IoT based Health Monitoring and Activity Detection for Elderly Care

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Abstract— It is very important to monitor the health condition and activity of the elderly people especially when they are living alone or due to reduced connection with their children and relatives. To automate the elder s activity monitoring, we developed an IoT-based (Internet of Things) health monitoring system with integrating various technologies of wearable and non-wearable devices that are connected to the wireless communication network. Heart rate sensor is wearable and fixd PIR sensors used for find the location. All sensors will communicate and send data to a cloud storage through a home Wi-Fi network. In this system, doctors or guardians can be monitoring elders heart rate and able to track their real-time location through the data given by the sensors when they are living alone at home. Also, these data will be recorded in a remote IoT cloud. Thus these data can be used for data-driven predictions. Mobile app use for monitor the real-time health condition as well as actual location of the patient in the home. Also this app configured to push the notification when abnormal conditions are detected.

Keywords— **Assisted Living, Internet of Things, Smart Systems for Elderly Care, Sensors**

I. INTRODUCTION

The Internet of Things (IoT) is the internetworking of physical devices, sensors, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect, exchange data, and controlling. As people begin to grow older, they begin to lose the ability to do the same things that they were able to when they were younger. But, many elderly individuals prefer to live in their homes and refuse to move into an elderly care home. Each year millions of people experience abnormal heart rhythms (arrhythmias). Normal resting heart rate is 60 to 100 beats per minute (bpm). Abnormal heart rhythms can be described as a heart beating too fast (above 100 bpm) or slow (below 60 bpm). When electrical impulses in the heart become too fast, too slow, or irregular they cause the heart to beat irregularly[1][2] [3]. With effective monitoring and alarm systems, the adverse effects of unpredictable events such as heart attacks, sudden illnesses, falls, and so on can be ameliorated to some extent when they are staying alone. In this project, design state-of-the-art wearable technologies that can be used for elderly care. Elders need special attention to their health condition. What is the actual real-time health condition is the major problem facing by the relatives. In this project, we design a real-time health monitoring and behavior tracking system for elders. The project is to design the only one lightweight wearable heart rate sensor and few PIR location identification sensors. It designed for targeting elder people witch are living alone. This wearable sensor is very easy to wear and there are machine learning and prediction method is used when data are missed. However, the total system can apply any of any age of people that need more care of the health condition. Any authorized person can monitor real-time and analyze the historical health records through the internet. This system may allow the elderly to stay in their comfortable home environments and enjoy their normal lives safely. Others can also keep track of the overall health condition of the elderly in real-time and provide support from a distant place.

II. RELATED WORKS

H Basanta1 et al. developed a system support the real-time activity and monitor the healthcare system for the elderly citizens. In this method the information collected by various wearable sensors in real-time and stored in the central database. IoT H2U healthcare is a heterogeneous computing system of Apps and wearable devices that connect patients and healthcare service providers remotely by using the internet [4].

S. N. Malokar and S. D. Mali have developed a system that is supposed to be monitored continuously for Heart Rate, oxygen saturation level, and temperature as well. Analyzing different methods and techniques used for the health care monitoring system where doctors can continuously monitor the patient's condition on his smartphone and also the patient history will be stored on the webserver and doctors can access the information whenever needed from anywhere [5].

S. S. Kale and D. S. Bhagwat have developed a system that presents the architecture of IoT and architecture of Remote health monitoring using IoT. This system presents the problems and challenges that could come. Raspberry Pi kit, Wi-Fi modules, temperature, blood pressure, pulse

oximeter, heartbeat rate sensors are used for this IoT based health care system [6].

All of the above systems are used many number of sensors are connected to the human body and it is a very un-convenient method. The patient must wear the all sensors all over the day and those are not lightweight things. Also, few works used Raspberry Pi computer or other high-performance PCs to collect the data and push to the cloud [7][8][9]. Perhaps it may not an cost-effective method and also there is a lack of techniques for predicting patient condition whenever missed the sensor data involved.

III. SYSTEM OVERVIEW

The systems often consisted of four main parts which are wearable sensor, PIR sensors, cloud data storage, and mobile app. All units work together with an intelligent control system that allowed major advances and efficiency in health monitoring and controlling.

As shown in the above figure 1, heart rate sensors in the wearable unit are connected to the ESP8266 chip and data transmitted to the server by using TCP/IP protocol. All other non-wearable PIR sensors are mounted in different places in the home and those sensors monitor the activity of the person. All sensors are directly sending data to the cloud. All historical data and real-time health conditions can monitor by login to the system or can use the mobile app. Also Pop-up alert shows when the abnormal condition is detected.OLED display shows all real-time heart rate data to the person who is wearing the device. Blynk smart mobile app uses to monitor the real-time health condition as well as an actual location in the home. Also, this app configured to push the notification when abnormal conditions are detected..

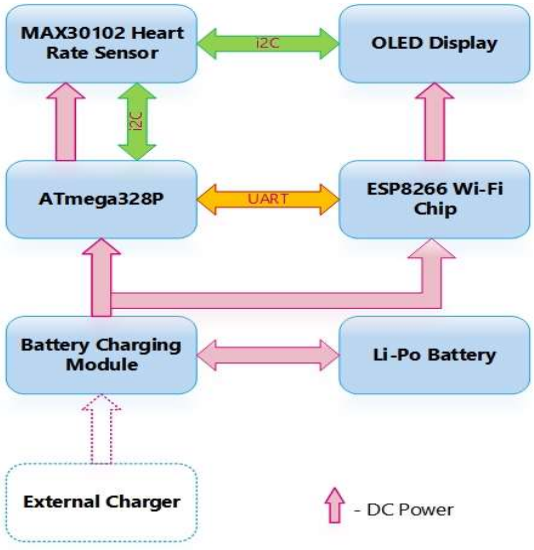

Figure 1: The system overview

III. DESIGN AND IMPLEMENTATION

The design and the implementation of the assited living system is detailed in this section.Figure 2,3 and 4 is show the wrist band heart rate monitor unit. Mainly it consisted of the MAX30102, OLED display, ATMega 328P chip and ESP8266 Wi-Fi module.The main device is wearable heart rate monitor is consist of MAX30102 chip. As shown in figure 5, it connect to the AtMega328 chip using I2C interface and OLED display used to show the heart rate. The AtMega328 chip send all data to the ESP8266 Wi-Fi module through UART port. Wi-Fi module send the heart rate data to the cloud and data store in the Google spreadsheet. First design the prototype unit by connect the all modules by using jumper. A 9900mAh Li-Ion batteries used for the first prototype. In final design, 500 mAh Li-Po battery was used as it is able to use the device for 24 hrs once fully charged.

Figure2: Wrist Band Design –Inside view

Figure3: Wrist Band Design –back side view

Figure4: Wrist Band Design

To trace the presence of elder in specific area, we have installed five PIR sensors in bedroom, kitchen,bathroom dining area and master bed room as shown in figure 6. We design this sensor node to connect directly 230 V AC domestic power supply line with PIR sensor and ESP8266 Wifi module. Designed circuit was PCB printed as shown

in figure 5. Which also includes a plastic enclose for protection.

Figure 5: PIR Sensor Node.

Figure 6: PIR Sensor arrangement inside the house.

IV. TESTING

This project was aimed to design as an elder's health monitoring system which consists of wearable heart rate monitoring devices and non-wearable PIR sensors. We installed five PIR sensors in a house and wear the wrist band by the elder. We get notifications to our mobile phone indicating the real-time location where the elder presently exists. Here we use freely available IoT cloud called 'Blynk' to get notifications to our mobile phone. Also, real-time heart rate value display in the same application. We collected heart rate data for five days of the same period of the day, each day and visualized it as shown in figure 7. We applied a moving average filter to remove outliers in the data pre-processing stage. Data visualization was It was very helpful for the study and understand about heart rate sensor behavior. We tested our system with the peoples in different ages and observed heart rate data and adjust the IR level of the sensor for work with all ages, body types, and body conditions. Blynk android app was used to receive the heart rate data. After that, data was collected for a few days to wear the device by the same person. All sensor data stored in the google drive.

Google spreadsheet saved in google drive used for store the heart rate data and PIR sensor data as shown in figure 7. A cloud-based architecture enables to collaborate with anyone, anytime, anywhere. Compatibility with external systems, including Microsoft Office and built on top of Google's infrastructure, Sheets gives the freedom to create, while helping to keep information secure.

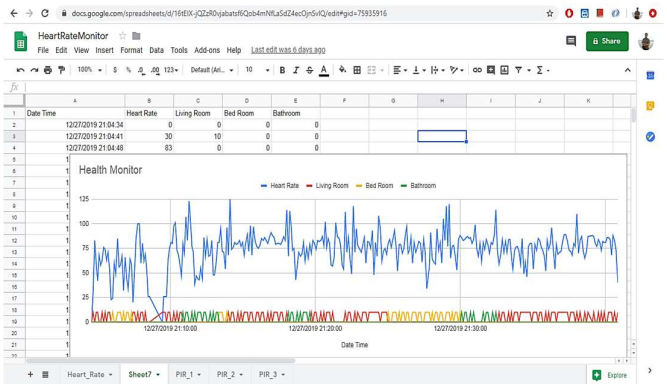

Figure 7: Screenshot of the saved data in the google sheet

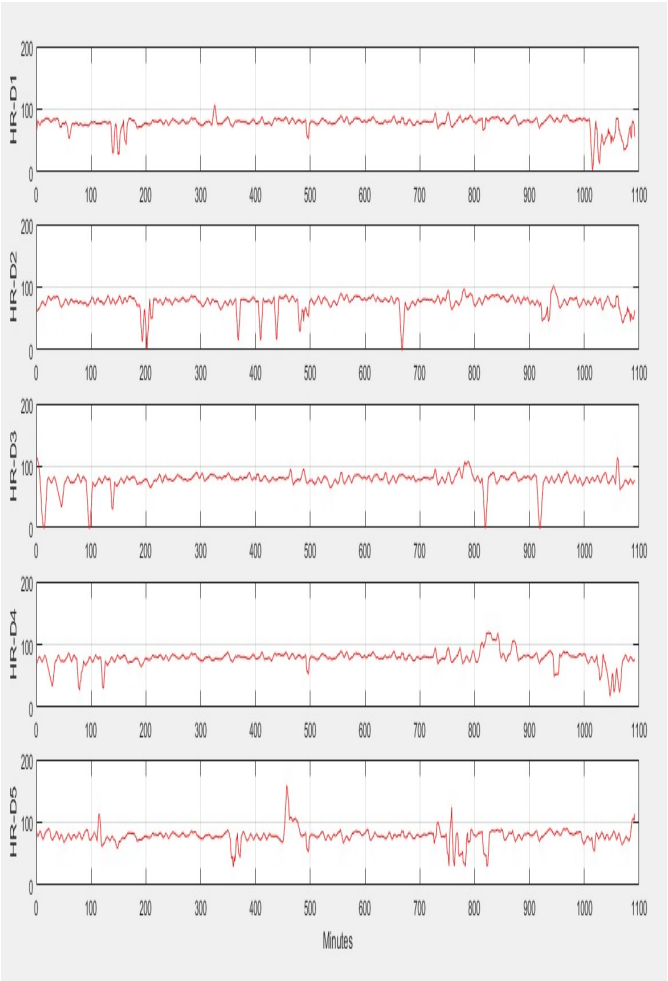

Figure 8: Heart Rate data for 24hrs

After completion of the heart rate sensing device and make the initial adjustments, data was collected of five different days (see figure 8) of the same period of the day by wearing the same person. Those data are plotted using MATLAB and graphs are shown in the above.

According to above plot, there was shows some positive overshoot and negative overshoot within very small time period such as between 1 minutes to 5 minutes. According to further studies and observations, those overshoots are happened when shock the sensor or fast vibrations occurs.

4th plot is created by doing hard exercise between 810 to 845 minutes and data shows the how increase the heart rate. In that case heart rate increased between 100 to 125 BPM for 30 minutes.

According to above graphs, fine-tuned the alert message generating algorithm. Short overshoots are ignored and considered continuous heart rate increases or decreases than normal range more than 10 minutes were abnormal heart rate. According to above observation, program running in the ATmega328P chip was changed as like show in below flowchart of figure 9. Also referred the medical article of heart rate variation for prepare this algorithm [10].

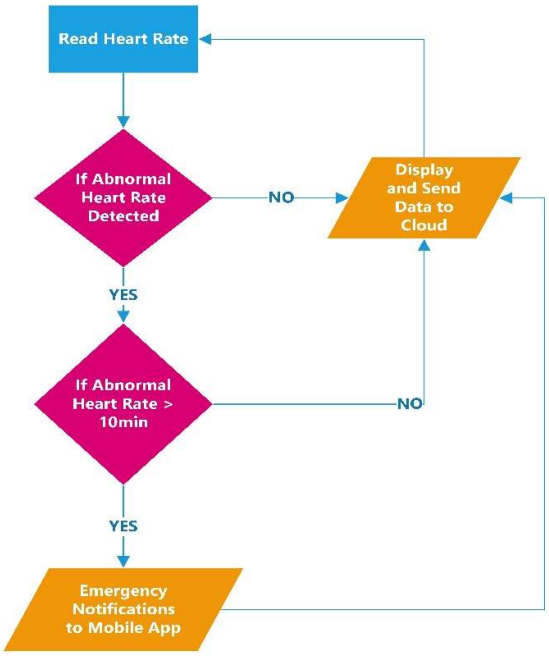

Figure 9: Flowchart of the emergency alert message generating algorithm

V. SUMMARY

We came up with a successful IoT based design for assisted living for elders. In this solution, doctors and relatives can be connected easily and monitor the elder's condition and activities using real-time sensors data and also analyzed the historical data saved in an IoT cloud for predictions. This system helps the elder peoples to intervene from any worries hopefully preventing any difficulties when they stay alone at home as well as gardiance can receive the emergency alert messages when detect the abnormal conditions. Also, This health monitoring and predictive analytics system provides early treatment and early detection of signs of danger, avoiding hospitalization. Saved historical data on the IoT cloud, can access anywhere is a major advantage of the system. Sensors are connected through the IoT system is quite cost-effective and ensures a higher security level in terms of communication. As future works, machine learning can be integrated with this solution. As the system runs on electronics components and wireless networks. At any point, those components of data connection maybe fail. Also, the heart rate sensor is warble device and humans sometimes are maybe not ware it properly. That kind of situation, data could be lost. To overcome that issue machine learning prediction algorithms can be used to rebuild the missing data.

References

[1] O.A. Postolache, E. Sazonov, S. C. Mukhopadhyay, *Sensors in the Age of the Internet of Things: Technologies and applications,* Stevenage: Institution of Engineering & Technology, 2019.

[2] V. Osetskyi, "IoT in Healthcare: Use Cases, Trends, Advantages, and Disadvantages DZone IoT," dzone.com, 14-Jun-2019. [Online]. [Accessed: Jan. 2, 2020].

[3] Mayo Clinic, Heart arrhythmia, Mayo Clinic Hospital, Methodist Campus, 201 W. Center St. Rochester, MN U.S, Nov. 19, 2019. Accessed on: Jan. 2, 2020. [Online].

[4] H. Basanta, Y. Huang and T Lee," Intuitive IoT-based H2U healthcare system for elderly people," in Proceedings of *2016 IEEE 13th International Conference on Networking, Sensing, and Control,* Mexico City, Mexico, April 28-30, 2016

[5] S. N. Malokar, S. D. Mali "An IOT Based Health Care Monitoring System-A Review," in *International Journal of Innovative Research in Computer and Communication Engineering,* Vol. 5, Issue 6, June 2017, pp. 11583-11589. Accessed on: Jan. 23, 2020. [Online].

[6] S. S. Kale, D. S. Bhagwat "Highly Secured IoT Based Health Care System for Elderly People using Body Sensor Network," in *International Journal of Innovative Research in Computer and Communication Engineering,* Vol. 5, Issue 10, June 2016, pp. 17796-17801.

[7] L. Mainetti, L. Patrono, A. Secco and I. Sergi, "An IoT-aware AAL system for elderly people," 2016 International Multidisciplinary Conference on Computer and Energy Science (SpliTech), Split, 2016, pp. 1-6, doi: 10.1109/SpliTech.2016.7555929.

[8] Chayapathy, G. S. Anitha and B. Sharath, "IOT based home automation by using personal assistant," 2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon), Bangalore, 2017, pp. 385-389, doi: 10.1109/SmartTechCon.2017.8358401.

[9] R. Nunes Oliveira, V. Roth, A. Felippeto Henzen, J. M. Simao, P. Nohama and E. C. Gomes Wille, "Notification Oriented Paradigm Applied to Ambient Assisted Living Tool," in *IEEE Latin America Transactions*, vol. 16, no. 2, pp. 647-653, Feb. 2018, doi: 10.1109/TLA.2018.8327425.

[10] Murray Longmore, Ian Wilkinson, Andrew Baldwin, and Elizabeth Wallin, Oxford Handbook of Clinical Medicine, 9th ed. Oxford University Press, 2014.

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N.D.N.M. Narasinghe obtained his BSc (Hons) in Electronics and Commmunication from University of Wolverhampton UK and his master degree in Applied Electronics from the University of Colombo. He also has IET membership and more than 10 years working experience as an electronics design engineer in IoT and Military & Aerospace field.

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