UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZEPP HEALTH CORPORATION

Petitioner

v.

WORCESTER POLYTECHNIC INSTITUTE;
THE RESEARCH FOUNDATION
FOR THE STATE UNIVERSITY OF NEW YORK

Patent Owners

Case No. IPR2025-00522
U.S. Patent No. 9,713,428

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,713,428

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<u>Exhibit List</u>[1]

Exhibit No.	Description
Ex-1001	U.S. Patent No. 9,713,428
Ex-1002	Declaration of Dr. George E. Yanulis ("Yanulis Decl.")
Ex-1003	Curriculum Vitae of George E. Yanulis
Ex-1004	File History of U.S. Patent No. 9,713,428
Ex-1005	Asada, H. Harry, Phillip Shaltis, Andrew Reisner, Sokwoo Rhee, and Reginald C. Hutchinson. "Mobile Monitoring with Wearable Photoplethysmographic Biosensors." *IEEE Engineering in Medicine and Biology Magazine*, vol. 22, no. 3 (July 1, 2003): 28-40. ("Asada")
Ex-1006	International Patent Application Publication No. WO 2009/018570, filed on August 4, 2008 and published on February 5, 2009 ("Chon-570")
Ex-1007	Delorme, Arnaud, Scott Makeig, and Terrence Sejnowski. "Automatic Artifact Rejection for EEG Data Using High-Order Statistics and Independent Component Analysis." *Proceedings of the 3rd International Independent Component Analysis and Blind Source Decomposition Conference* (pp. 9-12). San Diego, CA: Institute for Neural Computation, University of California (April 4, 2003) ("Delorme")
Ex-1008	Chon, Ki H., Yuru Zhong, Leon C. Moore, Niels H. Holstein-Rathlou, and William A. Cupples. "Analysis of Nonstationarity in Renal Autoregulation Mechanisms Using Time-Varying Transfer and Coherence Functions." *American Journal of Physiology. Regulatory, Integrative and Comparative Physiology,* vol. 295, issue 3 (May 21, 2008): R821–R828. ("Chon-2008")
Ex-1009	Chon, Ki H., Shishir Dash, and Kihwan Ju. "Estimation of Respiratory Rate from Photoplethysmogram Data Using Time–Frequency Spectral Estimation." *IEEE Transactions on Biomedical Engineering*, vol. 56, no. 8 (July 28, 2009): 2054-2063. ("Chon-2009")
Ex-1010	Greco, Antonino, Nadia Mammone, Francesco Carlo Morabito, and Mario Versaci. "Kurtosis, Renyi's Entropy and Independent

[1] In this Petition, 4-digit pin citations that begin with "0" refer to the branded numbers added by Petitioner in the bottom right corner of the exhibits. All other pin citations in this Petition refer to original page, column, paragraph, or line numbers.

	Component Scalp Maps for the Automatic Artifact Rejection from EEG data. *International Journal of Signal Processing*, vol. 2, no. 4 (January 31, 2006): 240-244. ("Greco")
Ex-1011	U.S. Patent Application Publication No. 2007/0100246, filed on October 31, 2006 and published on May 3, 2007 ("Hyde")
Ex-1012	U.S. Patent No. 4,510,944 was filed on December 30, 1982 and published on April 16, 1985 ("Porges")
Ex-1013	Zhao, He, Sheng Lu, Rui Zou, Kihwan Ju, and Ki H. Chon. "Estimation of Time-Varying Coherence Function Using Time-Varying Transfer Functions." *Annals of Biomedical Engineering*, vol. 33, no. 11 (November 30, 2005): 1582–1594. ("Zhao")
Ex-1014	Declaration of Dr. Sylvia Hall-Ellis ("Hall-Ellis Decl.")
Ex-1015	Judge Robert W. Schroeder, III (E.D. Tex.) – Calendar Events Set for 2/17/2026
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Ex-1017	Docket entries in *Research Foundation for The State University of* *New York v. Xiaomi Corporation et al.*, No. 2:23-cv-00353-RWSRSP (E.D. Tex.)
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I. INTRODUCTION

Zepp Health Corporation ("Petitioner") requests *inter partes* review ("IPR") of Claims 1-11, 15-27, 29-30, 32-37, 39-40, 42-46 of the U.S. Patent No. 9,713,428 ("the '428 Patent" or "Patent") (Ex-1001).

The challenged claims of the '428 Patent would have been obvious to a person of ordinary skill in the art ("POSITA") as of their invention date. These claims recite nothing more than an obvious combination of generic computer components, generic patient monitoring sensors, and known statistical techniques. Accordingly, the Board should institute IPR and cancel the challenged claims.

II. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8

A. Real Parties-in-Interest

The sole real party-in-interest is Petitioner Zepp Health Corporation.

B. Related Matters

- *Research Foundation for The State University of New York, University of Connecticut, and Worcester Polytechnic Institute v. Xiaomi Corporation, Xiaomi Communications Co., Ltd., Xiaomi H.K., Ltd., Xiaomi, Inc., and Zepp Health Corporation*, No. 2:23-cv-00353-RWS-RSP (E.D. Tex.) (the "Related Litigation").
- *Research Foundation for The State University of New York, University of Connecticut, and Worcester Polytechnic Institute v. Samsung Electronics Co., Ltd., Samsung Electronics America, Inc., Samsung Austin Semiconductor, LLC, and Samsung Semiconductor, Inc.*, No. 2:23-cv-00141-RWS-RSP (E.D. Tex.).
- *Research Foundation for The State University of New York, University of Connecticut, and Worcester Polytechnic Institute v. Huawei Device Co., Ltd.*, No. 2:23-cv-00553-RWS-RSP (E.D. Tex.).

C. Lead and Back-Up Counsel, and Service Information

Pursuant to 37 C.F.R. §§ 42.8(b)(3)-(4), Petitioner identifies its counsel as follows. Petitioner consents to electronic service at the counsel's email addresses below.

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Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney from Petitioner is attached.

D. Fee Authorization

The Office is authorized to charge all fees due for this proceeding to Deposit

Account No. 502075.

III. GROUNDS FOR STANDING

Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '428 Patent is available for *inter partes* review, and that Petitioner is not barred or estopped from requesting an *inter partes* review of the challenged claims on the grounds identified in the petition.

IV. IDENTIFICATION OF CHALLENGES (37 C.F.R. § 42.104(B))

Petitioner seeks to invalidate Claims 1-11, 15-27, 29-30, 32-37, 39-40, 42-46 of the '428 Patent under the following grounds, as supported by the Declaration of George Yanulis (Ex-1002).

Ground	Summary
1	Claims 1, 3-11, 15, 21, 23-27, 29-30, 37, 39-40 are Obvious in view of Asada (Ex-1005) and Chon-570 (Ex-1006)
2	Claims 1-11, 15, 21-27, 29-30, 37, 39-40 are Obvious in view of Asada, Chon-570, and Delorme (Ex-1007)
3	Claims 16-20, 32-36, 42-46 are obvious in view of Asada, Chon-570, and Chon-2008 (Ex-1008)

V. BACKGROUND

A. The '428 Patent (Ex-1001)

The '428 Patent was filed on January 20, 2012. '428 Patent, Cover. On its face, the '428 Patent claims priority to three provisional applications Nos. 61/434,862 (filed on January 21, 2011), 61/512,199 (filed on July 27, 2011), 61/434,856 (filed on January 21, 2011), and 61/566,329 (filed on December 2, 2011). *Id.*

The '428 Patent describes systems and methods for analyzing physiological signals, such as PPG, EKG signals, and apply statistical methods to analyze the signals. '428 Patent, Abstract; Yanulis Decl. (Ex-1002), ¶¶29-30. Accordingly, the '428 Patent can detection motion artifacts or atrial fibrillation (AF) from the statistical analyses. '428 Patent, Abstract, 13:1-24; Yanulis Decl., ¶¶29-30.

The '428 Patent discloses applying standard signal processing techniques, such as bandpass filters or detrending, to preprocess the signals. '428 Patent, 5:32-39, Yanulis Decl., ¶¶29, 44. After the preprocessing, the system applies statistical methods such as Kurtosis and Shannon Entropy on the preprocessed segments. '428 Patent, 5:57-6:22. It then determines whether this segment of the data should be accepted or rejected by comparing the result of the analyses with a threshold. *Id.*, 6:33-46.

The '428 Patent also describes determining atrial fibrillation by comparing a time-varying coherence function (TVCF) with a threshold quantity. *Id.*, 13:3-5, 13:10-20; Yanulis Decl., ¶40. The TVCF is obtained by multiplying two time-varying transfer functions (TVTFs). '428 Patent, 13:25-28. The two TVTFs are obtained using two adjacent data segments with one data segment as input signal and the other data segment as output to produce the first TVTF, and the second TVTF is produced by reversing the input and output signals. *Id.*, 13:5-13.

B. Description of the Claims

Claims 1-11, 15, 21-27, 29-30, 37, 39-40 are about analyzing physiological data using Shannon Entropy and detecting motion artifacts. The plain language of these claims does not state whether they can be performed with or without Independent Component Analysis. This group of claims is sometimes referred to as "Shannon Entropy Claims."

The '428 Patent also has Claims 16-20, 32-36, and 42-46 which are about analyzing physiological data using TVCF function derived from two TVTF functions. These claims explicitly exclude the use of Independent Component Analysis. This group of claims is sometimes referred to as "TVCF Claims."

C. Prosecution History of the '428 Patent

During the prosecution, Examiner rejected the claims under 35 U.S.C. § 101. In an attempt to overcome the Section 101 rejection, Patentee repeatedly argued that "The claimed invention is an improvement in the technology of physiological parameter monitoring in home or ambulatory environment." Ex-1004, 0547, 0551, 0608, 0613.

In addition, in the last office action response prior to allowance, on December 22, 2016, the patentee added the element "the physiological indicator signal being obtained from one of an image acquisition component, a PPG sensor, and an electrocardiogram sensor" to all independent claims. *Id.*, 0702-0716.

The patentee additionally added the element: "

$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number, and p(i) is the probability distribution of the preprocessed segment" to the Shannon Entropy Claims. *Id.*

Separately, the patentee also added the element "wherein analysis does not include independent component analysis" to the TVCF Claims. *Id.*

D. Priority Date

Petitioner does not concede that any claim of the '428 Patent is entitled to the priority date of the one or more of its provisional applications. All references asserted in this Petition are prior art under 35 U.S.C. §§ 102 and 103 (pre-AIA), irrespective of whether the '428 Patent can claim priority to its provisional(s).

E. Person of Ordinary Skill in the Art

A person of ordinary skill in the art ("POSITA") at the time of the purported invention of the '428 Patent would have had a working knowledge of physiological monitoring technologies and/or signal processing as used in physiological monitoring technologies. The POSITA would have had a bachelor's degree in an academic discipline related to electrical, computer, software, optical, or biomedical technologies, in combination with two years of work experience related to the capture and processing of data or information signals, or designing and using biomedical sensors or systems, including but not limited to physiological monitoring technologies. Alternatively, a POSITA would have had a master's degree in one of the above academic disciplines with one year of work experience as described above. Additional education can substitute work experience, and vice versa. Yanulis Decl. (Ex-1002), ¶16. The level of skill for the POSITA would not change if a different priority of the invention date is found. *Id.* ¶17.

F. Claim Construction

Petitioner interprets the claim terms of the '428 Patent according to the Phillips claim construction standard. 37 C.F.R. §42.100(b). Petitioner applies the plain and ordinary meaning to each claim term of the Patent as it would have been understood by a POSITA.

Further, the parties have not yet submitted claim construction contentions in the district court litigation. Petitioner respectfully reserves all rights to raise claim construction and other arguments in the district court litigation.

VI. OVERVIEW OF PRIOR ART

A. Overview of the State of the Art

Detecting motion artifacts or AF are not new problems at the time of '428 Patent. Yanulis Decl., ¶43. The concepts of monitoring patient's physiological parameters at home, or in an ambulatory environment, in real-time, have also been known in the art at the time of the ’428 Patent’s purported invention. *Id.*, ¶44.

At the time of the ’428 Patent, many statistical methods were around to analyze physiological data. For example, statistical methods such as Shannon Entropy which measures probability of data’s “oddness” and Kurtosis which determines unusually peaky values have already existed for many years. *Id.*; Delorme, §2; Greco, Abstract (artifact rejection based on “some high order statistics such as kurtosis and Shannon’s entropy, was proposed some years ago in literature.”). Patentee also admitted that Shannon entropy has been around for a long time. Ex-1004, 0550.

As another example, time-varying coherence function was not a new concept in the art. The examiner, during the prosecution of the ’428 Patent, found that “[t]ime-varying coherence function(s) for analyzing two signals are known in the art.” *Id.*, 0142. The techniques for deriving time-varying coherence function using time-varying transfer functions also have been around for a long time. Yanulis Decl. (Ex-1002), ¶44; Zhao, Abstract.

B. Asada (Ex-1005)

Asada is titled “Mobile Monitoring with Wearable Photoplethysmographic Biosensors.” Asada was publicly available no later than July 1, 2003. Hall-Ellis

Decl. (Ex-1014), §§IV.A & V. Asada is thus prior art to the '428 Patent under pre-AIA 35 U.S.C. §102(b).

Asada describes wearable biosensors (WBS) for real-time monitoring, at home or ambulatory environment, of patient's vital signs such as heart rate, blood pressure, oxygen saturation, respiratory rate, and cardiac output, among others. Asada (Ex-1005), 28-29; Yanulis Decl. (Ex-1002), ¶46. Asada describes using PPG sensors to acquire physiological data, although other types of sensors such as acoustic sensors, optical sensors, etc., are also contemplated. Asada, 28-29; Yanulis Decl., ¶46.

Asada recognizes the problems of motion artifacts and addresses the technical issues of reducing motion artifacts through sensor arrangement, lighting modulation, among other techniques. Asada, 28, 30-32; Yanulis Decl., ¶47. For example, Asada teaches a dual photodetector design (as shown in the figure below), where one of the photodetectors serves as a motion sensor to reduce noise in the signal acquired by the other photodetector. Asada, 33.

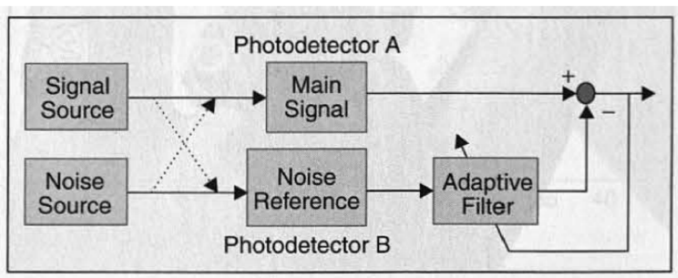


Fig. 8. Block diagram of adaptive noise cancellation using second PPG sensor as noise reference.

(Asada (Ex-1005), Fig. 8)

Asada also teaches using "data processing and decision-making algorithms for the waveform data." Asada, 28. Asada teaches that the WBS system has a PIC microcomputer which performs device controls, data acquisition and signal processing. *See*, *e.g.*, Asada (Ex-1005), 34, 35.

C. Chon-570 (Ex-1006)

Chon-570 is an international patent publication (WO 2009/018570) filed on August 4, 2008 and published on February 5, 2009. Chon-570 is thus prior art to the '428 Patent under Pre-AIA 35 U.S.C. § 102(b).

Chon-570 teaches analyzing ECG data with statistical methods such as Root Mean Square of Successive RR interval differences (RMSSD), a Turning Points Ratio (TPR), Shannon Entropy (SE), and an autocorrelation (ACORR) index. Chon-570, 3:23-29, 4:6-18; Yanulis Decl., ¶51. Chon-570 discloses that Shannon Entropy (SE) is calculated using the following formula.

$$SE = -\sum_{i=1}^{16} p(i)\frac{\log(p(i))}{\log(\frac{1}{16})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Chon-570, 7:20. As described in Chon-570, SE is used to detect outliers in the signal data. Chon-570 (Ex-1006), 6:27-7:20.

Chon-570 also teaches that these statistical techniques are employed to detect atrial fibrillation (AF). Chon-570 at 1:8-10; Yanulis Decl., ¶51.

The results of the calculations from these statistical measures are compared with thresholds to determine their meaning or statistical significance. *See* Chon-

570, 8:5-6, 8:28-9:22, 10:14-17. FIG. 1(d) of Chon-570, reproduced below, describes the threshold for Shannon Entropy, and FIG. 1(f) describes the threshold for detecting AF.

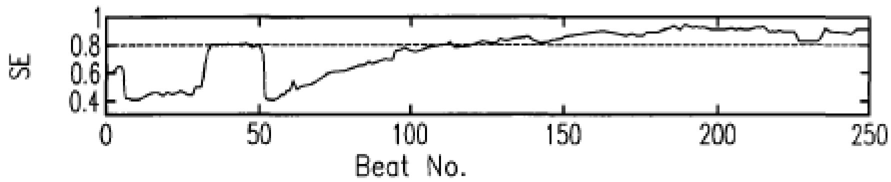


FIG. 1(d)

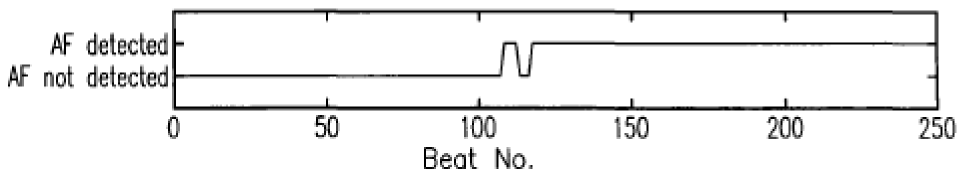


FIG. 1(f)

Chon-570 (Ex-1006), FIGS. 1(d), 1(f).

D. Delorme (Ex-1007)

Delorme is titled "Automatic artifact rejection for EEG data using high-order statistics and independent component analysis." Delorme was publicly available no later than April 4, 2003. Hall-Ellis Decl. (Ex-1014), §§IV.C & V. Delorme is prior art to the '428 Patent at least under pre-AIA 35 U.S.C. §102(b).

Delorme describes using higher order statistics such as Shannon Entropy and Kurtosis to detect motion artifacts. Delorme (Ex-1007) at Section 2; Yanulis Decl. (Ex-1002), ¶ 51. Delorme states that rejecting artifacts based on low-order signal statistics (min, max) might not be sufficient "to detect muscle activity" and it finds that "[h]igher order statistical properties of EEG signals might contain more relevant information about this and other types of artifacts." Id. Delorme also teaches using thresholds for Shannon Entropy and Kurtosis to reject values. Id. Although Delorme used Independent Component Analysis (ICA) to isolate the data segment, it also identified other algorithms such as principal component analysis (PCA) for similar purposes. Delorme (Ex-1007), §3.1.

E. Chon-2008 (Ex-1008)

Chon-2008 is titled "Analysis of Nonstationarity in Renal Autoregulation Mechanisms Using Time-Varying Transfer and Coherence Functions." Chon-2008 was publicly available no later than May 21, 2008. Hall-Ellis Decl. (Ex-1014), §§IV.F & V. Chon-2008 is thus prior art to the '428 Patent at least under pre-AIA 35 U.S.C. §102(b).

Chon-2008 describes statistical methods such as time-varying transfer functions (TVTFs) and time-varying coherence function (TVCF). Chon-2008 (Ex-1008), Abstract. Chon-2008 teaches obtaining TVCF from 2 TVTFs. Chon-2008, R827. The first TVTF is obtained with a first signal segment as input x and the second signal segment as output y. Chon-2008, R827, Formula A8. The second TVTF is obtained by reversing "the input and output relationship such that the variables y and x represent input and output signals, respectively." Chon-2008, R827, Formula A9. The paper uses TVCF and TVTFs to analyze nonstationarity in whole kidney blood flow data collected from animal studies. Chon-2008, R822; Yanulis Decl. ¶52.

VII. GROUND 1 – CLAIMS 1, 3-11, 15, 21, 23-27, 29-30, 37, 39-40 ARE OBVIOUS IN VIEW OF ASADA AND CHON-570

A. A POSITA Would be Motivated to Combine Asada and Chon-570

A POSITA would be motivated to combine Asada (Ex-1005) and Chon-570 (Ex-1006) because they are in the same field of monitoring and analyzing physiological data in real-time, particularly those parameters related to heart conditions. Asada at 28; Chon-570 at 4:1-4. Combining Asada and Chon-570 involves applying a known technique, such as the Shannon Entropy technique in Chon-570 to a known device, such as the WBS in Asada, to achieve a predictable result. Yanulis Decl. (Ex-1002), ¶59. The algorithm in Chon-570 is platform agnostic and can run on general hardware, which the WBS in Asada provides. As stated in Asada, "WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities of CV catastrophe for high-risk subjects." Asada, 28 ("WBS hardware solution must be adequate to make reliable physiological measurements during activities of daily living…"); 34 ("The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication"); Figure 10 (showing CPU). Thus, a POSITA reading Asada would be motivated to combine it with the algorithms in Chon-570 to enhance detections by WBS. Yanulis Decl. (Ex-1002), ¶ 59.

Furthermore, a POSITA would be motivated to combine Asada with Chon-570 to detect or reduce motion artifacts. Yanulis Decl., ¶59. For example, at the time of the '428 Patent, Shannon Entropy has long been used to detect motion artifacts. Yanulis Decl., ¶59. And the particular formula of Shannon Entropy claimed has been known in the field, as evidence by Chon-570. Chon-570, 7:20. Asada recognizes motion artifacts and attempts to address it. Asada, 28. Thus, to detect or reduce motion artifacts, a POSITA would be motivated to combine Asada with a Shannon Entropy technique to achieve this result. As there is a finite number of Shannon Entropy methods, and Chon-570 teaches one of them, a POSITA would be motivated to use the Shannon Entropy's formula in Chon-570 in Asada's system to detect or reduce motion artifacts. *See* Yanulis Decl. (Ex-1002), ¶59.

B. Independent Claim 1

1. Preamble: A method for physiological parameter monitoring, the method comprising

While the preamble is not limiting, Asada with Chon-570 discloses this element. Asada with Chon-570 monitors physiological parameters such as heart rate, oxygen saturation, heart rate variability, etc. Asada (Ex-1005), 28 & 35; Chon-570 (Ex-1006), 3:23-4:18; Yanulis Decl. (Ex-1002), ¶¶62-63.

2. *Element 1[i]: providing a physiological indicator signal to a handheld mobile communication device; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor*

Asada discloses providing a physiological indicator signal to the WBS to monitor, for example, the patient's heart rate, oxygen saturation, and heart rate variability. Asada, 28-29. The WBS has a ring, as shown in the image below.

Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

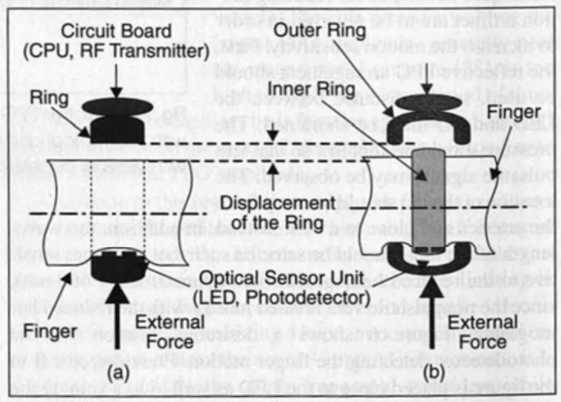


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force (31).

(Asada (Ex-1005), Figs. 9-10)

The ring has a "PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication." Asada, 34.

Asada discloses that "the acquired waveforms … are transmitted to a PDA or a cellphone carried by the patient. The cellular phone then accesses a Web site for data storage and clinical diagnosis." Asada, 34. A POSITA reading Asada, would be motivated to use the sensor in the ring to acquire physiological indicator signals and send them to a handheld mobile communication device for further analysis. Yanulis Decl., ¶¶65, 68-69. The ring and the mobile device, either individually or in combination can be considered as a handheld mobile communication device. The ring is considered as a handheld communication device, as it can be held by hand, and it communicates with other devices such as a PDA or a cellphone "through an RF link of 105kbps at a carrier frequency of 915MHz." Asada, 34. A POSITA would also understand that the PDA and the cellphone is a handheld communication device. Yanulis Decl., ¶¶65, 69.

Asada teaches acquiring PPG signal, which is a type of physiological indicator signal, from one or more PPG sensors. Asada at 28 (the system "combines miniaturized data acquisition features with advanced photoplethysmographic (PPG) techniques to acquire data related to the patient's cardiovascular state."). Asada also mentions that the system works with data acquired from other components such as optical sensors, electrochemical sensors, etc. Asada at 29. It would be obvious to a POSITA to acquire physiological signals from various sensors such as image acquisition component, PPG sensor, and ECG sensor, which were typical data acquisition components at the time. Yanulis Decl., ¶67. For example, Chon-570 discloses acquiring ECG signals from ECG sensors. Chon-570 at 4:2-3; Yanulis Decl., ¶71. Thus, it would be obvious for a POSITA achieve a system using already existing sensors to obtain various types of physiological signals. *See* Yanulis Decl., ¶ 67.

3. Element 1[ii]: analyzing, using the handheld mobile communication device, the physiological indicator signal

Asada discloses this element. For example, the ring in the WBS system performs analyses such as signal processing and filtering. Asada, 34 ("The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication"). WBS in Asada receives the PPG signals, and analyzes them to monitor a patient's cardiovascular data. Asada, 28, 30, 35 (monitor "a patient's heart rate, oxygen saturation, and heart rate variability."). WBS also works with a PDA and Cellphone which performs clinical diagnosis from these physiological signals. Asada, 34.

Chon-570 describes analyzing physiological signals such as piezoelectric or ECG signals for processing. Chon-570, 4:1-4. The algorithms disclosed in Chon-570 do not have restrictions on the type of platform that they can run. Thus, the analysis using these algorithms can be performed on WBS's microcomputer or in the PDA and cellphone disclosed in Asada. Yanulis Decl., ¶71.

4. Element 1[iii]: obtaining, from said analyzing, measurements of one or more physiological parameters; and

As discussed above in subsection 3, Asada with Chon-570 analyzes physiological signals. The prior art obtains measurements of physiological parameters, such as those related to a patient's heart rate, oxygen saturation, and heart rate variability. Asada at 28, 30, 35 (monitor "a patient's heart rate, oxygen saturation, and heart rate variability."); Chon-570 at 3:23-31; 4:6-1 (obtaining various measurements from ECG data (e.g., RR intervals, heart rate variability, etc.); Yanulis Decl., ¶¶76-77. A POSITA would understand that the analysis of the patient's physiological data, such as those from PPG and ECG would result in measurements of the physiological parameters. Yanulis Decl., ¶77.

5. Element 1[iv]: detecting, using the handheld mobile communication device and using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters and deciding whether to retain the measurements based on detected effects of motion artifacts

Asada discloses detecting and reducing motion artifacts using the signals from the PPG sensors. Asada, 28 ("Technical issues, including motion artifact, … will be addressed"), 30 (the header states "Techniques for Reduced Motion Artifact"), 34 ("The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact.").

Asada also teaches eliminating artifacts which includes performing the element of "deciding whether to retain the measurements based on detected effects of motion artifacts." *See* Asada, 30 ("the development of the ring sensor has stressed first an understanding of and then the subsequent elimination of front-end signal artifacts."). A POSITA would understand that the elimination of unwanted motion artifacts would render it obvious to reach a decision on retaining the non-eliminated measurements. Yanulis Decl., ¶79.

A POSITA understands that Asada with Chon-570 teaches detecting effects of motion artifacts using only the measurements of the one or more physiological parameters. The prior art does not require another parameter to detect motion artifacts, and thus, Asada with Chon-570 teaches the situation where only the measurements of the one or more physiological parameters are used to detect motion artifacts. Yanulis Decl., ¶78.

6. Element 1[v]: wherein detecting effects of motion artifacts in the measurements comprises

Asada with Chon-570 discloses this element for the same reasons as those discussed in subsections 7-10.

7. Element 1[va]: bandpass filtering and detrending a segment from the measurement of one physiological parameter; wherein a bandpass filtered and detrended segment is hereinafter referred to as a preprocessed segment

In light of the teachings in Asada and Chon-570, a POSITA would be motivated to apply bandpass filtering and other preprocessing steps to signal segments. Yanulis Decl., ¶¶82-84.

The '428 Patent describes "a finite impulse response (FIR) band pass filter of order 64 with cut-off frequencies of 0.1Hz and 10Hz." '428 Patent, 5:35-36. As to detrending, the specification defines it as "the process of finding a best polynomial fit to a time series and subtracting that best polynomial fit from the time series." '428 Patent, 3:46-48.

Asada teaches using bandpass filtering to eliminate large segments of DC signals. Asada, 30. Asada also teaches the use of "adaptive filtering" and "a noise cancellation filter" to filter PPG data, as well as "adaptive noise cancelling methods … to recover the true pulsation signal from corrupted waveforms." Asada, 33, 34 ("The dual photodetector design shown in Figure 6 provides both main signal and noise reference that are distinct. This allows us to implement noise-canceling filters effectively despite complex motion artifact."). A POSITA would have understood that, in order to perform accurate calculations and analyze data in a meaningful way, it is often necessary to eliminate outliers and noise. Yanulis Decl., ¶84. Bandpass filtering and detrending are two very well-known techniques for accomplishing those goals. Yanulis Decl., ¶¶82, 84, *citing* Hyde, [0037] ("Detrending and covariance techniques are both known method of data analysis."); ¶36, *citing* Ex-1004 (where the examiner found that detrending and bandpass filtering are known in the art). Thus, it would be obvious to incorporate or substitute the adaptive filters and noise cancelling filters in Asada with commonly known techniques such as bandpass filters and detrending to achieve the same result, to reduce noises and outliers.

8. Element 1[vb]: obtaining a value of at least one indicator of volatility, used in determining whether motion artifacts are present, for the preprocessed segment; the at least one indicator of volatility being at least Shannon entropy (SE) for the preprocessed segment; where

$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number and, p(i) is the probability distribution of the preprocessed segment

Asada teaches detecting and reducing motion artifacts in physiological signals. *See, e.g.*, Asada, 28, 30. It is obvious to a person of ordinary skill in the art to combine Asada with other known methods to detect motion artifacts, such as Shannon Entropy.

Chon-570 discloses the formula in this claim as follows.

The SE is then calculated utilizing Equation (4):

$$SE = -\sum_{i=1}^{16} p(i) \frac{\log(p(i))}{\log(\frac{1}{16})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Chon-570 at 7:20. Chon-570 uses number 16 instead of the constant "k."

The '428 Patent's specification explicitly states that "16 bins (k=16) have been used to obtain a reasonably accurate measure of SE." '428 Patent, 6:20-22. Thus, a POSITA reading the specification and the Chon-570 would understand that the Chon-570 discloses the claimed formula.

While Chon-570 does not explicitly apply this Shannon Entropy formula to detecting motion artifacts, but it would be obvious to do so in light of the art at the time. Shannon Entropy essentially measures the probability that a segment contains an outliner (e.g., a noise or a motion artifact). Yanulis Decl., ¶87. At the time of the '428 Patent, Shannon entropy has already been applied to detect motion artifacts. *See* Yanulis Decl., ¶89, *citing* Delorme (which uses Kurtosis and Shannon Entropy for automatic artifact rejection); Greco ("A technique for the automatic artifact rejection, based on …some high order statistics such as kurtosis and Shannon's entropy, was proposed some years ago in literature."). Thus, it would be obvious to a POSITA to use the Shannon Entropy formula in Chon-570 to obtaining a value of an indicator of volatility (e.g., to probabilistically detect outliners such as motion artifacts). Yanulis Decl., ¶89. This process merely involves applying a known formula in a known way to achieve a predictable result. Yanulis Decl., ¶89.

9. Element 1[vc]: including the segment in analyses of physiological measurements, when comparison of the value of the at least one indicator of volatility with a predetermined threshold indicates noise/motion artifacts are not present; and

Comparing a value of an indicator of volatility with a predetermined threshold to determine whether to include or exclude the segment from being considered a valid measurement data is commonly used by a POSITA. Yanulis Decl., ¶93. One example of a predetermined Shannon Entropy threshold is shown in Chon-570.

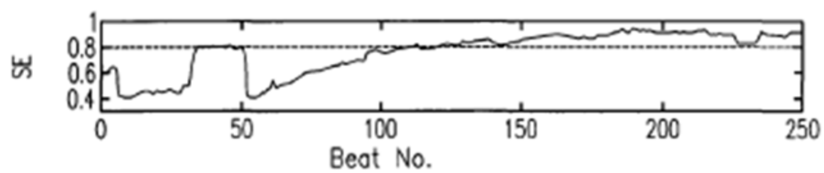


FIG. 1(d)

Chon-570, FIG. 1(d), 9:14-18. The ’428 Patent acknowledges that using threshold values for detecting motion artifacts were previously known. For example, the ’428 patent cites to a 2004 paper which describes receive-operator characteristics (ROC) analysis for setting thresholds. ’428 Patent, 6:30-45, *citing* S.H. Park et. al., Receiver Operating Characteristic (ROC) Curve: Practical Review for Radiologists, Korean J Radiol. 2004 January-March; 5(1): 11-18.

Asada teaches detecting and eliminating signal artifacts. *See* Asada, 30 (“the development of the ring sensor has stressed first an understanding of and then the subsequent elimination of front-end signal artifacts.”). Thus, a POSITA reading

Asada would understand that this process involves determining whether to include or exclude a signal segment based on whether that segment indicates the presence of motion artifacts. *See* Yanulis Decl., ¶91. This teaching in Asada coupled with Chon-570's teaching on Shannon Entropy thresholding, would therefore discloses the step of including a signal segment if a comparison of a volatility indicator value to a threshold indicates that the signal segment does not have motion artifacts.

10. Element 1[vd]: selecting another segment of the signal from the physiological measurement and proceeding to step (a) when the value of the at least one indicator of volatility is less than a predetermined threshold and when another segment is available.

Both Asada (Ex-1005) and Chon-570 (Ex-1006) disclose continuously monitoring and calculating Shannon Entropy in segments of signals. Asada, 34; Chon-570, 4:1-18. As discussed in subsection 9, Asada and Chon-570 disclose whether to include a data segment depending on whether it has motion artifact. A POSITA recognizes that artifacts distort the analysis of the signals, and thus would select those data segments that have little or no artifacts. Yanulis Decl., ¶97, *citing* Greco at Abstract ("Artifact rejection is a key topic in signal processing. The artifacts are unwelcome signals that may occur during the signal acquisition and that may alter the analysis of the signals themselves."). Thus, if the artifact is present in one segment, a POSITA would be motivated to apply the statistical analysis on another segment, if the other segment is available. Yanulis Decl., ¶97.

C. Dependent Claim 3

Dependent Claim 3 additionally recites "The method of claim 1 wherein the predetermined threshold is determined using receiver operator characteristic (ROC) analysis." '428 Patent, Claim 3. Chon-570 discloses this element.

Chon-570 discloses determining thresholds for root mean square of successive RR differences (RMSSD), Shannon Entropy (SE), and Turning Points Ratio (TPR) using receiver operator characteristic (ROC) curves. Chon-570 at 10:11-17. For example, Figure 1(d) of Chon-570 discloses a chart with Shannon Entropy values, where the dotted line represents a "threshold value[] as determined by the ROC." Chon-570 at 10:14-16; Yanulis Decl. (Ex-1002), ¶98.

D. Dependent Claim 4

Dependent Claim 4 additionally recites "placing a portion of a subject's body over an objective lens of a camera in a handheld mobile communication device; and obtaining video images of the portion of the subject's body." '428 Patent, Claim 4.

Asada renders these elements obvious as a POSITA reading through Asada would be able to use a video camera of a mobile device (which acquires frames at a predetermined time) to obtain video images of body parts in proximity to the camera's lens. *See* Yanulis Decl., ¶¶99-100.

Asada discloses that "there are numerous WBS modalities that can offer physiological measurements" and an example of which is optical sensors. Asada, 29. Asada also discloses that the WBS works with handheld devices such as PDAs, cellphones. Asada at 34. As patentee acknowledged during the prosecution, camera on a handheld device is a type of optical sensor. *See* Ex-1002, 2016-12-22 Affidavit under Rule 132 (patentee stated that "the image acquisition component in a camera is a sensor."). It would be obvious to a POSITA substitute the optical sensors mentioned in Asada's with camera in a handheld communication device to reach Claim 4. Yanulis Decl., ¶100. This substitution of similar known elements achieves the same results. *Id.*

E. Dependent Claim 5

Dependent Claim 5 recites "[t]he method of claim 1 wherein providing a physiological indicator signal comprises obtaining a signal from a physiological monitoring sensor." '428 Patent, Claim 5. Asada and Chon-570 both disclose this element. For example, Asada obtains a signal from a physiological sensor such as PPG. Asada, 28 ("This WBS combines miniaturized data acquisition features with advanced photoplethysmography (PPG) techniques to acquire data related to the patient's cardiovascular state …"), 31 (describing two sets of PPG sensors attached to the same finger). Chon-570 obtains signals from sensors for piezoelectric signals or ECG. Chon-570 at 4:1-4, 11:20-22, Fig. 4; Yanulis Decl. (Ex-1002), ¶102.

F. Dependent Claim 6

Dependent Claim 6 recites "[t]he method of claim 5 wherein the physiological monitoring sensor is a photoplethysmographic (PPG) sensor or an electrocardiogram sensor." '428 Patent, Claim 6. As discussed above for Claim 5, Asada teaches using PPG sensors to monitor a patient. Asada, 23, 31. Chon-570 also discloses this element where it obtains signals from ECG sensors. Chon-570, 4:1-4, 11:20-22, Fig. 4; Yanulis Decl. (Ex-1002), ¶103.

G. Dependent Claim 7

Dependent Claim 7 recites: "[t]he method of claim 1 wherein the one or more physiological measurements comprise heart rate and heart rate variability." Asada discloses this element. For example, Asada discloses that the "sensor is capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability." Asada, 28, 35 ("[t]hese modifications greatly improved the ability of the device to measure traditionally difficult variables such as heart rate variability."); Yanulis Decl. (Ex-1002), ¶105.

H. Dependent Claim 8

Dependent Claim 8 recites "The method of claim 7 wherein obtaining measurements of heart rate and heart rate variability comprise: determining beats for the physiological indicator signal; determining beat to beat intervals; and applying a cubic spline algorithm to obtain a substantially continuous beat to beat interval signal indicative of heart rate." '428 Patent, Claim 8.

Chon-570 detects the presence of atrial fibrillation using "piezoelectric or ECG signals" which involves determining beats from the signals. Chon-570, 4:1-7. Chon-570 determines beat to beat intervals as it "select[s] a beat segment of RR intervals centered on that beat for each analyzed heart beat." Chon-570, 4:7-8; Yanulis Decl. (Ex-1002), ¶106.

It would be obvious to a POSITA to apply a cubic spline algorithm or any other interpolation or smoothing measures known in the art to obtain a substantially continuous beat to beat interval signal indicative of heart rate. As discussed above in Claim 1, detrending is a common technique to filter data, and cubic spline algorithm was well-known in the art to remove undesired low frequency noise. Yanulis Decl., ¶107 *citing* Hyde at [0063] ("the data are detrended with a numeric analytical technique known as cubic spline approximation. The cubic spline parameters are selected to remove the undesired low frequency noise."); Petition, § VI.B.7. Thus, it would be obvious to apply a known algorithm to a typical data processing (i.e. detrending), to obtain useable data for subsequent analyses. Yanulis Decl. (Ex-1002), ¶107.

I. Dependent Claim 9

Asada discloses "[t]he method of claim 1 wherein the one or more physiological measurements comprise respiratory rate." Asada, 29; '428 Patent, Claim 9. For example, Asada states that "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs': … respiratory rate". Asada (Ex-1005), 29; Yanulis Decl. (Ex-1002), ¶112.

J. Dependent Claim 10

Claim 10 of the '428 Patent recites "[t]he method of claim 9 wherein measurement of respiratory rate comprises: obtaining time-frequency spectrum of the physiological indicator signal utilizing variable frequency complex demodulation (VFCDM); and obtaining respiratory rates by extracting a frequency component that has a largest amplitude for each time point at a heart rate frequency band." '428 Patent, Claim 10.

The '428 Patent's specification admits that the claimed VFCDM analysis has already been in the prior art, such as by Chon-2009. '428 Patent at 7:36-8:35 ("The development of the VFCDM algorithm has been previously disclosed in" Chon-2009…). Chon-2009 describes using VFCDM to extract respiratory rate as follows:

> The VFCDM method has been published and tested with different physiological signals". Chon-2009 at 2055. It then went on summarizing using VFCDMs for estimating TFS.

Chon-2009 at 2055-2056 (Section A).

It also describes using VFCDM to extract respiratory rate where "[o]nce the TSF is obtained via the VFCDM method as described before, respiratory rates are determined by extracting the frequency component that has the largest amplitude for each time point at the heart rate frequency band." Chon-2009 at 2057 (Section B); Yanulis Decl. (Ex-1002), ¶114.

Thus, a POSITA at the time would have been motivated to use an existing method, i.e., VFCDM, and combine it with Asada's teaching of measuring respiratory rate, so that respiratory rate in Asada is extracted using the VFCDM approach. Yanulis Decl. (Ex-1002), ¶114.

K. Dependent Claim 11

Dependent Claim 11 recites "[t]he method of claim 1 wherein the one or more physiological measurements comprise a measure of oxygen saturation." '428 Patent, Claim 11. Asada teaches obtaining a measure of oxygen saturation. For example, Asada states that "WBS solutions, in various stages of technologic maturity, exist for measuring established cardiopulmonary 'vital signs'" which includes "arterial oxygen saturation." Asada, 29; Yanulis Decl. (Ex-1002), ¶109.

L. Dependent Claim 15

Claim 15 recites: "The method of claim 1 wherein the one or more physiological measurements comprise a measure of atrial fibrillation." '428 Patent, Claim 15. Asada describes that WBS can monitor patients living alone to detect arrhythmias. Asada, 37 (with automated defibrillators for home, "the general public will be increasingly able to respond to victims of life-threatening arrhythmias when such catastrophes are detected."). As atrial fibrillation (AF) is a typical form of arrhythmia, Asada teaches detecting AF. *See* Yanulis Decl. (Ex-1002), ¶162.

In addition, Chon-570 specifically describes detecting AF using Shannon Entropy. Chon-570 at 4:5-18 ("it is again identified as an AF candidate, a third identification of the beat segment is performed by calculating a Shannon Entropy (SE) of the segment and determining whether the SE is greater than an SE threshold."). Thus, Asada and Chon-570 disclose calculating a measure of AF.

M. Independent Claim 21

While Claim 21 essentially has the same elements as Claim 1, Claim 21 additionally recites: "a handheld mobile communication device comprising: at least one processor; and at least one computer usable medium, the computer usable medium having computer readable code embodied therein, the computer readable code causing the at least one processor to" perform the recited functions. '428 Patent, Claim 21.

Asada discloses these elements. For example, Asada teaches a WBS system which has features such as processor, memory and executes code to filter physiological data acquired from sensors, such as the PPG sensors. Yanulis Decl.,

¶68; Asada, 28, 34 ("The ring has a PIC microcomputer performing all the device controls and low-level signal processing, including LED modulation, data acquisition, filtering, and bi-directional RF communication"); Figure 10 shown below (emphasis added).

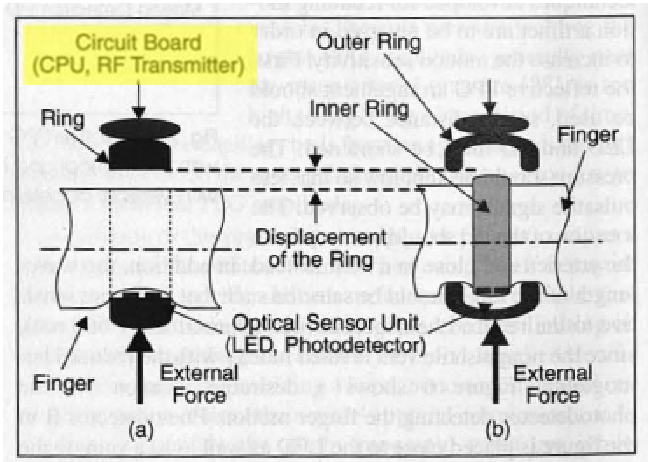


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force (31).

(Asada (Ex-1005), Fig. 10)

Asada also discloses that the physiological data can be sent to devices such as PDA and cellphone for further analysis. Asada at 34. These devices are understood as handheld devices. They have memory, processor and can execute code. Yanulis Decl. (Ex-1002), ¶69.

N. Dependent Claim 23

Dependent Claim 23 is obvious for the same reason as dependent Claim 3.

O. Dependent Claims 24, 25

Dependent Claims 24 and 25 are obvious for the same reason as dependent Claim 4. Claim 24 requires an image acquisition component to be "capable of acquiring a number of frames, each frame acquired at a predetermined time" and Claim 25 additionally requires that the handheld mobile communications device comprise the image acquisition component in Claim 24. '428 Patent, Claims 24, 25.

In addition to the reasons discussed above as Claim 4, the phrase "acquisition component capable of acquiring a number of frames, each frame acquired at a predetermined time" which does not change the result because a camera or optical sensors are capable of acquiring videos which are frames acquired at predetermined time. Yanulis Decl., ¶ 100.

P. Dependent Claim 26

Dependent Claim 26 is obvious for the same reasons as Claim 5.

Q. Dependent Claim 27

Dependent Claim 27 is obvious for the same reasons as Claim 6.

R. Dependent Claim 29

Dependent Claim 29 essentially recite the same elements as dependent claims 7, and 8 and thus are obvious in view of Asada and Chon-570 for the same reasons.

S. Dependent Claim 30

Dependent Claim 30 essentially recite the same elements as dependent Claims 9, 10 and thus are obvious in view of Asada and Chon-570 for the same reasons.

T. Claims 37, 39, 40

Independent Claim 37 is obvious for the same reasons as independent Claim 21. Dependent Claims 39, 40 are obvious for the same reasons as dependent Claims 29, 30, respectively.

VIII. GROUND 2 – CLAIMS 1-11, 15, 21-27, 29-30, 37, 39-40 ARE OBVIOUS IN VIEW OF ASADA, CHON-570, AND DELORME

A. A POSITA Would Be Motivated to Combine Asada, Chon-570, and Delorme

In addition to the motivations to combine Asada with Chon-570 discussed in Ground 1, a POSITA would be motivated to combine Asada with Delorme because both references are to improve processing of physiological data and to reduce or eliminate the effect of motion artifacts. Indeed, Asada explicitly contemplates combining with other algorithms to improve detection. Asada, 28 ("WBS, in conjunction with appropriate alarm algorithms, can increase surveillance capabilities …"); Yanulis Decl., ¶115. Here, combining Delorme's algorithm with Asada's platform is simply to combine known elements in the prior art to improve the detection of patient's conditions and motion artifacts.

A POSITA would also be motivated to improve Delorme with Chon-570, where the Shannon Entropy formula disclosed in Delorme is improved by the Shannon Entropy formula disclosed in Chon-570 to detection motion artifacts. Both formulae already known in the art at the time of the '428 Patent, and they both detect irregularities in signals. Thus, it would involve minimal efforts for a POSITA to implement Chon-570's formula in the context of detecting motion artifacts. *See* Yanulis Decl., ¶116.

B. Independent Claim 1

Asada and Chon-570 disclose the preamble, and elements 1[i] through 1[iii] for the same reasons as Ground 1. '428 Patent, Claim 1. Moreover, Asada, Chon-570, and Delorme additionally disclose elements 1[iv], 1[v], and 1[va]-1[vd] for the additional reasons below.

1. Element 1[iv]: detecting, using the handheld mobile communication device and using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters and deciding whether to retain the measurements based on detected effects of motion artifacts;

Asada and Chon-570 disclose this element for the same reasons as Ground 1 above. Delorme also discloses this element where it detects effects of motion artifacts. *See* Delorme, Abstract ("isolating both artifacts and cognitive related activations in EEG data."), §2 ("Isolating artifacts thus involves detecting such events."). A POSITA would be motivated to implement Delorme's techniques on the handheld mobile communication device(s) disclosed in Asada, since the device(s) in Asada comprises generic computing components and can run any algorithms such as the ones in Delorme. *See* Yanulis Decl., ¶120.

Delorme discloses "deciding whether to retain the measurements based on detected effects of motion artifacts." For example, Delorme discloses "rejecting independent components and noisy single data trials based on their statistical properties." Delorme, Abstract, §1 ("use statistics on the independent component activities to locate and reject both artifactual data trials and artifactual components."); §3.1("isolate and measure these artifacts…"). According, Delorme decides whether or not to retain the measurements based on motion artifacts, and if the effects of the motion artifacts are too significant, the measurements will not be retained. Yanulis Decl., ¶123.

2. Element 1[v]: wherein detecting effects of motion artifacts in the measurements comprises:

This element is obvious for the same reasons as element 1[iv] and elements [va]-[vd] below. Furthermore, a POSITA would be motivated to modify Asada's system with Delorme so that the system detects motion artifacts with Shannon Entropy. Both Asada and Delorme are directed to detecting motion artifacts. See, e.g., Asada, 28, 30 ("Techniques for Reduced Motion Artifact"), 33 ("Questionable data can be rejected if the wearable sensor has a means to monitor the hand motion and other sources of disturbances."); Delorme, Abstract. While Asada may not expressly specify a statistical algorithm for detecting motion artifacts, a POSITA would have recognized that higher order statistical methods are more relevant to isolating and identifying motion artifacts. Delorme, §1 ("[h]igher order statistical properties of the EEG signals might contain more relevant information about [muscle activity] and other types of artifacts."). Thus, a POSITA would be motivated to apply high order statistical methods, such as Shannon Entropy and Kurtosis to improve Asada's motion artifacts detection. Yanulis Decl. (Ex-1002), ¶124.

A POSITA would further recognize that Delorme's entropy-based method could be improved by using the Shannon Entropy formula as discussed in in Chon-570. Yanulis Decl., ¶124. While both aimed at quantifying signal irregularity using Shannon Entropy, Delorme's method had known limitations. A POSITA would be motivated to improve the Shannon Entropy from Delorme, in light of Greco's finding that Delorme's Shannon Entropy technique did not identify all motion artifacts. Yanulis Decl., ¶124, *citing* Greco (Ex-1010), 241 (Delorme's method "showed some failures of the procedure in detecting some artifactual signals, thus we wonder whether any entropy definition would improve the performance of the method."). While the Shannon Entropy method discussed in Chon-570 was not available at the time Greco, at the time of the '428 Patent's invention, a POSITA in search for optimizing Shannon Entropy calculations would be motivated to use Chon-570's approach, since as it provides a more rigorous entropy calculation that is specifically suited for detecting irregularities in the physiological data. Yanulis Decl. (Ex-1002), ¶124.

3. Element 1[va]: bandpass filtering and detrending a segment from the measurement of one physiological parameter; wherein a bandpass filtered and detrended segment is hereinafter referred to as a preprocessed segment;

This element is obvious for the same reasons as discussed for the same element in Ground 1 above.

4. Element 1[vb]: obtaining a value of at least one indicator of volatility, used in determining whether motion artifacts are present, for the preprocessed segment; the at least one indicator of volatility being at least Shannon entropy (SE) for the preprocessed segment; where $SE = -\sum_{i=1}^{k} \frac{p(i)*\log(p(i))}{\log\left(\frac{1}{k}\right)}$ and where i represents the bin number and, p(i) is the probability distribution of the preprocessed segment;

In addition to the reasons mentioned in Ground 1, where Asada and Chon-570 disclose this element. Asada and Chon-570 in combination with Delorme also teach this element. Delorme, for example, teaches using high order statistics to calculate indicator of volatility from Kurtosis and Shannon Entropy. *See* Delorme, §2 ("Isolating artifacts thus involves detecting such events. To do so, we chose two measures: probability distribution and kurtosis"), §3.3 ("We used three high-order statistical measures for each component: the entropy of the activity of the component (over all trials), kurtosis of the activity, and the kurtosis of the components' spatial map."); Yanulis Decl., ¶129.

In Delorme, the entropy is measured using the following formula:

$$H(i) = -\sum_{x \in D_i} p_{D_i}(x) \log(p_{D_i}(x)) \quad (5)$$

where $p_{D_i}(x)$ is the probability of observing the activity values x in the observed probability distribution of activity D_i from component i. Delorme at §3.3; id. ("this measure should be able to detect these outlier components" … "If the component contains a homogenous distribution of high frequencies, it is likely to be an artifact component…"). H(i) is the entropy of the ith element, which corresponds to an indicator of volatility.

While Shannon Entropy formula in Delorme is not exactly the same as the claimed Shannon formula (reproduced below).

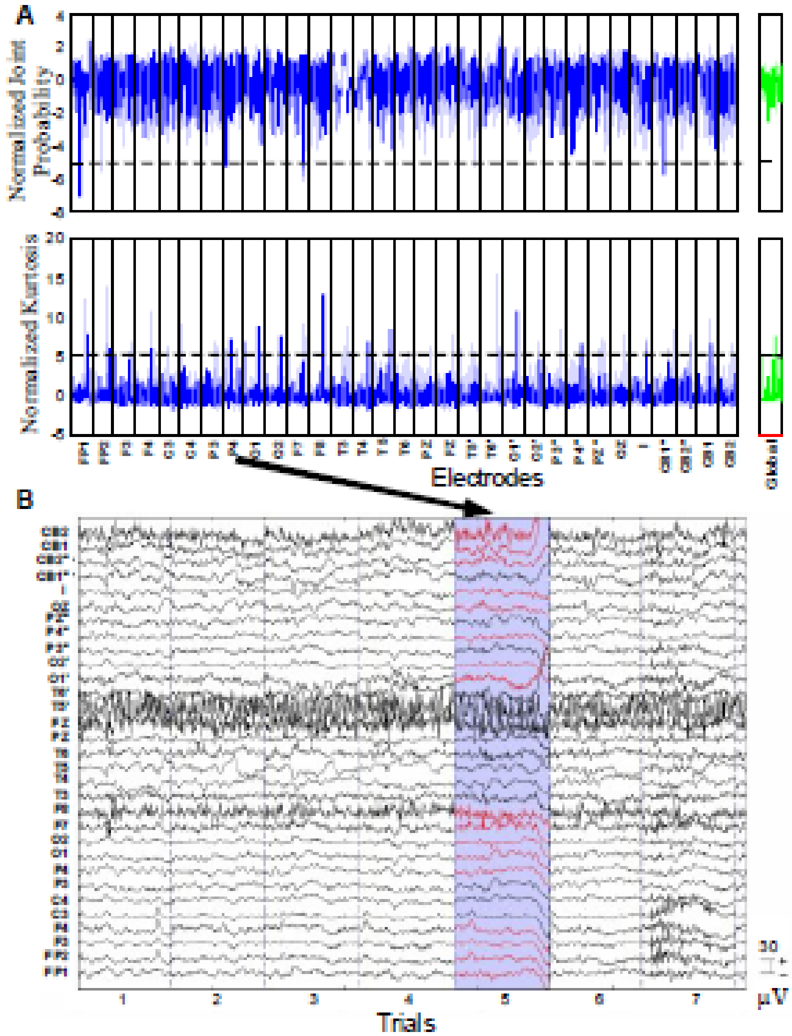
$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number, and p(i) is the probability distribution of the preprocessed segment. It would be obvious to a POSITA to try Chon-570's Shannon Entropy formula. Yanulis Decl., ¶¶132-133. A POSITA would find it obvious to use the SE formula found in Chon-570 instead of Delorme's formula because both methods use entropy to quantify signal irregularities (Delorme for EEG artifact detection, Chon-570 for atrial fibrillation in ECG data), i.e., measuring the unpredictability of a probability distribution. Yanulis Decl., ¶132. Since both references teaches Shannon Entropy, a POSITA would recognize that improving Delorme's formula with Chon-570's formula requires minimal efforts which improved the interpretation of signal irregularity without changing the underlying mathematical concept. Yanulis Decl., ¶132. Furthermore, it would be obvious to try to improve a known formula with another formula directed to calculating the same type of information to yield to a better result for determining motion artifacts. *See* Yanulis Decl., ¶133.

5. Element 1[vc]: including the segment in analyses of physiological measurements, when comparison of the value of the at least one indicator of volatility with a predetermined threshold indicates noise/motion artifacts are not present; and

In addition to the reasons discussed in Ground 1, Delorme also discloses this element. Delorme teaches rejection thresholds for Shannon Entropy and Kurtosis. Delorme, §2, §3.3 ("one can also set a rejection threshold for relevant higher order statistics"). Delorme "define[s] thresholds in terms of a number of standard deviations from the mean" (show in the figure below) after normalizing the entropy and Kurtosis "to 0-mean and standard deviation 1." Delorme, §2. Based on the comparison of Shannon Entropy to the rejection threshold, Delorme determines whether to keep a segment. Yanulis Decl., ¶135.

Figure 1 of Delorme (reproduced below) demonstrates how the predetermined threshold is used to determine whether to include a segment based on the comparison of the threshold.



(Delorome (Ex-1007), Fig. 1)

Part A of Figure 1 of Delorme above includes "horizontal dashed bars indicat[ing] rejection thresholds (in numbers of standard deviations from the mean). If the measure for one trial exceed one of these rejection thresholds, the trial is marked for rejection." Delorme, §2. Part B of Figure 1 of Delorme highlights the segment marked for rejection due to the presence of motion artifacts, whereas the other non-highlighted segments indicate the absence of motion artifacts. A POSITA would understand that the non-rejected segments are considered "clean" and should be included in the analyses of physiological measurements. Yanulis Decl. (Ex-1002), ¶135.

6. Element 1[vd]: selecting another segment of the signal from the physiological measurement and proceeding to step (a) when the value of the at least one indicator of volatility is less than a predetermined threshold and when another segment is available.

As discussed in Ground 1 and subsection 5 above, it is obvious to compare the result of the statistical analysis from a predetermined threshold to see whether a signal segment should be included. Also as discussed in subsection 5 above, Delorme discloses a rejection threshold for detecting motion artifacts. Delorme, §§2, 3.3. A POSITA would recognize that modifying the rejection threshold to function as "acceptance" threshold would involve minimal efforts, where a smaller number indicates signal corruption and a bigger number indicates a clean signal. Yanulis Decl., ¶137. This modification would be a simple logical inversion of the same rejection principle that leads to the same result. Id. It would further be obvious to a POSITA that if motion artifacts are present in one segment, the system would proceed to another component to determine if that component is clean or not. Yanulis Decl., ¶137.

C. Independent Claims 21, 37

Independent Claims 21 and 37 recite similar elements as Claim 1 and thus are invalid for the same reasons as §VII.B of the Petition. Independent Claims 21 and 37 also recite certain features such as processor, memory, and computer executable code, which are obvious as previously discussed in Ground 1.

D. Dependent Claims 2 and 22

Dependent Claim 2 recites "The method of claim 1 wherein said at least one indicator of volatility also comprises kurtosis." '428 Patent, Claim 2. Dependent Claim 22 also recites similar element. Delorme discloses these claims.

Delorme teaches using kurtosis to determine indicators of volatility in signals. Delorme, §2 (use "probability distribution and kurtosis" for artifact rejection and "In some artifact trials, the distribution of activation is very peaky … [t]o measure this peakyness, we used the kurtosis of the activity values in each trial"). Yanulis Decl., ¶139.

E. Dependent Claims 3-11, 15, 23-27, 29-30, 39-40

These claims are invalid for the same reasons as those discussed with respect to Ground 1.

IX. GROUND 3 – CLAIMS 16-20, 32-36, 42-46 ARE OBVIOUS IN VIEW OF ASADA, CHON-570, AND CHON-2008

A. A POSITA would be motivated to combine Asada, Chon-570, and Chon-2008.

Asada discloses arrhythmia surveillance which measures vital signs such as "heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output." Asada, 29. Chon-570 also measures various vital signs, particularly those related to a patient's heart, to detect atrial fibrillation (AF). Chon-570, 1:8-10. AF is a form of arrhythmia. Yanulis Decl., ¶¶ 148, 162. Accordingly, a POSITA would be motivated to combine Asada and Chon-570 where the known algorithm of Chon-570 is used in the known WBS system in Asada to yield predictable result, i.e., to detect AF.

A POSITA would also be motivated to combine Asada, Chon-570, and Chon-2008. Prior art at the time acknowledges that "[t]he characterization of physiological systems with the TVTF is important because the admittance gain between input and output signals is correctly characterized to be transient, and not stationary, as is assumed with the time-invariant transfer function." Yanulis Decl., ¶ 148, *citing* Zhao at 1582. Also, at the time, deriving TVCF with 2 TVTFs are already known in the art. Yanulis Decl., ¶38 *citing* Ex-1004 at 0142 ("time-varying coherence function(s) for analyzing two signals are known in the art"), ¶52 *citing* Chon-2008, ¶57 *citing* Zhao.

Thus, a POSITA would be motivated to use the existing statistical method, such as deriving TVCF with TVTFs in Chon-2008, and apply this statistical method to solve a similar problem in Chon-570 in the context of detecting AF. In Chon-2008, the signals acquired is not stationary, as renal blood flow dynamics vary in time, particularly because blood pressure is not consistent over time. Chon-2008, Abstract, R821 ("A transfer function is the input-output relationship between an independent variable (blood pressure) and a dependent variable [renal blood flow (RBF)]. Its output is given in terms of gain, which reports fluctuation of the output with respect to the input and phase that contains the temporal relationship between the two signals.”). Similar to Chon-2008, the physiological signals acquired in Chon-570 and Asada are also include variations due to an independent variable, such as motion artifacts. Yanulis Decl., ¶148. Thus, it would be obvious to a POSITA to use statistical methods such as TVTFs and TVCFs which previously applied to non-stationary signals, to detect motion artifacts.

B. Independent Claim 16

1. Preamble Through Element 16[ii]

These elements recite the following:

> 16[pre]. A method for physiological parameter monitoring, the method comprising:
> [i]. providing a physiological indicator signal to a handheld mobile communication device; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;
> [ii]. analyzing, using the handheld mobile communication device, the physiological indicator signal;

’428 Patent, Claim 16. Asada and Chon-570 disclose these elements for the same reasons as Ground 1.

2. *Element 16[iii]: wherein analysis does not include Independent Component Analysis;*

Asada, Chon-570, and Chon-2008 teaches this element as none of the references requires independent component analysis (ICA). Yanulis Decl., ¶155.

The specification of the ’428 Patent does not mention excluding “Independent Component Analysis” nor does it discuss excluding ICA for TVCF. During the ’428 Patent’s prosecution, patentee argued that the description for applying a statistical method such as Shannon Entropy, supports analyses both with and without ICA. Ex-1004, 0717 (“the applicants’ disclosure discloses or suggest the Shannon entropy for the Independent Components in the Independent Component Analysis and the applicants can decide what bounds of protection to seek and can decide, within their written description requirement to exclude Independent Component Analysis.”). In other words, according to patentee, by not specifying whether a statistical method should be only applied with ICA, the method can cover both ICA or non-ICA. Thus, it would be obvious to a POSITA to select either approach, in this case, without ICA to achieve the claimed invention. Yanulis Decl., ¶156.

A POSITA would understand that using ICA is a routine design choice and just one of that there are many other methods available to identify data segment for analysis, such as, e.g., principal component analysis (PCA). Yanulis Decl., ¶156. Thus, it would be an obvious variation to apply known methods of identifying the data segments for analyses without using ICA, applying the same statistical methods to achieve expected results.

3. Element 16[iv]-[v]

These elements recite:

> 16[iv]. obtaining, from said analyzing, measurements of one or more physiological parameters; and
> 16[v]. detecting, using the handheld mobile communication device and using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters and deciding whether to retain the measurements based on effects of motion artifacts in the measurements;

’428 Patent, Claim 16. Asada and Chon-570 disclose these elements for the same reasons as Ground 1. Furthermore, it would be obvious to POSITA to decide whether to retain the measurements based on the effects of motion artifacts. A POSITA understands that motion artifacts are noise and may distort interpretations of the data. Thus, in the analysis of physiological signals, a POSITA would decide whether to retain data depending on the effects of motion artifacts. Yanulis Decl., ¶161.

4. Element 16[vi]: wherein the one or more physiological measurements comprise a measure of atrial fibrillation;

Asada with Chon-570 teaches this element. Asada discloses patient monitoring for arrhythmia surveillance and measures vital signs such as “heart rate, arterial blood pressure, arterial oxygen saturation, respiratory rate, temperature, and even cardiac output.” Asada, 29. Asada also discloses “chronic surveillance using WBS [for] the management of heart failure" using various parameters. Asada, 38-39. A POSITA would understand that Asada teaches the physiological measurements relevant to AF, which is a form of arrhythmia. Indeed, the art at the time acknowledged that "Atrial Fibrillation (AF), is one of the most common cardiac arrhythmias, affecting approximately 2-3 million Americans." Chon-570 at 1:8-10; Yanulis Decl., ¶162. Thus, a POSITA would be motivated to implement an algorithm for detecting AF on Asada's system in glight of Chon-570's teachings of AF detection. *See* Yanulis Decl., ¶162.

5. Element 16[vii]: wherein obtaining the measure of atrial fibrillation comprises

As discussed above, a POSITA would be motivated to combine Asada's system with the algorithms in Chon-570 and Chon-2008 to detect AF. Chon-570 uses four statistical methods to identify AF, as demonstrated below.

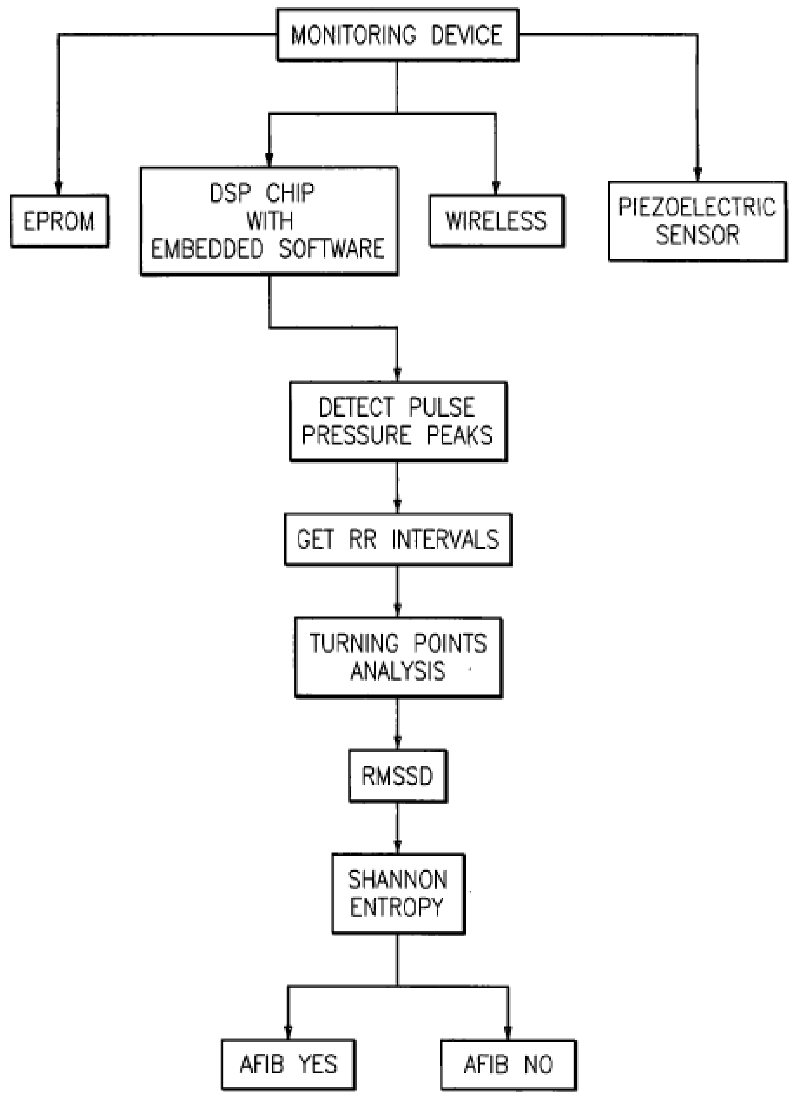


FIG. 7

Chon-570 (Ex-1006), FIG.7, 3:24-29 ("the present invention combines four statistical techniques to exploit a Root Mean Square of Successive RR interval differences to quantify variability (RMSSD), a Turning Points Ratio to test for randomness of the time series (TPR), a Shannon Entropy (SE) to characterize its complexity and a autocorrelation (ACORR) index to characterize correlation between the first two RR intervals."). The results of each of these statistical analyses are compared wit threshold values determined by receiver operator characteristics (ROC). Chon-570, 10:14-17, FIGS. 1(a)-1(f).

While Chon-570 does not explicitly mention using TVCF (derived from 2 TVTFs) to detect AF, it would have been obvious to a POSITA to use this existing method of deriving TVCF taught in Chon-2008 in the detection AF disclosed in Chon-570. Chon-570 determines AF by measuring correlations between signals segments through the autocorrelation function. Chon-570, 7:21-8:7. Since correlation and covariance are both statistically known concepts for measuring the relationships between two segments, a POSITA would find it obvious to try TVCF, in addition to or as an alternative to autocorrelation, to achieve the same purpose of measuring the relationships between the two signal segments. Yanulis Decl., ¶163.

6. Element 16[viii]: obtaining a time-varying coherence function by multiplying two time-varying transfer functions (TVFTs), the two time-varying transfer functions obtained using two adjacent data segments, from the physiological indicator signal, one of the two adjacent data segment as an input signal and another of the two adjacent data segment as an output signal to produce a first TVTF; a second TVTF is produced by reversing the input and the output signals, using said another of the two adjacent data segment as the input signal and said one of the two adjacent data segment as the output signal

Deriving TVCF from two TVTFs was known in the art. Yanulis Decl., ¶166, *citing* Zhao, Abstract (TVCF is estimated by the "multiplication of [] two TVTFs," where "[t]he two TVTFs are obtained using signal x as the input and signal y as the output to produce the first TVTF, and signal y as the input and signal x as the output to produce the second TVTF.". Chon-2008 also discloses this element as follows:

> To demonstrate the use of the TVTF in obtaining the TVCF, we first define the TVCF via the nonparametric time-frequency spectra
>
> $$|\gamma(t,f)|^4 = \left(\frac{|S_{xy}(t,f)|^2}{S_{xx}(t,f)S_{yy}(t,f)}\right)\left(\frac{|S_{yx}(t,f)|^2}{S_{yy}(t,f)S_{xx}(t,f)}\right) \qquad (A7)$$
>
> where $S_{xy}(t, f)$ and $S_{yx}(t, f)$ represent the time-frequency cross spectrum, and $S_{xx}(t, f)$ and $S_{yy}(t, f)$ denote the auto spectrum of the two signals x and y, respectively….We note that for a linear time-varying system with x and y as the input and output signals, respectively, the following TVTF in terms of time-frequency spectra can be obtained
>
> $$H_{xy}(t,f) = \frac{S_{xy}(t,f)}{S_{xx}(t,f)} \qquad (A8)$$
>
> where $H_{xy}(t, f)$ denotes the TVTF from the input *x* to the output *y* signals. Similarly, if we reversed the input and output relationship such that the variables *y* and *x* represent input and output signals, respectively, then the following TVTF can be obtained
>
> $$H_{yx}(t,f) = \frac{S_{yx}(t,f)}{S_{yy}(t,f)} \qquad (A9)$$
>
> The desired relationship of *Eq. A7* can be obtained by multiplying the two TVTF relationships of *Eq. A8* and *Eq. A9*, which yields
>
> $$|H_{xy}(t,f)H_{yx}(t,f)|^2 = \left|\frac{S_{xy}(t,f).}{S_{xx}(t,f)S_{yy}(t,f)}\right|^2 \cdot \left|\frac{S_{yx}(t,f)}{S_{yy}(t,f)S_{xx}(t,f)}\right|^2$$
> $$= \frac{|S_{xy}(t,f)|^2}{S_{xx}(t,f)S_{yy}(t,f)} \cdot \frac{|S_{yx}(t,f)|^2}{S_{yy}(t,f)S_{xx}(t,f)} = |\gamma(t,f)|^4 \qquad (A10)$$
>
> Thus, time-varying magnitude squared coherence, $|y(t, f)|^2$, is then obtained by multiplying the two transfer functions, $|Hxy(t, f)Hyx(t, f)|$, together.

Chon-2008 at R827. In sum, Chon-2008 teaches obtaining TVCF from two TVTFs where the input and output signals are reversed.

7. Element 16[ix]: determining whether the time-varying coherence function is less than a predetermined quantity

Comparing TVCF with a predetermined quantity to determine whether it is below a predetermined quantity was known in the art. Yanulis Decl., ¶168, *citing* Zhao at 299 ("[d]ue to unknown a priori knowledge of the aforementioned conditions, we normally set the threshold value to 0.0001 and 0.001 for clean and noise-corrupted signals, respectively."). This demonstrates that it is common practice to set a predetermined threshold for TVCF in signal processing applications, depending on whether the signal is clean or corrupted. A POSITA would recognize that applying a predetermined threshold to a coherence function is an obvious approach because threshold-based comparisons is a standard technique used to identify statistically significant data. Yanulis Decl., ¶168.

Additionally, Chon-2008 discloses comparing TVCF with a predetermined quantity. For example, a coherence value of less than 0.5 for frequence range 0.03-0.05Hz would "demonstrate substantial nonstationarity in autoregulatory dynamics in demonstrate substantial nonstationarity in autoregulatory dynamics" in certain animal studies. Chon-2008 at Abstract.

C. Dependent Claim 17

Dependent Claim 17 additionally recites "wherein determining whether the time-varying coherence function is less than the predetermined quantity comprises: obtaining one or more indicators of atrial fibrillation; and determining whether the one or more indicators of atrial fibrillation exceed predetermined thresholds." '428 Patent, Claim 17.

Chon-570 discloses this element. Yanulis Decl., ¶¶ 170-171. For example, Chon-570 describes obtaining one or more indicators of atrial fibrillation through applying algorithms such as TPR, RMSSD, SE, and ACORR. Chon-570 at pgs. 5-8. Chon-570 also discloses that "[a] threshold of 0.02 was used for ACORR, that is any value that is greater than 0.02 is considered as AF." Chon-570 at 8:6-7.

Figures of Chon-570 below show ACORR and it demonstrates the threshold for AF detection.

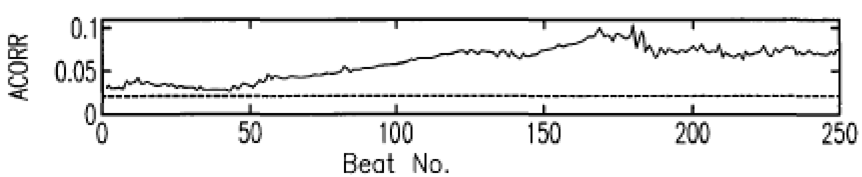


FIG. 1(e)

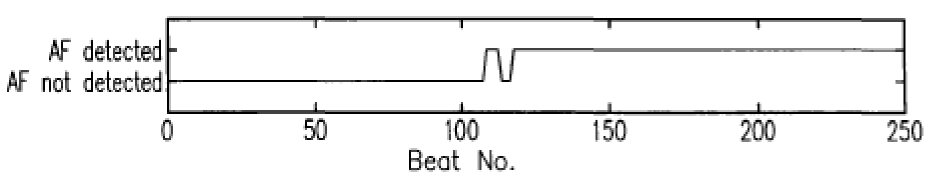


FIG. 1(f)

(Chon-570 (Ex-1006), FIGS. 1(e) & 1(f))

D. Dependent Claim 18

Dependent Claim 18 recites "The method of claim 17 wherein the one or more indicators of atrial fibrillation comprise a variance of the time-varying coherence function." '428 Patent, Claim 18. 172. A POSITA would understand and expect that the variance of TVCF values would be different when a signal segment includes AF as compared to another signal segment that does not have AF. Yanulis Decl., ¶172. Thus, it would be obvious to look at the variance of TVCF to determine AF.

E. Dependent Claim 19

Dependent 19 recites: "The method of claim 18 wherein the one or more indicators of atrial fibrillation also comprise Shannon entropy." '428 Patent, Claim 19. Chon-570 discloses this element. For example, as shown below, Chon-570 discloses using Shannon Entropy (SE) to detect AF.

> In view of a general consideration of AF as being a random sequence of heart beat intervals with markedly increased beat-to-beat variability, the present invention combines four statistical techniques to exploit a Root Mean Square of Successive RR interval differences to quantify variability (RMSSD), a Turning Points Ratio to test for randomness of the time series (TPR), a Shannon Entropy (SE) to characterize its complexity and a autocorrelation (ACORR) index to characterize correlation between the first two RR intervals.

Chon-570 at 3:23-29.

F. Dependent Claim 20

Claim 20 recites: "The method of claim 17 wherein the predetermined thresholds are determined using receiver operator characteristic (ROC) analysis." Chon-570 discloses determining thresholds for root mean square of successive RR differences (RMSSD), Shannon Entropy (SE), and Turning Points Ratio (TPR) using receiver operator characteristic (ROC) curves. Chon-570 at 10:11-17. As demonstrated in figures 1(b)-1(f) of Chon-570, the threshold value is determined using ROC. Chon-570 at FIGS. 1(b)-1(f), 10:16 ("Dotted lines in (b-e) represent threshold values as determined by the ROC.").

G. Independent Claims 32, 42

Independent Claims 32 and 42 are obvious for the same reasons as those discussed in Claim 16. These elements merely describe the conventional hardware components, such as a processor, memory, and computer readable media, used to execute the functions recited in the claims. The use of such hardware components as well as the sensors are well-known in the field of physiological monitoring systems. *See* §§VII.M, VII.B.2.

H. Dependent Claims 33-36, 43-46

These claims correspond to the representative claims previously. The table below summarizes the correspondence.

Representative Claim	Similar Claims
17	33, 43
18	34, 44
19	35, 45
20	36, 46

Accordingly, Dependent Claims 33-36, 43-46 are obvious for the same reasons as those discussed with respect to Claims 17-20.

X. THE BOARD SHOULD REACH THE MERITS OF THIS PETITION

A. Broad Should Not Deny Institution Under § 314(a)

The Board should decline to exercise its discretion to deny institution under 35 U.S.C. §314(a). While Director Vidal's June 21, 2022 Guidance made clear that "Fintiv is limited to facts of that case," for completeness, Petitioner addresses the factors set forth in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential). The six factors set out in *Fintiv* do not justify denying institution.

Factor 1: Potential Stay

The first *Fintiv* factor is neutral because Zepp has not yet moved to stay the district court proceedings pending IPR, and the PTAB should not infer how the district court would rule should a stay be requested. *See, e.g., Hulu LLC v. SITO Mobile R&D IP, LLC et al.*, IPR2021-00298, Paper 11 at 10-11 (PTAB May 19, 2021).

Factor 2: Proximity of Trial to FWD

For the second *Fintiv* factor, the Related Litigation was filed in the Eastern District of Texas on July 31, 2023, a waiver of service was signed on February 6, 2024 and filed with the court on February 7, 2024, and is currently set for trial before District Judge Robert W. Schroeder, III on February 17, 2026. Ex-1015, pg. 1; Ex-1017, 0004, Ex-1019, pg. 1. Even if trial proceeds in February 2026, this timing does not tip in favor of denying this Petition. Indeed, "a court's general ability to set a fast paced schedule is not particularly relevant … where, like here, the forum itself has not historically resolved cases so quickly." *In re Apple Inc.*, 979 F.3d 1332, 1344 (Fed. Cir. 2020). Here, Judge Schroeder currently has seven other patent trials scheduled to begin on February 17, 2026. Ex-1015. Although the currently-scheduled trial date is about six months before a final written decision will issue here (around August 2026), the Board has granted institution in similar circumstances. *See, e.g., NetNut Ltd. v. Bright Data Ltd.*, IPR2021-01492, Paper 12 (PTAB March 21, 2022) (granting institution when trial was scheduled six months before the final written decision deadline).

Further, Judge Schroeder currently has 135 active patent cases and a median time-to-trial of 50.6 months—pushing the realistic trial date here to likely a much later date than February 17, 2026. Ex-1016.

This factor favors institution or is, at worst, neutral.

Factor 3: Investment in Parallel Proceeding

The third *Fintiv* factor weighs strongly against denial. The Related Litigation is in its early stages, with major activities including claim construction term exchanges not even having started as of the filing of this Petition. *See* Ex-1017 (docket entries). The court has not issued any substantive orders, and the parties have not yet invested substantial time in the litigation. *Id*. Because the investment in the trial has been minimal and Petitioner acted diligently, this factor weighs strongly against discretionary denial. *See, e.g., See, e.g., Hulu LLC v. SITO Mobile R&D IP, LLC et al.*, IPR2021-00298, Paper 11, 13.

Factor 4: Overlapping Issues

This factor weighs against discretionary denial. Petitioner offered the following stipulation: If the Board institutes review, Petitioner will not pursue in the Related Litigation the grounds raised or that reasonably could have been raised in this Petition with respect to the claims for which review is instituted. *See Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 at 16-19 (Dec. 1, 2020) (precedential as to §II.A); *see also* Ex-1018. Petition also filed a stipulation to that effect in the Related Litigation. Ex-1018. The Director's June 2022 memorandum states that, when a petitioner so stipulates, "the PTAB will not discretionarily deny institution" due to parallel litigation. June 2022 Memo, supra n.1, at 7.

Furthermore, a FWD in this matter will occur about six months of the currently-scheduled district court trial (assuming that date holds). Thus, to the extent there is any overlapping validity issues, "there is a reasonable likelihood that the Board will address the overlapping validity issues prior to the district court reaching them at trial…, thereby providing the possibility of simplifying issues for trial." *Juniper Networks, Inc. v. Packet Intelligence LLC*, IPR2020-0039, Paper 21, 18 (PTAB Sept. 10, 2020).

Factor 5: The Parties

On the fifth *Fintiv* factor, the Board should give little weight to the fact that Petitioner and Patent Owner are the same parties as in district court. *See Weatherford U.S., L.P., v. Enventure Global Tech., Inc.*, IPR2020-01684, Paper 16, 11-13 (PTAB Apr. 14, 2021). This factor does not outweigh the other factors that strongly weigh against discretionary denial.

Factor 6: Other Circumstances

The Petition's merits are particularly strong as reflected above, which favors institution. *See Align Tech., Inc. v. 3Shape A/S*, IPR2020-01087, Paper 15, 42-43 (PTAB Jan. 20, 2021). Moreover, denying institution would negate Congress's intent in providing a 1-year period to file petitions and would encourage forum shopping.

Taken together, the *Fintiv* factors strongly weigh against denial.

B. Broad Should Not Deny Institution Under § 325(d)

The Board should not exercise its discretion under §325(d) to deny institution. *See Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8, at 17-18 (PTAB Dec. 15, 2017) (precedential) (listing non-exclusive factors).

First, the Board looks to "the similarities and material differences between the asserted art and the prior art involved during examination." *Supra.*, at 17. The primary reference Asada was not considered during examination. Nor are Chon-570 and Chon-2008 references.

Separately, specific with respect to Ground 2, while the Delorme reference was mentioned in the prosecution history for the Shannon Entropy Claims, it was not used to reject a specific claim element, but rather to establish the knowledge of POSITA. Ex-1004, 0614-0617 & 0728. Further, examiner only allowed the rejected independent claims 1, 21, 37 to issue after adding the elements of

- "the physiological indicator signal being obtained from one of an image acquisition component, a PPG sensor, and an electrocardiogram sensor";
- " $SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$ and where i represents the bin number, and p(i) is the probability distribution of the preprocessed segment."

Ex-1004, 0712-716 (2016-12-22 Amendment to Claims). However, these two elements are taught by other prior art not discussed during the prosecution, such as Asada, and Chon-570 respectively.

Second, the examiner never considered the Asada and Chon-570 combination asserted herein, and the Board has declined to exercise discretion to deny a petition under §325(d) where the evidence was insufficient to persuade the Board that the examiner considered the asserted combination. *See, e.g., Weber, Inc. v. Provisur Technologies, Inc.*, IPR2019-01467, Paper 7, at 4 (PTAB, Feb. 14, 2020).

Third, the Board looks to "the extent of the overlap between the arguments made during examination and the manner in which Petitioner relies on the prior art." *Becton, Dickinson*, 17-18. During prosecution, the examiner did not consider the Shannon Entropy formula disclosed in Chon-570 and Asada's disclosures of real-time monitoring with various sensors. Furthermore, while the Patentee argued that the prior art teaches Independent Component Analysis, only the TVCF Claims exclude Independent Component Analysis. Ex-1004, 0677, 0681-0683. The patentee's arguments on ICA are not applicable to the Shannon Entropy Claims. Ex-1004, 0617.

Fourth, at no point during prosecution was the question as to whether Delorme constituted teachings within the relevant art resolved in the applicant's favor. Although the applicant argued that "One skilled in the art following Greco (and with knowledge of Delorme) will not use the Shannon entropy of the preprocessed segment, where the preprocessed segment is the bandpass filtered and detrended segment of the data, and would instead apply ICA and use the Shannon entropy of the components of the ICA." Ex-1004, 0617. Examiner is not persuaded by this argument and maintained the rejection. Moreover, none of the Shannon Entropy Claims excludes ICA. Ex-1004, 0677, 0681-683. As described above, only after the applicant amended all independent claims to include features purportedly above did the examiner allowed the application to issue. Ex-1004, 0712-0716 (2016-12-22 Amendment to Claims).

Thus, the Board should not deny institution under Section 325(d).

XI. CONCLUSION

Accordingly, Petitioner respectfully requests that the Board institute IPR and cancel Claims 1-11, 15-27, 29-30, 32-37, 39-40, 42-46 of U.S. Pat. No. 9,713,428.

Respectfully submitted,

/Jack Shaw/
Jack Shaw (Reg. No. 72,262)

CLAIM LISTING

1[pre]. A method for physiological parameter monitoring, the method comprising:

[i] providing a physiological indicator signal to a handheld mobile communication device; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;

[ii] analyzing, using the handheld mobile communication device, the physiological indicator signal;

[iii] obtaining, from said analyzing, measurements of one or more physiological parameters; and

[iv] detecting, using the handheld mobile communication device and using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters and deciding whether to retain the measurements based on detected effects of motion artifacts;

[v] wherein detecting effects of motion artifacts in the measurements comprises:

a. bandpass filtering and detrending a segment from the measurement of one physiological parameter; wherein a bandpass filtered and detrended segment is hereinafter referred to as a preprocessed segment;

b. obtaining a value of at least one indicator of volatility, used in determining whether motion artifacts are present, for the preprocessed segment; the at least one indicator of volatility being at least Shannon entropy (SE) for the preprocessed segment; where

$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number and, p(i) is the probability distribution of the preprocessed segment;

c. including the segment in analyses of physiological measurements, when comparison of the value of the at least one indicator of volatility with a predetermined threshold indicates noise/motion artifacts are not present; and

d. selecting another segment of the signal from the physiological measurement and proceeding to step (a) when the value of the at least one indicator of volatility is less than a predetermined threshold and when another segment is available.

2. The method of claim 1 wherein said at least one indicator of volatility also comprises kurtosis.

3. The method of claim 1 wherein the predetermined threshold is determined using receiver operator characteristic (ROC) analysis.

4. The method of claim 1 wherein providing a physiological indicator signal comprises:

placing a portion of a subject's body over an objective lens of a camera in a handheld mobile communication device; and

obtaining video images of the portion of the subject's body.

5. The method of claim 1 wherein providing a physiological indicator signal comprises obtaining a signal from a physiological monitoring sensor.

6. The method of claim 5 wherein the physiological monitoring sensor is a photoplethysmographic (PPG) sensor or an electrocardiogram sensor.

7. The method of claim 1 wherein the one or more physiological measurements comprise heart rate and heart rate variability.

8. The method of claim 7 wherein obtaining measurements of heart rate and heart rate variability comprise:

determining beats for the physiological indicator signal;

determining beat to beat intervals; and

applying a cubic spline algorithm to obtain a substantially continuous beat to beat interval signal indicative of heart rate.

9. The method of claim 1 wherein the one or more physiological measurements comprise respiratory rate.

10. The method of claim 9 wherein measurement of respiratory rate comprises:

obtaining time-frequency spectrum of the physiological indicator signal utilizing variable frequency complex demodulation (VFCDM); and

obtaining respiratory rates by extracting a frequency component that has a largest amplitude for each time point at a heart rate frequency band.

11. The method of claim 1 wherein the one or more physiological measurements comprise a measure of oxygen saturation.

15. The method of claim 1 wherein the one or more physiological measurements comprise a measure of atrial fibrillation.

16[pre]. A method for physiological parameter monitoring, the method comprising:

[i] providing a physiological indicator signal to a handheld mobile communication device; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;

[ii] analyzing, using the handheld mobile communication device, the physiological indicator signal;

[iii] wherein analysis does not include Independent Component Analysis;

[iv] obtaining, from said analyzing, measurements of one or more physiological parameters; and

[v] detecting, using the handheld mobile communication device and using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters and deciding whether to retain the measurements based on effects of motion artifacts in the measurements;

[vi] wherein the one or more physiological measurements comprise a measure of atrial fibrillation;

[vii] wherein obtaining the measure of atrial fibrillation comprises:

[viii] obtaining a time-varying coherence function by multiplying two time-varying transfer functions (TVFTs), the two time-varying transfer functions obtained using two adjacent data segments, from the physiological indicator

signal, one of the two adjacent data segment as an input signal and another of the two adjacent data segment as an output signal to produce a first TVTF; a second TVTF is produced by reversing the input and the output signals, using said another of the two adjacent data segment as the input signal and said one of the two adjacent data segment as the output signal; and

[ix] determining whether the time-varying coherence function is less than a predetermined quantity.

17. The method of claim 16 wherein determining whether the time-varying coherence function is less than the predetermined quantity comprises:

obtaining one or more indicators of atrial fibrillation; and

determining whether the one or more indicators of atrial fibrillation exceed predetermined thresholds.

18. The method of claim 17 wherein the one or more indicators of atrial fibrillation comprise a variance of the time-varying coherence function.

19. The method of claim 18 wherein the one or more indicators of atrial fibrillation also comprise Shannon entropy.

20. The method of claim 17 wherein the predetermined thresholds are determined using receiver operator characteristic (ROC) analysis.

21[pre]. A system for physiological parameter monitoring, the system comprising:

[i] a physiological indicator signal sensing component; the physiological indicator signal sensing component being one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor; and a handheld mobile communication device comprising:

[ii] at least one processor; and

[iii] at least one computer usable medium, the computer usable medium having computer readable code embodied therein, the computer readable code causing the at least one processor to:

[iv] analyze the physiological indicator signal;

[v] obtain, from results of analyzing, measurements of one or more physiological parameters; and

[vi] detect effects of motion artifacts in the measurements of the one or more physiological parameters;

[vii] wherein the computer readable code, in causing the at least one processor to detect effects of motion artifacts, causes the at least one processor to:

a. bandpass filter and detrend a segment from the measurement of one physiological parameter; wherein a bandpass filtered and detrended segment is hereinafter referred to as a preprocessed segment;

b. obtain a value of at least one indicator of volatility, used in determining whether motion artifacts are present, for the preprocessed segment; the at least one indicator of volatility being at least Shannon entropy (SE) for the preprocessed segment; where

$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number, and p(i) is the probability distribution of the preprocessed segment;

c. include the segment in analyses of physiological measurements when comparison of the value of the at least one indicator of volatility with a predetermined threshold indicates noise/motion artifacts are not present; and

d. select another segment of the signal from the physiological measurement and proceeding to step (a) when the value of the at least one indicator of volatility is less than a predetermined threshold and another segment is available.

22. The system of claim 21 wherein said at least one indicator of volatility also comprises kurtosis.

23. The system of claim 21 wherein the predetermined threshold is determined using receiver operator characteristic (ROC) analysis.

24. The system of claim 21 wherein the physiological indicator signal sensing component comprises an image acquisition component, said acquisition component capable of acquiring a number of frames, each frame acquired at a predetermined time.

25. The system of claim 24 wherein the handheld mobile communications device comprises said image acquisition component.

26. The system of claim 21 wherein the physiological indicator signal sensing component comprises a physiological monitoring sensor.

27. The system of claim 26 wherein the physiological monitoring sensor is a photoplethysmographic (PPG) sensor or an electrocardiogram sensor.

29. The system of claim 21 wherein the one or more physiological measurements comprise heart rate and heart rate variability; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

determine beats for the physiological indicator signal;

determine beat to beat intervals; and

apply a cubic spline algorithm to obtain a substantially continuous beat to beat interval signal indicative of heart rate.

30. The system of claim 21 wherein the one or more physiological measurements comprise respiratory rate; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

obtain time-frequency spectrum of the physiological indicator signal utilizing variable frequency complex demodulation (VFCDM); and

obtain respiratory rates by extracting a frequency component that has a largest amplitude for each time point at a heart rate frequency band.

32[pre]. A system for physiological parameter monitoring, the system comprising:

[i] a physiological indicator signal sensing component; and a handheld mobile communication device comprising:

[ii] at least one processor; and

[iii] at least one computer usable medium, the computer usable medium having computer readable code embodied therein, the computer readable code causing the at least one processor to:

[iv] analyze the physiological indicator signal; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;

[v] wherein analysis does not include Independent Component Analysis;

[vi] obtain, from results of analyzing, measurements of one or more physiological parameters; and

[vii] detect effects of motion artifacts, using only the measurements of one or more physiological parameters, in the measurements of the one or more physiological parameters; wherein the one or more physiological measurements comprise a measure of atrial fibrillation; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

[viii] obtain a time-varying coherence function by multiplying two time-varying transfer functions (TVFTs), the two time-varying transfer functions obtained using two adjacent data segments from the physiological indicator signal, one of the two adjacent data segment as an input signal and another of the two adjacent data segment as an output signal to produce a first TVTF; a second TVTF is produced by reversing the input and the output signals, using said another of the two adjacent data segment as the input signal and said one of the two adjacent data segment as the output signal; and

[ix] determine whether the time-varying coherence function is less than a predetermined quantity.

33[pre]. The system of claim 32 wherein the computer readable code, in causing the at least one processor to determine whether the time-varying coherence function is less than the predetermined quantity, causes the at least one processor to:

[i] obtain one or more indicators of atrial fibrillation; and

[ii] determine whether the one or more indicators of atrial fibrillation exceed predetermined thresholds.

34. The system of claim 33 wherein the one or more indicators of atrial fibrillation comprise a variance of the time-varying coherence function.

35. The system of claim 34 wherein the one or more indicators of atrial fibrillation also comprise Shannon entropy.

36. The system of claim 34 wherein the predetermined thresholds are determined using receiver operator characteristic (ROC) analysis.

37[pre]. A non-transitory computer usable medium having computer readable code embodied therein, the computer readable code causing at least one processor to:

[i] analyze a physiological indicator signal; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;

[ii] obtain, from said analyzing, measurements of one or more physiological parameters; and

[iii] detect, using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters;

[iv] wherein the computer readable code, in causing the at least one processor to detect effects of motion artifacts, causes the at least one processor to:

a. bandpass filter and detrend a segment from the measurement of one physiological parameter; wherein a bandpass filtered and detrended segment is hereinafter referred to as a preprocessed segment;

b. obtain a value of at least one indicator of volatility, used in determining whether motion artifacts are present, for the preprocessed segment; the at least one indicator of volatility being at least Shannon entropy (SE) for the preprocessed segment; where

$$SE = -\sum_{i=1}^{k} \frac{p(i) * \log(p(i))}{\log\left(\frac{1}{k}\right)}$$

and where i represents the bin number, and p(i) is the probability distribution of the preprocessed segment;

c. include the segment in analyses of physiological measurements when comparison of the value of the at least one indicator of volatility with a predetermined threshold indicates noise/motion artifacts are not present; and

d. select another segment of the signal from the physiological measurement and proceeding to step (a) when the value of the at least one indicator of volatility is less than a predetermined threshold and another segment is available.

39. The computer usable medium of claim 37 wherein the one or more physiological measurements comprise heart rate and heart rate variability; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

determine beats for the physiological indicator signal;

determine beat to beat intervals; and

apply a cubic spline algorithm to obtain a substantially continuous beat to beat interval signal indicative of heart rate.

40. The computer usable medium of claim 37 wherein the one or more physiological measurements comprise respiratory rate; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

obtain time-frequency spectrum of the physiological indicator signal utilizing variable frequency complex demodulation (VFCDM); and

obtain respiratory rates by extracting a frequency component that has a largest amplitude for each time point at a heart rate frequency band.

42[pre]. A non-transitory computer usable medium having computer readable code embodied therein, the computer readable code causing at least one processor to:

[i] analyze the physiological indicator signal; the physiological indicator signal being obtained from one of an image acquisition component, a photoplethysmographic (PPG) sensor and an electrocardiogram sensor;

[ii] wherein analysis does not include Independent Component Analysis;

[iii] obtain, from said analyzing, measurements of one or more physiological parameters; and

[iv] detect, using only the measurements of one or more physiological parameters, effects of motion artifacts in the measurements of the one or more physiological parameters; wherein the one or more physiological measurements comprise a measure of atrial fibrillation; and wherein the computer readable code, in causing the at least one processor to analyze the physiological indicator signal, causes the at least one processor to:

[v] obtain a time-varying coherence function by multiplying two time-varying transfer functions (TVFTs), the two time-varying transfer functions obtained using two adjacent data segments, from the physiological indicator signal, one of the two adjacent data segment as an input signal and another of the two adjacent data segment as an output signal to produce a first TVTF; a second TVTF is produced by reversing the input and the output signals, using said another of the two adjacent data segment as the input signal and said one of the two adjacent data segment as the output signal; and

[vi] determine whether the time-varying coherence function is less than a predetermined quantity.

43. The non-transitory computer usable medium of claim 42 wherein the computer readable code, in causing the at least one processor to determine whether the time-varying coherence function is less than the predetermined quantity, causes the at least one processor to:

obtain one or more indicators of atrial fibrillation; and

determine whether the one or more indicators of atrial fibrillation exceed predetermined thresholds.

44. The non-transitory computer usable medium of claim 43 wherein the one or more indicators of atrial fibrillation comprise a variance of the time-varying coherence function.

45. The non-transitory computer usable medium of claim 44 wherein the one or more indicators of atrial fibrillation also comprise Shannon entropy.

46. The computer usable medium of claim 43 wherein the predetermined thresholds are determined using receiver operator characteristic (ROC) analysis.

CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME LIMITATION, TYPEFACE REQUIREMENTS, AND TYPE-STYLE REQUIREMENTS

Pursuant to 37 C.F.R. §42.24(d), I certify that the foregoing Petition complies with the type-volume limitation of 37 C.F.R. §42.24 and contains 11,814 words based on the word count indicated by the word-processing system used to prepare the paper, excluding the parts exempted by 37 C.F.R. §42.24(a). Further, the foregoing Petition complies with the general format requirements of 37 C.F.R. §42.6(a) and has been prepared using Microsoft Word in 14-point Times New Roman.

Dated: February 4, 2025

Respectfully submitted,

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CERTIFICATE OF SERVICE (37 C.F.R. §42.6(e)(1))

The undersigned hereby certifies that the above document was served on February 4, 2025, by filing this document through the Patent Trial and Appeal Board P-TACTS System, as well as delivering a copy via express mail upon the following attorneys of record for the Patent Owner.

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