Grenze International Journal of Engineering and Technology, Jan Issue

Smart Healthcare Support for Remote Patient Monitoring

Dr.K.Kalaiselvan[1], Dr.M.Sahithullah[2], Diron Balachandaran G[3], V.Sakthi[4] and M.Srianth[5]
[1-5]Er.Perumal Manimekalai College of Engineering/Electrical and Electronics Engineering, Hosur, India
Email: kalai123selvan@gmail.com, dironbalachandaran4823@gmail.com, shakthiavinash11@gmail.com
srigowda58164@gmail.com

***Abstract*—Social distancing and quarantining are now standard practices which are implemented worldwide since the outbreak of the novel coronavirus (COVID-19) disease pandemic in 2019. Due to the full acceptance of the above control practices, frequent hospital contact visits are being discouraged. However, there are people whose physiological vital needs still require routine monitoring for improved healthy living. Interestingly, with the recent technological advancements in the areas of Internet of Things (IoT) technology, smart home automation, and healthcare systems, contact-based hospital visits are now regarded as non-obligatory. To this end, a remote smart home healthcare support system (ShHeS) is proposed for monitoring patients' health status and receiving doctors' prescriptions while staying at home. Besides this, doctors can also carry out the diagnosis of ailments using the data collected remotely from the patient. An Android based mobile application that interfaces with a web-based application is implemented for efficient patients-doctors dual real-time communication. Sensors are incorporated in the system for automatic capturing of physiological health parameters of patients. Also, a hy- perspace analogue to context (HAC) was incorporated into the current monitoring framework for service discovery and context change in the home environment towards accurate readings of the physiological parameters and improved system performance. With the proposed system, patients can be remotely monitored from their homes, and can also live a more comfortable life through the use of some features of smart home automation devices on their phones. Therefore, one main significant contribution of this study is that patients in self-isolation or self-quarantine can use the new platform to send daily health symptoms and challenges to doctors via their mobile phones. Thus, improved healthy living and a comfortable lifestyle can still be achieved even during such a problematic period of the 2019 COVID-19 pandemic that has already recorded 20,026,186 million cases so far with 734,020 thousand deaths globally.**

***Index Terms*— Internet of Things (IoT) technology, smart home automation, and healthcare systems, contact-based hospital.**

I. INTRODUCTION

Independent and convenient, healthy living is the aim of any human being no matter their age, gender, location or health status. However, there are limitations due to age, illness, medication, hospitalization, epidemic, pandemic and other circumstances. Health monitoring sys- tems have evolved to assist convenient healthy living, more accessible communication between healthcare givers and patients for close moni- toring, measurement of

Grenze ID: 01.GIJET.7.1.609

vital health parameters, routine consultation and overall healthy living. Moreover, with the recent advances in information and communication technologies (ICT) through the adoption of Internet of Things (IoT) technology, smart health monitoring and support systems now have a higher edge of development and accept- ability for enhanced healthy living. The study conducted by Zikali [1], revealed that with the rapid in- crease in the population of older or senior citizens, patients who require health monitoring have also increased exponentially. The same study predicts that by the year 2045 the number of senior citizens who are considered the most vulnerable in society will exceed the number of children and young adults as a recent population census shows an in- crease in older people. However, a shortage of home health helpers, nursing assistants and home healthcare givers is looming worldwide, which makes care for the elderly expensive. Therefore, a health monitoring system can play a vital role in lessening physical contact, hospitalization, consultation time, queuing list and overall health cost for a patient while also reducing workload, burden and stress on medical staff [2]. Advancements in information and communication technolo- gies for connectivity anywhere and anytime make a valuable contribu- tion to the development of the modern healthcare system utilized in telemedicine solutions and other portable medical platforms.

The advent of smart home technologies proposes healthy living and improved quality of healthcare support services for the elderly and handicapped for independent and comfortable lifestyles while at home, instead of nursing homes, hospitals or other confinement facilities. The healthcare module, as a part of the smart home automation system, will improve healthcare facilities for patients while at home or in remote locations outside the hospitals. Thus, there is a reduction in depression that arises from loneliness in the hospital wards for patients. The doctors can monitor patients from their office, prescribe medication and view measured vital health parameters for a remote diagnosis. Also, the rapid improvement of software and hardware technologies in the smart home healthcare system, makes it possible for patients, especially the elderly or disabled, to control certain home appliances with ease from devices such as smartphones, tablets, laptops, internet, etc.

In this paper, we propose a mobile application-based prototype smart home healthcare system for efficient and effective health monitoring for the elderly and disabled for their convenient and independent living while at home. A section of the proposed system allows the patient to remotely upload or capture essential health symptoms information during an era of a pandemic such as the ongoing COVID-19 disease for their doctor's assisted diagnosis. The new healthcare support system measures and records specific health parameters such as weight, pulse, blood pressure, glucose level and body temperature. Also, it assists with the control of a few home appliances for the conducive home living of the user. This system is also designed to send a reminder to patients on the use of certain medications with input supplied by the user. An algorithm was developed based on Hyperspace Analogue Context (HAC) for a pervasive environment, to address the need for choice for the user among numerous devices placed in the smart home healthcare system.

The technical contributions of this paper are as follows: A proposal for a smart health support system for remote patients monitoring during quarantines. Implementation of IoT based smart home healthcare support framework capable of reducing unnecessary burdens on the hospitals due to disease outbreak. Mainly, the new system which is also able to provide essential comforts using the IoTs enabled home appliances only, encourages patients with severe and critical conditions to utilize hospital facilities.

Extraction and interpretation of patient's health data from wearable, built-in, and mobile sensors for medical diagnoses and prescriptions.

II. Motivation

The provision of services through assisted means enables a comfortable and convenient lifestyle. The primary role of any smart home automation system is to assist users in remotely controlling and monitoring appliances. With this in mind, we are motivated to develop a system that not only controls and monitors the home but also supports an improved healthy lifestyle of users. Smart home automation as an emerging area of IoT has been applied in various areas such as: easy and assisted daily living especially for the provision of support to humans, remote control of home appliances detection of movement in the house, energy management in the home and security and provision of healthcare services to out-patients, disabled and elderly persons. However, the design of a sys- tem for both health monitoring and home control is yet to be fully explored. People who have been in contact with positively tested individuals, but who are not showing symptoms, are also counselled to self-isolate or self-quarantine for some days. Positive patients with mild symptoms are advised to observe quarantine. The self-isolation or quarantine can be observed from home while the affected person sends signs or symptoms of any ailment observed to the doctor at regular intervals. To this end, we are motivated to broaden the scope of the

smart home healthcare system to accommodate the upload of symptoms affected by COVID-19from the comfort of their respective homes.
There may be some instances whereby the user might need to change his position in the house, increase or decrease the home temperature, and other environmental factors that might affect the physiological parameters recorded. To address the external factors that influence the values of the physiological readings, we build on the discovery approach used. The approach is based on Hyperspace Analogue to Context (HAC) in a pervasive environment. The HAC concept implemented for the current study is discussed below.

III. Overview of the Proposed System

With the advent of the IoT, remote health monitoring, consultations and prescription have been made a reality while patients are at home. IoT technologies have made medical equipment smart; examples are sensors, actuators, microcontrollers and boards that have made it easier for doctors to have the patient's data and oversee their health without a visit to the hospital. On the patients' side, it has greatly assisted in stress reduction as patients do not need to waste time in queues in hospitals, and again, they can send and receive information from their doctors through IoT enabled systems for health monitoring. Furthermore, the physiological parameters of patients can be measured and transmitted to the database for a doctor's perusal towards clinical diagnosis and advice on treatment.
In this COVID-19 era experienced globally, infected patients and people in contact with the infected patients are counselled to self-isolate or quarantine depending on the level of infection. We propose a Smart Home Health Monitoring System. The proposed system described in our work is intended to perform a dual function of controlling home appliances as well as monitoring and recording the patient's physiological data such as blood pressure, body temperature, pulse rate, body weight and sugar level and other symptoms related to a specific virus. The values of measured physiological parameters are keyed into the system wirelessly through sensors or manually by the caregiver for transmission to the doctor. The main aim of the system is to assist out-patients and patients in prescribed isolation to live a comfortable life at home and reduce the stress of visiting hospitals often before consultation with their doctors.
Disabled and older adults are also factored into consideration of our system as the system is designed for comfortable daily living in the home. In our proposed system, the home is remotely controlled through a developed mobile application installed on a smartphone, and the user can also communicate with his doctor through another module in the same application. Medical conditions, such as chronic hypertension and diabetes, were used as the focus of our design. The system takes into consideration the role of family member or caregiver who will be responsible for helping the patient while at home. Hence, the proposed system has three major users: patient, doctor and home caregiver. In the proposed system, patients can upload values of physiological health parameters, chat with doctors, leave a message and book an appointment.

IV. System Architecture

The architecture includes the home appliances, smartphone, sensors, actuators, Wi-Fi module, and an Arduino board, which serves as the microcontroller. In the system, sensors are installed for measurement of the indoor temperature or humidity levels, and detection of motion and smoke. In our work, communication between the user and the home is wireless. The Arduino microcontroller collects data from various sensors, home appliances and physiological devices through the ESP8266 wireless module and transmits it over the internet to the user. The user receives and sends commands to the home through the developed Android mobile application to the microcontroller for necessary actions.

A. Home control scenario

The selected controlled area for the work is a room in the house. Features to be controlled by the application are the temperature, cooling system and other basic home appliances like the light switch and television. For temperature control of the home, the desired temperature is entered by the user through the developed mobile application and saved in the memory unit of the Arduino microcontroller. The temperature is measured using the DHT11 humidity and temperature sensor. The Arduino continuously reads the temperature and compares it with the value inserted by the user; if the value measured by the system is lower than the desired value given as input by the user, a notification is sent to the user, and the system automatically puts on the heater to make the area warm. If the measured value is higher than the user's desired value, the fan is automatically turned on, and a notification is also sent to the user via the mobile application. For control of other appliances in the home, the user selects the desired appliance he wants to control on the mobile application and a signal is sent to the

Arduino microcontroller for necessary action on the appliance. The communication between the user, the devices and appliances is wireless using the ESP8266 Wi-Fi module.

B. Home health monitoring scenario

The user's physiological parameters are measured manually using conventional equipment such as a sphygmomanometer for blood pres- sure, a thermometer for body temperature and a glucometer for sugar level, with the assistance of the healthcare or family member caregiver at home. The values of the measured parameters and symptoms of the virus are sent to the doctor via the internet. The values are stored in the created database for the developed system and the doctor views the parameters and other information from the patient such as message, chat and complaints through the developed web application. On the other hand, the physiological body parameters can be obtained through the use of body sensors and the values are received wirelessly by the microcontroller. If the measured parameters received are not within the normal specified range as discussed earlier, our algorithm 1 is used to perform basic checks using the HAC context types. The microcontroller sends the received values to the database and the values are then transmitted over the internet to the doctor for further diagnosis. The doctor communicates with the patient via the mobile application by placing a call, leaving a message or using the chat box option on the platform. Several devices are involved in IoT systems, thus the need for a gateway that serves as a means of integration between the devices in the system and communication modules. Home appliances are connected to the Arduino board for control through relay pins on the board. Also, data generated from the smart sensors used for measuring physiological.

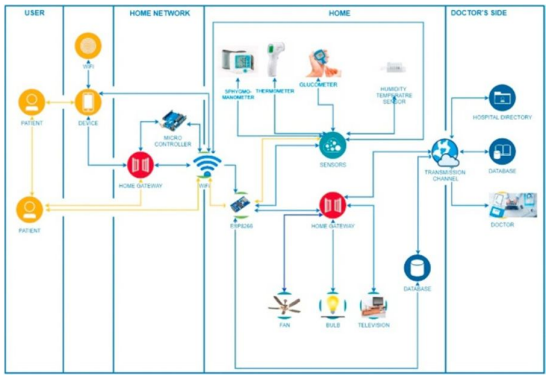

Figure. 1. System architecture

The algorithm works based on the HAC definitions to perform necessary actions for accurate readings. If the readings do not fall within the expected range, context change, position and other factors in the HAC are put into consideration for subsequent readings. The following terminologies are used:

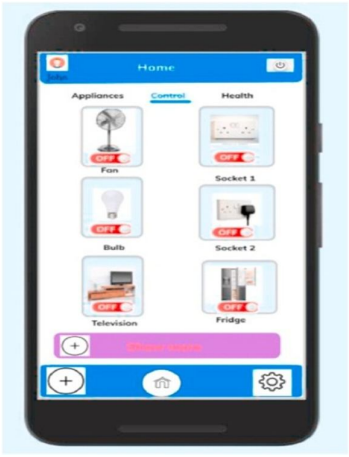

Figure. 2. appliances control

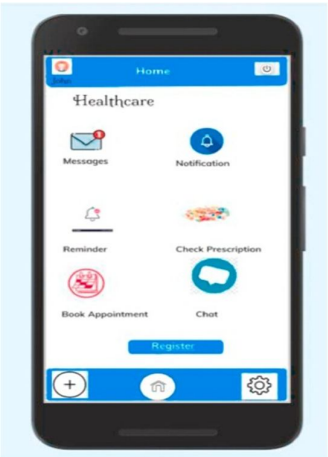

Figure. 3. Communication with the doctor

V. RESULTS

As presented in the architecture, the proposed smart home health- care system has both user's and doctor's sides. At the user side, two main parties are involved: registered user and the family member responsible for overseeing and taking care of the patient at home. The user (patient) can perform the following basic functions on the system after successful Control home devices

- Check for medication and prescription
- Send symptoms of the virus to the doctor while under isolation
- Chat with the doctor or leave a message
- Enter physiological values of measured parameters manually
- Book appointment with the doctor
- View medical data.

The role of the family member in the system is to assist the patient with uploading and retrieval of information when necessary, commu- nication with the doctor on behalf of the patient, and also use the application for home control. The doctor, after successful registration and login, can communicate with the patient either by chats or message, view messages from patients, prescribe medications, diagnose any ailment from the received physiological vitals and provide other medical consultations

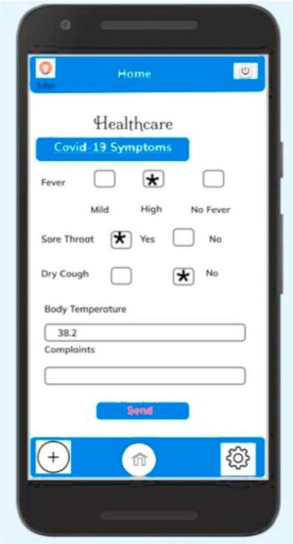

Figure. 4. COVID-19 page

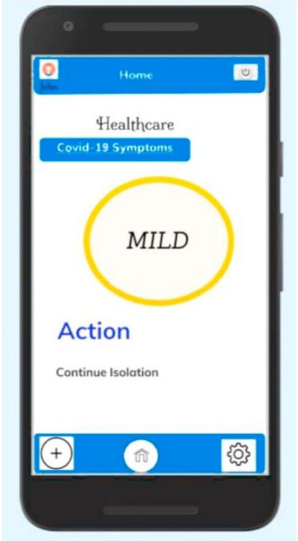

Figure. 5. COVID-19 response

The android studio integrated development environment was used for designing and developing the Android mobile application for the control of home appliances, health devices and communication with the doctor from home. Fig. 2 shows the home page of the designed mobile application. The user can gain access to the mobile application by registering on the application; after successful registration, access can be gained to login (Fig. 3) and then directed to the desired page either as patient or family member depending on the information submitted. The user registers home appliances to be controlled, and there is an option to add more appliances for future purposes. After the registration of de- vices, home appliances that can be controlled are displayed (Fig. 4). The application is designed to allow manual input data in case the sensors irritate the patient's body, and automatic measurement of physiological conditions is not possible. For automatic capturing of health data, the user will click on the parameter to send while on the health parameter page. The health interface of the mobile application allows the user to perform functions like chatting, leave a message or check the prescrip- tion of previous medication from the doctor (Fig. 5). Also, the mobile application can be used to communicate with the doctor concerning COVID-19 diagnoses, especially when the patient is observing self- isolation at home or government obligatory quarantine. Specific symp- toms are monitored and checked at intervals and sent to the doctor with the range of the readings. A response is received after the patient has successfully keyed-in the values and responses for the COVID-19 symptoms. The application is designed to analyse the input received and give a response for the next action to be taken by the patient. Colour code red means the patient should

report to the nearest hospital or COVID-19 treatment facility with immediate effect, an orange colour indicates that the patient is exhibiting above 80% of COVID-19 symp- toms and should be screened and further tested as soon as possible, a yellow colour indicates that the patient is exhibiting very mild symp- toms of the virus and hence should continue to self-isolate and avoid contact with people while the green colour indicates that the patient is not showing any symptoms at all. Based on the input received a mild indication and the necessary action to be taken by the patient. The doctor will further advise and prescribe necessary medications based on the parameters received at the doctor's end. From the doctor's side, a web-based application was designed which can be managed by an administrator. Users and family members are to register with the doctor to have their data in the database similar to the hospital filing system. The doctor and administrator are the major users of the web application. It is designed for monitoring patients' health, delivery of services such as consultations, prescriptions, evaluation of physiological values for diagnosis, treatment or further directive on medical tests required. The system is designed for the doctor to manage as many patients that are registered on the platform. In summary, the main goal of the developed hybrid smart healthcare based Android mobile web application framework discussed in this paper serves the vast purpose of enabling remote monitoring of patients concerning those diseases that might require constant visits to the hospitals even though such diseases can be diagnosed and treated remotely by doctors. The proposed mobile application similarly offers features that can monitor the patient's condition in real-time, which can help reduce hospital costs and most importantly protect the hospital against any further exposure of patients to highly contagious diseases, especially during a pandemic like the COVID-19 where most hospitals are grappling with high numbers of patients.

VI. CONCLUSION

The application of Internet of Things in smart home automation has led to a great deal of improvement in convenient living, remote access to home appliances, mobile health care and improved social lifestyle pri- current system is its physical deployment with IoT devices, a testing phase of the mobile application using the real-world scenario and documentation of feedbacks for improvement.

It is recommended that after rigorous testing and evaluation, the proposed system can be deployed in hospitals for use in various units. The designed mobile and web application, once fully developed, can be plugged into existing web domains of hospitals as a portal and can be launched as a fresh application for hospitals without existing domains. It is also recommended that new features such as a physiological data capturing device be incorporated into the current system.

As a future direction, we plan to extend our application beyond Android platform to other IOS platforms for wide adaptability. With the efficient technique presented in this paper, it is believed that this research can be extended to other areas of IoT such as agriculture for monitoring of livestock and consultation of farmers with veterinary doctors towards diagnosis, prescription and treatment of diseases in livestock in farms. Also, the new system can be extended for use in the pharmaceutical sector. The doctors can send prescriptions to the pharmacist for recommendation of dosage and possible dispensing of medications to patients. Finally, it will be of interest to carry out an evaluation of the overall performance of the proposed system using different mathematical and statistical evaluation tools.

REFERENCES

[1] Zikali Z. *"Health-E news "No suitable care for SA's elderly,"* 22 august 2018 [Online]. Available, https://health-e.org.za/2018/08/22/no-suitable-care-for- sas-elderly-population/.

[2] Mirza MB, Hamid G. *Smart health monitoring systems: an overview of design and* modeling, J Med Syst 2013;37(9898):1–14.

[3] Katharina R, Fei L, Sanjin S, Rassul A, Schahram *D. Context-Driven personalized service discovery in pervasive environments. World Wide Web 2011;(14):295–319.* 2011.

[4] Aleksandar K, Natasa K, Saso K. E-health monitoring system. In: International conference on applied internet and information technologies; 2016.

[5] Sparsh A, Chiew TL. Remote health monitoring using mobile phones and web services. Telemedicine and e-Health Journal 2010;16(5):603–7.