Jestr

Journal of Engineering Science and Technology Review 13 (4) (2020) 206 - 213

JOURNAL OF
Engineering Science and Technology Review

Research Article

www.jestr.org

Automated Assistive Health Care System for Disabled Patients utilizing Internet of Things

M. Anisha[1,*], J. Francis Felix Sindhuja[1], C. Jim Elliot[1], R. Lijia Rani[1], J. Durga Devi[1], K.Monal[1], Ponmozhi Chezhiyan[2], A. Abdul Majeeth[1] and U.Shalini[1]

[1]*Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Virdhunagar, Tamilnadu, India*

[2]*Department of Computer Applications,Kalasalingam Academy of Research and Education, Krishnankoil, Virdhunagar, Tamilnadu, India*

Received 20 April 2020; Accepted 2 August 2020

Abstract

The advancements in information and communication technologies have lead a way for the usage of internet and mobile in health care applications. It may give a drastic increase in the life expectancy of disabled people over the whole world especially the developing world. In order to meet the needs of elderly or disabled peoples' health care services, it is necessary to develop an effective assistive device that is cost-effective, affordable, and easy to use. The work is undertaken to develop a smart assistive device that combines sensor technology and telecommunication technology to enable the remote monitoring of disabled patients. The health care system is based on the Internet of Things (IoT) that makes disabled patients lead an independent life. When the person has whole or partial body movement impairments, they cannot express their needs to the physicians or care-takers, and moreover, they are unable to communicate like normal people. So they cannot manage their basic day-to-day activities like holding an object to eat, drink, or to do any activity. The assistive health care system thereby assists the patients as and when they receive SMS from the patient with the aid of the IoT network. Each and every slight movement of the patient fingers are converted into their corresponding needs. Also, it monitors the physiological vital parameters such as heartbeat, temperature, blood pressure, and respiratory rate. The network will send a corresponding message to the physicians and it will display the needs on their mobile phone or display gadget. Thus this system makes it possible for the health care professional to track the patient and to provide distant care in case of an emergency.

Keywords: Disabled Patients, Flex Sensors, IoT, Personalized Health Care, Real-Time Monitoring.

1. Introduction

Recent advancements in telecommunication technologies provide people with not only sophisticated communication but also to do a particular task in remote.Nowadays most people are affected by stroke due to aging, trauma, or psychosocial factors which results in brain damage and leads to disability. A disability is any condition that makes it more difficult for a person to do certain basic day-to-day activities or to interact with the world around them. It is due to the restriction of body movements in the patients. The spinal cord is said to succumb in most or all of the ortho related ailments. The disabled people affected by one part of their body also, they need some form of assistive devices for their independent daily life. Some kinds of spinal cord injury have mild effects and some have a lasting disability. In other words, spinal cord injury can be temporary or even recurring. Around 80% of people suffer from disabilities in one way or the other. It can be either partial or complete disability. There are many different causes of disability that often affect basic activities of daily living such as, eating drinking, dressing, and maintaining personal hygiene [10]. In which about 83% of people face non-communicative issues. So, they cannot convey their needs to their caretakers at the time of emergency. The dependence on nurses, healthcare professionals, and doctors can give an economic burden for these patients. According to the recent statistics the disabled patient spends $177K per year on assistive living [38]. In 2017, according to the budget of Ontario, Canada has seen a massive increase of $11.5 billion as an investment in its health care services. Hence it may create a socio-economic burden for the developing countries. In addition to this scenario, many people are suffering from different kinds of disabilities, so they are living with the help of assistance from family, friends, or health caretakers.

In order to eliminate the issues faced by disabled people, a new and innovative technological solution has been given. The information and communication technologies give personalized, cost-effective health care for these patients. Recent advances in sensor technology have also been used for the detection of hand movements [49]. Therefore, a need for cost-effective and assistive devices is the need for the hour in this ever-changing world to increase the standard of living of disabled patients.

In case of emergency, the disabled patients need immediate health care otherwise it may lead to fatal consequences. It can be eliminated by 24x7 monitoring of these patients. Remote health monitoring is a platform in which the patients at their home can be able to obtain high-quality healthcare that may lead to the independent living of

*E-mail address: anisha@klu.ac.in
ISSN: 1791-2377
doi:10.25103/jestr.134.20

disabled patients. Nowadays healthcare service has seen greater changes over the past years. Mobile and the internet have a major role in the personalized healthcare system. Recently, m-health (mobile health) is the term which is used to represent the usage of smart devices in healthcare.

The proposed system combines various sensors such as a heartbeat sensor, blood pressure sensor, spo2 sensor, temperature sensor, and flex sensor to monitor the patient's health continuously. Most commonly hand and eye gestures are used to assist these patients. Sensors such as flex sensors, MEMS sensors, and EOG sensors can be used to detect these gestures. The system uses flex sensors attached with the glove to detect the hand movements with higher accuracy. The sensors are interfaced with Arduino Uno. The collected data from the gestures are processed with the help of Arduino and send it to the distant area via the IoT network. It digitizes and reduces the data, then sends it down through the network channel. Hence, this wearable assistive health care system helps the physicians and caretakers to take care of the disabled patients when they are not nearby.

2. Remote Health Monitoring

In recent times, the number of disabled patients is increasing rapidly day by day. According to the World Health Organization, about 15% of the population lives with some form of disability, out of which 2-4% experience significant difficulties in functioning. The primary disability faced by most of the people is blindness and hearing impaired which is about 19%. The second common disability is the movement and speech-related disability of about 18%. Figure 1 shows the percentage of paralysis patients at different age levels.

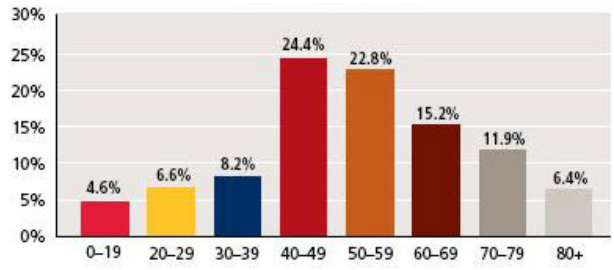

Fig. 1. Percentage of Paralysis Patients at Different Age Levels.

Disabled people meet a variety of barrier that includes a few of the following:

i) Prohibited costs: transportation and availability of services are the main reason for not receiving proper healthcare for low-income patients.

ii) Limited availability: the occurrence of disability in urban areas was about 19.27% and in the rural area was about 28.07%. Rural regions do not have advanced health care services. Hence the disabled patients in this rural region cannot get proper treatment in case of an emergency. Hence, it is needed to send the disabled patients to urban hospitals for better treatment.

The above barriers to disabled patients can be eliminated by the implementation of remote health monitoring. It does monitoring of these patients to get an improved quality of life. Recent advances in telecommunication technologies can pave a way for remote health monitoring and the advances in miniaturized sensor technologies along with the internet leads to the invention of home-based remote health monitoring. Here the miniaturized wearable sensors (flex sensors) detect the finger movements of the disabled patient and send it to the Wireless Area Network (WAN). It sends the collected information to the distant area and gives notification about the patient's particular need. The collection of sensors monitors the patient essential need and sends the detected information to the distant area for health assistance. E-health and M-health are the terms in the personalized health care system for continuous health monitoring.

i) E-health and M-health: Due to the advancements in the information technologies to enable the automation of health care such as e-records, e-prescriptions, etc. for example the e-record contains all the medical information about the patients with high security and privacy at any part of the world. Hence it facilitates remote health monitoring. In addition, it can also be stored in e- health care system for future use with the help of e-storage systems. Hence it gives a fully functional personalized health care system. The architecture of E-health is illustrated in Figure 2.

Telemedicine is the emerging field in e-health which provides great support for home health monitoring. It collects all the information available via recent technologies and makes use of it for giving treatment in an affordable and faster manner. It helps to reduce hospital stay and mortality rate due to chronic diseases. The sensor network had been connected with the mobile phone using the GSM/IoT network. Thus the smart phone is acting as a gateway for distant communication such as WAN (Wide Area Network) or WLAN (Wireless Local Area Network). These systems detect various physiological parameters of the patient like a heartbeat, pulse rate, temperature, blood pressure, motion, etc. In addition, it sends the detected information to the physicians/health worker to track the patient's state over the internet. The system has effective authentication in order to ensure the privacy and security of transmitted medical data.

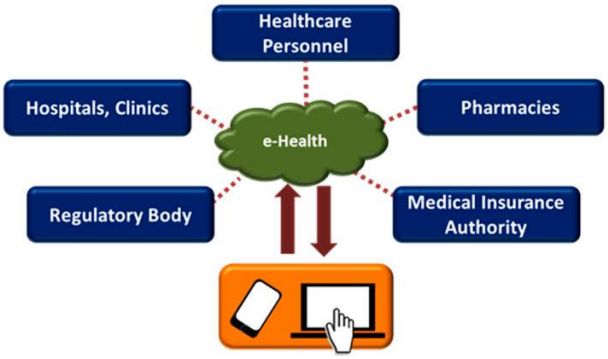

Fig. 2. Architecture of E-Health

However, recent compact and portable smart devices had created M-health an essential technology to users in remote health care that are mostly based on mobile phones, and computers. Recent mobile communication technologies such as GSM (Global System for Mobile communication), HSPA (High-Speed Packet Access) and LTE (Long Term Evolution) can be used for the data transfer from one region to another region.

3. Related Works

In the domain of health care, the internet has its unavoidable role. Due to the largest advancements in information and communication technology, it is possible to make the health care system into a personalized one. Variety of technologies

used in the healthcare system such as GSM, Bluetooth, RFID, etc as shown in Figure 3. Each technology has its own merits and demerits summarized in Table 1. In addition, there is an embedded framework called SEEKS which enables access for disabled and elderly people based on IP addresses [7].

ies which is fully automated. It is

Smart homes are the recent advancement of internet technologies more helpful for elderly people who are staying in their homes. It gives safe, independent, and quality of life for elderly people [2].

Table 1. Comparison between various Data Transmission Technologies

Technique	Pros	Cons
Bluetooth	Low cost, low power, and long battery life	Low bandwidth and short-range communication
RFID	Convenient, small portable database and real-time communication	High-security issues and high cost
Microwave	Point to point communication, more gain, and high bandwidth	Incorporate signal absorption and cost
Infrared	Cheap, low power and easy to use	Cannot move around while transmission occurs, very short-range communication
LTE	High data transmission and saves time	Needs the user to have a 4G phone, rural regions do not have the LTE facility.
GSM	Worldwide communication and low cost	May cause electronic interference and slower than LTE.

Fall detection with the help of IoT, which will detect and track the elderly people with the help of software named Microsoft Kinect SDK with high accuracy. If it is an emergency, it sends a notification to a nearby hospital with two processes, which are data processing and feature detection [5].

Wearable IoT based remote monitoring system had been used to measure the physiological parameters like a heartbeat, blood pressure; temperature, etc. It uses a system called WISE (Wearable IoT-cloud baSed hEalth monitoring system along with the BASN (Body Area Sensor System). It displays the results in the LCD for diagnosis and treatment [13].

Wireless sensor networks had been used for monitoring ICU patients. It uses the USH-Ubiquitous Sensing for Healthcare system, which analyzes the user's activity and user's information [33].

In addition to the IoT, the RFID (RF identification) technology also used for remote health monitoring that is a low cost, high energy and it uses the replaceable sensors to detect the patient's physiological parameters. It collects a single channel or multichannel data of the patient [35].

A sensor network consists of a number of sensors that are embedded into a small miniature device. It collects the physiological parameters. The data is stored on mobile and sent to a remote area through Wi-Fi. However, there is a loss of patient data in this system [51].

Most of the health care systems are single-mode communication, so it can be expanded to modes such as GSM, BLE, and IoT. Also, it can be effectively used in health care monitoring. The system is highly complex and has a limited speed [52].

A system called an autonomous elderly patient care system is used to measure the parameters such as temperature, glucose, and fall detection by continuous monitoring and it will send notifications via the cloud layer to the mobile phones. Also, it does not have security while transmitting the patient's data [53].

The IoT based system can be used in a real-time environment to monitor cardiac patients and detects the conditions of their diseases. So the physician can diagnose at anytime, anywhere without any external support [54].

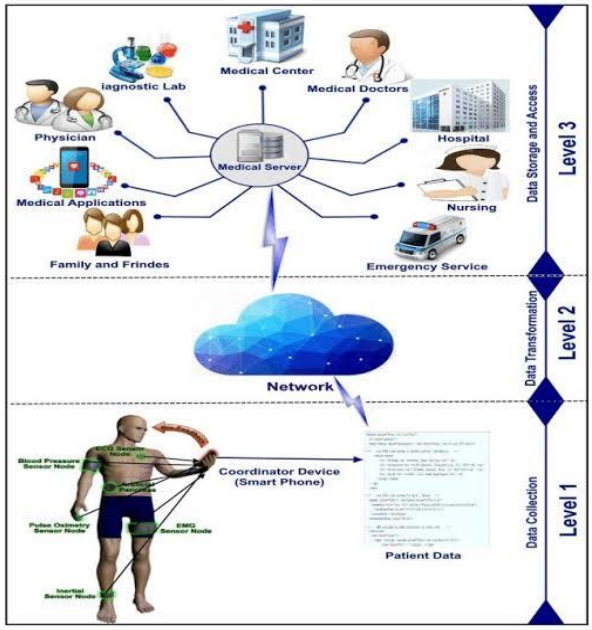

Fig. 3. Generic overview of Remote Health Monitoring

A fall sensing technology that helps the elderly person works with the help of ZigBee and microprocessor unit in which the algorithms are developed to transmit the data and vice versa. It has a low transmission rate [55]. An IoT based secured system was developed for real-time monitoring of post-chemotherapy [56].

Thus the wearable health monitoring system helps to effectively monitor the disabled and elderly people. So it is very useful for those patients in case of emergency and increases their lifetime by immediate treatment.

4. Methodology

The proposed assistive health care system uses telecommunication and wearable sensor technology. It combines a few hardware sensors and its circuits and software like the Arduino IDE compiler to interface with the network. The main components used in the system are the heartbeat sensor, blood pressure sensor, spo2 sensor, temperature sensor, flex sensors, and the Arduino Uno board for the

processing of data. In addition, it consists of three major tasks. These are mentioned as follows:

- To detect the various physiological parameters and the hand movements of disabled patients with the sensors.
- To transmit the collected data to the distant area with the help of the IoT network
- To understand the patient's needs with the help of detected data from the patients.

The vital signs that are measured in this system are given as follows:

- Heartbeat
- Spo2
- Blood pressure
- Temperature

Also, it detects the finger movements of the patients and gives it as a readable data with their corresponding need.

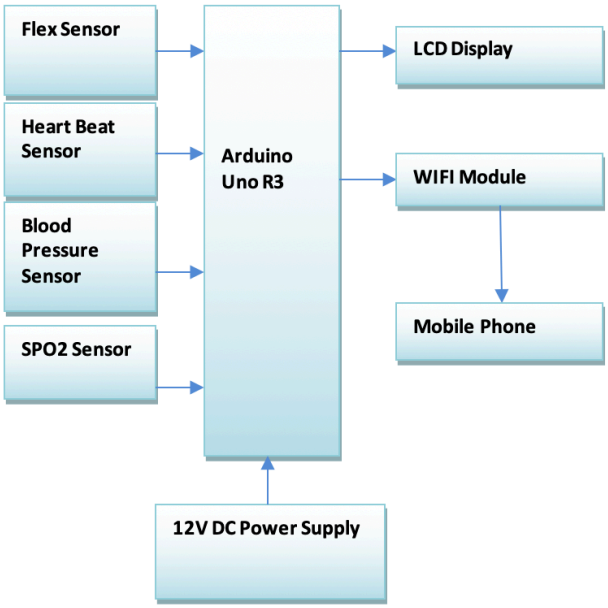

Fig 4. Block Diagram

The assistive system design is a combination of two modules that are the transmitter and receiver sections. The transmitter end that is the patient side consists of the glove with the sensors, Arduino Uno and the receiver end consists of the buzzer or alarm, mobile phone, or display.

The proposed assistive health care system is more compatible because of its wearable sensors and it will not create any discomfort to the patients. These sensors collect the information from the patient's finger movement and send it to the Arduino for further processing. Then it sends the processed data to the IoT wifi network for transmission.

5. System Implementation

Various software and hardware are used to implement the major tasks like detecting the hand gestures of the patients, to transmit the data, and to understand the patient needs with the help of different hand gestures. Figure 4 illustrates the workflow of the research undertaken.

A. Software Implementation

The software called the Arduino IDE compiler was used in the proposed system. Any programming language can be used to write coding on this software. It supports the programming languages like C, C++, etc. then compiles the written program and control the given process with the help of Arduino Uno. Software implementation in this system design is performed with the help of C programming to interface the acquisition of the patient's physiological parameters like a heartbeat, respiration rate, blood pressure, temperature and motion, then sends the processed data over the network IoT module for the transmission.

B. Hardware Implementation

i) Interfacing of Arduino with flex sensors

A flex sensor is a kind of sensor that is used to measure the amount of bending movement. The sensor design is made using materials like plastic and carbon. The required voltage of this sensor to activate it ranges from 3.3-5V. One end of the flex sensor is connected to Arduino GND and another end is connected to the analog input.

The linear surface of the flex sensor resembles the normal resistance. When it is bent 45^0, its resistance will increase twice as before and 90^0 indicates the increase in resistance as four times higher than normal resistance. The increase in the resistance is linearly dependent on the angle of bending. Then this resistance is converted into voltage with the help of the voltage divider circuit shown in figure 5. It has the resistive network which combines two resistances R1 and R2. Where voltage divider R1 and an impedance buffer are used. Hence the output voltage is given by the following equation: $V_{OUT} = V_{IN} \{R1/ (R1+R2)\}$.

The disabled patients have limited hand movements and it is difficult for normal people or health care professionals to understand their needs with their simple movements. So there is a need for a device that amplifies their simple finger movements into understandable language. These flex sensors will detect each and every slight movement of the patient's finger/hand and it sends it to the Arduino Uno for further processing.

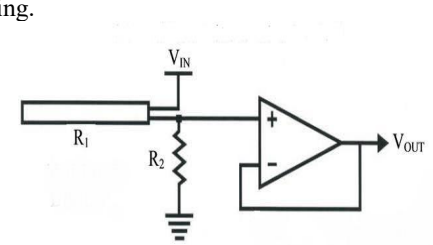

Fig. 5. Circuit of Flex Sensor

The Arduino coding was written for different finger movements according to the patient's needs. The patient should be taught and made familiar with the procedure involved in detecting finger movements. Accordingly, they provide with the personalized movements and convey their needs easily. In addition, it is possible to add more number of movements and signs into this system according to the patient's need.

ii) Interfacing of the heartbeat sensor

Heart rate is the window for human health; it is an easier way to diagnose many severe diseases. It can be calculated with the help of a heartbeat sensor. It works based on an optical method which is also known as photoplethysmography. It measures the heart rate by means of blood volume changes. The output pin of the sensor is connected to Arduino, it reads

the input pulses given by the heartbeat sensor and calculates the heart rate.

iii) Interfacing of the temperature sensor

LM 35 is a sensor that is used to detect the body temperature level. The LM35 has three terminals in it. First and third pins are connected to 5V power supply and ground, whereas the second pin gives the temperature of the body. It doesn't require any external device to operate and it is connected to the Arduino Uno R3. The detected temperature will give a 10mV output voltage when it senses temperature level increases in the range of 1 degree.

iv)Interfacing between the blood pressure sensor and respiration sensor

BMP 180 sensor is used to measure blood pressure. It is a non-invasive sensor designed to measure human blood pressure. A respiratory sensor is sensitive to stretch. With the stretching levels, it measures the respiration range. It is very useful in terms of detecting the parameters continuously. All these sensor outputs are connected to Arduino Uno R3 and it process all the collected information. Hence it will give notifications about the sensed physiological parameters.

v) WIFI Module

The collected data is processed by the Arduino and sent to the IoT wifi module. According to the different gestures, the Arduino sends particular commands to the IoT wifi module and it performs specific tasks like giving alarm or message notification to the caretaker.

vi) Arduino Uno

Arduino Uno is a microcontroller board which is equipped with a set of digital and analog input and outputs pins. It can be interfaced with various devices and circuits. The Arduino process collected data from the patient when they move their hand. Further, it will send the processed data to the IoT wifi module.

The Arduino has been programmed for various movements like 90^0 and 45^0 of the patient's finger. Each angle of a finger shows a particular need for a patient like an emergency, food, etc. The system has four basic needs that are food, water, emergency, and requiring medicine. In case of emergency, the system will send an emergency notification to the specialists.

vii) Power Supply

12V regulated power supply is connected to the Arduino for its operation. Linear 12V power supplies are very stable and regulated supply stabilizes the circuit. It gives its whole output to the Arduino Uno R3, the Arduino will convert the voltage into the operating voltage as required.

Table 2 shows the different signs or finger movements and their corresponding patient's needs. Each movement has a different meaning. The signs and their indications have to be trained by the patients therefore they can fulfill their needs easily with the help of this system. It can be extended for more number of movements according to the disabled patient's needs

Table 2. Finger Signs According to the Patient Needs

Sl. No.	Signs	The need of a Patient
1.		Food
2.		Water
3.		Emergency
4.		Requiring Medicine

6. Results and Discussion

The recent information and communication technology contributes more to the personalized health care system. In addition to that, wearable sensors like heartbeat sensors, temperature sensors, blood pressure sensors, and respiration sensors and flex sensors are used to detect the various physiological parameters of the patients. The detected information can be accessed by the physicians or dependents from a distant area with the help of telecommunication technology. Hence the disabled patient's finger movements and physiological parameters have been detected continuously and accurately. And also it's more comfortable for the patients because of the wearable sensors which are attached to the hand glove. Three flex sensors used in the work detect four types of movements. It may be extended with an increase in the number of flex sensors. Hence the health care professional or relatives can easily track the patient with the help of sensor technology.

The proposed design is very useful for disabled people who are restricted to body movements. The complete design of this system is shown in figure 5. It continuously monitors the patients' needs with the help of flex sensors and it sends the commands to smartphone/laptop as shown in figure 6.

Table 3. Comparison of the proposed system with the existing health monitoring system

Author & Year	Methodology	Uses
Amendola, et al. 2014	RFID technology for IoT based personal healthcare in smart spaces. [58]	The proposed system gathers information such as Temperature, humidity, and gas levels of the user's living environment.
Ghasemi, et al. [2019]	The structural and behavioral reference model for IoT based elderly health care systems in the smart home.[2]	The proffered system monitors Heart rate, temperature, blood pressure, and glucose levels of the patients.
Kong, Xiangbo, et al.2019	A HOG SVM based fall detection IoT system for elderly persons using deep sensors [57]	The persons are tracked and detected only when fall happens.

Benisha.et al.[2020]	An IoT Secured System Design for Real-Time Health Monitoring of Post-Chemotherapeutic Effects	A health care monitoring system was proposed to monitor the vital parameters only at post Chemotherapy. In case of emergency, health care professionals are notified through email or SMS using IoT
Proposed Work	Automated assistive health care system for disabled patients using IoT	An assistive health care system is proposed with a noble intension to assist the disabled patients in their essential needs based on their hand movements, also monitors the vital parameters.

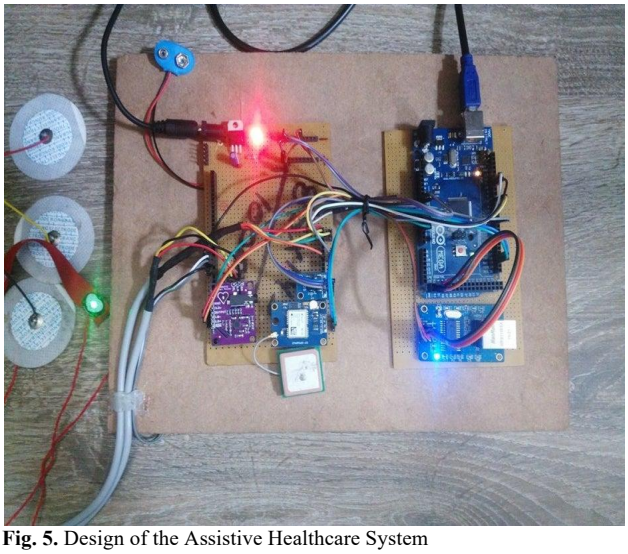

Fig. 5. Design of the Assistive Healthcare System

It is done with the help of predesigned programs; each movement represents the different needs of disabled patients such as food, medicine, water, and emergency. Since the proposed system uses IoT, it has recompenses over other existing techniques listed in table 2 such as Rich data transfer, enhanced security, efficiency, and saves time.

The work undertaken is compared with the existing systems and detailed in Table 3. Existing systems either detects fall or monitors vital parameters but the current work exclusively recognizes the hand movements and converts them into appropriate massages to address their needs.

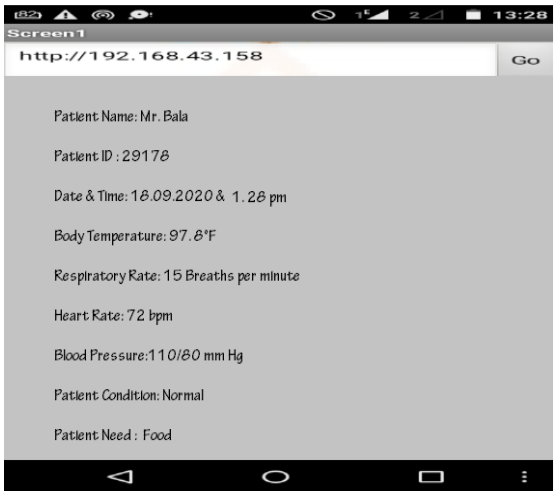

Fig. 6. Indication of Patient Need (Food)

7. Conclusion

The proposed health care system is a greater assistive device for disabled patients who are suffering from non-communicative disorders. So these patients can easily convey their needs to the physicians or caretakers by means of this wearable assistive health care system. In addition, there are various sensors fixed to the patients to monitor their health conditions. This is a fully automated system hence; there is no need for the caretaker or physician to be there at the patient's side always. They can only be available at the time of emergency for the patient. Also, it operates in a continuous manner, hence in case of any medical emergencies; it will send an immediate message to the doctors who are in urban hospitals. So it improves the quality of life for disabled patients. This would be a boon to the disabled persons to perform their day-to-day activities in a much better way.

In the future, the system can be enhanced with GSR, HBO2, and fall detection features.

References

[1] Pei Huang, Linke Guo, Ming Li, and Yuguang Fan "practical preserving ECG based authentication for IoT based health care", Internet of Things Journal, , IEEE 2019.

[2] Farideh Ghasemi, Ali Rezaee, Amir Masoud Rahmani, "Structural and behavioral reference model for IoT based elderly health care systems in smart home", Wiley 2019.

[3] Sathiyabhama Balasubramaniam and Rajeswari Kurubarahalli Chinnasamy, "IoT-Based NoninvasiveWearable and Remote Intelligent Pervasive Healthcare Monitoring Systems for the Elderly People", Intelligent Pervasive Computing Systems for Smarter Healthcare, John Wiley 2019.

[4] Rihab Boussadaa, Balkis Hamdaneb, Mohamed Elhoucine, "Privacy preserving aware data transmission for IoT based e-health", Journal of computer networks, Elsevier 2019.
[5] Xiangbo Konga, Zelin Menga, Naoto Nojirib, Yuji Iwahoric, Lin Mengd, Hiroyuki, "A HOG-SVM Based Fall Detection IoT System for Elderly Persons Using Deep Sensor" , Elsevier 2019.
[6] Seyed Farhad Aghilia, Hamid Malaa, Mohammad Shojafar ,Pedro Peris-Lopezc, "LACO: Light weight Three Factor Authentication, Access Control and Ownership Transfer Scheme for E-Health Systems in IoT", future generation computer systems, Elsevier 2019.
[7] Anastasios Fanariotis, Foteini Andriopoulou, Theofanis Orphanoudakis , Ilias Politis, "An embedded framework enabling access of elderly and disabled persons to IP-based emergency communications", microprocessors and micro systems, Elsevier 2019.
[8] P.Mohamed Shakeel, S.Baskar, V.R. Sarma Dhulipala, Sukumar Mishra, Mustafa Musa Jaber, "Maintaining Security and Privacy in Health Care System Using Learning Based Deep-Q Networks", Journal of medical systems, Springer 2018.
[9] Jayeeta Saha, Arnab Kumar Saha, Aiswarya Chatterjii, Suyash Agarwal, Angita Saha, Avirup Kar, Himadri Nath Saga, "Advanced IOT Based Combined Remote Health Monitoring, Home Automation and Alarm System", internet of things journal, IEEE 2018.
[10] Caixue Zhou, "Comments on Light-weight and Robust Security-Aware D2D-assist Data Transmission Protocol for Mobile-Health Systems", IEEE 2018.
[11] IoT Based Smart Edge for Global Health: Remote Monitoring with Severity Detection and Alerts Transmission. Rahul Krishnan Pathinarupothi, P.Durga, Ekanath Srihari Rangan. IEEE, 2018.the internet of things journal.
[12] Convergence of IoT and product life cycle management in medical health care. Ali Hassan Sodhro, Sandeep prabulal,arun kumar sangaiah. Elsevier, 26 march 2018. Future generation computer systems.
[13] Wearable IoT enabled real time health monitoring system. Jie Wan, Munnasar A.A.H.Awlq, Mingsong Li,Michale O'Grady,Xiang Gu,Jin Wang and Ning Cao. Springer,2018.Journal on wireless communications and networking.
[14] The views of homeless people and healthcare professionals on palliative care and the desirability of setting up a consultation service: a focus group study Hanna T. Klop, MSc, Sophie I. van Dongen, Anneke L. Francke, Anke J.E. de Veer, Judith A.C. Rietjens, Jaap R.G. Gootje, Bregje D. Onwuteaka-Philipsen, 31 May 2018, Elsevier, Journal of Pain and Symptom Management,
[15] Real-Time Event-Driven Classification Technique for Early Detection and Prevention of Myocardial Infarction on Wearable Systems, Dionisije Sopic Amin Aminifar David Atienza, 2018 IEEE Transactions On Biomedical Circuits And Systems
[16] IoT based Mobile Healthcare System for Human Activity Recognition, Abdulhamit Subasi, Mariam Radhwan, Rabea Kurdi, Kholoud Khateeb, 2018 IEEE, Internet Of Things Journal.
[17] Smart-Log: A Deep-Learning based Automated Nutrition Monitoring System in the IoT, Prabha Sundaravadivel, Kavya Kesavan, Lokeshwar Kesavan, Saraju P. Mohanty, and Elias Kougianos, 2018 IEEE, IEEE, Transactions on Consumer Electronics
[18] A Personalized Point-of-Care Platform for Real-Time ECG Monitoring, Sandeep Raj and Kailash Chandra Ray, 2018 IEEE, IEEE transactions on electronics.
[19] Wearable IOT data stream traceability in a distributed health information system, Richard K Lomotey, Joseph Pry,Sumanth Sriramoju, IEEE, 2017,
[20] An Intelligent Real Time IoT Based System (IRTBS) for Monitoring ICU Patient, Bharat Prajapati, Satyen Parikh, and Jignesh Patel, Springer (ICTIS 2017) - Volume 2, Smart Innovation systems and Technologies,
[21] A Standard Mutual Authentication Protocol for Cloud Computing Based Health Care System, Prerna Mohit, Ruhul Amin, Arijit Karati, G. P. Biswas, Muhammad Khurram Khan, 5 February 2017, Springer, Science+Business Media,
[22] Internet of Things for Smart Healthcare, Technologies, Challenges, and Opportunities Stephanie Baker, Wei Xiang, and Ian Atkinson, 2017 IEEE Access,
[23] Real-Time or Near Real-Time Persisting Daily Healthcare Data into HDFS and ElasticSearch Index inside a Big Data Platform, Dequan Chen, Yi Chen, Brian N. Brownlow, Pradip P. Kanjamala, Carlos A. Garcia Arredondo, Bryan L. Radspinner, and Matthew A. Raveling, 2017 IEEE, IEEE Transactions on Industrial Informatics,
[24] Comparison of two techniques for monitoring of human movements, Jakub Wagner, Paweł Mazurek , Andrzej Mie¸kina, Roman Z. Morawski, Frode Fadnes Jacobsen , Tobba Therkildsen Sudmann, Ingebjørg Træland Børsheim, Knut Øvsthus, Tomasz Ciamulski , 17 April 2017, Elsevier, journal of measurement.
[25] Real-Time Signal Quality-Aware ECG Telemetry System for IoT-Based Health Care Monitoring. Udit Satija, Barathram.Ramkumar, and M. Sabarimalai Manikandan, 2017 ,Internet of Things Journal,
[26] Federated Internet of Things and Cloud Computing Pervasive Patient Health Monitoring System, Jemal H. Abawajy and Mohammad Mehedi Hassan, 2017 IEEE, Internet of thingd journal.
[27] An Automatic Health Monitoring System for Patients Suffering From Voice Complications in Smart Cities, Zulfiqar Ali1, Ghulam Muhammad1, And Mohammed F. Alhamid, March 9, 2017IEEE Access
[28] An RFID-WSN hybrid monitoring system for smart health care environments, Toni Adame, Albert Bel, Anna Carreras, Joan Meli`a-Segu´ı, Miquel Oliver, Rafael Pous, 17 December 2016 , Elsevier, Future Generation Computer Systems
[29] Toward A Wearable RFID System for Real-time Activity Recognition using Radio Patterns, Liang Wang Xianping Tao Jian Lu Tao Gu, , JANUARY 2016, IEEE, IEEE Transactions on Mobile Computing Journal Of LaTeX Class Files,
[30] The Internet of Things for Health Care: A Comprehensive Survey S. M. Riazul Islam, Daehan Kwak, Md. Humaun Kabir, Mahmud Hossain, And Kyung-Sup Kwak, IEEE Access, June 4, 2015.
[31] Embedded DSP-Based Telehealth Radar System for Remote In-Door Fall Detection, Carmine Garripoli, Marco Mercuri Peter Karsmakers, Ping Jack, 1 January 2015, IEEE, Journal of biomedical and health informatics.
[32] An Implementation of Light-Weight Compression Algorithm for Wireless Sensor Network Technology in Structure Health Monitoring¸ Chia-Hao Hsu, Chih-Ting LiHui-Ping Tserng, Jen-Yu Han, 2014, IEEE World Forum on Internet of Things (WF-IoT).
[33] Ubiquitous WSN for Healthcare: Recent Advances and Future Prospects, Yuan Zhang, Limin Sun, Houbing Song and Xiaojun Cao, 4 August 2014, IEEE, Internet of things journal.
[34] Novel Cloud and SOA-Based Framework for E-Health Monitoring Using Wireless Biosensors, Abdelghani Benharref and Mohamed Adel Serhani, January 2014, IEEE, Journal Of Biomedical And Health Informatics.
[35] RFID Technology for IoT-Based Personal Healthcare in Smart Spaces, Sara Amendola, Rossella Lodato, Sabina Manzari, Cecilia Occhiuzzi, and Gaetano Marrocco, IEEE April 2014, Internet of things journal.
[36] Health Internet of Things: Metrics and methods for efficient data transfer, Mersini Paschou, Evangelos Sakkopoulos, Efrosini Sourla, Athanasios Tsakalidis, Elsevier 2013, Simulation Modelling Practice and Theory
[37] Security and privacy mechanism for health internet of things, Kang Kai, Pang Zhi-bo, Wang Cong, Elsevier December 2013, The Journal of China Universities of Posts and Telecommunications.
[38] Wearable Multi-sensor Gesture Recognition for Paralysis Patients, A. Nelson, J. Schmandt, P. Shyamkumar, W. Wilkins, D. Lachut, N. Banerjee, S. Rollins, J. Parkerson, V. Varadan, IEEE 2013,
[39] Privacy in the Internet of Things: threats and challenges, Henrik Ziegeldorf, Oscar Garcia Morchon and Klaus Wehrle, 10 June 2013,wiley,security and communication networks.
[40] Smart Wearable Hand Device for Sign Language Interpretation System with Sensors Fusion. B. G. Lee and S. M. Lee, IEEE 2017 ,
[41] The Internet of Things (IoT): Applications, investments, and challenges for enterprises In Lee, Kyoochun Lee,2015 Elsevier,
[42] Health and emergency-care platform for the elderly and disabled people in the Smart City, Aamir Hussain, Rao Wenbi , Aristides Lopes da Silva, Muhammad Nadhera and Muhammad Mudhish , 22 August 2015 Elsevier, *The Journal of Systems & Software,*
[43] BSN-Care: A Secure IoT-Based Modern Healthcare System Using Body Sensor Network Prosanta Gope and Tzonelih Hwang, November 17, 2015IEEE,,IEEE Sensors Journal,
[44] An IoT-Aware Architecture for Smart Healthcare Systems, Luca Catarinucci, Danilo de Donno, Luca Mainetti, Luca Palano, Luigi Patrono, Maria Laura Stefanizzi, and Luciano Tarricone, December 2015 IEEE, IEEE Internet Of Things Journal,
[45] Smart wearable systems: Current status and future challenges, Marie Chana, Daniel Estèvea, Jean-Yves Fourniols, Christophe Escriba Eric Campoa, 19 september 2012 Elsevier, Artficial intelligents in medicine

[46] Digital cities of the future:extending at home assistive technologies for the elderly and disabled, 19 august 2010, Elsevier, telematics and informatics journal,

[47] Wireless Measurement System for Structural Health Monitoring With High Time-Synchronization Accuracy, Alvaro Araujo, Jaime García-Palacios, Javier Blesa, Francisco Tirado, Elena Romero, Avelino Samartín, and Octavio Nieto-Taladriz, 2010 IEEE, IEEE Transactions on instrumentation and measurement,

[48] A 700-u W Wireless Sensor Node SoC for Continuous Real-Time Health Monitoring, Tee Hui Teo, Xinbo Qian, Pradeep Kumar Gopalakrishnan, Yee Shan Hwan, Kuruveettil Haridas, Chin Yann Pang, Hyouk-Kyu Cha, and Minkyu Je, *N*ovember 2010 *IEEE, IEEE* journal of solid-state circuits,

[49] Prognosis—A Wearable Health-Monitoring System for People at Risk: Methodology and Modeling, Alexandros Pantelopoulos, and Nikolaos G. Bourbakis, May 2010, *IEEE,* IEEE Transactions on information technology in biomedicine

[50] Mobile And Wearable Technologies In Healthcare For The Aging Population, Shwatembara Malwade, Liezel Colliers, Xinxin Zhu, Chun-Por Wong , Panagiotisbamids, Luis Fernandaz Luque, Yu-Chun Li, Shabbier Syed Abdul, Mohy Uddin, Alidilas Achmad Nurseetyo, 26 April 2018, Elsevier, Computer Methods And Programs In Biomedicine.

[51] A Smart Phone Based Wearable Sensors for Monitoring Real Time Physiological Data, Fang-Yie Ko, Chia-Yin Ko, Kim-Kwang Raymond Choo, Chi-Lun Ho, July 2017, Elsvier, Computers and Electrical Engineering.

[52] A Health Monitoring System for Vital Signs Using IoT, K.Narendra Swaroop, Kavitha Chandu, Ramesh Gorrepotu and Subimal Deb, January 2019, Elsevier, Internet of Things.

[53] Intell8gent Autonomous Elderly Patient Homemonitoring System, Mai Ali, Asma Ali, Abd-Elhamid Taha, Imedben Dhaou And Tuan Nguyen Gia, 2019, IEEE Xplore.

[54] An Efficient IoT Based Platform For Remote Real Time Cardiac Activity Monitoring, Sandeep Raj, 2020, IEEE Transactions on Consumer Electronics.

[55] A Low Power Fall Sensing Technology Based on FD-CNN, Jianhe, Zihao Zhang, Xiaoyi Wang And Shenqiyang, 2019, IEEE Sensors Journals.

[56] Benisha.M, Rubala.R, Anisha.M, Thandiah Prabu.R, Ponmozhi Chezhiyan, "An IoT Secured System Design for Real-Time Health Monitoring of Post-Chemotherapeutic Effects" International Journal of Advanced Science and Technology Vol. 29, No. 5, (2020), pp. 10193 – 10201

[57] Kong, Xiangbo, et al. "A HOG-SVM based fall detection iot system for elderly persons using deep sensor." *Procedia computer science* 147 (2019): 276-282.

[58] Amendola, S., Lodato, R., Manzari, S., Occhiuzzi, C. and Marrocco, G., 2014. RFID technology for IoT-based personal healthcare in smart spaces. *IEEE Internet of things journal*, *1*(2), pp.144-152.