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DECLARATION OF GERARD P. GRENIER

I, Gerard P. Grenier, am over twenty-one (21) years of age. I have never been convicted of a felony, and I am fully competent to make this declaration. I declare the following to be true to the best of my knowledge, information and belief:

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2. IEEE is a neutral third party in this dispute.

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8. The article below has been attached as Exhibit A to this declaration:

A.	G. Comtois, et al. "A Comparative Evaluation of Adaptive Noise Cancellation Algorithms for Minimizing Motion Artifacts in a Forehead-Mounted Wearable Pulse Oximeter" 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007, August 22-26, 2007.

9. I obtained a copy of Exhibit A through IEEE Xplore, where it is maintained in the ordinary course of IEEE's business. Exhibit A is a true and correct copy of the Exhibit as it existed on or about October 25, 2016.

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11. G. Comtois, et al. "A Comparative Evaluation of Adaptive Noise Cancellation Algorithms for Minimizing Motion Artifacts in a Forehead-Mounted Wearable Pulse Oximeter" was published in the 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007. The 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007 was held from August 22-26, 2007. Attendees of the conference were provided copies of the publication no later than the last day of the conference. The article is currently available for public download from the IEEE digital library, IEEE Xplore.

12. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

I declare under penalty of perjury that the foregoing statements are true and correct.

Executed on: 25 Oct. 2016

EXHIBIT A

A Comparative Evaluation of Adaptive Noise Cancellation Algorithms for Minimizing Motion Artifacts in a Forehead-Mounted Wearable Pulse Oximeter

3 Author(s)

Gary Comtois ; Yitzhak Mendelson ; Piyush Ramuka

View All Authors

Abstract:
Wearable physiological monitoring using a pulse oximeter would enable field medics to monitor multiple injuries simultaneously, thereby prioritizing medical intervention when resources are limited. However, a primary factor limiting the accuracy of pulse oximetry is poor signal-to-noise ratio since photoplethysmographic (PPG) signals, from which arterial oxygen saturation (SpO_2) and heart rate (HR) measurements are derived, are compromised by movement artifacts. This study was undertaken to quantify SpO_2 and HR errors induced by certain motion artifacts utilizing accelerometry-based adaptive noise cancellation (ANC). Since the fingers are generally more vulnerable to motion artifacts, measurements were performed using a custom forehead-mounted wearable pulse oximeter developed for real-time remote physiological monitoring and triage applications. This study revealed that processing motion-corrupted PPG signals by least mean squares (LMS) and recursive least squares (RLS) algorithms can be effective to reduce SpO_2 and HR errors during jogging, but the degree of improvement depends on filter order. Although both algorithms produced similar improvements, implementing the adaptive LMS algorithm is advantageous since it requires significantly less operations.

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Noise cancellation, Biomedical monitoring, Pulse measurements, Heart rate, Least squares approximation, Injuries, Limiting, Signal to noise ratio, Fingers, Motion measurement

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plethysmography, accelerometers, blood vessels, cardiology, least mean squares methods, oximetry, oxygen, patient diagnosis

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recursive least square algorithm, adaptive noise cancellation algorithms, motion artifacts, wearable pulse oximeter, photoplethysmographic signals, arterial oxygen saturation, heart rate, least mean squares algorithm

Algorithms, Artifacts, Clothing, Diagnosis, Computer-Assisted, Forehead, Humans, Monitoring, Ambulatory, Movement, Reproducibility of Results, Sensitivity and Specificity

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