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ORIGINAL

Smart watch for early heart attack detection and emergency assistance using IoT

Reloj inteligente para la detección precoz de infartos y la asistencia de emergencia mediante IoT

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ABSTRACT

This research introduces a Smart Watch equipped with advanced physiological monitoring capabilities for the early detection of heart attacks and automatic initiation of emergency assistance. Cardiovascular diseases, particularly heart attacks, are a leading cause of global mortality. Rapid response during a heart attack significantly improves patient outcomes, emphasizing the need for innovative solutions. The proposed Smart Watch integrates a combination of sensors, including ECG (Electrocardiogram) and PPG (Photoplethysmography), to continuously monitor the user's heart rate, rhythm, and other relevant physiological parameters. Machine learning (Time Series Analysis algorithm) is employed to analyse the collected data in real-time, identifying patterns indicative of a potential heart attack.Upon detecting abnormal cardiac activity, the Smart Watch triggers an immediate response by connecting to a dedicated mobile application. The application utilizes built-in communication features to establish a connection with emergency services, providing vital information about the user's condition, location, and medical history. Simultaneously, the Smart Watch alerts predefined emergency contacts, ensuring a swift response from friends or family members.

Keywords: Smart Watch, Physiological monitoring, Heart attack detection, Emergency assistance, ECG(Electrocardiogram), PPG (Photoplethysmography), Machine learning.

RESUMEN

Esta investigación presenta un reloj inteligente equipado con funciones avanzadas de monitorización fisiológica para la detección precoz de infartos de miocardio y el inicio automático de la asistencia de emergencia. Las enfermedades cardiovasculares, en particular los infartos de miocardio, son una de las principales causas de mortalidad en el mundo. Una respuesta rápida durante un infarto mejora significativamente los resultados de los pacientes, lo que subraya la necesidad de soluciones innovadoras. El reloj inteligente propuesto integra una combinación de sensores, entre ellos ECG (electrocardiograma) y PPG (fotopletismografía), para monitorizar continuamente la frecuencia y el ritmo cardíacos del usuario, así como otros parámetros fisiológicos relevantes. El aprendizaje automático (algoritmo de análisis de series temporales) se emplea para analizar los datos recogidos en tiempo real, identificando patrones indicativos de un posible infarto de miocardio.Al detectar una actividad cardiaca anormal, el reloj inteligente desencadena una respuesta inmediata conectándose a una aplicación móvil específica. La aplicación utiliza las funciones de comunicación integradas para establecer una conexión con los servicios de emergencia, proporcionando información vital sobre el estado del usuario, su ubicación y su historial médico. Simultáneamente, el reloj inteligente alerta a los contactos de emergencia predefinidos, garantizando una respuesta rápida por parte de amigos o familiares.

Palabras clave: Reloj Inteligente; Monitorización Fisiológica; Detección de Infarto; Asistencia de Emergencia; ECG(Electrocardiograma); PPG (Fotopletismografía); Aprendizaje automático.

INTRODUCTION

The Internet of Things (IoT) stands at the forefront of technological innovation, heralding a new era where the physical and digital worlds converge to revolutionize how we interact with our surroundings. At its essence, IoT embodies a vast ecosystem of interconnected devices, infrastructure, and services that seamlessly collect, exchange, and act upon data. These devices, spanning from commonplace household gadgets to sophisticated industrial machinery, are equipped with sensors, actuators, and communication capabilities, forming the foundational building blocks of IoT systems. The proliferation of IoT devices has been made possible by advancements in miniaturization, connectivity, and computational power, allowing for the embedding of intelligence into everyday objects. These devices communicate through various networks, including Wi-Fi, Bluetooth, cellular, and low-power wide-area networks (LPWANs), enabling them to connect with each other and with centralized systems or cloud services. This interconnected network facilitates the flow of data, enabling real-time monitoring, analysis, and control of physical processes. At the heart of IoT lies data – vast streams of information flowing from sensors embedded in the environment, capturing everything from temperature and humidity to motion and light. Cloud computing platforms play a pivotal role in harnessing this data, offering scalable storage, processing, and analytics capabilities. By leveraging cloud-based services, organizations can derive actionable insights from IoT data, enabling predictive maintenance, intelligent decision-making, and personalized experiences. The applications of IoT span a multitude of industries and domains, each harnessing the power of connected devices to drive efficiency, innovation, and sustainability. In smart cities, IoT technologies enable intelligent urban planning, traffic management, and resource optimization, leading to improved quality of life for residents and reduced environmental impact. In healthcare, IoT devices monitor patient vitals, track medication adherence, and enable remote patient monitoring, enhancing care delivery and improving patient outcomes. However, the proliferation of IoT also raises significant challenges, particularly in the realms of security and privacy. With billions of interconnected devices collecting and transmitting sensitive data, the attack surface for cyber threats expands exponentially. Ensuring the security and integrity of IoT ecosystems requires robust measures, including encryption, authentication, and intrusion detection, to safeguard against potential vulnerabilities and breaches. Moreover, interoperability and standardization are critical to the success and scalability of IoT deployments. As the IoT landscape continues to evolve, the adoption of common protocols and standards becomes increasingly important, enabling seamless integration and communication between diverse devices and platforms. By adhering to interoperability standards, IoT stakeholders can unlock the full potential of connected ecosystems, driving innovation, collaboration, and market growth. In conclusion, the Internet of Things represents a transformative force with the power to reshape industries, enhance experiences, and address some of society's most pressing challenges. As we navigate the complexities of this burgeoning landscape, it is imperative to prioritize security, privacy, and interoperability to realize the full potential of IoT and unlock the promise of a more connected and intelligent future. Integrating IoT technology into smartwatches for heart rate detection offers significant advantages. By continuously monitoring heart rate, these devices provide real-time insights into cardiovascular health, enabling early detection of irregularities and abnormalities. This continuous monitoring, coupled with personalized data analysis, empowers users to take proactive steps towards improving their heart health. Moreover, IoT-enabled smartwatches facilitate remote monitoring and telemedicine, allowing for seamless communication between users and healthcare providers. This integration with health and fitness apps further enhances the user experience, promoting a holistic approach to wellness. Overall, IoT-enabled smartwatches not only offer convenience and functionality but also contribute to improved heart health management and overall well-being.

Before the widespread adoption of IoT technology in smartwatches for heart rate detection, traditional methods were relied upon. These methods typically included periodic measurements taken using specialized medical devices like electrocardiograms (ECGs or EKGs) in clinical settings or through consumer heart rate monitors worn as chest straps or wristbands. Individuals also resorted to manual tracking by checking their pulse at the wrist or neck. While these methods provided insights into heart rate, they lacked the continuous monitoring and convenience offered by IoT-enabled smartwatches. Clinical assessments conducted by healthcare professionals offered comprehensive evaluations of cardiovascular health but were infrequent and required visits to healthcare facilities. The introduction of IoT technology in smartwatches has revolutionized heart rate monitoring by providing continuous, real-time tracking in a convenient and accessible manner. This advancement has empowered individuals to take proactive steps towards managing their heart health and well-being.

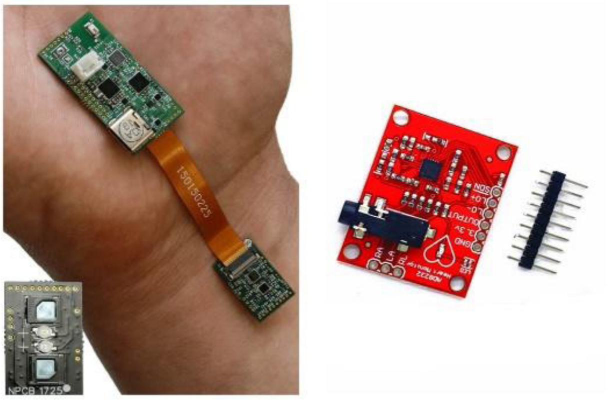

Figure 1. PPG and ECG sensors

Normally, Heartbeat rate for Newborns (0-1 month): 70-190 bpm, Infants (1-11 months): 80-160 bpm, Toddlers (1-2 years): 80-130 bpm, Preschoolers (3-4 years): 80-120 bpm, School age (5-12 years): 70-110 bpm, Adolescents (13-18 years): 60-100 bpm.

IoT enables machines to complete tedious tasks without human intervention. We can connect two devices without the need of human intelligence, but it is already programmed to do those tasks.Smart devices rely on the IoT to connect to sensors. These sensors are attached to objects or other network-connected devices and gather data from their surroundings. Smart devices can then store this data, share it with other smart devices and conduct data analyses to provide insights to users.

Related works

Eduardo Casilari et al.[1] The system consists of a smartwatch and a smartphone with an Android operating system and embedded mobility sensors. The smartwatch was a LG W110 G Watch R model with a 1.2GHz Qualcomm Snapdragon 400 MSM8226 processor, 512MB RAM, 410 mAh battery capacity, and 4GB internal storage. The smartphone was a LG Nexus 5, with a Qualcomm Snapdragon 800 2.26 GHz processor, 2GB RAM, and a 2300 mAh battery.

Gang Li et al.[2] The study proposes a method for automated drowsiness detection and estimation of driving severity using EEG signals. The approach involves three stages: data collection, model building, and model testing. Data collection involves a one-hour simulated driving experiment, while model building involves off-line MATLAB implementation to develop threshold probabilities for early and full drowsy warning groups. The well-trained model is then transferred to a smartwatch for real-time testing. The proposed approach aims to improve drowsiness detection and estimation.

Blaine Reeder et al.[3] Smart watch studies face technical challenges such as limited battery power, signal noise, data quality, usability, and watch placement. Limited battery power is a common issue, as more analysis is needed in field settings. Signal noise can interfere with accelerometer data collection, and data quality can be affected by charging, short breaks, and missed data. Raw data should be processed before transmission to overcome these limitations. Usability challenges include improper watch placement, which can lead to overreporting or under-reporting activity levels, especially for activities requiring high wrist action. Improper device placement can also limit the effectiveness of recording step counts for hand-limited activities. Data collection difficulties can be particularly concerning for patients with movement disorders.

Mohsen Masoumian Hossein et al.[4] A scoping review is a method used to identify and map relevant evidence on a topic, field, or question that meets predetermined inclusion criteria. It provides insights into a body of evidence and can highlight knowledge gaps for subsequent syntheses. Scoping reviews differ from traditional systematic reviews, which present searchable databases to identify knowledge gaps and future research needs. They do not make recommendations for clinical practice and often do not assess methodological quality or risk of bias. The PRISMA ScR is a new approach to reporting scoping reviews based on the PRISMA statement and checklist.

Weiping Ding et al.[5] proposed a 3-D coverage problem for efficient sensor distribution in small-scale areas. Bai et al. presented two static patterns of sensors in 3-D space, preserving connectivity and coverage. Andersen and Tirthapura proposed a discrete formulation to reduce the number of needed sensors. Sharma and Gupta presented a multiobjective formulation considering distance between two sensors and the number of sensors. The Harmony search algorithm was used to maximize coverage and reduce network cost. The proposed scheme was deployed for real-life applications, improving network lifetime performance. Healthcare studies are scarce, but Liu et al. introduced the artificial fish swarm algorithm (AFSA) for enhancing patient coverage.

N.V.L.M. et al.[6] developed a medical gadget using the Internet of Things (IoT) to gather data on patients’ hearts before and after cardiac disease. The Higher-Order Boltzmann Deep Belief Neural Network (HOBDBNN) was used to analyze the data, and deep learning was employed to learn heart disease characteristics. The system's performance was assessed using a hybrid learning model for IoT-enabled heart disease monitoring. The proposed improved PF-HHO algorithm and fuzzy-LSTM framework were also discussed. The experimental evaluation was conducted using Python with a population size of 10 and an iterative count of 10.

FarMan Ali et al.[7] Wearable sensors and Electronic Medical Records (EMRs) are crucial in healthcare monitoring systems for heart disease patients. However, extracting features from sensor data and transforming them into structured data is a challenging task. Additionally, feature selection and assigning weights to them is another challenge for machine learning-based systems. This section discusses the proposed smart healthcare monitoring system (SHMS) for heart disease prediction, which is divided into different layers to provide a comprehensive understanding of each stage's information groundwork.

METHOD

The proposed system aims to significantly reduce the response time during critical cardiac events, potentially saving lives and minimizing long-term health consequences. User privacy and data security are paramount, and the system is designed to comply with stringent privacy regulations and encryption standards. This research contributes to the advancement of wearable health technologies, demonstrating the potential of Smart Watches not only as fitness trackers but also as life-saving devices. The integration of real-time monitoring, machine learning algorithms, and seamless communication mechanisms positions the Smart Watch as a valuable tool in the early detection and management of cardiovascular emergencies.

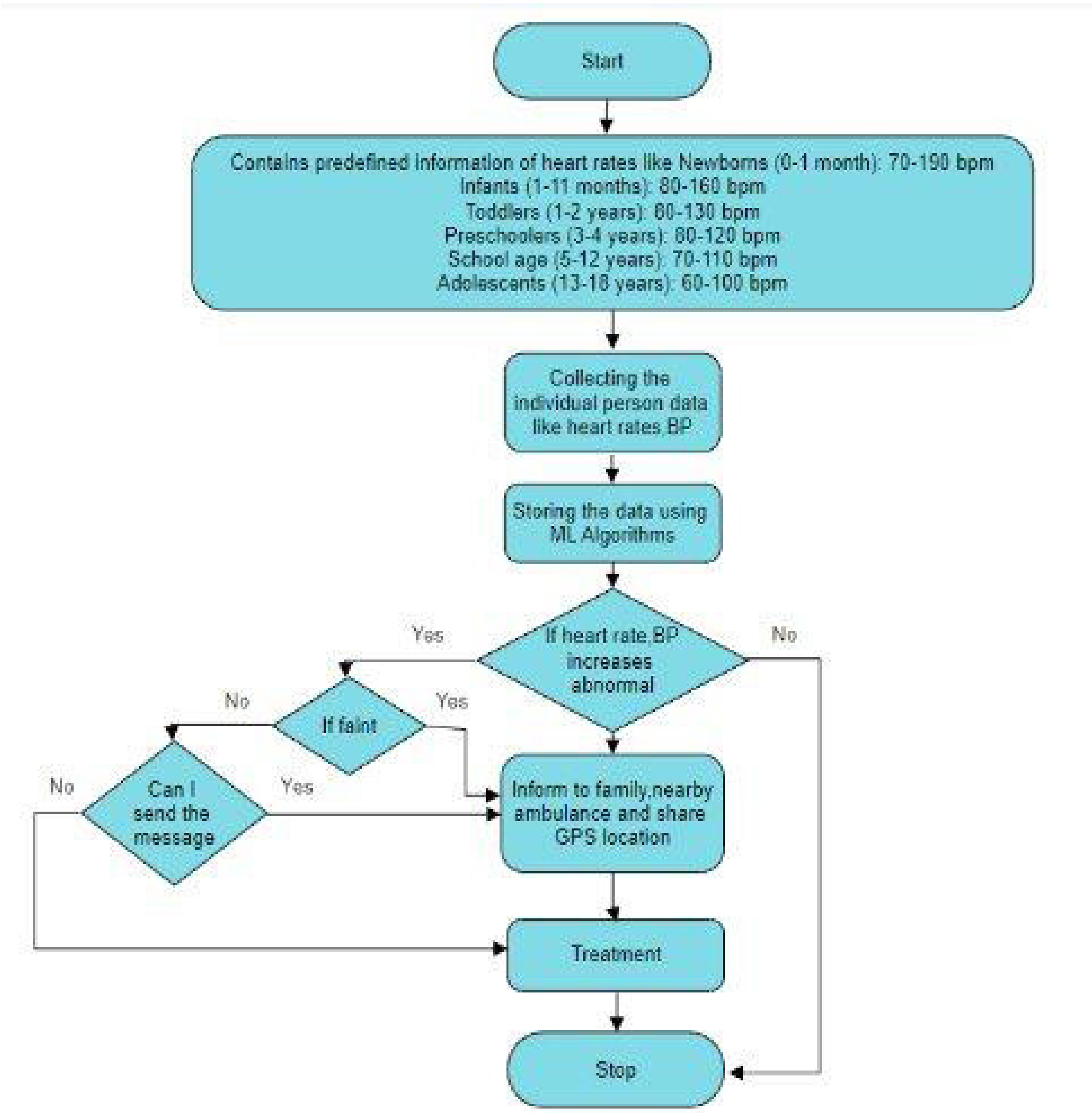

Figure 2. Flow chart of smart watch heart attack detection

Flow chart explanation

From the above flow diagram, we can understand the working flow of the smart watch. It contains the predefined information of heart rate based on the age of the individual which can be identified by the normal observations like heart rate, blood pressure, number of steps,etc. The collected information's are stored using machine learning algorithms.If the heart rate increased or decreased abnormally,it will move to the next procedure for emergency assistance.It will use a sensor like accelerometer and gyroscope to check the user is faint if so, it automatically informs to the family members and call to the ambulance by sharing GPS locations. If the user is suffering from severe pain, it will send a display message to confirm the emergency by touching the screen then inform to the family and ambulance services.

Sensors included

Sensor Integrate various sensors into the smart watch, including Optical heart rate sensor which measures heart rate continuously, Accelerometer and gyroscope which detect sudden movements or falls, Electrocardiogram (ECG) sensor which provides detailed heart rhythm analysis.Data Collection and Processing continuously collect data from the sensors and process the data using onboard algorithms to detect anomalies in heart rate, irregular heart rhythms, sudden changes in movement patterns, and other indicators of potential heart attack or distress. Machine Learning Models utilizes machine learning algorithms to analyses the collected data and identify patterns associated with heart attacks. It is trained model on a diverse dataset of heart attack cases and non-emergency situations to improve accuracy. Real-time Monitoring Implement real-time monitoring of vital signs. Set thresholds for heart rate variability, abnormal heart rhythms, and sudden movements to trigger alerts. Alert System develop an alert system that notifies the user upon detecting potential signs of a heart attack. Prioritize alerts based on the severity of the detected condition. It provides customizable alerts to include vibration, sound, and visual notifications. Emergency Assistance Integration Integrate with emergency assistance services and medical professionals. Enable users to call for help directly from the smart watch interface. Automatically alert emergency contacts or nearby medical facilities with the user's location and vital signs in case of emergency.

User Interface design a user-friendly interface to display vital signs, alerts, and emergency options clearly. It provides instructions for users on how to respond in case of an alert. Continuous Improvement gathers user feedback and data on the effectiveness of the system. It regularly updates algorithms and software to improve accuracy and reliability. It is Collaborated with healthcare professionals to validate the effectiveness of the smart watch in detecting heart attacks and providing timely assistance. Regulatory Compliance ensures compliance with relevant medical device regulations and standards. It is conducted thorough testing and certification processes to ensure the safety and effectiveness of the smart watch for medical use. Privacy and Security implement robust security measures to protect users' sensitive health data. It provides options for users to control data sharing and access permissions.

Analysis of data

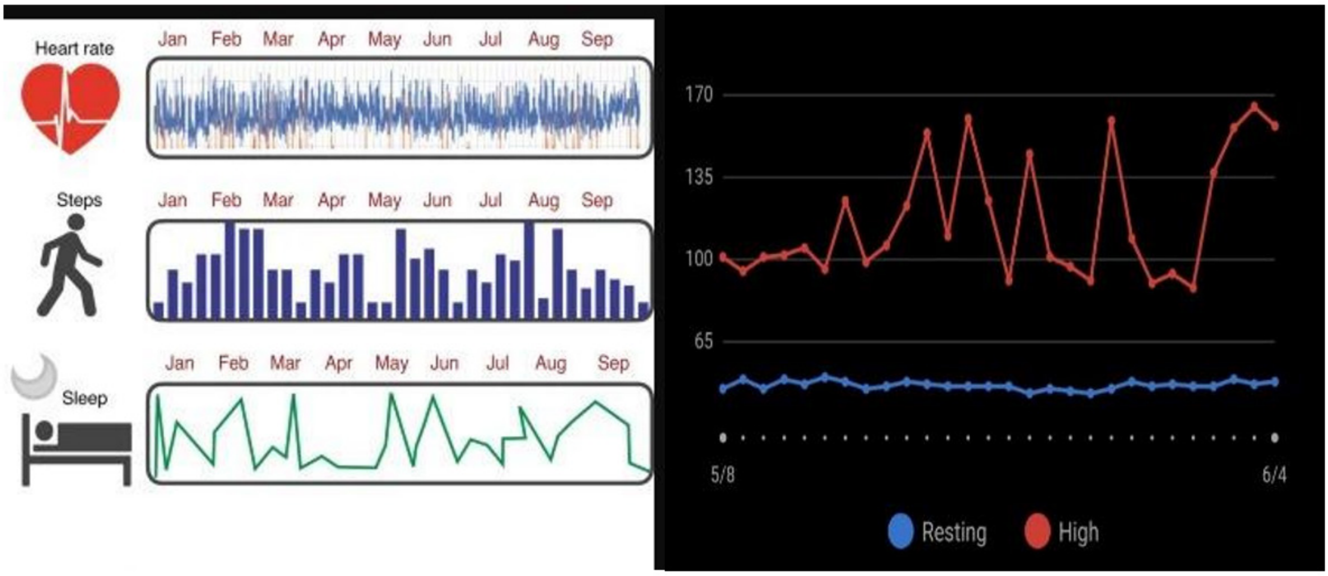

Figure 3. Data of the heart rate, number of Graph of heart rate detection with accuracy steps and sleep timing

RESULTS AND DISCUSSION

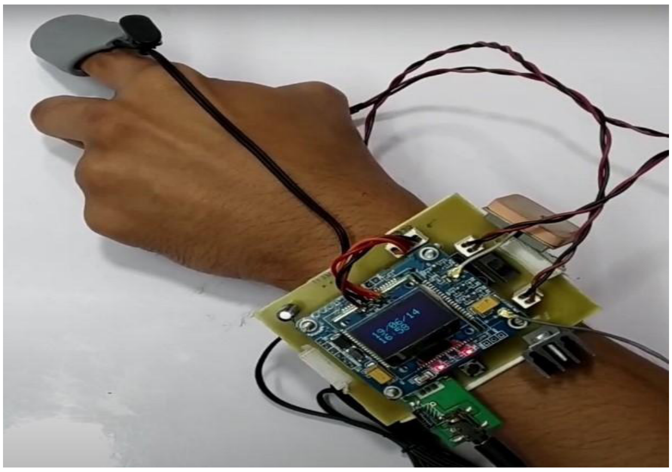

Figure 4. Working model of smart watch

The figure 4 detects the heart rate of the human if it is normal, it just stores the data if it is high, it sends the message to the hospital ambulance service and the family member how the figure 4 shows how the call send to another member.

Figure 5. Heart rate

CONCLUSION

Finally, smartwatches play an important role in healthcare by delivering a wide range of health monitoring features. These gadgets allow users to take control of their health by monitoring numerous variables such as heart rate, sleep patterns, physical activity, stress levels, and more. Smartwatches use powerful sensors and algorithms to provide useful insights into users' general health and lifestyle patterns, allowing them to make informed decisions to improve their quality of life. Furthermore, smartwatches are useful tools for managing health-related chores including medication reminders, hydration tracking, and menstrual cycle monitoring. They can also provide safety features such as fall detection and emergency SOS notifications, giving users and their loved one's peace of mind.

In future, AI assistants embedded in smartwatches could evolve to become sophisticated health coaches, offering personalized guidance on nutrition, exercise, medication adherence, and overall well-being. These assistants could leverage vast amounts of health data to provide actionable insights and support long-term health goals.

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CONFLICT OF INTEREST
None.

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Writing - proofreading and editing: S. Muthusundari, M. Priyadharshii, V.Preethi, K.Priya, K.Priyadharcini.