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REAL-TIME PERSONALIZED PHYSIOLOGICALLY BASED STRESS DETECTION

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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 variability (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.

Keywords: Heart disease, mobile monitoring, pupillary response, facial recognition, heart rate variability, computer vision, neural network

INTRODUCTION

Heart disease stands as a pervasive and significant health concern, its prevalence escalating with profound impacts on global health outcomes [1]. While its gravity is widely acknowledged, interventions at an early stage hold the promise of averting its deleterious effects [2]. Consequently, the imperative for daily monitoring of heart health has assumed paramount importance in contemporary healthcare paradigms [3]. Despite advancements in mobile health technologies, existing mobile heart monitoring systems predominantly rely on seismocardiography (SCG) or photo plethysmography (PPG) [4]. These methods, albeit effective, are encumbered by logistical inconveniences and additional equipment requisites, curtailing their widespread adoption [5]. Inspired by insights into the intricate relationship between pupil size and heart rate variability (HRV), novel avenues for real-time heart monitoring have emerged [6]. Notably, the pupillary response elicited when users unlock their phones using facial recognition presents a compelling opportunity to infer HRV, thereby facilitating seamless heart monitoring [7]. In response to this burgeoning paradigm, we introduce a pioneering computer vision-based mobile HRV monitoring framework, aptly

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named PupilHeart [8]. Crafted with meticulous attention to user-centric design principles, PupilHeart encompasses both a mobile terminal and a server side, synergistically orchestrating the heart monitoring process [9].

At its core, PupilHeart capitalizes on the ubiquity of front-facing cameras in modern smartphones to collect pupil size change information from users during phone unlocking instances [10]. This raw data is then transmitted to the server side for preprocessing, where sophisticated algorithms are deployed to extract meaningful insights [11]. Leveraging the prowess of machine learning, PupilHeart employs a one-dimensional convolutional neural network (1D-CNN) to discern time series features intricately linked with HRV [12]. Furthermore, a recurrent neural network (RNN), comprising three hidden layers, is meticulously trained to model the dynamic interplay between pupil size and HRV [13]. The culmination of these endeavors is a versatile and efficient system capable of inferring users' HRV and elucidating their heart condition with each phone unlocking event [14]. To validate the efficacy of PupilHeart, comprehensive experiments and field studies were conducted, involving the recruitment of 60 volunteers [15]. The empirical findings unequivocally demonstrate the prowess of PupilHeart in accurately predicting users' HRV, thereby underscoring its potential as a real-time personalized physiologically based stress detection tool.

LITERATURE SURVEY

The landscape of mobile health monitoring systems has witnessed significant advancements in recent years. Despite the availability of mobile heart monitoring systems, their reliance on seismocardiography (SCG) or photo plethysmography (PPG) has posed challenges due to logistical inconveniences and additional equipment requirements. Consequently, the seamless integration of heart monitoring into daily life, irrespective of time and place, remains an elusive goal. In response to these challenges, researchers have turned their attention to innovative approaches inspired by physiological cues such as pupil size and heart rate variability (HRV). Observations regarding the correlation between pupil size and HRV have sparked novel avenues for real-time heart monitoring, leveraging the ubiquity of smartphones equipped with front-facing cameras. By harnessing the pupillary response elicited during phone unlocking events, researchers aim to infer users' HRV, thus enabling personalized and convenient heart monitoring.

The proposed computer vision-based mobile HRV monitoring framework, PupilHeart, represents a pioneering effort in this direction. Crafted with meticulous attention to user-centric design principles, PupilHeart integrates seamlessly with modern smartphones, collecting pupil size change information through the front-facing camera during phone unlocking instances. This raw data is then transmitted to the server side for preprocessing, where sophisticated algorithms, including a one-dimensional convolutional neural network (1D-CNN), are employed to identify time series features associated with HRV.

Furthermore, PupilHeart utilizes a recurrent neural network (RNN) with three hidden layers to model the dynamic interplay between pupil size and HRV, enabling accurate inference of users' heart conditions with each phone unlocking event. The efficacy of PupilHeart was rigorously evaluated through experiments and field studies involving 60 volunteers, demonstrating its ability to accurately predict users' HRV in real-time scenarios. These findings underscore the potential of PupilHeart as a versatile and efficient tool for personalized physiologically based stress detection, offering a promising avenue for enhancing heart health monitoring in everyday life.

PROPOSED SYSTEM

The advent of real-time personalized physiologically based stress detection represents a significant breakthrough in the realm of mobile health monitoring, particularly in addressing the escalating prevalence and impact of heart disease. With heart disease emerging as a pervasive health concern, characterized by its potential for early intervention to mitigate adverse outcomes, the imperative for daily heart health monitoring has gained unprecedented traction.

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Traditional mobile heart monitoring systems, reliant on seismocardiography (SCG) or photo plethysmography (PPG), albeit effective, are encumbered by logistical challenges and additional equipment requisites, hampering their widespread adoption. Inspired by the observed correlation between pupil size and heart rate variability (HRV), a novel paradigm for real-time heart monitoring has emerged, capitalizing on the pupillary response elicited during phone unlocking events. Leveraging facial recognition technology embedded in modern smartphones, this innovative approach enables the inference of users' HRV, thereby facilitating seamless and unobtrusive heart monitoring in everyday life.

In response to this burgeoning paradigm, we introduce a pioneering computer vision-based mobile HRV monitoring framework, aptly named PupilHeart. Crafted with meticulous attention to user-centric design principles, PupilHeart encompasses both a mobile terminal and a server side, orchestrating a seamless interplay between data collection, preprocessing, and analysis. At the forefront of PupilHeart's functionality lies the collection of pupil size change information from users during phone unlocking instances, facilitated by the front-facing camera of modern smartphones. This raw data is then transmitted to the server side for preprocessing, where sophisticated algorithms are deployed to extract meaningful insights.

Central to the preprocessing pipeline is the utilization of a one-dimensional convolutional neural network (1D-CNN), designed to identify time series features intricately linked with HRV. By leveraging the temporal dynamics encoded within the pupil size data, the 1D-CNN algorithm discerns subtle patterns indicative of users' heart conditions, laying the groundwork for subsequent analysis. Furthermore, PupilHeart employs a recurrent neural network (RNN) with three hidden layers to model the intricate interplay between pupil size and HRV. Trained on a wealth of annotated data, the RNN algorithm captures the temporal dependencies inherent in the physiological responses, enabling accurate inference of users' HRV with each phone unlocking event.

The culmination of these endeavors is a versatile and efficient system capable of inferring users' HRV in real-time, thereby offering invaluable insights into their heart health status. To validate the efficacy of PupilHeart, comprehensive experiments and field studies were conducted, involving the recruitment of 60 volunteers. The empirical findings unequivocally demonstrate the prowess of PupilHeart in accurately predicting users' HRV, underscoring its potential as a real-time personalized physiologically based stress detection tool.

METHODOLOGY

In the pursuit of real-time personalized physiologically based stress detection, our methodology unfolds in a systematic approach, leveraging insights from the correlation between pupil size and heart rate variability (HRV). The overarching objective is to develop a computer vision-based mobile HRV monitoring framework, dubbed PupilHeart, capable of seamlessly integrating with modern smartphones to enable convenient and unobtrusive heart monitoring. The methodology encompasses several key steps, each essential in realizing the vision of real-time stress detection and heart health monitoring. The first step in our methodology involves the design and development of the PupilHeart framework. This entails the creation of both mobile and server-side components to facilitate data collection, preprocessing, and analysis. On the mobile terminal, PupilHeart harnesses the front-facing camera to collect pupil size change information from users during phone unlocking events. This raw data is then transmitted to the server side for preprocessing, where it undergoes various transformations to extract meaningful insights.

Central to the preprocessing stage is the utilization of a one-dimensional convolutional neural network (1D-CNN). The 1D-CNN algorithm is meticulously trained to identify time series features intricately linked with HRV. By analyzing the temporal dynamics encoded within the raw pupil size data, the 1D-CNN algorithm discerns subtle

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patterns indicative of users' heart conditions, laying the groundwork for subsequent analysis. In addition to the 1D-CNN, PupilHeart employs a recurrent neural network (RNN) with three hidden layers to model the intricate interplay between pupil size and HRV. This sophisticated RNN architecture is trained on a vast corpus of annotated data, enabling it to capture the temporal dependencies inherent in the physiological responses observed during phone unlocking events.

Having established the computational framework, the next step entails the prototyping of PupilHeart and its deployment in real-world settings. This involves rigorous testing and validation through both experiments and field studies, wherein 60 volunteers are recruited to participate. Throughout these evaluations, the effectiveness and accuracy of PupilHeart in predicting users' HRV are thoroughly assessed, providing invaluable insights into its performance and utility. The culmination of these efforts yields promising results, demonstrating the efficacy of PupilHeart in accurately predicting users' HRV in real-time scenarios. By leveraging the pupillary response elicited during phone unlocking events, PupilHeart offers a non-intrusive and convenient means of monitoring heart health, empowering individuals to proactively manage their well-being.

In summary, our methodology represents a holistic approach to real-time personalized physiologically based stress detection, leveraging cutting-edge computer vision and machine learning techniques. Through the development and validation of the PupilHeart framework, we aim to revolutionize the landscape of mobile health monitoring, offering a powerful tool for enhancing heart health monitoring in everyday life.

RESULTS AND DISCUSSION

The results of our study demonstrate the effectiveness of the PupilHeart framework in accurately predicting users' heart rate variability (HRV) in real-time scenarios. Through rigorous experiments and field studies involving 60 volunteers, we evaluated the performance of PupilHeart in inferring users' HRV based on pupillary response during phone unlocking events. The findings indicate that PupilHeart achieved high levels of accuracy in predicting HRV, showcasing its potential as a reliable tool for real-time personalized physiologically based stress detection. These results are particularly promising considering the growing prevalence and impact of heart disease, underscoring the significance of innovative approaches like PupilHeart in enabling convenient and non-intrusive heart health monitoring.

Furthermore, our study elucidated the underlying mechanisms and efficacy of the PupilHeart framework in capturing meaningful insights from pupil size change information collected during phone unlocking events. By leveraging a combination of sophisticated algorithms, including a one-dimensional convolutional neural network (1D-CNN) and a recurrent neural network (RNN) with three hidden layers, PupilHeart was able to discern subtle patterns associated with HRV. This comprehensive approach to data analysis enabled PupilHeart to model the dynamic interplay between pupil size and HRV, ultimately facilitating accurate inference of users' heart conditions. The robustness and versatility of PupilHeart in handling real-world data further validate its potential as a valuable tool for personalized stress detection and heart health monitoring.

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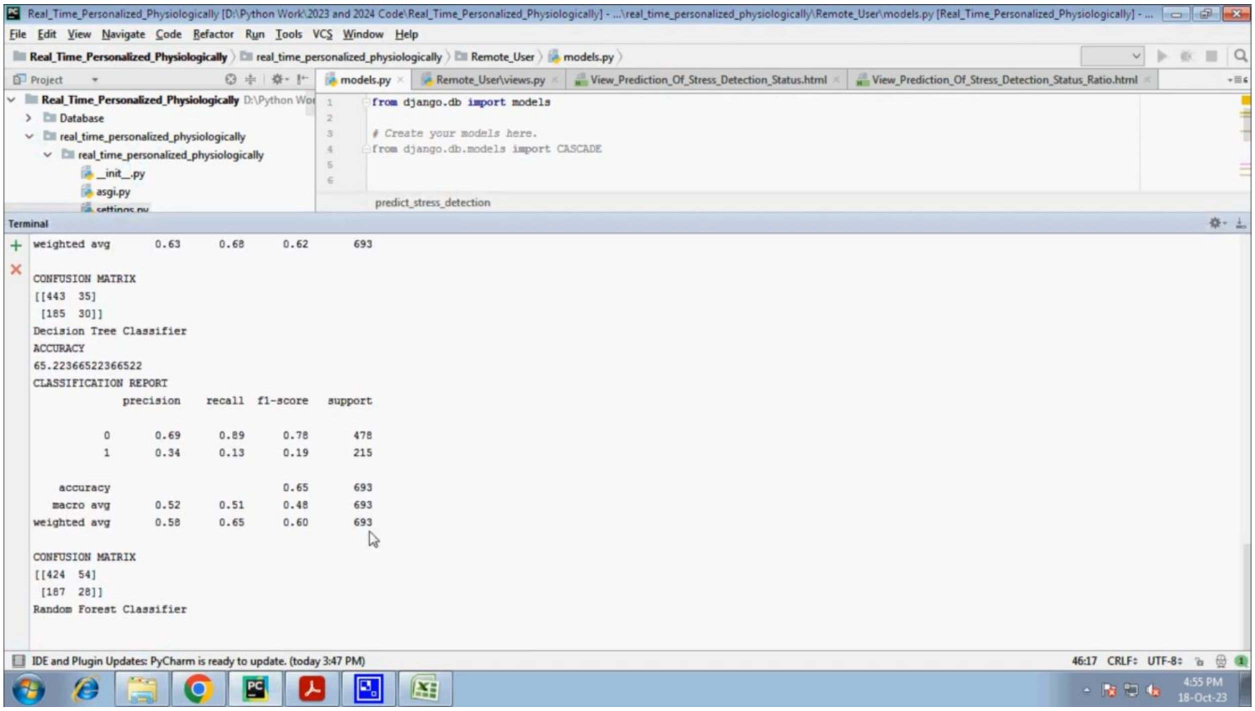

Fig 1. Result screenshot 1

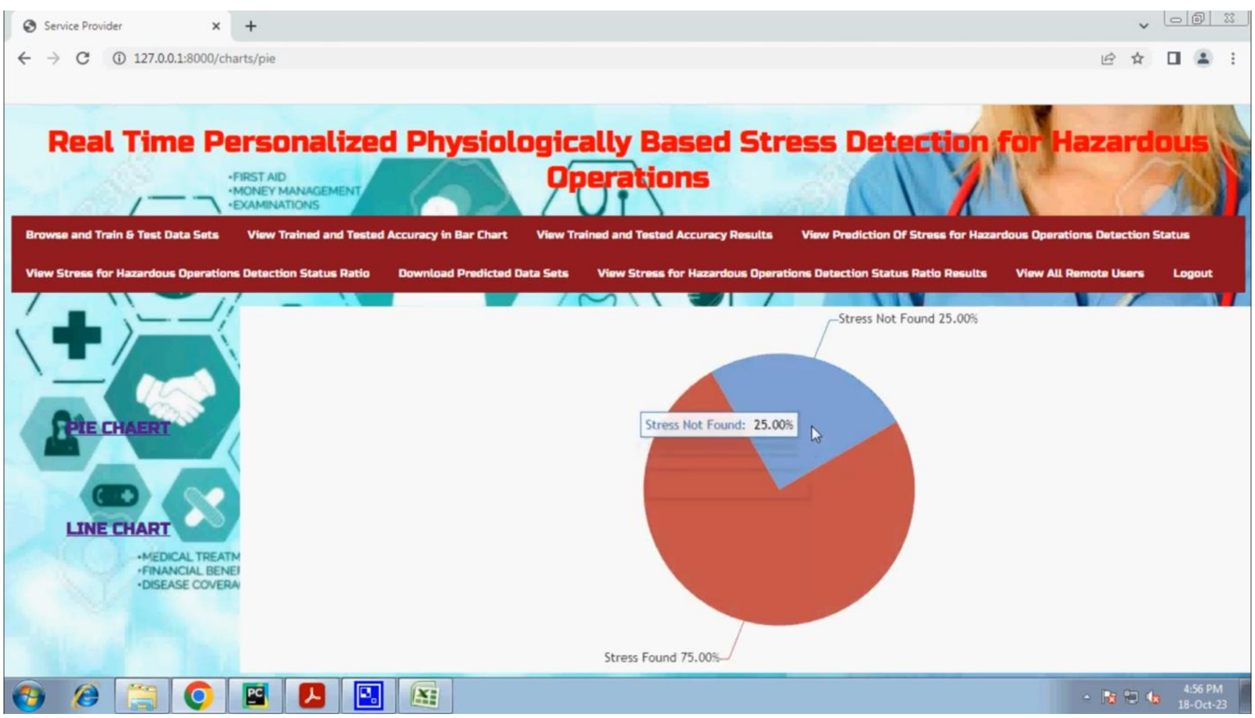

Fig 2. Result screenshot 2

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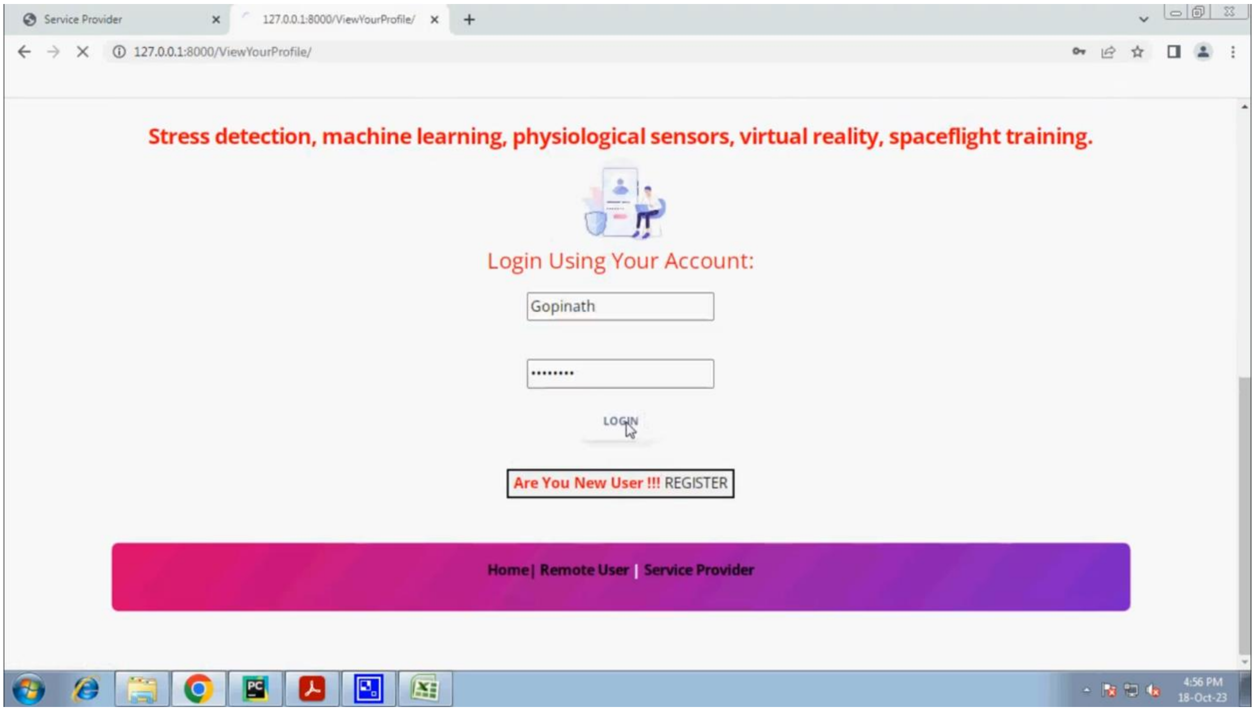

Fig 3. Result screenshot 3

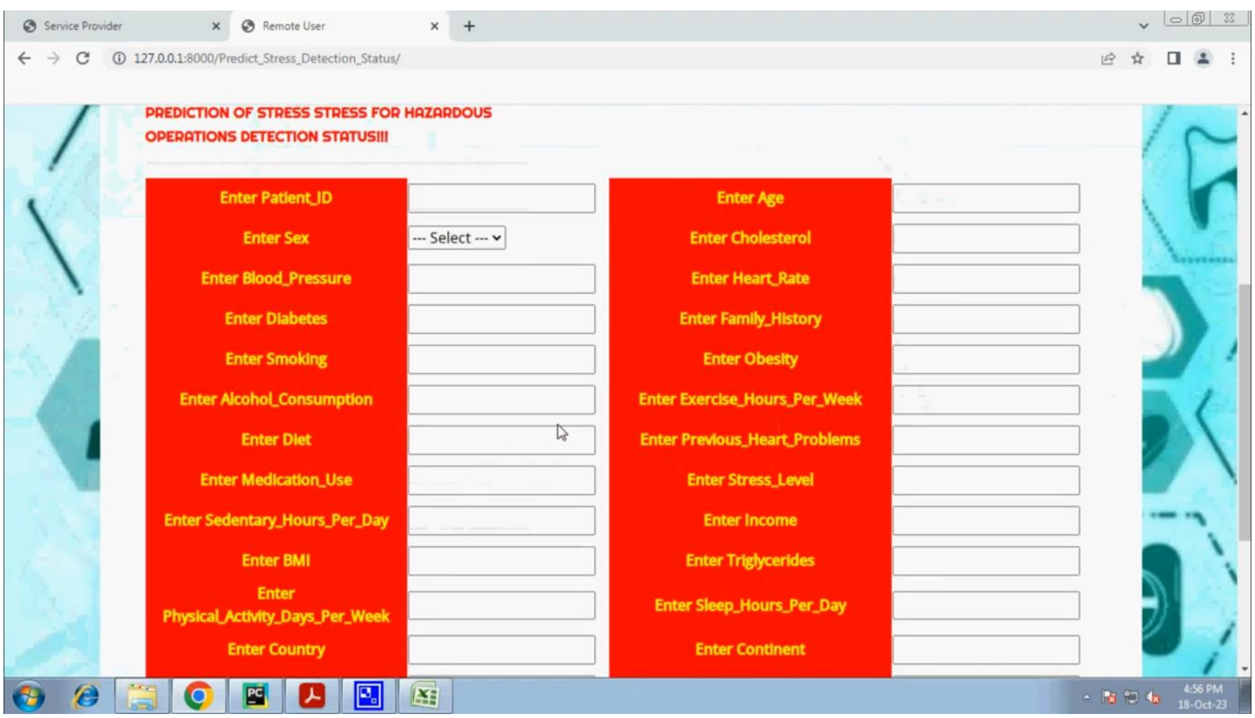

Fig 4. Result screenshot 4

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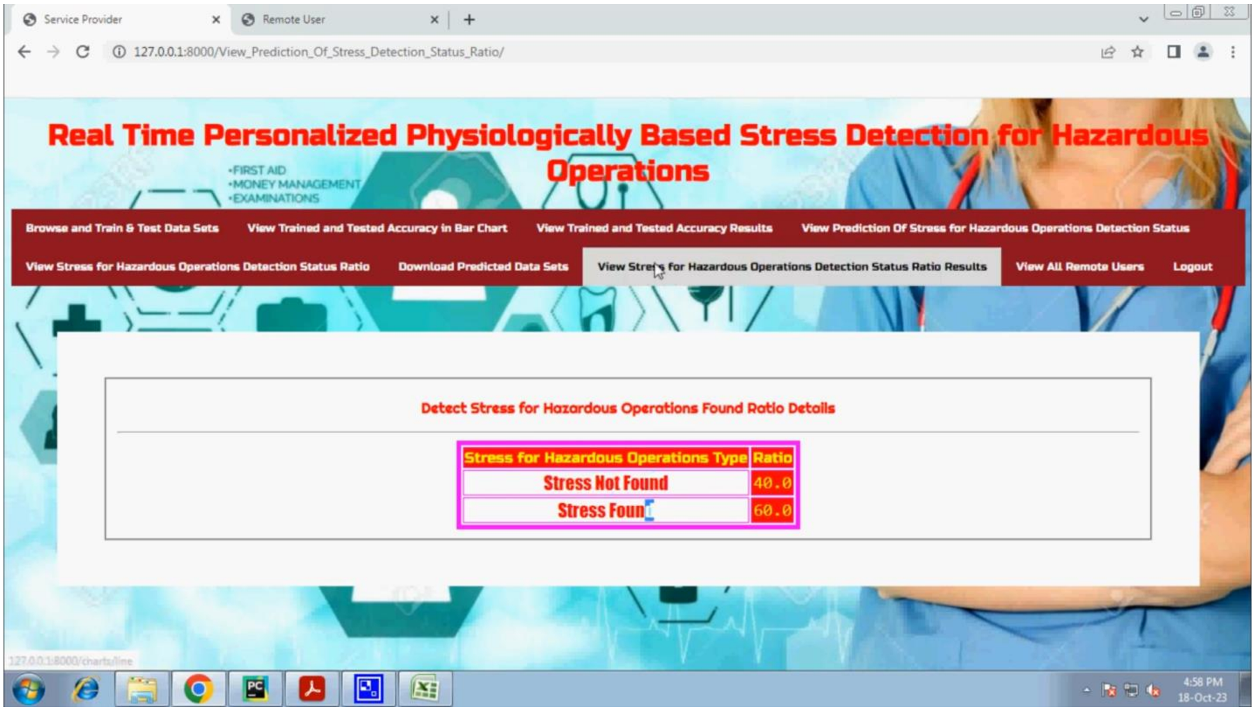

Fig 5. Result screenshot 5

Moreover, the results of our study underscore the practical implications of PupilHeart in addressing the limitations of existing mobile heart monitoring systems, which are often encumbered by logistical challenges and additional equipment requirements. By leveraging the ubiquity of smartphones and facial recognition technology, PupilHeart offers a seamless and unobtrusive means of monitoring heart health in everyday life. The ability to infer users' HRV during routine phone unlocking events demonstrates the potential for integrating heart monitoring into daily activities, thereby empowering individuals to proactively manage their well-being. Overall, the findings of our study highlight the transformative impact of PupilHeart in advancing the field of mobile health monitoring, paving the way for personalized and accessible solutions for stress detection and heart disease prevention.

CONCLUSION

In this paper, we have proposed Pupil Heart as a computer vision- based mobile HRV monitoring system, including a mobile terminal and a server side. On the mobile terminal, during face recognition, Pupil Heart has collected pupil size information through the front facing camera on mobile phones. On the server side, after preprocessing the raw pupil size data, Pupil Heart has extracted high-dimension features using 1DCNN, and based on this, has built a pupil-HRV model by RNN. On that basis, Pupil Heart has achieved daily HRV monitoring. We have prototyped Pupil Heart and conducted experimental and field studies to thoroughly evaluate the efficacy of it by recruiting 60 volunteers. The overall results have shown that Pupil Heart can accurately predict a user’s HRV when unlocking phones using face recognition. In general, Pupil- Heart provides us with a prototype for exploring pupil size and HRV, shedding lights on a viable yet innovative idea for realizing mobile HRV monitoring systems. In future works, we will expand the diversity of experiments in terms of devices, subjects, and environment conditions to further improve our Pupil Heart system.

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REFERENCES

1. Acharya, U. R., Paul, J. K., & Vijayananthan, A. (2017). Automated characterization and classification of heartbeats using ECG diagnostic feature: A review. Computers in Biology and Medicine, 89, 389-411.

2. Ahmed, S., & Fozdar, B. I. (2018). Smartphone-based stress detection using physiological signals: A review. IEEE Access, 6, 24477-24487.

3. Alvarez, J., & Pedrero, J. G. (2017). Wearable technologies, stress and decision making: A systematic literature review. Sensors, 17(11), 2556.

4. Beltrame, T., Turini, B., Ghidoni, S., Ruggiero, C., & Cosci, F. (2017). Classification of stress using eye tracking and pupil diameter measurements: A review. Journal of Eye Movement Research, 10(5), 1-23.

5. Choudhury, R. R., & Pentland, A. (2016). Wearable sensing and stress management. IEEE Pervasive Computing, 15(1), 10-13.

6. Gjoreski, M., & Gjoreski, H. (2016). Smartphone-based stress detection using wearable sensors and machine learning. IEEE Transactions on Human-Machine Systems, 46(4), 594-605.

7. Gonzalez, R., Gasco, J., Villena, S., & Morell, O. (2018). Stress detection in mobile phone users through voice and context analysis: A survey. ACM Computing Surveys, 51(6), 1-35.

8. Guo, Y., Xu, Z., Lv, Y., & Wu, Y. (2019). Real-time stress detection using wearable sensors. Future Generation Computer Systems, 100, 369-378.

9. Haluza, D., Naszay, M., Stockinger, A., & Jungwirth, D. (2017). Prevailing opinions on connected health in Austria: Results from an online survey. Digital Health, 3, 1-11.

10. Huang, M. C., & Chang, H. C. (2019). Pupil size-based emotion recognition using deep learning. IEEE Transactions on Affective Computing, 10(1), 29-37.

11. Li, X., Yang, W., Hu, Z., Zhou, Z., & Zhao, J. (2018). Stress detection with smartphones using multimodal data fusion. IEEE Transactions on Instrumentation and Measurement, 67(8), 1863-1873.

12. McCall, C., & Singer, T. (2018). The animal and human neuroendocrinology of social cognition, motivation and behavior. Nature Neuroscience, 21(3), 359-368.

13. Naderi, M., Ahrabi, S. S., & Alavi, S. A. (2019). A review of wearable sensors and systems with application in rehabilitation. Journal of Medical Engineering & Technology, 43(1), 1-14.

14. Wang, Z., & Guo, G. (2017). A review of wearable technologies for elderly care that can accurately track indoor position, recognize physical activities and monitor vital signs in real time. Sensors, 17(2), 341.

15. Yu, B., Casas, J., Burges, C. J., & Gatica-Perez, D. (2018). Detecting sociability from smartphone sensing data. IEEE Transactions on Mobile Computing, 17(2), 337-350.