Vitals: Camera-based Physiological Monitoring and Health Management Platform

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ABSTRACT

Remote photoplethysmography (rPPG) enables an effective way to measure human physiological signals by capturing subtle light variations on the skin with an off-the-shelf camera. Due to its non-contact nature and compatibility with a widespread of existing hardware, rPPG offers significant potential in the future of digital health and wellness applications. We developed *Vitals*, a practical and cost-effective solution for remote vital signs measurement and health management that can be easily deployed to our everyday devices and embedded into our daily routines. In addition, the solution provides the feature to manage one's health information over time, which enables historical analysis of trends and further insights into health risk factors. *Vitals* demonstrates the promise of camera-based physiological monitoring and illustrates its potential as a tool for pervasive healthcare.

ACM Reference Format:
Kwan Long Wong, Jing Wei Chin, Tsz Tai Chan, Kunnipa Prae-arporn, Richard H.Y. So. 2022. Vitals: Camera-based Physiological Monitoring and Health Management Platform. In *ACM/IEEE International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE' 22), November 17–19, 2022, Washington, DC, USA*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3551455.3559612

1 INTRODUCTION

Vital signs are useful indicators to assess the human body's basic functions and well-being. Routine monitoring of metrics like heart rate (HR), respiration rate (RR), body temperature (BT), oxygen saturation (SPO2), and blood pressure (BP) can provide insights into a person's health, detect underlying issues, improve health awareness, and encourage a healthier lifestyle. Significant fluctuation in a person's vital signs can further indicate the possibility of cardiovascular, respiratory, or neurological diseases and other chronic illnesses [4].

Photoplethysmography (PPG) is an optical technique that measures the change in blood volume under the skin based on the amount of transmitted and reflected light captured by a photodetector. The extracted PPG signal contains clinically relevant information about a subject's vital signs and other physiological characteristics [1, 4]. Pulse oximeters are common instruments that utilize PPG to measure SPO2 and HR. However, as with many contact-based devices, they suffer from various usability and cost limitations. Therefore, remote PPG (rPPG) methods have received significant interest, especially when the pandemic has not subsided at the time of writing this paper.

Over the last decade, rPPG has opened many new possibilities for remote patient monitoring research and applications. The technology utilizes an off-the-shelf camera (e.g., digital, webcam, mobile) to extract the PPG signal typically from the face, the so-called rPPG signal. While HR is currently the most widely studied vital sign, researchers have already been able to successfully extract RR, heart rate variability (HRV), SPO2, and BP from the rPPG signal [2, 6]. Studies have also used rPPG to indirectly monitor a person's autonomic nervous system [3?].

Camera-based physiological monitoring will play a pivotal role in the future of digital health, empowering industries such as telemedicine, chronic disease management, elderly and neonatal care, autonomous vehicles, corporate wellness, and more. In this work, we propose *Vitals*, a software-based solution for remote measurement of vital signs without the need to a contact-based device. Due to its flexible architecture and minimal hardware requirement, *Vitals* is compatible with most existing cameras and devices, demonstrating an efficient and accessible solution that can be integrated into our daily routines.

2 TECHNOLOGY

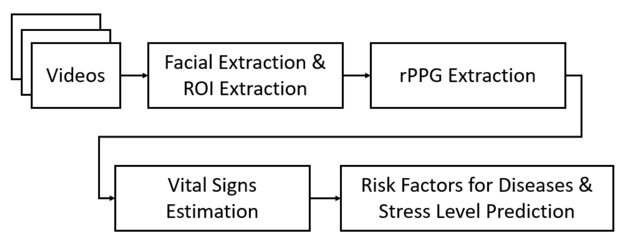


Figure 1: Software Pipeline to Extract Physiological Information from Facial Videos

Vitals utilizes innovative computer vision and signal processing techniques to obtain physiological information from facial videos [2, 5, 6]. Figure 1 presents the general software pipeline of *Vitals*. First, a face detector (e.g., Viola and Jones algorithm) identifies the face box of the person in each video frame. Pre-processing methods (e.g., skin detection and filtering) are applied to mask any areas that may contain noise. Next, the rPPG signal is extracted from selected regions-of-interest (ROIs), such as the cheeks, defined within each processed face box. After that, various machine learning and post-processing techniques (e.g., machine learning, frequency analysis and peak detection) are used to extract specific vital signs such as HR, RR, HRV, and BP from the rPPG signal [2, 6]. Along with the user's demographic information, the extracted vital signs are used

CHASE' 22, November 17–19, 2022, Washington, DC, USA

ACM ISBN 978-1-4503-9476-5/22/11.
https://doi.org/10.1145/3551455.3559612

to predict potential risk factors and attributes of the autonomic nervous system. *Vitals* has been validated against FDA-approved contact-based devices in experimental (Figure 2) and real-world settings, achieving a promising accuracy of over 98% for selected vital signs.

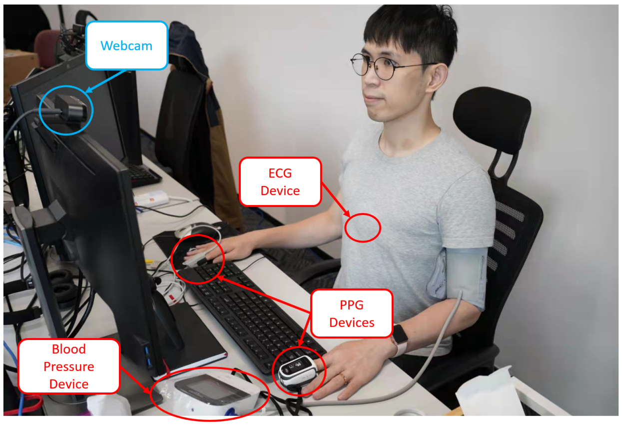
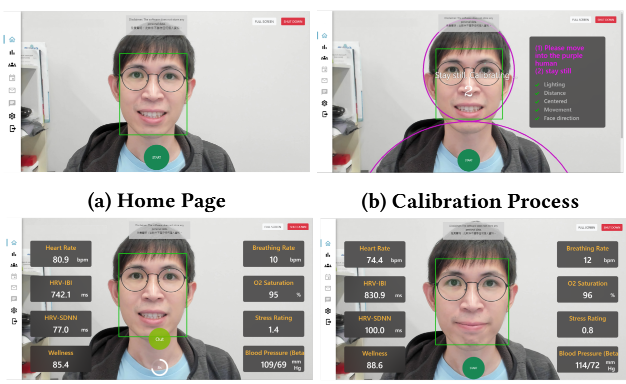


Figure 2: Demonstration of the validation setup against FDA-approved contact-based devices. Subject sat in front of a normal webcam connected to a PC running the *Vitals* software.

3 USER INTERACTION

3.1 Vital Signs Measurement



(a) Home Page **(b) Calibration Process**

(c) 30-second Scan **(d) Finish Scanning**

Figure 3: (a) Home Page with face box overlay on the user (b) Calibration process and condition checking before scan. (c) Real-time visualizations during the 30-second scan. (d) Final display after scan completion.

Vitals is designed for a single user to measure their vital signs by looking at the camera for 30 seconds. Figure 3 illustrates the general flow of the measurement process. After starting up the software, the user will arrive on the Home Page and observe the green face box overlay to indicate that a face has been detected. After clicking the start button, the software will perform a calibration check for lighting, distance, centering, movement, and face orientation. Once the calibration process finishes, the software will proceed to the scanning phase and continuously update the vital sign measurements for 30 seconds.

3.2 Health Management

Figure 4: Dashboard for Health Management

After completing the vital signs measurement, the user will be directed to the personalized health management dashboard (Figure 4). The dashboard provides a simple interface to visualize the user's measurements over a specified time period and includes warning indications of any abnormalities. For each vital sign, the user can also view the normal range according to their demographic information, trend analysis, and suggestions to improve or maintain their reading.

4 CONCLUSION

We present an innovative solution for vital signs monitoring and health management without the use of a contact-based device. *Vitals* is an example that represents the potential of digital health technologies that enable pervasive healthcare. Especially during the time of the pandemic, the value of remote patient monitoring technologies will only continue to grow.

REFERENCES

[1] Malak Abdullah Almarshad, Md Saiful Islam, Saad Al-Ahmadi, and Ahmed S BaHammam. 2022. Diagnostic Features and Potential Applications of PPG Signal in Healthcare: A Systematic Review. In *Healthcare*, Vol. 10. MDPI, 547.
[2] Chun-Hong Cheng, Kwan-Long Wong, Jing-Wei Chin, Tsz-Tai Chan, and Richard HY So. 2021. Deep learning methods for remote heart rate measurement: a review and future research agenda. *Sensors* 21, 18 (2021), 6296.
[3] Oliver Faust, Wanrong Hong, Hui Wen Loh, Shuting Xu, Ru-San Tan, Subrata Chakraborty, Prabal Datta Barua, Filippo Molinari, and U Rajendra Acharya. 2022. Heart rate variability for medical decision support systems: A review. *Computers in Biology and Medicine* (2022), 105407.
[4] Hui Wen Loh, Shuting Xu, Oliver Faust, Chui Ping Ooi, Prabal Datta Barua, Subrata Chakraborty, Ru-San Tan, Filippo Molinari, and U Rajendra Acharya. 2022. Application of Photoplethysmography signals for Healthcare systems: An in-depth review. *Computer Methods and Programs in Biomedicine* (2022), 106677.
[5] Kwan Long Wong, Jing Wei Chin, Tsz Tai Chan, Ismoil Odinaev, Kristian Suhartono, Kang Tianqu, and Richard H.Y. So. 2022. Optimising rPPG Signal Extraction by Exploiting Facial Surface Orientation. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops*. 2165–2171.
[6] Sebastian Zaunseder and Stefan Rasche. 2022. Clinical applications for imaging photoplethysmography. *Contactless Vital Signs Monitoring* (2022), 149–164.