^- = \begin{cases} -\sin \hat{\theta}_k^- \\ \cos \hat{\theta}_k^- \cdot \sin \hat{\psi}_k^- \\ \cos \hat{\theta}_k^- \cdot \cos \hat{\psi}_k^- \end{cases}$$

(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, Bassompierre discloses a first variation of this embodiment in which the state vector (x) is a “quaternion.” (Ex. 1006, 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.) Bassompierre 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.)⁵

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:

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

(Ex. 1002, ¶52.) The above equation shows that the EKF of Bassompierre 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 $(\omega_x, \omega_y^{\square}, \omega_z^{\square})$ and the difference

⁵ Bassompierre also provides the well-known equations for converting between quaternions and Euler angles. (Ex. 1006, 20:13–17; 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

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

With respect to the language of the '687 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 '687 patent variously as the “**updated state**” or “**third quaternion**” or “**updated quaternion**”) as follows.

$$\hat{x}_k = \begin{pmatrix} \Theta_{k-1} \\ \Psi_{k-1} \end{pmatrix} + T_e \left(\alpha \sqrt{\omega_y^2 + \omega_z^2} \right) + K_k \left(\begin{bmatrix} \alpha_{x,k} \\ \alpha_{y,k} \\ \alpha_{z,k} \end{bmatrix} - \begin{vmatrix} -\sin \theta_k^- \\ \cos \theta_k^- \cdot \sin \Psi_k^- \\ \cos \theta_k^- \cdot \cos \Psi_k^- \end{vmatrix} \right)$$

current quaternion (time T) (Ψ_k^-, θ_k^-)
updated quaternion (T) previous quaternion (T-1) measured angular velocities (time T) measured acceleration (time T) predicted acceleration (time T)

(Ex. 1002, ¶53.)

Step 2 of Bassompierre'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; Ex. 1002, ¶54.)

Bassompierre 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:

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

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

(Ex. 1001, 19:10–11; *see also id.*, 5:7–9, 29:6–9 (claim 11).)

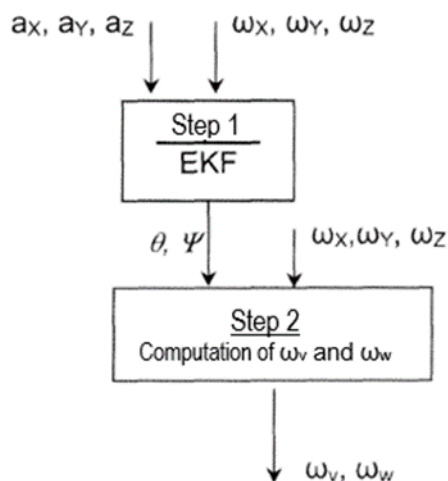


FIG.6

(*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.)

Bassompierre is analogous art to the ’687 patent. The ’687 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, 5:36-6:3, FIGS. 1, 2; Ex. 1002, ¶46.) As described above, Bassompierre too discloses 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.* at 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).⁶

⁶ 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, 7, and 14 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 the U.S. Patent Application No. 13/072,794 (“the ’794 Application”) whereas the ’687 patent is a “continuation” of the ’794 Application. The relevant disclosures of the ’978 and ’687 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.

Here, claims 1, 7, and 14 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.” (Ex. 1002, ¶40.) The Board and Petitioner’s construction is the correct construction in view of the specification.

The '687 patent explains that the “spatial reference frame” refers to a 3-axis reference frame of a 3D pointing device. (*See, e.g.*, Ex. 1001, 9:16-28, 9:60-10:9, FIGS. 1-4; Ex. 1002, ¶41.) “The spatial reference frame is analogous to the reference frame $X_P Y_P Z_P$ also shown in FIG. 1 and FIG. 2.” (Ex. 1001, 9:16-28.) 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.*, 1:54–57.)

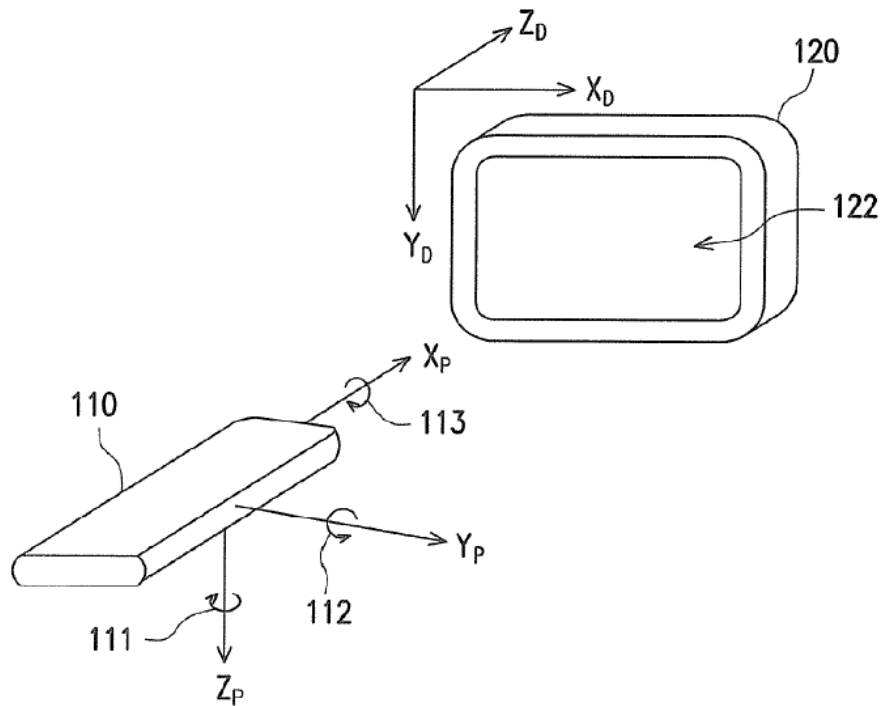


FIG. 1 (RELATED ART)

(*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 are unpatentable.

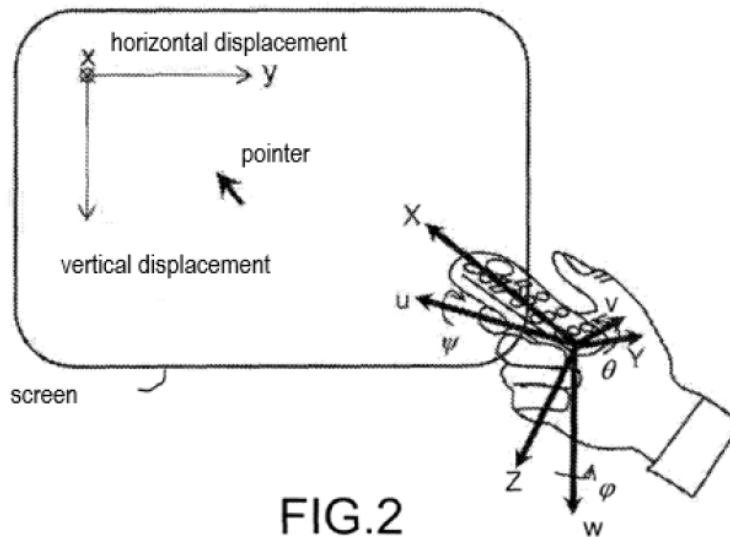
A. Ground 1: Bassompierre Renders Obvious Claims 1-7, 12, 14 and 25

1. Claim 1:

- i) [1.pre] “1. An electronic device subject to movements and rotations in a spatial reference frame, comprising:”**

To the extent the preamble of claim 1 is limiting, Bassompierre discloses the limitations therein. (Ex. 1002, ¶44, App. [1.pre].) Bassompierre discloses “a [pointer] 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.) The pointer is an “**electronic device**.”⁷



(*Id.*, FIG. 2.)

The pointer is subject to “**movements and the rotations 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 ($\omega_x \cdot \omega_y$) in the frame of reference (XYZ) of the pointing device**.”) (emphasis added). Bassompierre further describes the accelerometer 30:

⁷ Claim language is bolded and underlined in the analysis of the prior art.

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 Bassompierre, the reference frame XYZ of the pointing device has a fixed point of origin where the X, Y, and Z axes meet. 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, Bassompierre states that the accelerometer and gyroscopes respectively return “measurements noted (a_X, a_Y, a_Z) and ($\omega_x \cdot \omega_y$) in the frame of reference (XYZ) of the pointing device.” (Ex. 1006, 12:14–15.) The “**movements and the rotations**” of the electronic device are therefore “**in a spatial reference frame.**” (Ex. 1002, ¶45.)

- ii) [1.a] “a motion sensor module having sensor circuitry configured to generate measured angular velocities and measured axial accelerations; and”⁸

Bassompierre discloses this limitation. (Ex. 1002, ¶¶44-45, App. [1.a].)

Bassompierre 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.)

⁸ The term “motion sensor module” does not invoke 35 U.S.C. § 112(f) because the claim itself recites sufficient structure (e.g., sensor circuitry). 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, 10:34-37.)

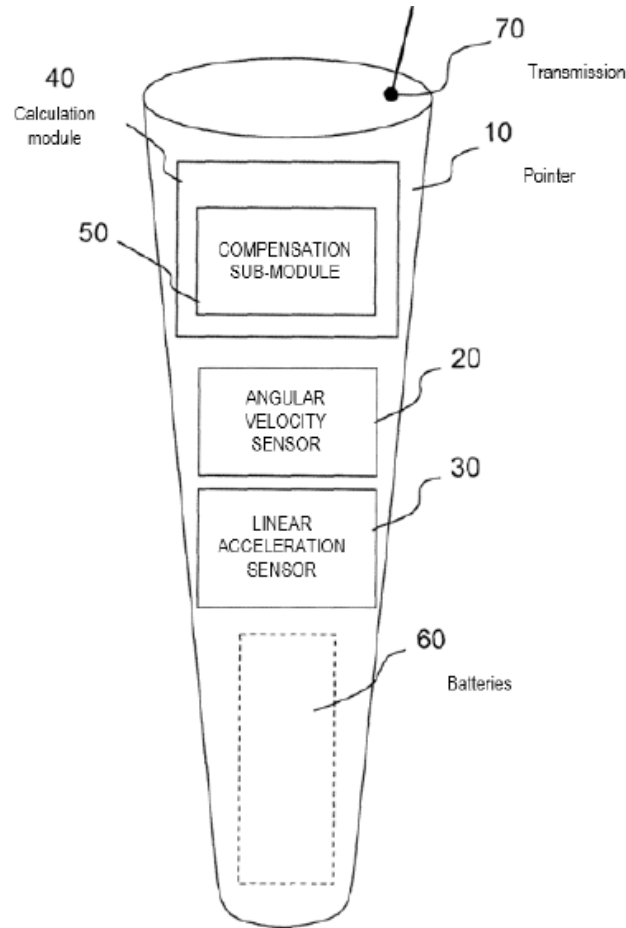


FIG. 1

(*Id.*, FIG. 1.)

Bassompierre 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.)

- iii) [1.b] “a computing processor having processor circuitry configured to calculate a resulting deviation associated with the movements and the rotations of the electronic device in the spatial reference frame by performing the following in sequence:”

Bassompierre discloses this limitation. (Ex. 1002, ¶¶47-54, App. [1.b].) 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” (*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 , which are calculated by the “**computing processor**,” are “**resulting deviation 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.)

As will be described, the process of Bassompierre that maps to elements [1.c] through [1.g] are performed “**in sequence**”. (*See infra* Section IX.A.1.iv-vii.)

- iv) [1.c] “**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, without using the measured angular velocities corresponding to time T;**”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶49, 52, 53, App. [1.c].) Claim elements [1.c] through [1.g] describe the calculations performed for one loop, i.e., the present loop at time T, of the EKF algorithm described in the ’687 patent. (*See infra* Section IX.A.1.iv-viii.) 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, ¶¶49, 52, 53, App. [1.c].) Claim element [1.c] 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.*)

To estimate the pitch angle θ and roll angle ψ by an EKF, Bassompierre defines the angles θ and ψ as a state vector. (Ex. 1006, 17:5–6 (“the state vector chosen to

solve the problem is: $x=[\theta \ \psi]$. Where θ and ψ are respectively the pitch and roll angles.”); *see also id.*, 28:3–5.) In particular, Bassompierre discloses using the state vector $\hat{x}_{k-1}^-$ from the previous iteration $k-1$ ⁹ (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.)

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

(*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, App. [1.c].) But Bassompierre 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

⁹ Bassompierre 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. [1.c], fn. 5.)

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 were well-known. (*See* Ex. 1007, p. 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, ¶¶55-56.) 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. (*See, e.g.*, Ex. 1007, p. 1-3; Ex. 1002, ¶¶24, 55-57, 65-66.) Also, 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, p. 44.) The PTAB consequently found that “knowledge of quaternion mathematics [was] within the level of ordinary skill.” (*Id.*, pp. 44–45.)

Bassompierre, in fact, uses a quaternion formulation to obtain a current quaternion based on a previous quaternion and the current angular velocities. (Ex. 1002, ¶¶66-71.) Specifically, Bassompierre discloses utilizing a previous quaternion (q_0, 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, ¶68.) This is explained further below with reference to claim element [1.d]. (*See infra* Section IX.A.1.v.)

The previous quaternion of Bassompierre is provided “**without using the measured angular velocities corresponding to time T.**” Though angular velocities corresponding to time T (ω_x, ω_y and ω_z) are later used to secure the current quaternion (*id.*), the previous quaternion is provided from the prior loop (T-1)

without any reference to the current angular velocity readings. Because each loop of the EKF uses measured acceleration at time T (*see infra* Section IX.A.1.viii) and measured angular velocities at time T (*see infra* Section IX.A.1.v), the previous quaternion is “**based on the measured axial accelerations corresponding to time T-1 and the measured angular velocities corresponding to time T-1**”.

- v) [1.d] “converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶49, 52, 53, 65-71 App. [1.d].) 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 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.iv. 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 Bassompierre 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**”).¹⁰ The “**previous quaternion**” is represented by the vector $q = (q_0, q_1, q_2, q_3)$. The solution to the differential equation is “**converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T.**” The solution

¹⁰ Bassompierre also teaches the conversion of the gyroscope readings taken in only two directions (i.e., without ω_x). (*Id.*, 20:21–21:1.)

thus yields the “**current quaternion.**” (Ex. 1002, ¶¶66-71.) Equation 1 of the challenged ’687 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, 16:57-63; Ex. 1002, ¶¶65-71.)

- vi) [1.e] “**converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;**”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶50, 52, 53, , 72-75, App. [1.e].) Bassompierre determines an “*a priori* estimation of the [acceleration] measurement” (“**predicted axial accelerations corresponding to time T**”) based on the *a priori* estimation of the state vector (“**variables of the current quaternion**”). (Ex. 1006, 19:4–5; *see also id.*, 28:15–17.) This *a priori* estimation of the [acceleration] measurement is determined in time step k and calculated as follows using the pitch and roll angles of the current quaternion ($\hat{\theta}_k^-$, $\hat{\psi}_k^-$) (“**associated with the pitch and roll angles of the electronic device**”):

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

(*Id.*, 19:4–5 (equation 22); *see also id.*, 4:27–5:1, 28:15–17 (claim 8).) In the above equation, the $(\hat{\theta}_k^-, \hat{\psi}_k^-)$ variables of $\hat{x}_k^-$ (“**variables of the current quaternion**”), which as explained above were determined using measured angular velocities corresponding to time T based on the previous quaternion, are used to determine the **predicted axial accelerations** $\hat{y}_k^-$. This process uses pitch and roll angles only, but does not use yaw angles (“**without being associated with the yaw angle of the electronic device**”).

Further, as noted above, Bassompierre 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 the $\hat{x}_k^-$ in quaternion form (“**variables of the current quaternion corresponding to time T**”) as described by Bassompierre:

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 Bassompierre 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 '687 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 Bassompierre 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, p.3 (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 '687 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, 17:30-34 (equations 2-4); Ex. 1002, ¶¶72-74.) 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. (Ex. 1002, ¶¶72-75.) In the above formula, q_0 , q_1 , q_2 , and q_3 correspond to the quaternion equivalent of $\hat{x}_k^-$. (*Id.*, ¶¶72-73, App. [1.e].)

- vii) [1.f] “comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶51-53, 76, 77, 79, App. [1.f].) Bassompierre 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).) Bassompierre 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 Bassompierre, 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 Bassompierre. (*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 ’867 patent describes as “utilizing signals generated by motion sensors while reducing or eliminating noises associated with said motion sensors.” (Ex. 1001, 2:43-49.)

Petitioner notes that Patent Owner has admitted that the EKF equations, like that disclosed in Bassompierre (*e.g.*, Ex. 1006, 16:10–17:4) and those discussed in the ’687 patent (Ex. 1001, 17:61–18:38, 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, ¶37, App. [1.f].)

While Bassompierre’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]).

viii) [1.g] “obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶51-53, 76-79, App. [1.g].) 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.)

Bassompierre 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 ’687 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 ’687 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, ¶37.)

As Dr. Sarrafzadeh explains, following Bassompierre’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:

$$\hat{q}_k = \hat{q}_k^- \otimes (K_k(z_k - h(\hat{q}_k^-)))$$

where $\hat{q}_k$ is the updated quaternion, $\hat{q}_k^-$ is the current quaternion, and $z_k - h(\hat{q}_k^-)$ represents the difference or comparison between measured acceleration $z_k(\begin{bmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{bmatrix})$

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 Bassompierre, except that it utilizes quaternions instead of Euler angles in the manner known by a person of ordinary skill in the art, just as Bassompierre recommends. (*Id.*, ¶¶76-79.)

Any person of skill in the art would appreciate and understand that for the dimensions of $\hat{q}_k^-$ and $z_k - h(\hat{q}_k^-)$ to match, the Kalman gain 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, Bassompierre provides that the Kalman gain is multidimensional. (Ex. 1006, 16:13–15 (equations 5–10 (referring to the Kalman gain as “G”).) Consequently, $K_k(z_k - h(\hat{q}_k^-))$ 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, ¶¶78-79.) The quaternion multiplication $\otimes$ of that error and the current quaternion $\hat{q}_k^-$ results in the updated quaternion $\hat{q}_k$. (*Id.*, ¶79.)

ix) [1.h] “using the updated quaternion as a next occurrence of the previous quaternion; and”

$\hat{x}_k$ (“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:

$\dot{q} = \frac{1}{2} \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{bmatrix} \otimes \begin{bmatrix} 0 \\ \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}$ (Ex. 1006, 20:21 (equation 26) (emphasis added).)	$\hat{x}_k^- = \begin{pmatrix} \hat{\theta}_k^- \\ \hat{\psi}_k^- \end{pmatrix} = \begin{pmatrix} \hat{\theta}_{k-1} \\ \hat{\psi}_{k-1} \end{pmatrix} + T_e \begin{pmatrix} \alpha \sqrt{\omega_y^2 + \omega_z^2} \\ \omega_x \end{pmatrix}$ (<i>Id.</i>, 19:3 (equation 21) (emphasis added).)
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(Ex. 1002, App. [1.h].)

x) [1.i] “providing the resulting deviation based on the updated quaternion;”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶54, 80-85, App. [1.i].) Bassompierre 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 ω_v , ω_w , 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:

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

(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 Bassompierre 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 $(\theta \ \psi)$ and the output of the step 2 process is ω_v and ω_w calculated using Equation 24 above (using Euler angles).

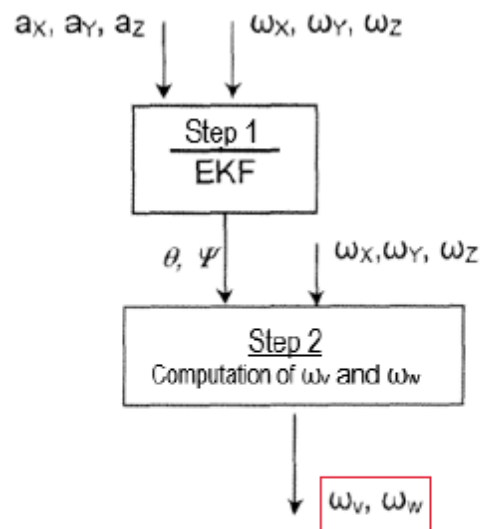


FIG.6

(*Id.*, 19:11; Ex. 1002, ¶54.)

Thus, a POSA would understand that if the output of Bassompierre’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.¹¹ 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

¹¹ 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.)

embodiment, the state vector chosen to solve the problem is: $\mathbf{x}=[\theta \ \psi]$. **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, ¶¶53-54.)

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 Bassompierre 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 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.*)

xi) [1.j] “wherein the processor circuitry is further configured to provide content based on the resulting deviation in the spatial reference frame.”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶28-30, 44, App. [1.j].) The “**processor circuitry**” of Bassompierre (*see supra* Section IX.A.1.iii) is configured to translate the pitch and roll angles (θ ψ) (“**resultant 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). (*Id.*) 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)” (“**provide content**

based on the resulting deviation in the spatial 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:

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

(*Id.*, 19:10–11 (equation 24).)

As discussed at *supra* Section IX.A.1.x, a POSA would have understood that if the output of Bassompierre’s equation 23 is a quaternion representing the pitch and roll angles (*see supra*, analysis for [1.g]) such a quaternion would then be translated into pitch and roll angles in Euler angle format for purposes of equation 24 to allow for “**provid[ing] content**” on the screen “**based on the resulting deviation.**” Also, for the reasons discussed *supra* Section IX.A.1.x, 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**”. (Ex. 1011, p. 49.)

2. Claim 2:

- i) [2.a] “The electronic device of claim 1, wherein: the motion sensor module further comprises a rotation sensor and an accelerometer;”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶44-46, App. [2.a].) Bassompierre discloses that the “**motion sensor module**” of the pointer (*see supra* Section IX.A.1.ii) 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.)

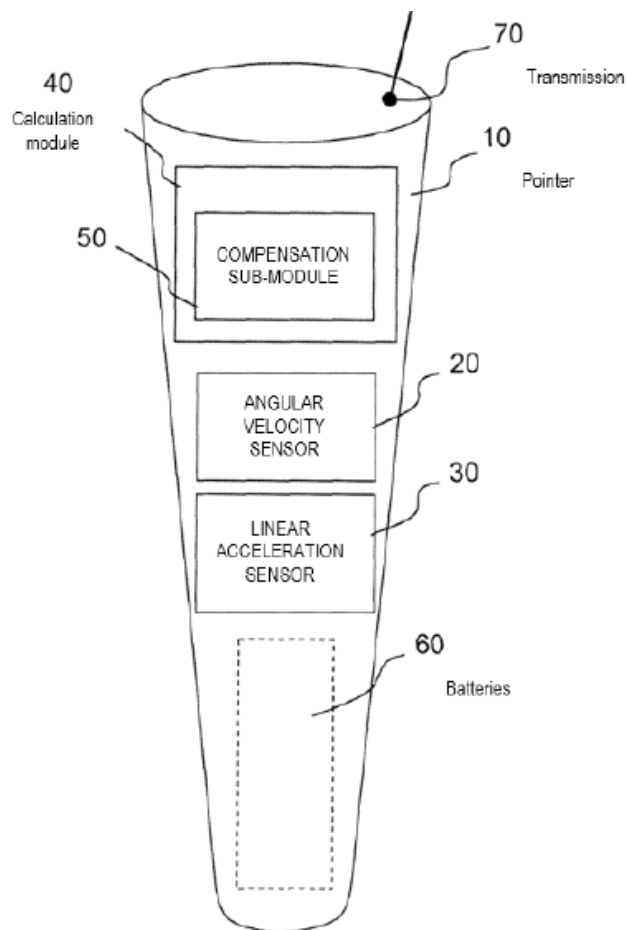


FIG.1

(*Id.*, FIG. 1.)

- ii) [2.b] “the rotation sensor has sensor circuitry configured to generate the measured angular velocities;”

Bassompierre discloses this limitation. (Ex. 1002, ¶44-45, App. [2.b].)

Bassompierre explains that the angular velocity sensor 20 (also referred to as a “gyrometer”) (*id.*, 9:25–29) (“rotation sensor”) 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 (emphases added).)

- iii) [2.c] “the accelerometer has circuitry configured to generate the measured axial accelerations; and”

Bassompierre discloses this limitation. (Ex. 1002, ¶45, App. [2.c].) 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.”)
(emphasis added).)

- iv) [2.d] **“both the rotation sensor and the accelerometer are associated with the movements and the rotations of the electronic device in a spatial reference frame.”**

Bassompierre discloses this limitation. (Ex. 1002, ¶¶44-46, App. [2.d].)
Bassompierre’s gyroscope (“**rotation sensor**”) 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).)

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 ($\omega_x \cdot \omega_y$) in the frame of reference (XYZ) of the pointing device.**”) (emphasis added). Bassompierre 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 Bassompierre, 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, Bassompierre states that the accelerometer and gyroscopes respectively return “measurements noted (a_X, a_Y, a_Z) and $(\omega_x . \omega_y^{\square})$ 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.**”

3. **Claim 3: “The electronic device of claim 1, wherein the converting the measured angular velocities corresponding to time T based on the previous quaternion is performed without using the measured axial accelerations corresponding to time T.”**

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶49, 52, 53, 65-71, App. [3].) As described in Section IX.A.1.v above for claim element 1.[d], Bassompierre performs the step of “converting the measured angular velocities corresponding to time T based on the previous quaternion.” As evident from the equations 21 and 26 of Bassompierre for converting the angular velocities based on the previous quaternion, 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**”). (See Ex. 1006, 19:3 (equation 21); see also *id.*, 4:23-26, 28:13; 20:20-23 (equation 26); see also *id.*, 6:3–7, 30:1-5.)

4. **Claim 4: “The electronic device of claim 1, wherein 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.”**

Bassompierre discloses or suggests this limitation. (Ex. 1002, App. [4].) Bassompierre 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* Sections IX.A.1.v and 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, ¶¶65-66; *see also supra* Section IX.A.1.iv (“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 roll angles at time T-1, is calculated “**based on the measured axial accelerations corresponding to time T-1.**” (*See supra* Section IX.A.1.viii (explaining that equation 23 provides the output pitch and roll angles based on the measured accelerations during that loop).)

5. Claim 5: “The electronic device of claim 1, wherein 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.”

Bassompierre discloses or suggests this limitation. (Ex. 1002, App. [5].)

As described *supra* Section IX.A.1.vii, the “**first comparison result**” is the difference between “**measured axial accelerations corresponding to time T**”

$\begin{pmatrix} a_{x,k} \\ a_{y,k} \\ a_{z,k} \end{pmatrix}$ and predicted axial accelerations $(\hat{y}_k^-)$

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

(Ex. 1006, 19:8–9 (equation 23) (emphasis added).) Bassompierre discloses that the

predicted axial accelerations $\hat{y}_k^-$ 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, ¶¶49, 65-66; *see also supra* Section IX.A.1.iv (“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 roll 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).)

6. Claim 6: “The electronic device of claim 1, wherein the content is visual content.”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶28-30, 44, 46-47, 54, App. [6].) As already described, Bassompierre teaches providing content based on the resulting deviation in the spatial reference frame. (*See supra* Section IX.A.1.ix, claim element [1.j].) Bassompierre further discloses that the content includes “**visual content**” such as “the displacement of the mobile element on the screen (d_y and d_z).” (Ex. 1006, 11:25–12:9, FIG. 2.) Calculating the displacement of the mobile element enables the pointer to be used for “games applications,” and other applications:

remote control of an **audiovisual apparatus** (television, reader/recorder of disks, hi-fi system), where the point is a program or a function to be chosen from a menu; . . . **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.); assistance for the man-machine interface or remote control for people with reduced mobility (for example, fixing a pointer to the head, spectacles, an earpiece, or any other part tied to the displacements of the head, so as to aid persons with motion deficiency or who are unable to use a conventional hand-held mouse to **direct a pointer at the screen**). . . . 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.

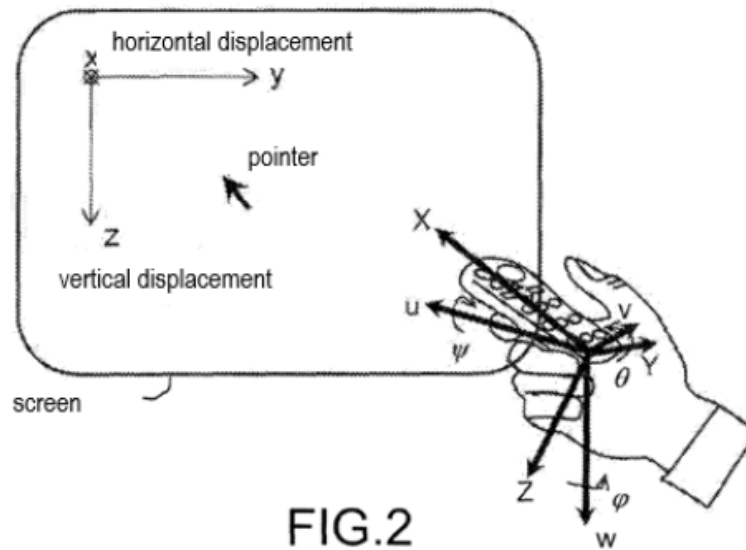
(Ex. 1006, 1:7-18, 9:1-4 (emphases added); *see also id.*, FIG. 2.)

7. **Claim 7: “The electronic device of claim 6, wherein the processor circuitry is further configured to translate the resulting deviation in the spatial reference frame into a real-time movement pattern in a display reference frame.”**

Bassompierre discloses or suggest this limitation. (Ex. 1002, 28-30, 44, 46, 54, App. [7].) As discussed above, “**processor circuitry**” of Bassompierre (*see supra* Section IX.A.1.iii) is configured to translate the pitch and roll angles (θ ψ) (“**resultant deviation in the spatial reference frame**”) into a movement pattern on

a display, which has its own reference frame (“**display reference frame**”). (*Supra* Section IX.A.1.xi.) For example, the pointer of Bassompierre includes a processor that provides for “transmitted signals [that] are the commands corresponding . . . to the sensing of the displacement of the pointer.” (Ex. 1006, 9:10-16.) The transmitted commands “control the displacements of a cursor on the control screen of the object to be controlled” (“**real-time movement patterns in a display reference frame**”). (*Id.*) To perform this function, the processor calculates “ ω_v and ω_w ” that indicate “the displacement of the mobile element on the screen (d_y and d_z).” (*Id.*, 11:25–12:9.)

The screen, i.e., the display has its own reference frame. This can be seen from Figure 2 (reproduced below), which shows a screen which the three-dimensional movements of the pointer are displayed in two dimensions (y , z) (“**display reference frame**”) on a screen.



(*Id.*, FIG. 2; *see also id.*, 8:14–16.)

8. Claim 12:

- i) [12.a] “The electronic device of claim 1, wherein, in calculating the resulting deviation, the computing processor is further configured to: 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; and”

Bassompierre discloses or suggests the limitations therein. (Ex. 1002, ¶¶51, 76-79, App. [12.a].) As described in [1.f] above, as part of the process of “calculating resulting deviation” the EKF of Bassompierre includes “a first data association model” in the form of a 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”) 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.)

- ii) [12.b] “obtain the updated quaternion in response to determining that the compensation is needed.”

Bassompierre discloses or suggests this limitation. (Ex. 1002, ¶¶51, 76-79, App. [12.b].) As explained in the analysis of [12.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. [12.b].)

9. Claim 14:

- i) [14.pre] “A method for determining movements and rotations in a spatial reference frame, comprising:”

Bassompierre discloses this limitation for the reasons discussed above with reference to limitations [1.a] and [1.b]. (Ex. 1002, App. [14.pre]; *see also supra* Sections IX.A.1.ii-iii.)

- ii) **[14.a] “generating, with a motion sensor module having sensor circuitry, measured angular velocities and measured axial accelerations;”**

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.a]. (Ex. 1002, App. [14.a]; *see also supra* Section IX.A.1.ii.)

- iii) **[14.b] “calculating, with a computing processor having processor circuitry, a resulting deviation associated with the movements and the rotations in the spatial reference frame by performing the following in sequence:”**

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.b]. (Ex. 1002, App. [14.b]; *see also supra* Section IX.A.1.iii.)

- iv) **[14.c] “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, without using the measured angular velocities corresponding to time T;”**

Bassompierre discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.c]. (Ex. 1002, App. [14.c]; *see also supra* Section IX.A.1.iv.)

- v) **[14.d] “converting measured angular velocities corresponding to time T, based on the previous quaternion, into a current quaternion corresponding to time T, without using measured axial accelerations corresponding to time T;”**

Bassompierre discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.d]. (Ex. 1002, App. [14.d]; *see also supra* Section IX.A.1.v.)

- vi) **[14.e] “converting variables of the current quaternion into predicted axial accelerations corresponding to time T, which is associated with the pitch and roll angles of the electronic device and without being associated with the yaw angle of the electronic device;”**

Bassompierre discloses or suggests this limitation for the reasons discussed above with reference to limitation [1.e]. (Ex. 1002, App. [14.e]; *see also supra* Section IX.A.1.vi.)

- vii) **[14.f] “comparing the predicted axial accelerations with the measured axial accelerations corresponding to time T to obtain a first comparison result;”**

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.f]. (Ex. 1002, App. [14.f]; *see also supra* Section IX.A.1.vii.)

- viii) **[14.g] “obtaining an updated quaternion associated with time T based on the current quaternion and the first comparison result;”**

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.g]. (Ex. 1002, App. [14.g]; *see also supra* Section IX.A.1.viii.)

ix) [14.h] “using the updated quaternion as a next occurrence of the previous quaternion; and”

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.h], explaining the looping nature of Bassompierre’s EKF. (Ex. 1002, App. [14.h]; *see also supra* Section IX.A.1.ix.)

x) [14.i] “providing the resulting deviation based on the updated quaternion; and”

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.i]. (Ex. 1002, App. [14.i]; *see also supra* Section IX.A.1.x.)

xi) [14.j] “providing content based on the resulting deviation in the spatial reference frame.”

Bassompierre discloses this limitation for the reasons discussed above with reference to limitation [1.j]. (Ex. 1002, App. [14.j]; *see also supra* Section IX.A.1.xi.)

10. Claim 25:

i) [25.a] “The method of claim 14, wherein calculating the resulting deviation further comprises: 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”

Bassompierre discloses or suggests this limitation for the reasons discussed above with reference to limitation [12.a]. (Ex. 1002, App. [25.a]; *see also supra* Section IX.A.8.i.)

ii) [25.b] “obtaining the updated quaternion in response to determining that the compensation is needed.”

Bassompierre discloses or suggest this limitation for the reasons discussed above with reference to limitation [12.b]. (Ex. 1002, App. [25.b]; *see also supra* Section IX.A.8.ii.)

X. THE '687 PATENT IS NOT ENTITLED TO THE FILING DATE OF THE PROVISIONAL '558 APPLICATION

The '687 patent is not entitled to the January 6, 2010, filing date of the provisional '558 application.^{12 13} The provisional '558 application does not provide written description support under 35 U.S.C. § 112 for several claim elements of the '687 patent. (Ex. 1002, ¶86.) 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, ¶87.)

¹² In the co-pending litigation, Patent Owner confirmed that the '687 patent is entitled to a filing date of no earlier than November 11, 2010. (Ex. 1017 at 4.)

¹³ Petitioner is presenting this analysis in case Patent Owner tries to swear behind Bassompierre.

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 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 B_x and θ_y may be calculated by θ_x and θ_y 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, ¶87.)

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:

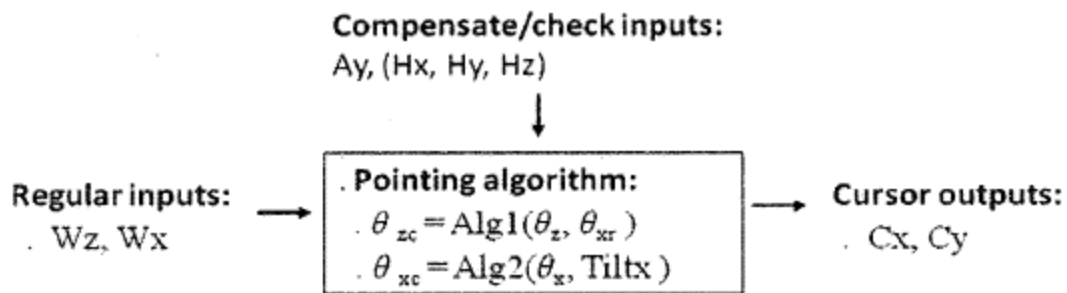


FIG. 5A

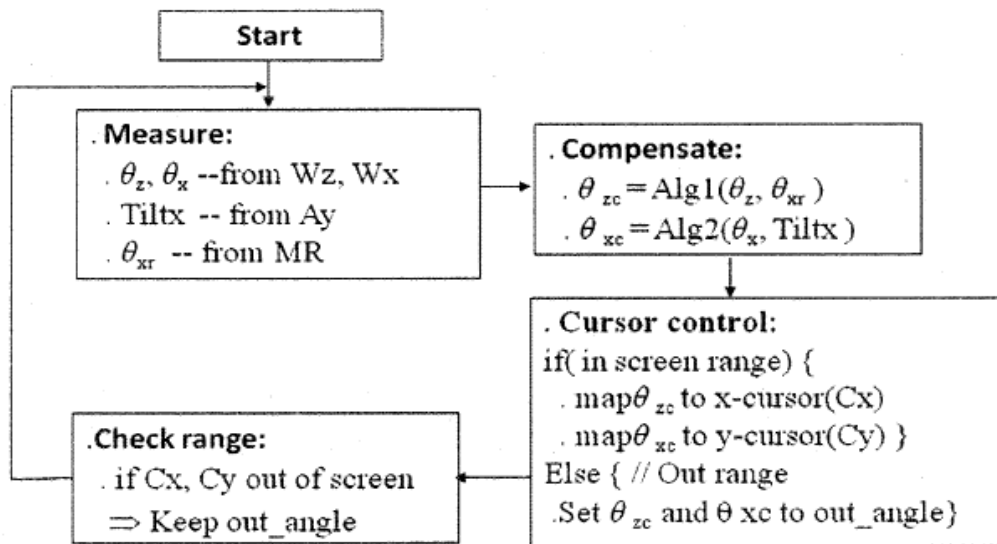


FIG. 5B

(Ex. 1014, FIGS. 5A, 5B; *see also id.*, ¶0040; Ex. 1002, ¶88.)

Therefore, the provisional '558 application lacks written description for at least claim elements [1.c], [1.d], [1.e], [1.g]. [3]. [12.a], [12.b], [14.c], [14.d], [14.e], [14.h], [14.i], [25.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 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, ¶89.) Therefore, the provisional '558 application lacks written description for at least the “comparing” recitation of claim elements [1.f], [5], and [14.f], [14.g].

XI. CONCLUSION

Petitioner requests institution of IPR for claims 1-7, 12, 14 and 25 of the '687 patent based on the grounds specified in this petition.

Respectfully submitted,

Dated: May 30, 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. 11,698,687 contains, as measured by the word-processing system used to prepare this paper, 12,468 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 30, 2025

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

CERTIFICATE OF SERVICE

I hereby certify that on May 30, 2025, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 11,698,687 and supporting exhibits to be served via express mail on the Patent Owner at the following correspondence address of record as listed on PAIR:

109673 - McClure, Qualey & Rodack, LLP
280 Interstate North Circle SE, Suite 530
Atlanta, GA 30339

Respectfully submitted,

Dated: May 30, 2025

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