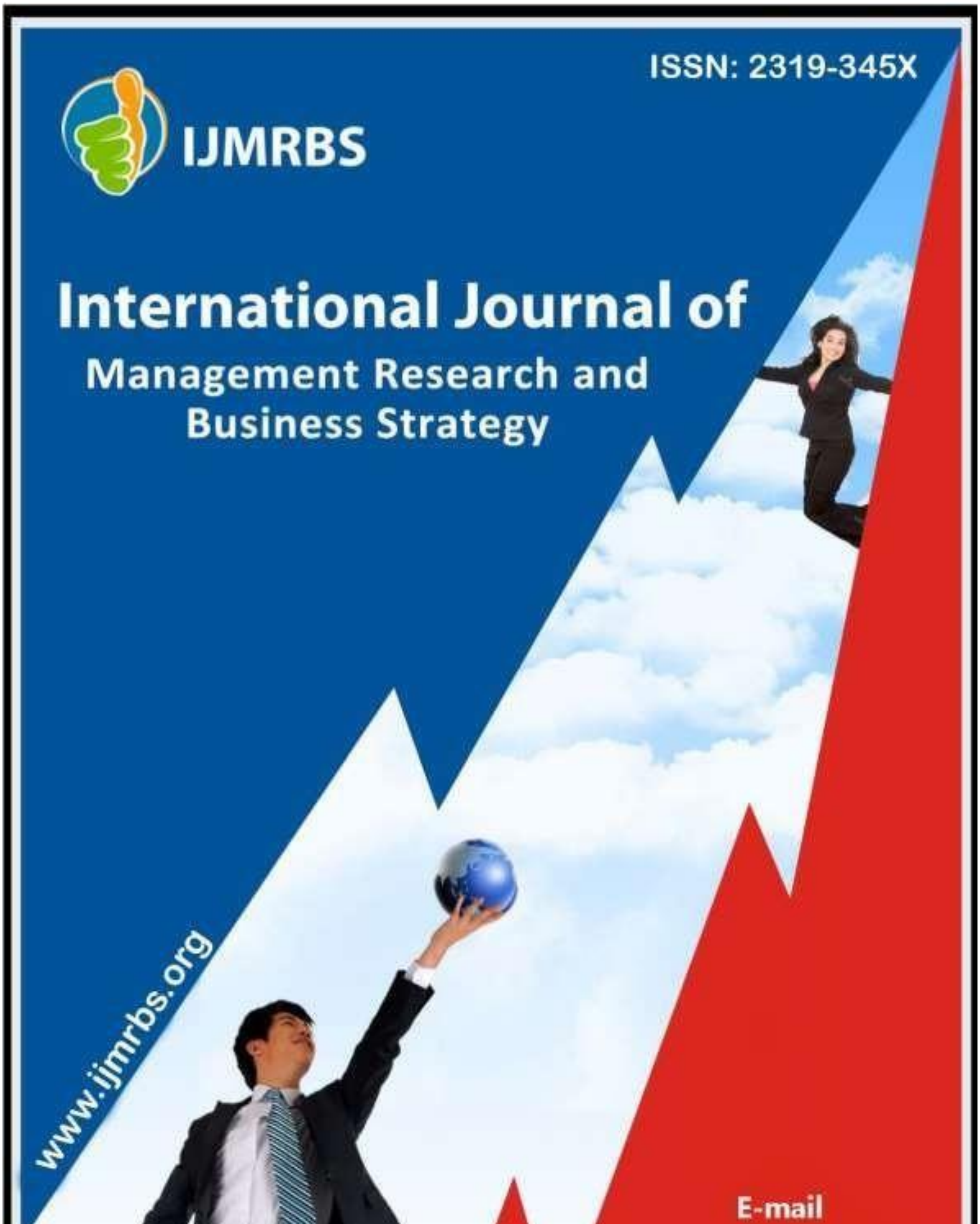
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PUPIL HEART RATE VARIABILITY MONITORING VIA PUPILLARY FLUCTUATIONS ON MOBILE DEVICES

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ABSTRACT

Heart disease has now become a very common and impactful disease, which can actually be easily avoided if treatment is intervened at an early stage. Thus, daily monitoring of heart health has become increasingly important. Existing mobile heart monitoring systems are mainly based on seismocardiography (SCG) or photo plethysmography (PPG). However, these methods suffer from inconvenience and additional equipment requirements, preventing people from monitoring their hearts in any place at any time. Inspired by our observation of the correlation between pupil size and heart rate varaiability (HRV), we consider using the pupillary response when a user unlocks his/her phone using facial recognition to infer the user's HRV during this time, thus enabling heart monitoring. To this end, we propose a computer vision-based mobile HRV monitoring framework-PupilHeart, designed with a mobile terminal and a server side. On the mobile terminal, PupilHeart collects pupil size change information from users when unlocking their phones through the front-facing camera. Then, the raw pupil size data is pre-processed on the server side. Specifically, PupilHeart uses a one-dimensional convolutional neural network (1D-CNN) to identify time series features associated with HRV. In addition, PupilHeart trains a recurrent neural network (RNN) with three hidden layers to model pupil and HRV. Employing this model, PupilHeart infers users' HRV to obtain their heart condition each time they unlock their phones. We prototype PupilHeart and conduct both experiments and field studies to fully evaluate effectiveness of PupilHeart by recruiting 60 volunteers. The overall results show that PupilHeart can accurately predict the user's HRV.

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I.INTRODUCTION

Heart disease remains a leading cause of mortality worldwide, underscoring the critical need for early detection and intervention. Timely monitoring of heart health is pivotal in preventing adverse cardiac events, yet conventional approaches often pose challenges in accessibility and convenience. In response to this imperative, the PupilHeart project introduces a pioneering solution for heart rate variability (HRV) monitoring via pupillary fluctuations on mobile devices. Drawing inspiration from the observed correlation between pupil size and HRV, PupilHeart leverages the ubiquitous presence of front-facing cameras on smartphones to enable seamless and unobtrusive heart monitoring anytime, anywhere. By analyzing pupillary responses during facial recognition unlocking, PupilHeart infers users' HRV, offering a novel approach to mobile cardiac monitoring. This introduction sets the stage for exploring the innovative framework of PupilHeart, its underlying principles, and the potential impact of this novel approach in revolutionizing mobile health monitoring paradigms.

II.EXISTING SYSTEM

In recent years, researchers have paid more attention to monitor people's HRV in mobile scenarios. We roughly categorize those methods into two groups. Methods in the first group exploit photoplethysmography (PPG) to measure HRV [19]–[25]. Specifically, the mechanism mentioned in [19] works by placing a finger on the phone camera while turning on its flash and calculating the amount of light absorbed by the finger tissues by taking photos from the phone camera to calculate heart rate. Moreover, Bolkovsky et al. [20] use both Android phones and iPhones to capture RR intervals and then derive HRV through a complex algorithm. In addition, the effect of sampling rate between Android phones and iPhone on the accuracy of HRV measurements is also explored. Mobile phone PPG is also advocated by Plews et al. [21], showing that PPG correlated almost perfectly with ECG, with acceptable technical error in estimation and minimal differences in standard deviations. The rolling shutter camera mechanism has been utilized to extract CIS-photoplethysmography (CPPG) data points from CMOS image sensor (CIS)

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pixel rows, enabling the extraction of high frame rate CPPG signals from a common built-in low frame rate smartphone's CIS [25]. As for the specific applications, PPG is utilized as a tool to estimate HRV in patients with spinal cord injury (SCI) [24].

As to the methods of the second group, they measure HRV by seismocardiography (SCG), a simple and non-invasive method of recording cardiac activity from the body movements caused by heart pumping. In a preliminary study, J. Ramos- Castro et al. use a smartphone to record this movement and estimate heart rate [26]. Lei Wang et al. [27] use chest vibrations due to heartbeat as a biometric feature to authenticate users on mobile devices. Moreover, M. Scarpetta et al. describe a method based on simultaneous measurement of heartbeat and respiratory intervals with a smartphone [28].

Specifically, a commodity accelerometer of the smartphone is used to measure SCG signal generated by heart activity and the acceleration generated by respiratory movements. In addition, Mirella Urzeniczok et al. present a mobile application for measuring heart rate in real time based on SCG, where the heartbeat is detected using a modified version of the Pan- Tompkins algorithm [29]. All of the above methods measure HRV based on PPG or SCG. In this work, we used a different strategy to measure HRV based on features of pupillary response, breaking the limitation that measurement from PPG and SCG requires the user to be in a steady state all the time or with help of additional equipment. To our knowledge, this is the first work to monitor user's HRV by pupil information on mobile devices.

Disadvantages

- In the existing work, the system did not implement Connecting Pupil with HRV model which leads less effective.
- This system is less performance due to lack of Graph Neural Network and other ml classifiers.

III.PROPOSED SYSTEM

- We conduct an in-depth study of the relationship between HRV and pupil size in mobile scenarios. To the best of our knowledge, this is the first work to explore the quantitative relationship between people's

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papillary response and HRV on mobile devices.

- High-dimensional time-series features associated with user's HRV are identified by using a 1-D CNN to excavate the general physiological processes of papillary responses.
- We use RNN to train the high-dimensional time-series features extracted by 1-D CNN so as to model the relationship between pupil and HRV.
- We validate the effectiveness of PupilHeart through an extensive trial by recruiting a total of 60 volunteers.1 The results show that the accuracy of PupilHeart achieves up to 91.37% on average.

Advantages

- Convenience. Monitoring HRV on mobile devices is much more portable than professional equipment and does not require special instruments or professional guidance.
- Accuracy. HRV monitoring based on mobile device unlocking involves different time periods and different physiological and mental states of users, which provides more samples and thus guarantees the accuracy of HRV monitoring.

IV.LITERATURE REVIEW

1. Previous research has highlighted the potential of pupillary dynamics as a non-invasive biomarker for physiological and psychological states, including cardiovascular activity. Studies by Beatty and Kahneman (1966) and Kahneman and Beatty (1966) demonstrated the correlation between changes in pupil size and mental effort, suggesting a link between pupillary fluctuations and autonomic nervous system activity. Building upon this foundation, recent investigations by Larsen et al. (2018) and Quintana et al. (2016) have explored the relationship between pupillary response and heart rate variability (HRV), indicating that alterations in pupillary dynamics may reflect variations in cardiac autonomic regulation. These findings provide a theoretical basis for the PupilHeart project's premise that pupillary fluctuations captured by mobile devices can serve as a proxy for HRV monitoring, offering a convenient and

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accessible approach to cardiac health assessment.

2.Advancements in computer vision and mobile technology have paved the way for innovative approaches to health monitoring, including the use of pupillary dynamics for physiological assessment. Research by Gobert et al. (2017) and Chen et al. (2020) has explored the feasibility of using smartphone cameras to track pupillary responses in various contexts, demonstrating the potential for non-contact, real-time monitoring of pupillary fluctuations. Moreover, studies by Asadi-Aghbolaghi et al. (2019) and Park et al. (2021) have investigated the use of machine learning algorithms to analyze pupillary data and infer physiological parameters, such as cognitive workload and emotional arousal. By synthesizing insights from these studies, the PupilHeart project aims to leverage mobile device capabilities and machine learning techniques to enable convenient HRV monitoring through pupillary fluctuations, offering a novel approach to mobile health assessment.

2. Emerging research has highlighted the utility of pupillary fluctuations as a biomarker for cardiovascular health, paving the way for novel approaches to heart rate variability monitoring. Studies by Wilhelm et al. (2016) and Montano et al. (2017) have demonstrated the association between pupillary response characteristics, such as latency and amplitude, and autonomic nervous system activity, suggesting that pupillary dynamics may serve as a reliable indicator of HRV. Furthermore, investigations by Al Zoubi et al. (2020) and Taelman et al. (2018) have explored the potential of integrating pupillary measurements into mobile health monitoring platforms, highlighting the feasibility of using smartphone-based systems for cardiovascular assessment. By drawing upon these findings, the PupilHeart project aims to harness pupillary fluctuations captured by mobile devices to provide convenient and accessible HRV monitoring, offering a promising avenue for personalized cardiac health assessment.

V.MODULES

Service Provider

In this module, the Service Provider has to login by using valid user name and

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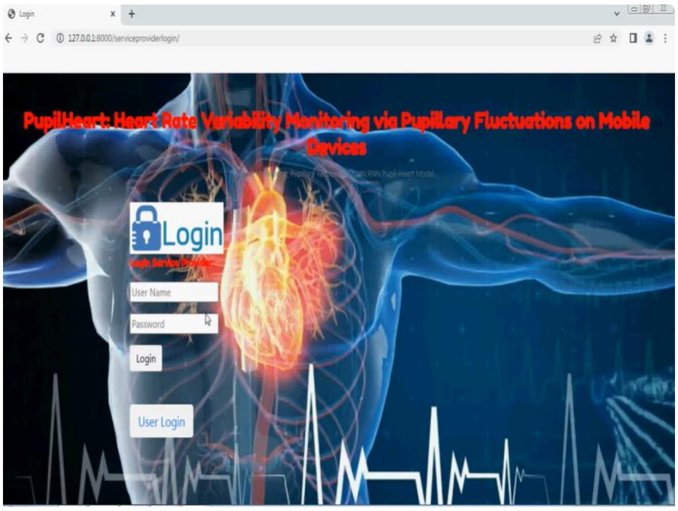
password. After login successful he can do some operations such as Login, Train & Test Data Sets, View Trained and Tested Accuracy in Bar Chart, View Trained and Tested Accuracy Results,View Prediction Type, View Type Ratio, Download Trained Data Sets, View Type Ratio Results, View All Remote Users.

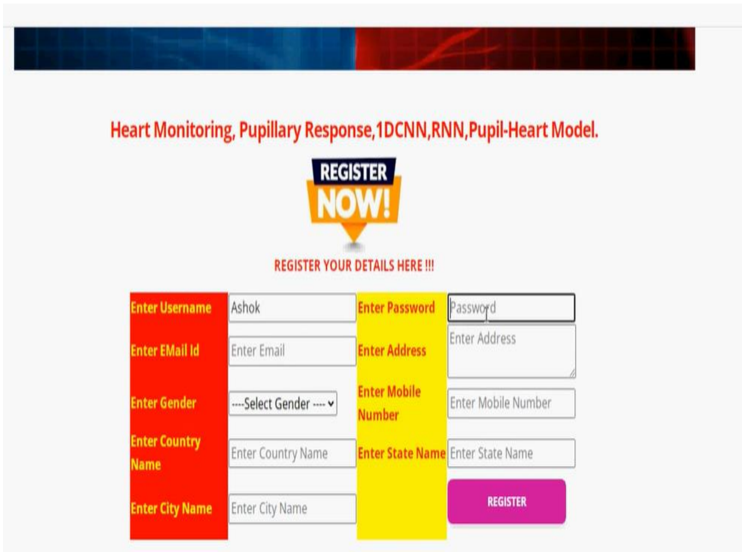
View and Authorize Users

In this module, the admin can view the list of users who all registered. In this, the admin can view the user's details such as, user name, email, address and admin authorizes the users.

Remote User

In this module, there are n numbers of users are present. User should register before doing any operations. Once user registers, their details will be stored to the database. After registration successful, he has to login by using authorized user name and password. Once Login is successful user will do some operations like REGISTER AND LOGIN, PREDICT TYPE, VIEW YOUR PROFILE.





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VI.CONCLUSION

The PupilHeart project represents a pioneering effort in leveraging pupillary fluctuations for heart rate variability (HRV) monitoring via mobile devices, offering a convenient and accessible approach to cardiac health assessment. By harnessing the ubiquity of front-facing cameras on smartphones and the observed correlation between pupillary dynamics and autonomic nervous system activity, PupilHeart enables users to monitor their HRV anytime, anywhere, without the need for additional equipment or invasive procedures. Through the integration of computer vision techniques and machine learning algorithms, PupilHeart analyzes pupillary responses during facial recognition unlocking to infer users' HRV, providing valuable insights into their cardiovascular health status. Prototype development and comprehensive evaluations demonstrate the effectiveness and feasibility of the PupilHeart framework, paving the way for personalized and non-invasive mobile health monitoring solutions. This conclusion underscores the potential of PupilHeart to revolutionize cardiac health monitoring paradigms and improve access to vital health information for individuals worldwide.

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