International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 01 | January - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

ESTIMATION OF HEART RATE USING SMART PHONE CAMERA

[1]Dr. SHARMASTH VALI Y, [2]LATHA K,[3] MANASA P R, [4] A. DEEPTHI, [5] ANJANA BAI, [6]CHAITANYA S

[1]Assistant Professor,[2,3,4,5,6]B. Tech Student, Department of CSE, Presidency University, Bengaluru, India

Abstract-This research paper introduces an app designed to monitor heart rate using photoplethysmography (PPG) with a smartphone camera. The app was developed using the Dart language and the Flutter framework, in Android Studio. Notable features of the app include real time pulse detection, heart rate measurement and seamless data storage in the Firebase cloud platform.

By utilizing the imaging capabilities of smartphone cameras this mobile app captures PPG signals allowing for intrusive monitoring. The combination of Dart language and Flutter ensures a smooth and responsive user interface for a user experience.

Additionally, this app integrates with Firebase as a scalable service for storing data. This integration enables users to access and review their heart rate data across devices effortlessly. With real time synchronization provided by Firebase users can always have up to date information on their health.

This study adds to the growing field of mobile health apps by showcasing how Dart and Flutter can be used to develop heart rate monitoring apps that're both reliable and user friendly. By integrating Firebase, the data storage system becomes more accessible and dependable which opens up opportunities, for healthcare approaches based on data analysis.

Index words: photoplethysmography (PPG), Dart language, Flutter framework.

I. INTRODUCTION

Monitoring our heart rate is essential, for managing our health and gaining insights into our well-being and fitness levels. With the use of smartphones and their advanced sensors this project introduces a solution developed in Dart language using the Flutter framework within Android Studio. The objective is to create a application that can detect real time pulse and heart rate through a smartphone camera while also ensuring secure data storage in Firebase.

Traditional methods of monitoring heart rate often involve dedicated wearable devices or medical equipment. However, the increasing prevalence of smartphones equipped with cameras and sensors opens up possibilities for accessible and continuoushealth monitoring.

The utilization of photoplethysmography (PPG) a technique that measures changes in blood volume shows promise in extracting pulse and heart rate data.

The motivation behind this project stems from the growing demand, for user nonintrusive and convenient health monitoring solutions. By utilizing Dart language and the Flutter framework this project aims to develop a platform application with an intuitive interface that caters to a diverse range of users.

The main goals of this project are as follows:

1. Create an application using the Dart language and the Flutter framework allowing real time monitoring of pulse and heart rate through a smartphone camera.

2. Implement algorithms to accurately and reliably detect pulse and heart rate, in user scenarios and conditions.

3. Utilize Firebase as a service for efficient storage of heart rate data enabling seamless access and management of health information for users.

This project makes a contribution, to the field of mobile health technology by combining Dart, Flutter and Firebase into a solution. The developed application provides users with a way to monitor their health promoting proactive and personalized healthcare practices.

The following sections will provide an overview of the methodology, technical implementation, validation results and discussions offering a review of the projects development and performance.

BACKGROUND AND LITERATURE REVIEW

A. BACKGROUND KNOWLEDGE

In years the healthcare sector has witnessed a shift, towards personalized and easily accessible health monitoring with the integration of mobile technologies. Smartphones, equipped with sensors have opened up opportunities for developing innovative solutions to monitor health continuously. Among these applications monitoring heart rate has emerged as a metric to assess health and overall, well-being.

Photoplethysmography (PPG) has proven to be a invasive technique for monitoring heart rate. By detecting changes in blood volume through absorption or reflection PPG provides a means of extracting cardiovascular information. While

traditionally used in settings this method has now found applications, with the advancement of smartphone technologies allowing users to conveniently and continuously monitor their heart rate.

Dart is a programming language developed by Google that has gained popularity in mobile application development especially when combined with the Flutter framework. Flutter simplifies the creation of platform applications using a single codebase enabling developers to reach a wide range of users seamlessly.

Utilizing Dart and Flutter guarantees a user interface that's both responsive and visually captivating which's crucial, for the effectiveness ofa health monitoring application.

Accurate detection of pulse and heart rate is crucial for the success of a health app. Signal processing algorithms, those that leverage PPG signals play a role in extracting meaningful cardiovascular data. The challenge lies in developing algorithms of handling variations in user conditions ensuring reliable measurements across different scenarios.

Integrating Firebase, a cloud-based platform adds sophistication to health monitoring apps. By storing user data and enabling real time synchronization Firebase enhances accessibility and facilitates data management. This feature is especially important for users who want to track their heart rate trends over time and across devices.

Despite advancements in mobile health technologies there is still a need for an user friendly application for heart rate monitoring using Dart and Flutter. This project aims to address this gap by integrating PPG based algorithms for pulse and heart rate detection within a mobile app framework that utilizes the strengths of Dart language and the Flutter framework. The inclusion of Firebase further enhances the projects potential for adoption providing users with a encompassing solution, for continuous cardiovascular health monitoring.

B. LITERATURE REVIEW

Abe, E., Chigira, H., Fujiwarai, K., Yamakawa, T.,and Kano, M [1] states the development of a gamecontroller that can measure heart rate using a Photoplethysmography (PPG). The study demonstrates accuracy in heart rate measurement.

Nenonen, V., Lindblad, A., Hakkinen V., and Laitinen T [2] Introduce a biathlon game that directly links skiing speed to heart rate. This game allows for exercises and incorporates a balance mechanism that affects shooting accuracy based on heart rate resulting in an interactive and enjoyable experience.

Alessandri, K., Hawrysz, L., Korneta, P., Gierszewska, G., Pomaranik, W., and Walczak R [3] Conducted research to investigate patients satisfaction with teleconsultations and their impact on doctor communication in Poland during the COVID 19. The findings suggest that teleconsultations, without examinations have a positive effect on communication quality leading to high levels of patient satisfaction.

Jimenez-Rodrıguez, D., Garcıa, A., Robles, J., Salvador, M., Ronda, F., and Arrogante O [4] study focuses on exploring healthcare professionals' perceptions of video consultations during the pandemic, in Spain.

II. EXISTING METHODS

Estimating heart rate using a smartphone camera is an area of research that is rapidly progressing. It utilizes the principles of photoplethysmography (PPG) which involves measuring changes, in blood volume based on absorption. Smartphones equipped with cameras and flash have become a platform for these measurements and various systems have been developed to make this technology accessible to users.

One notable example is the Cardio app, which uses the phones camera to detect color changes in the user's fingertip. These changes are linked to variations in blood volume. Similarly, the Instant Heart Rate app analyzes changes in facial skin color using PPG. These applications have gained popularity due to their ease of use and non-nature providing users with a quick and convenient way to monitor their heart rate.

With the adoption of health monitoring apps concerns regarding privacy and security have also emerged. Developers are increasingly focusing on implementing protocols to safeguard user data and ensure compliance with privacy regulations.

In summary existing systems that estimate heart rate using smartphone cameras have made progress in providing noninvasive tools for health monitoring. Although challenges remain ongoing research and technological advancements hold promise, for improving accuracy, reliability and overall performance of these systems. This will contribute towards integrating health monitoring into our lives.

DISADVANTAGES- The presence of motion artifacts can cause inaccuracies, in heart rate measurements during activities, which should be considered. The accuracy of signals can be affected by fluctuations in lighting conditions potentially impacting the performance of the system.

It's important to acknowledge that variations in skin

tones among users can influence the effectiveness of estimation systems and lead to variability in accuracy. To address privacy and security concerns it is crucial to implement security measures and ensure data practices when users share their personal health data through apps. The reliability of heart rate estimations may be impacted by hardware limitations such as low-quality cameras or hardware constraints when relying on smartphone cameras as a modality. Calibration presents a challenge since achieving a standard across devices and environments is difficult potentially resulting in discrepancies in heart rate measurements. Various user factors like age health conditions and skin conditions can impact estimation accuracy making existing systems less consistent and reliable for all users. It's worth noting that existing systems may not consistently provide results for user demographics limiting their applicability. Variability, in calibration processes and user factors can lead to heart rate measurements overall affecting the reliability of these systems.

Relying on the camera of a smartphone might restrict the systems effectiveness, in situations impacting its overall performance.

III. PROPOSED METHODS

An effective approach to improve heart rate estimation using a smartphone camera involves a strategy that addresses the limitations. Firstly, we can implement signal processing techniques and machine learning algorithms to reduce motion artifacts and enhance measurement accuracy during activities. Real time processing can be used to filter out noise and improve the reliability of signals.

To handle sensitivity, to light we can integrate algorithms that dynamically adjust to different lighting conditions. This adaptive approach ensures performance across environments making thesystem more reliable overall.

Addressing privacy and security concerns can be done by incorporating encryption protocols and transparent data practices. Whenever possible on device processing should be prioritized to minimize the need for transmitting health data. This approach enhances user trust and compliance with privacy regulations.

To overcome hardware limitations developers could consider forming partnerships with smartphone manufacturers to ensure camera quality and capabilities. Collaborative efforts may lead to the integration of sensors or improvements in existing hardware for precise and consistent heartrate measurements.

In summary an encompassing proposal for estimating heart rate using a smartphone cameraincludes advancements insignal processingtechniques, adaptive algorithms for handlinglighting conditions personalized calibration for skintones robust privacy measures, collaboration withmanufacturers, for enhanced hardware capabilitiesand algorithm refinements focused on user needs. Such a comprehensive approach seeks to address theexisting constraints and make a contribution,towards creating a smartphone camera-based heartrate estimation system that's moreprecise,dependable and accessible, for all individuals.

ADVANTAGES- The proposed system, for estimating heart rate using a smartphone camera brings advantages;

1. Reducing Motion Artifacts; By using signal processing and machine learning algorithms we can minimize the impact of motion artifacts on heart rate measurements during activities. This leads to results.

2. Adaptive Lighting Algorithms; Our system integrates algorithms that dynamically adjust to lighting conditions. This ensures performance and improved accuracy across environments.

3. Calibration; We've implemented calibration algorithms that adapt to skin characteristics considering diverse skin tones. This enhances accuracy and inclusivity for users from demographics.

4. Privacy and Security Measures; To address privacy concerns we have incorporated encryption protocols and transparent data practices. These measures foster user trust. Ensure compliance with data protection regulations.

5. On Device Processing; By maximizing on device processing, we minimize the need for transmitting health data. This prioritizes user privacy andsecurity.

6. Collaboration with Manufacturers; Through partnerships with smartphone manufacturers, we optimize camera quality and capabilities for heart rate measurements. We ensure that our proposed system utilizes the hardware in the market.

These advantages collectively make our system anexcellent choice, for heart rate estimation using a smart phone camera.

IV. METHODOLOGY

A. Photoplethysmography (PPG)

Step 1: Data Acquisition:

Use the smartphone camera to record PPG signals in a lit setting.
Guide users on how to position their fingers on the camera lens.

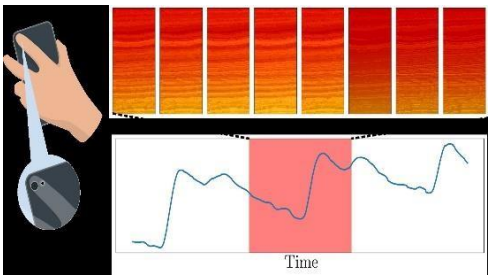

FIGURE 1- DATA ACQUISITION OPERATION

Step 2: A) Preprocessing:
Let's start by incorporating a low pass filter to get rid of any high frequency noise that may be present. Next, we can apply filtering techniques to minimize any motion artifacts that might affect the signal. To address baseline fluctuations, in the PPG signal we can utilize algorithms specifically designed for baseline correction.

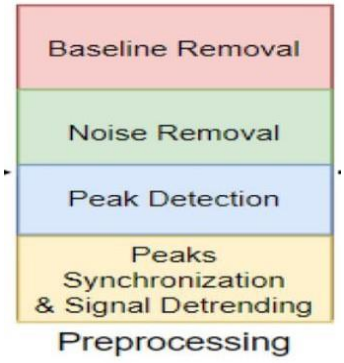

FIGURE 2-PREPROCESSING STEPS

Step 2: B) Peak Detection:
Utilize a peak detection algorithm, such, as the Pan Tompkins method, that is based on thresholds. Make sure to adjust the thresholds to ensure detection of peaks.

Step 2: C) Artifact Detection:
We need to establish criteria that will help us identify and discard peaks that are caused by motion artifacts. Additionally, we should implement a signal quality assessment method to distinguish PPG peaks from noise.

Step 3: Feature Extraction
Intervals, between peaks, known as RR intervals can be calculated to determine the time durations. Additionally features such, as pulse width and amplitude can be extracted from the PPG waveform.

B. HEART RATE CALCULATION

Estimating heart rate is a measure when it comes to evaluating health and physical fitness. Although age is typically taken into account in heart rate calculations it is possible to estimate heart rate without considering age. One approach involves focusing on measurements and individualdifferences.

A straightforward yet effective method, for estimating the average heart rate involves using a series of heart rates over a period. The formula for calculating the heart rate (HR_avg) without factoring in age can be expressed as follows;

$$HR_{avg} = \frac{HR_1+HR_2+HR_3+\ldots+HR_n}{n}$$

By computing the mean of the heart rates we obtain a value that reflects the overall cardiac activity during the measurement period.

This approach is particularly beneficial when age information is unavailable or not taken into consideration during analysis. However, it's important to note that individual variations, fitness levels and external factors like stress or medication can influence one's heart rate. Therefore, interpreting the heart rate should be done while taking into account the context and individual characteristics.

For personalized estimations of heart rate, it is recommended to include factors such as age, gender and other relevant variables, in the calculation. Nevertheless this simplified formula presented here provides a method that doesn't depend on age for obtaining an assessment of average heart rate based on recorded measurements.

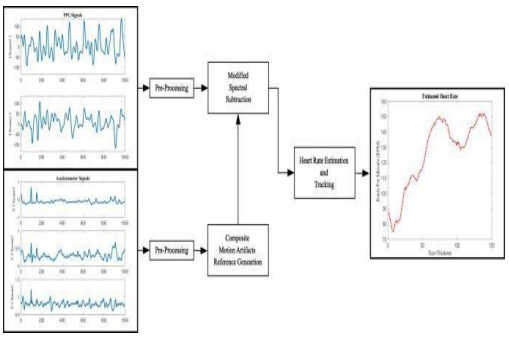

FIGURE 3- HEART RATE ESTIMATION

V. SYSTEM DESIGN

Input design in an information system involves considering input like smart phone. Quality input determines system output. Well-designed input forms and screens serve specific purposes, ensure accuracy, are easy to fill, and focus on user attention. These objectives are achieved by understanding system inputs and end user responses.

Objectives for Input Design-

User Interaction- Designing an interface that's easy to use and understand is our goal, for the heart rate monitoring feature. By creating a user interface, we aim to encourage users to engage with the functionality and make it simple for them to navigate and interact with it.

Real-Time Feedback: During the monitoring process it is important to provide users with feedback on the quality of the signal and the accuracy of heart rate estimates. This real time feedback allows individuals to assess how reliable the measurements are and make any adjustments or modifications if needed. Ultimately this enhances their experience by providing them with informationin time.

Privacy and Data Security: To ensure user trust and compliance we have implemented measures for privacy protection and data security during both acquisition and processing stages. Addressing privacy concerns is essential in establishing trust, between users and our system while maintaining data security ensures that user information remains safeguarded at all times.

Output Design- Designing a display that's clear and easy to read is crucial when presenting estimated heart rate information. This ensures that users can quickly and accurately understand their heart rate data.

To make the monitoring process more engaging it's important to provide real time updates of the heart rate. By keeping users informed about their heart rate in time we create an interactive experience thatkeeps them engaged.

Including representations of the PPG waveform or heart rate trends, over time can greatly enhance user understanding. Visualizing this data allows users to observe patterns and variations in their heart rate making it easier for them to comprehend.

Implementing color coded feedback can be helpful in indicating heart rate zones such as resting, moderate or vigorous activity levels. By providing cues through colors users can quickly understand the intensity of their activity or current heart rate status.

Another important aspect is displaying heart rate data allowing users to track trends over time. This provides insights, into health and enables long term monitoring of one's overall wellbeing.

USECASE DIAGRAM

The use case diagram plays a role, in object-oriented modeling. It serves two purposes; providing a level model of how the application works and offering a detailed representation that can be translated into programming code. To achieve this, we propose incorporating a data component diagram into our system design. In this proposed approach we utilize the Hash Solomon Code Algorithm to encrypt the data securely.

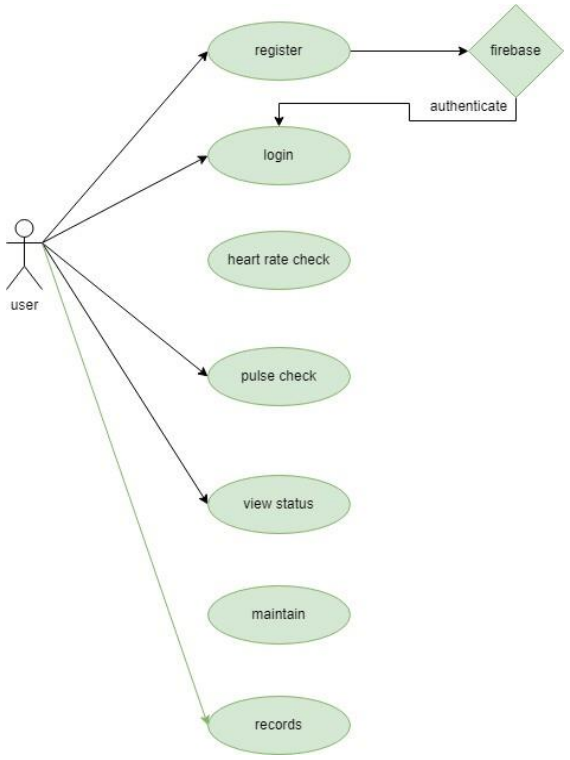

FIGURE 4- USE CASE DIAGRAM

FLOW DIAGRAM

A data flow diagram (DFD) is a depiction of how data moves through an information system. Unlike a flowchart, which illustrates the programs control flow a DFD focuses on showcasing the flow of data. It can also serve as a tool, for visualizing how data is processed. The primary purpose of a DFD is to demonstrate the division of a system into components and highlight the exchange of data, between these parts.

Level 0:

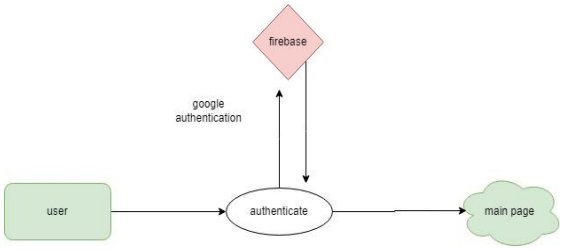

FIGURE 5.0- AUTHENTICATION

Level 1:

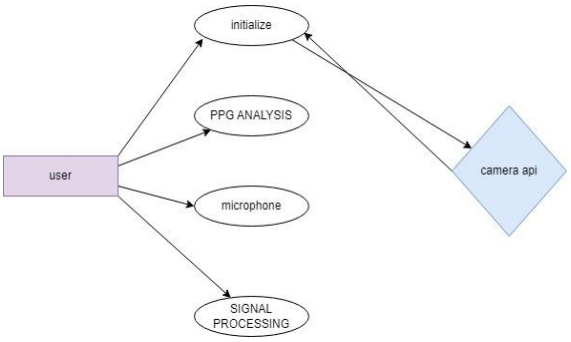

FIGURE 5.1- SIGNAL PROCESSING

Level 2:

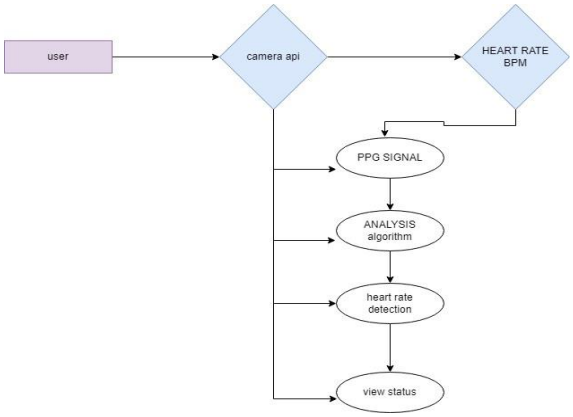

FIGURE 5.2- HEART RATE STATUS

VI. SYSTEM MODEL

Users are individuals who need to verify their identities in order to use the system. The central component of the system is the Google Authentication Manager, which's responsible, for verifying user identities and granting them access. User data like usernames, passwords and authentication tokens is stored in Firebase, a cloud- based database. The login process involves users entering their credentials into the system. Authentication occurs when the Google Authentication Manager verifies these credentials. Approval refers to the process by which the Google Authentication Manager grants users access to the system. Users can view their current authentication status through the "View Status" feature. Additionally, users have the ability to create accounts using the "Register" feature. Although not fully explained in the image there are two features called "Pulse Monitoring" and "Stats," which could be used to monitor system health and view statistics, on user activity respectively. Overall, this system prioritizes security and reliability.

Googles Authentication Manager implements security measures to safeguard user data, including encryption and two factor authentication. Moreover, the system is specifically engineered to be resilient ensuring operation in the event of component malfunction.

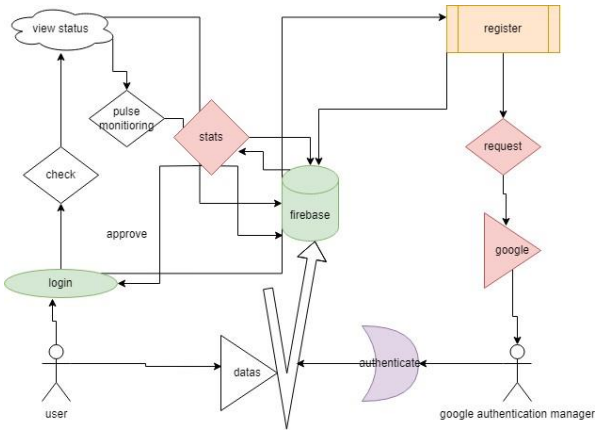

FIGURE 6- SYSTEM ARCHITECTURE

VII. REQUIREMENTS

The analysis of requirements is crucial for assessing the success of a system or software project, dividing them into hardware and software requirement.

HARDWARE REQUIREMENTS:

- PROCESSOR : INTEL I3
- RAM : 8 GB
- HARD DISK : 250 GB
- KEY BOARD
- MOUSE
- PC (PERSONAL COMPUTER)

SOFTWARE REQUIREMENTS:

- FRONT END : DART
- BACK END : DART
- OPERATING SYSTEM : WINDOWS 10
- IDE : ANDROID STUDIO
- DATABASE : FIREBASE

VIII. RESULTS

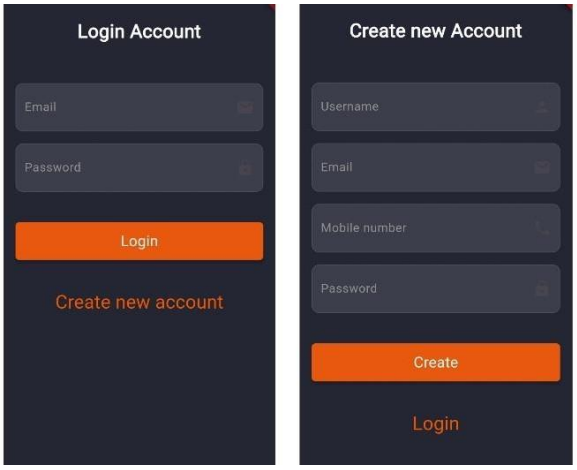

FIGURE -7.0 SIGNUP AND LOGIN

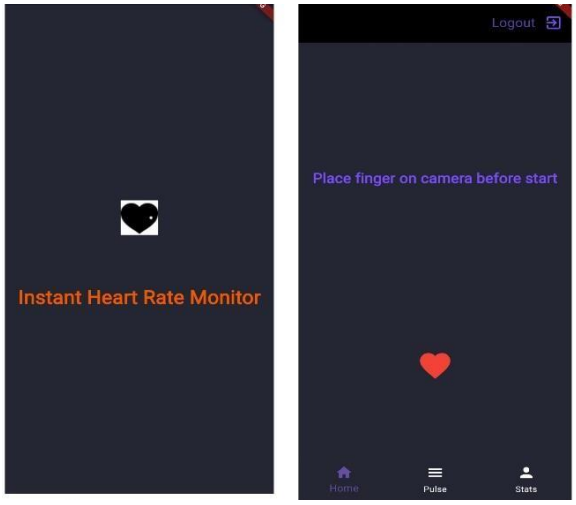

FIGURE-7.1 HOME PAGE

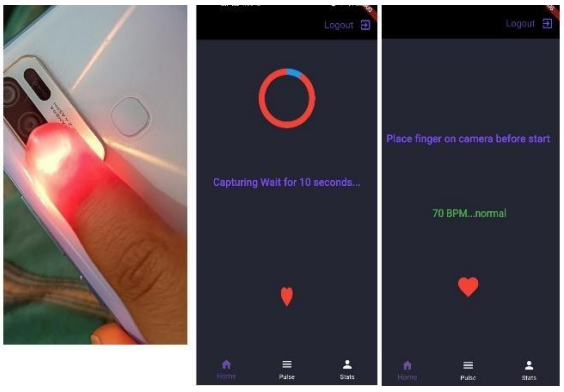

FIGURE-7.2 FINGERPRINT SCAN

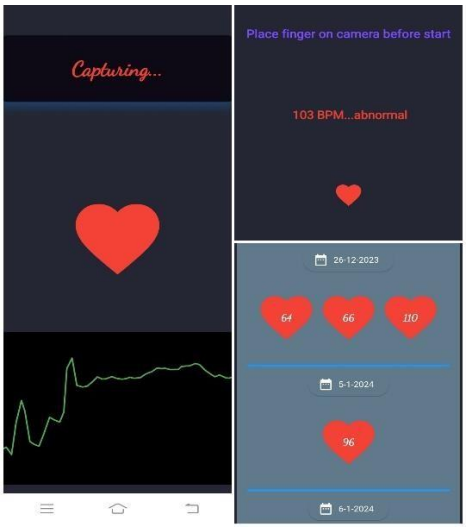

FIGURE -7.3 HEART RATE CAPTURE

IX. CONCLUSIONS AND FUTURESCOPE

In summary using a smartphone camera to estimate heart rate offers a convenient method, for individuals who want noninvasive and easily accessible ways to monitor their cardiovascular health. This technology relies on detecting changes in skin color caused by blood flow. The camera captures these changes and specialized algorithms analyze them. While this concept shows potential it's important to recognize the limitations and challenges involved. Factors like the lighting conditions movements that may introduce artifacts and variations in skin tone can affect the accuracy of heart rate measurements. Continuous advancements in smartphone technology and improvements in algorithms are expected to address these challenges making heart rate estimations more reliable.

Moreover, since smartphones are widely available to a population this approach has the potential for health monitoring. Integration with health and fitness applications allows users to conveniently track their heart rate while promoting management of wellbeing.

Looking ahead into the future as technology continues to evolve estimating heart rate through smartphone cameras may become a part of health monitoring. It can provide insights, into cardiovascular health. However ongoing research and development efforts are necessary to enhance accuracy overcome limitations and ensure the reliability of this approach.

Estimating heart rate using a smartphone camera is an promising field that holds potential, for future developments and applications.

1. Health Monitoring Apps; The integration of heart

rate estimation into health monitoring apps offers users real time feedback on their health. These apps can provide personalized insights, track trends over time. Notify users of any irregularities they shouldbe aware of.

2. Wearable Devices; By integrating this technology with devices like smartwatches or fitness trackers we can enhance the accuracy and convenience of heart rate monitoring. This allows for monitoring throughout the day giving individuals an understanding of their cardiovascular health.

3. Remote Patient Monitoring; Estimating heart rate remotely through a smartphone camera proves valuable in scenarios where remote patient monitoring's necessary. Healthcare professionals can receive real time data. Intervene promptly for patients with conditions.

4. Stress Management; Incorporating heart rate estimation into stress management applications helps users understand their stress levels better and provides strategies for stress reduction. These features may include guided breathing exercises or other techniques to help manage stress

5. Machine Learning Integration; Ongoing advancements, in machine learning algorithms hold the potential to improve the accuracy of heart rate estimation further.
Training machine learning models, on datasets and improving algorithms can improve their effectiveness, across demographics and situations.

6. Identifying Health Problems at a Stage; When heart rate data is combined with health measurements it has the potential to aid in the early identification of cardiovascular problems or other health issues. This could allow for intervention andpreventive actions.

X. REFERENCES

[1] Abe, E., Chigira, H., Fujiwarai, K., Yamakawa, T., and Kano, M. (2016). Heart rate monitoring by apulse sensor embedded game controller. 2015 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference(APSIPA), IEEE.
[2] Nenonen, V., Lindblad, A., Hakkinen V., and Laitinen T. (2007). Using ¨ heart rate to control an interactive game. Proceedings of the 2007 Conference on Human Factors in Computing Systems, CHI2007, San Jose, California, USA.
[3] Alessandri, K., Hawrysz, L., Korneta, P., Gierszewska, G., Pomaranik, W., and Walczak R. (2021).The impact of medical teleconsultations on general practitioner-patient communication during COVID-19: A case study from Poland. PLOS ONE. https://doi.org/10.1371/journal.pone. 0254960 (accessed on18 Nov 2021).
[4] Jimenez-Rodr ´ ´ıguez, D., Garc´ıa, A., Robles, J., Salvador, M., Ronda, F., and Arrogante O. (2020).Increase in video consultations during the COVID-19 pandemic: healthcare professionals perceptions about their implementation and adequate management. Int J Environ Res Public Health, MDPI,vol 17(14): 5112.
[5] Nelson, B., and Allen, N. (2019). Accuracy of consumer wearable heart rate measurement during an ecologically valid 24-hour period: intraindividual validation study. JMIR Mhealth Uhealth, PMC, vol.7(3).
[6] Nelson, B., Low, C., Jacobson, N., Arean, P., Torous, J., and Allen, ´ N. (2020). Guidelines for wrist-worn consumer wearable assessment of heart rate in biobehavioral research. npj Digital Medicine vol 3, Article number: 90.
[7] Liu, M. (2013). A Study of mobile sensing using smartphones. International Journal of Distributed Sensor Networks, Hindawi.
[8] Chen, H., Mahfuz, S., Zulkernine, F., and Nicholls, P. (2019). Smart phone based human activity recognition. Proc. of the IEEE International Conference of Machine Learning Applications (ICMLA) special session on machine learning in health, Florida, USA.
[9] Ajerla, D., Mahfuz, S., and Zulkernine, F. (2019). A real-time patient monitoring framework for fall detection. Wireless Communications and Mobile Computing, special issue on Mobile Technologies and Sensor Networks in Healthcare Environments (MSHE), Hindawi.
[10] Qiao, D., Zulkernine, F., Masroor, R., Rasool, R., and Jaffar, N. (2021). Measuring heart rate and heart rate variability with smartphone camera. International Conference on Mobile Data Management (MDM), Toronto, Canada.
[11] Gadzama, W., Joseph, B., and Aduwamai, N. (2019). Global smartphone ownership, internet usage and their impacts on humans. ResearchGate.
[12] Masoud, M., Jaradat, Y., Manasrah, A., and Jannoud, I. (2019). Sensors of smart devices in the internet of everything (IoE) era: big opportunities and massive doubts. Journal of Sensors, Volume 2019, Article ID 6514520.
[13] Majumder, S., and Deen, M. (2019). Smart phone sensors for health monitoring and diagnosis. Sensors. 19(9), 2164.
[14] Straczkiewicz, M., James, P., and Onnela, J. (2021). A systematic review of smartphone-based human activity recognition methods for health research. npj Digital Medcine 4, article number : 148.
[15] Hertzman, A.B. (1938). The blood supply of various skin areas as estimated by the photoelectricplethysmograph. American Journal of Physiology, 124, 328-340.