IJITCE

ISSN 2347- 3657

International Journal of
Information Technology & Computer Engineering

Email : ijitce.editor@gmail.com or editor@ijitce.com

International Journal of Information Technology & Computer Engineering
ISSN 2347–3657
Volume 15, Issue 3, 2024
https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

PUPILHEART: HEART RATE VARIABILITY MONITORING VIA PUPILLARY FLUCTUATIONS ON MOBILE DEVICES

[1]Dr. T.Ram Kumar,[2]S. Srinaya Reddy,[3]V. Archana,[4]V. Vennela
[1]Professor,[234]Students
Department Of CSE
Malla Reddy Engineering College for Women

ABSTRACT

Heart disease has escalated into a major public health concern despite the fact that it is preventable with early detection and treatment. Therefore, it is crucial to examine heart health every day. Seismocardiography (SCG) and photo plethysmography (PPG) are the mainstays of current mobile cardiac monitoring devices. People can't keep tabs on their hearts whenever and wherever they want to since these techniques are cumbersome and need extra equipment. We propose a method to monitor the user's heart rate by analyzing their pupillary reaction when they unlock their phone using face recognition. This method is based on our discovery of the association between pupil size and heart rate varaiability (HRV). We provide PupilHeart, a server-side and mobile terminal-based computer vision-based mobile HRV monitoring platform, with this goal in mind. At the time of phone unlock using the front-facing camera, PupilHeart records data on the user's pupil size change on the mobile terminal. The server side then pre-processes the raw pupil size data. In order to detect HRV-related time series characteristics, PupilHeart employs a 1D-convolutional neural network. The PupilHeart app also models the pupil and HRV using a three-layered recurrent neural network (RNN). With this model, PupilHeart can determine the user's heart state every time they unlock their phone by inferring their HRV. In order to thoroughly assess the efficacy of PupilHeart, we recruit 60 individuals and do both laboratory and field investigations using the prototype. All things considered, PupilHeart successfully predicts the user's HRV.

1. INTRODUCTION

HEART: The most vital organ in the body, it keeps metabolism regular and pumps blood to all the other parts of the body [1]. The risk to human life from heart disease is substantial. Heart disease is responsible for 30% of all deaths worldwide, killing around 17.5 million people year (WHO) [2]. So, it's crucial for people to keep an eye on their heart health in their daily lives.

The variability in the time between each pulse, sometimes called heart rate volatility (HRV) [3, 4], is a common metric used to assess cardiac health. Alternatively, it may be used for the diagnosis or prevention of cardiovascular and other disorders due to the implicit information it carries on the regulation of the circulatory system by neuro-humoral variables. Also, as stated in [6], HRV measurements and spectral component quantification are strong indicators of cardiovascular mortality and morbidity. So, it might be useful for determining when individuals suffering from ischemic heart disease can return to their jobs. Various medical conditions, as well as the heart's autonomic nervous system (ANS) activity and balance, may be revealed by clinical study of heart rate variability (HRV) [7]. As a general rule, a low HRV indicates that your body is less resilient and has trouble adjusting to new circumstances, both of which might be indicators of present or future health issues. Those with greater resting heart rates are likewise more likely to experience it. Reason being, variability is less likely to occur when your heart is pumping blood more quickly since there is less time between each beat. Diabetes, hypertension, cardiac arrhythmia, asthma, anxiety, and depression are common medical diseases that manifest in this way. Put simply, HRV monitoring may be used to track heart health.

There are primarily two types of heart rate monitors on the market today: those designed for medical use and those designed for consumer use [8]. The majority of hospital-based medical heart rate monitors, like ECG equipment, are connected and include a number of sensors [9]. Holter monitors, which are portable medical equipment, have also been created at this time [10]. Wireless consumer heart rate monitors, on the other hand, are designed for regular use. In particular, optical heart rate monitors and electrical ones are available to consumers [11]. A transmitter and receiver make up the electrical monitors. The transmitter is worn on the chest, and the receiver is attached to the monitor. The receiver receives a radio signal indicating the presence of a heartbeat and uses it to show or calculate the current heart rate [4], [12]. Smartwatches and other optical-based heart monitoring systems work by illuminating the skin with an LED light and then measuring the amount of light scattered off of blood vessels to get an accurate reading of the wearer's heart rate [13], [14]. Unfortunately, there are currently no easy ways to monitor heart rate without resorting to expensive and time-consuming expert supervision or supplementary equipment.

We pose the following question in this context: is it possible to track users' HRVs as they go about their everyday lives, without the need for specialized tools or expert advice? The sympathetic and parasympathetic nerves are responsible for controlling the heart rate and the pupils, according to recent research [15], [16].Hence, alterations in the pupil are associated with fluctuations in the heart rate. For instance, in response to fear, the parasympathetic nerve slows down while the sympathetic nerve speeds up, leading to a reduced pupil width and a higher heart rate. We investigate the quantitative relationship between HRV and pupil size based on this approach. Also, as technology progresses, more and more people are getting smartphones, and among them, the number of models that use face recognition to unlock is on the rise. More than 800 million people throughout the globe use smartphones with facial recognition capabilities, and the typical user unlocks their phone fifty times daily, according to

International Journal of Information Technology & Computer Engineering
ISSN 2347–3657
Volume 15, Issue 3, 2024
https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

[17], [18]. Consequently, in order to do HRV monitoring, we are considering employing the front-facing camera of mobile phones to capture the user's pupil movements when they unlock the phone using face recognition, all while respecting the privacy policy. If implemented properly, pupil-based mobile HRV monitoring has the potential to provide many benefits not seen with current approaches:

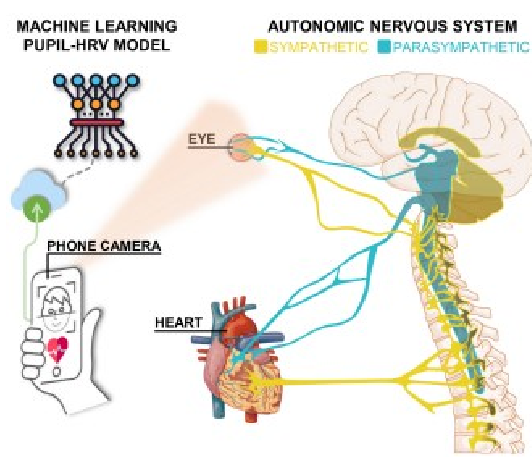
• Ease of use. There is no need for specialized equipment or expert instruction while monitoring HRV on mobile devices, and the equipment is far more portable than what is required by professionals.

• Precision. In order to ensure the accuracy of HRV monitoring, mobile device unlocking-based methods use various time periods and user physiological and mental states. This results in a larger sample size.

We start by looking at the first qualitative correlation between the size of the pupil and the heart rate as recorded by the front-facing camera of smartphones. On this basis, we infer HRV from papillary response in a more thorough and reliable manner. We face a number of significant technological obstacles on the path to success. To start, papillary response is a complex physiological process; although some elements may be extracted from this process, it is challenging to determine those features that are pertinent to heart rate variability (HRV). Even after identifying the characteristics of the papillary response, it is not easy to correlate them with HRV. Finally, there are niche difficulties that arise in mobile contexts. For instance, the recorded facial pictures might be severely affected by variations in light intensity or motion.

To overcome these obstacles, we present Pupil Heart, the first portable HRV monitoring device that takes use of the pupil's response, or the change in pupil size over time. First, we will take a look at Pupil Heart's related functions, as seen in the picture, and see how it takes use of the heart-eye connection in the autonomic nervous system. After that, in Section III, we investigate the connection between the user's heart rate and the diameter of their pupils. Pupil Heart's technical characteristics are detailed in Sec. IV. Section V presents the results of the Pupil Heart performance assessments. Sec. VI discusses the work's limitations, and Sec. VII concludes the work.

2. SYSTEM ARCHITECTURE



3. EXISTING SYSTEM

ISSN 2347–3657

Volume 15, Issue 3, 2024

https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

More and more studies in recent years have focused on tracking HRV in mobile settings. In general, we may divide such approaches into two categories. The first set of methods measures HRV using photoplethysmography (PPG) [19]-[25]. The method described in [19] relies on snapping pictures of the subject's finger with the phone's camera while activating the flash in order to determine the subject's heart rate based on the quantity of light that the finger tissues absorb.

In addition, Bolkovsky et al. [20] apply a complicated technique to estimate HRV from RR intervals captured by both Android and iPhone phones. Also investigated is how different sample rates for Android and iOS phones impact the precision of HRV readings. Plews et al. [21] also supports PPG via mobile phone, demonstrating a near-perfect correlation with ECG, with a tolerable amount of technical error in estimate and small variations in standard deviations. Extracting CIS-photoplethysmography (CPPG) data points from CMOS image sensor (CIS) pixel rows has been achieved using the rolling shutter camera mechanism. This allows for the extraction of high frame rate CPPG signals from a standard built-in low frame rate smartphone's CIS [25]. Regarding the particular uses, PPG is used to assess HRV in individuals who have suffered from spinal cord damage (SCI) [24].

The second set of researchers relies on seismocardiography (SCG), a non-invasive and straightforward technique for measuring HRV by capturing the motions of the heart as it pumps blood throughout the body. A smartphone is used to capture this movement and estimate heart rate in a pilot investigation by J. Ramos- Castro et al. [26]. As a biometric feature, Lei Wang et al. [27] employ chest vibrations caused by heartbeat to authenticate users on mobile devices. In addition, M. Scarpetta et al. [28] detail a technique that uses a smartphone to monitor both heart rate and breathing intervals at the same time.

For this purpose, we use a standard smartphone accelerometer to track the SCG signal produced by the heart and the acceleration caused by breathing. To add to that, Mirella Urzeniczok et al. [29] provide a SCG-based smartphone app for real-time heart rate monitoring, with the pulse being identified using a modified Pan-Tompkins method. Using either PPG or SCG, the aforementioned techniques all assess HRV. By using a distinct approach that relies on pupillary response characteristics, we were able to circumvent the need for the user to maintain a steady state or supplementary equipment for PPG and SCG measurements of HRV. This is the first study that we are aware of that uses pupil data on mobile devices to track a user's heart rate variability.

Disadvantages

- The system did not use the Connecting Pupil with HRV model in the current study, which results in reduced effectiveness.

International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 15, Issue 3, 2024

https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

- The absence of Graph Neural Network and other ML classifiers results in worse system performance.

4. PROPOSED SYSTEM

1) In mobile settings, we investigate the link between pupil size and HRV in detail. As far as we are aware, this is the first study to investigate the quantitative association between HRV on mobile devices and people's papillary responses.
2) By excavating the general physiological processes of papillary responses using a 1-D CNN, high-dimensional time-series characteristics linked to the user's heart rate variability are found.
3) To model the link between pupil and HRV, we employ RNN to train the high-dimensional time-series features recovered by 1-D CNN.
4) We enlist a total of 60 individuals for a comprehensive experiment to verify the efficacy of PupilHeart.1. The findings demonstrate that PupilHeart's accuracy may reach an average of 91.37%.

Advantages

- Convenience. Compared to professional equipment, mobile device HRV monitoring is much more portable and doesn't need specialized tools or expert advice.
- Precision. The accuracy of HRV monitoring is guaranteed by the use of many time periods and user physiological and mental situations in mobile device unlocking HRV monitoring, which yields a greater number of samples.

5. IMPLEMENTATION

Modules Description

Service Provider

A valid username and password are required for the Service Provider to access this module. He would be able to do actions like browsing datasets and running tests and training on them when he successfully logs in. Discover the Heart Rate Variability Detection Type Ratio, examine the Bar Chart showing Trained and Tested Accuracy, examine the Results of Trained and Tested Accuracy, examine the Prediction Of Heart Rate Variability Detection Type, and download the Data Sets With Predictions. See the Type Ratio Results for Heart Rate Variability Detection, See All Users From a Distance.

View and Authorize Users

The admin can get a complete rundown of all registered users in this section. Here, the administrator may see the user's information (name, email, and address) and grant them access.

Remote User

All all, there are n users in this module. Registration is required prior to performing any operations. Details will be entered into the database after a user registers. He will need to log in using the permitted username and password when registration is

International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 15, Issue 3, 2024

https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

completed. After logging in, users will be able to perform things like predict the kind of heart rate variability detection, REGISTER AND LOGIN, Check Out Your Account.

6. CONCLUSION

Pupil Heart is a suggested mobile HRV monitoring system in this study. It consists of a server side component and a mobile terminal based on computer vision. Pupil Heart has taken use of the front-facing camera on mobile phones to gather data on pupil size during face identification on the mobile terminal. After the raw pupil size data was preprocessed on the server side, Pupil Heart used 1DCNN to extract high-dimensional features. From this, a pupil-HRV model was generated using RNN. Based on that, Pupil Heart has successfully implemented daily HRV monitoring. We have recruited 60 people to participate in experimental and outdoor trials, and we have prototyped Pupil Heart to assess its effectiveness. Taken together, the findings demonstrate that Pupil Heart successfully predicts the user's HRV while using facial recognition to unlock phones. Overarchingly, Pupil-Heart gives us a model to investigate the relationship between pupil size and HRV, illuminating a practical and novel concept for developing HRV monitoring solutions for mobile devices. We want to further develop our Pupil Heart system in subsequent works by conducting trials with a wider variety of devices, people, and environmental circumstances.

REFERENCES

[1] J. I. Hoffman and S. Kaplan, "The incidence of congenital heart disease," Journal of the American college of cardiology, vol. 39, no. 12, pp. 1890–1900, 2002.

[2] G. WHO, "WHO methods and data sources for global burden of disease estimates 2000–2011," Geneva: Department of Health Statistics and Information Systems, 2013.

[3] R. Castaldo, P. Melillo, U. Bracale, M. Caserta, M. Triassi, and L. Pecchia, "Acute mental stress assessment via short term HRV analysis in healthy adults: A systematic review with meta-analysis," Biomedical Signal Processing and Control, vol. 18, pp. 370–377, 2015.

[4] F. Wang, X. Zeng, C. Wu, B. Wang, and K. R. Liu, "mmhrv: Contactless heart rate variability monitoring using millimeter-wave radio," IEEE Internet of Things Journal, vol. 8, no. 22, pp. 16 623–16 636, 2021.

[5] F. Lombardi, "Clinical implications of present physiological understanding of HRV components," Cardiac electrophysiology review, vol. 6, no. 3, pp. 245–249, 2002.

[6] E. Kristal-Boneh, M. Raifel, P. Froom, and J. Ribak, "Heart rate variability in health and disease," Scandinavian journal of work, environment & health, pp. 85–95, 1995.

[7] M. P. Tarvainen, P. O. Ranta-Aho, and P. A. Karjalainen, "An advanced detrending method with application to HRV analysis," IEEE transactions on biomedical

ISSN 2347–3657
Volume 15, Issue 3, 2024
https://doi.org/10.62646/ijitce.2024.v15.i3.pp784-790

engineering, vol. 49, no. 2, pp. 172–175, 2002.

[8] B. Makivi´c, M. Niki´c Djordjevi´c, and M. S. Willis, “Heart Rate Variability (HRV) as a tool for diagnostic and monitoring performance in sport and physical activities.” Journal of Exercise Physiology Online,
vol. 16, no. 3, 2013.

[9] P. J. Zimetbaum and M. E. Josephson, “Use of the electrocardiogram in acute myocardial infarction,” New England Journal of Medicine, vol. 348, no. 10, pp. 933–940, 2003.

[10] E. C, ic, ekli and E. Emre, “The effect of tension variability for sleep quality in headache patients: A Holter monitoring study,” Medicine, vol.101, no. 30, 2022.

[11] Y. Kurt Peker, G. Bello, and A. J. Perez, “On the Security of Bluetooth Low Energy in Two Consumer Wearable Heart Rate Monitors/Sensing Devices,” Sensors, vol. 22, no. 3, p. 988, 2022.

[12] Y. Gao, V. V. Soman, J. P. Lombardi, P. P. Rajbhandari, T. P. Dhakal, D. G. Wilson, M. D. Poliks, K. Ghose, J. N. Turner, and Z. Jin, “Heart monitor using flexible capacitive ECG electrodes,” IEEE Transactions on Instrumentation and Measurement, vol. 69, no. 7, pp. 4314–4323, 2019.

[13] J. Parak, A. Tarniceriu, P. Renevey, M. Bertschi, R. Delgado-Gonzalo, and I. Korhonen, “Evaluation of the beat-to-beat detection accuracy of PulseOn wearable optical heart rate monitor,” in 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). IEEE, 2015, pp. 8099–8102.

[14] W. Huang, W. Tang, H. Jiang, J. Luo, and Y. Zhang, “Stop deceiving! An effective defense scheme against voice impersonation attacks on smart devices,” IEEE Internet of Things Journal, vol. 9, no. 7, pp. 5304–5314, 2021.

[15] C.-A. Wang, T. Baird, J. Huang, J. D. Coutinho, D. C. Brien, and D. P. Munoz, “Arousal effects on pupil size, heart rate, and skin conductance in an emotional face task,” Frontiers in neurology, vol. 9, p. 1029, 2018.