Information Sciences Letters

Volume 11
Issue 4 *Jul. 2022*

Article 18

2022

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Information Sciences Letters
An International Journal

http://dx.doi.org/10.18576/isl/110418

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Received: 1 Mar. 2022, Revised: 12 Apr. 2022, Accepted: 5 May 2022
Published online: 1 Jul. 2022

Abstract: The advancement of technology in sensors and communication devices to the Internet has resulted in practical solutions in various networking sectors, public and private sector enterprises, and government organizations worldwide. In addition, the widespread use of Smart Devices and Mobile Technologies in the healthcare industry has enhanced their global reach and effect. Patient monitoring systems are classified into two basic categories: bedside patient monitoring systems and distant patient monitoring systems. The specialists in healthcare systems are increasingly profiting from the advantages of such technology, resulting in a significant development within the healthcare domain, both within and outside of clinical settings. Similarly, untold numbers of regular operators benefit from the advancements in M-Health (Mobile Health) and E-Health, in which healthcare is delivered using information and communication technology (ICT) to develop and preserve their health. For patients suffering from chronic diseases, the researchers hope to introduce a survey based on ontology, which will be able to track their health over time and provide standard workout recommendations.

Keywords: Context-Awareness, E-Health, Internet of Things, Ontology

1 Introduction

A current healthcare system should bring more improved healthcare facilities to people anywhere and anytime in a reasonable and patient-friendly way [1]. The healthcare system is changing from a conventional method into an efficient patient positioning method. Within the traditional way, doctors take part in the central role [2]. In the necessary analysis and directing, they must visit their in-volved patients. There exist two main issues that are based on this method. First, healthcare professionals should live and be availa-ble with the patient. Secondly, ensuring that the patient should be admitted to the hospital and prepared for bedside biomedical de-vices for a long time. To solve these two issues, the patient-oriented method is received. In this theme, patients are kept knowledge-able and information to act with a further active action through disease diagnosis and deterrence.

The essential item of the second method is a dependable and readily existing Patient Monitoring System (PMS)[3,4,5,6]. Health is considered a worldwide issue for humanity [7]. Based on the World Health Organization (WHO) structures, the most significant accessible standard of health represents a fundamental right for a person. Healthy individuals can protect their lifetime income and enlarge the gross domestic invention and tax incomes accordingly. Additionally, healthy individuals could minimize pressure on most existing hospitals, clinics, and medical specialists and reduce the workload on public safety charities, networks, and non-governmental or governmental centres[8]. A readily reachable contemporary healthcare system is required as a prior condition [3].

Arduino is considered an open-source software and hardware organization, project, and user community, which formulates and produces one-board microcontrollers and microcontroller kits to create shared substances and digital devices that can manage and sense in digital-physical manners. Its products are certified based on the GNU General Public License (GPL) or the GNU Lesser General Public License (LGPL)[9], which allows producing software distributions and Arduino boards by any person. Arduino boards commercially exist within a preassembled procedure or as forms of Do-It-Yourself (DIY) kits. The designs of the Arduino board apply various controllers and microprocessors.

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Boards are armed with analogue input/output (I/O) and digital pins, likely interfacing through various extension boards or breadboards (shields), including other circuits. The panels are distinguished by serial communications interfaces, comprising the Universal Serial Bus (USB) over a few methods applied to load different programs from individual devices efficiently. Micro-controllers are usually programmed by using a dialect of characteristics of the C and C++ programming languages. In addition to applying conventional compiler toolchains, the Arduino project gives an Integrated Development Environment (IDE) according to the Processing language project. The Arduino project began to take part in 2003 to form an integrated program for students within the Interaction Design Institute Ivrea, located in Ivrea, Italy [10]. This project aims to provide a low-cost and straightforward method for beginners and specialists to create devices that interrelate with their situation by applying actuators and sensors. Well-known examples of the developed devices made for novice hobbyists involve thermostats, simple robots, and motion detectors. Arduino is derived from a bar located in Ivrea, Italy, while some founders related to the project used to meet there. The Arduino project is launched at the Interaction Design Institute Ivrea (IDII), Italy. [10] Students since then applied a BASIC Stamp microcontroller at $50. This cost is considered a substantial expense incurred by several involved students. Hernando Barragan formed the develop-ment platform wiring in 2003 to represent a Master's thesis project at IDII, where Casey Reaps and Massimo Baozi supervised this thesis.

Casey Reas is commonly seen to act as a co-creator along with Ben Fry and the processing development platform. The project aimed to produce low-cost and straightforward tools for creating digital projects via non-engineers [10]. The Wiring platform con-tains a Printed Circuit Board (PCB), including an ATmega168 microcontroller and an IDE based on processing and library functions to seamlessly implement the microcontroller [4]. In 2003, Massimo Banzi, David Mellis, David Cuartielles, and another IDII student enhanced the cheaper ATmega8 microcontroller to Wiring. Apart from working on Wiring, the project is forked by them, also called Arduino [11]. The preliminary Arduino core team involved David Mellis, David Cuartielles, Tom Igoe, Gianluca Martino and Mas-simo Banzi [10]. However, Barragan was not asked to participate in the team [4]. After completing the Wiring platform, lighter and less costly versions were disseminated through the open-source society. During the mid-2011, an estimation of over 300,000 offi-cial Arduinos was commercially created[12] were 700,000 official boards had been in the hands of many users in 2013 [13]. Addi-tionally, 50% of the organizations ownership was secured by Arduino's former CEO and Federico Musto, in October 2016. Wired declared in April 2017 that Musto had "fabricated his academic record on his company's website, personal LinkedIn accounts, and even on Italian business documents, Musto was until recently listed as holding a Ph.D. from the Massachusetts Institute of Technology.

In some cases, his biography also claimed an MBA from New York University." Furthermore, Wired stated that no such University got any record of Musto's attendance where Musto had been involved in an interview with Wired, who had never gained those de-grees [13]. Simultaneously, Massimo Banzi declared that the Arduino Foundation represented "a new beginning for Arduino." [14]. One year after that, the Foundation is still unobvious where the projects case [15]. The debate of Musto was sustained when he allegedly obtained several schematics, code, and open-source licenses from Arduinos website in July 2017, by supporting out-cry and scrutiny [16]. Arduino declared its enterprise with ARM Holdings (ARM) in October 2017. The declaration posted that the "ARM recognized independence as a core value of Arduino ... without any lock-in with the ARM architecture. Arduino aims at continuing to perform with the entire technology sellers and architectures [17].

2 Patient Health Monitoring System

Based on the US Centres for Disease Control and Prevention (CDC), around 1,700 individuals die annually due to caused heart disease [1]. This is because the increased number of deaths represents the inexistence of qualified and timely assistance. An ongo-ing health monitoring system could maintain 60% of human lives based on timely detection to avert heart diseases. Normal individ-uals do not frequently sense the risk of having heart disease. Doctors and nurses cannot provide care for a patient when this patient exists at home[18]. One key answer to this issue is to have a patient monitoring system. There exist several grounds for building a health monitoring system in a hospital.

First, it is moveable; heart rates differ by age, with young people typically possessing an increased heart rate compared to people above 60 years old. One known problem for each age group is that they produce inefficient progress on medical equipment [2]. Additionally, a more excellent stationary monitoring tool is only applied in hospitals when patients are in bed. A demand for a de-vice that permits patients to keep tracking their health conditions is evident. Therefore, the qualities of intelligent health monitoring systems must form smaller sizes, be seamless when being used, be lightweight, and be transportable.

The second ground indicates that health conditions could constantly be monitored when individuals apply Health Monitoring Systems (HMS) in clinics and hospitals for home care purposes and when tracking athletes vitals that involve their body temperature, blood pressure, and heart rate. The entire data is followed by

many different sensors incorporated with the HMS. Health problems are repeatedly being encountered for more than 30 years now due to industrialization, climate change, and technical development, which cause to have reduced physical activity. Saving lives need to monitor health cases related to patients with chronic diseases or daily heart-related issues. Identifying such health issues in advance could save many lives further and minimize morbidity derived from the disease [19]. The significant change is since sensors that measure heartbeat rate, blood pressure, or body temperature are put over the body of patients, including a strap, without the need for including any wires. Such protocols as ZigBee or Bluetooth are efficient for a short distance of wireless data transmission. This solution is further suitable for patients since sensors are hands-free and wireless. Every wireless sensor device involves a transceiver and a group of sensors.

The third ground is that it could be less expensive than any available solutions; the price efficiency related to the solution is consid-ered essential when improving an HMS[20]. The number of lives which are likely to be saved is based on whether necessary and required tools do exist with them or not. Therefore, developing a system containing the required functions can efficiently minimize expenses when designing the HMS. Another facet that reduces prices is applying seamless, accessible, commonly used, and com-pletely configurable items to develop the HMS. Applying programmable items removes the likelihood of choosing an inconvenient, non-cost-effective device for the system.

The fourth ground is based on simplifying health monitoring for many medical staff members, where a seamless system is most advantageous when monitoring different health conditions of an involved patient. This patient can remain at home while nearby people or doctors on duty are regularly informed to deal with emergency cases[4]. Nonetheless, medical organizations contain sev-eral patients, and applying such a system to every patient is costly and inefficient. They require a single improved system for moni-toring each patient within a facility. Therefore, a health monitoring system for hospitals is necessary for the HMS to maintain and identify data about every patient [21]. A health monitoring system represents an effective procedure that could protect human lives. It is configurable and improved to specific demands, making it valuable and price-efficient for domestic and hospital use.

Archer-Soft contains massive medical software expertise, which has been developed for the past ten years because of their involved partnership with Medoc (Israel), which represents a dominator of medical neuro-diagnostic system improvement. Wearables, online platforms, smartphones, and a few different health technology applications have proceeded to the extreme according to the doctors' method to communicate patient comfort and information about their health[22]. Antiquated medical devices are being modified to involve digital characteristics, which can expand the use of the available

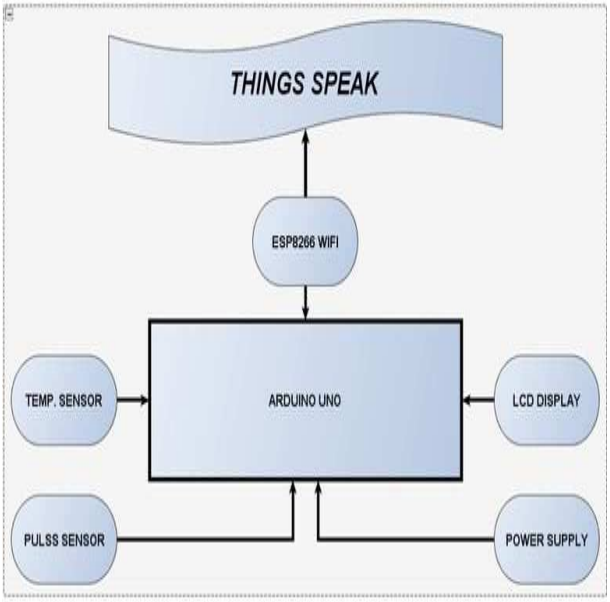

Fig. 1: Block diagram that explains IoT Based Patient Health Monitoring System using ESP8266 and Arduino

equipment. For example, several health tools can currently interconnect with many different health tools and applications, linking, establishing, and incorporating past other pieces of infor-mation. Health technology potential remains progressing as time passes, where several organizations, establishments, hospitals, ac-tivities, and medical centres are proceeding further to be further improved, as shown in Figure 1.

Up to date devices are made to support and enhance different health cases. The data gathered from these devices is not unavoidably suitable for each health case. Consequently, it is essential to allow dependable, case concentrated devices to serve healthcare suppliers who are experts in acting with particular issues [21,22,23,24,25], as shown in Figure 2.

3 Internet of Things (IoT)

The Internet of things consists of individualities and virtual characters performing in bright spaces by applying innovative interfaces for connecting and joining with each other through environmental, user, and social contexts [27,28]. It represents the Future of the Internet [5], where each object is linked to many different things. Additionally, each object is provided with a single identity within the network. These permit remote access devices involved in a particular network, anywhere and anytime. IoT allows objects to interconnect, access information throughout the Internet, and interrelate with many users to produce intelligence anywhere [29,30,31].

Fig. 2: The complete eHealth development platform in the market connecting more than 15 sensors[26].

IoT allows objects to interconnect, access information throughout the Internet, and interrelate with users producing intelligent, dis-seminated, and frequently linked environments. Additionally, IoT enables machine-to-machine communication (M2M) that allows machines to be managed via many different devices and the Internet. This could radically change the way of applying technology since the machine operates other machines that solve additional restraints many individuals face while interacting with various digi-tal systems. Appliances remain tracking sensors throughout the globe to create a massive quantity of valued information for human performance[32,33].

IoT applies the aspect of disseminated computing and ubiquitous computing with reality by permitting objects to perform in daily life, such as pacemakers, roadways, pill-shaped cameras within digestive tracks, cars, billboards that are modified for refrigerators, Passersby and cattle that are installed with sensors that interconnect with many individuals to assist them within each stage. IoTs application within the healthcare system is represented in the subsequent section [34,35,36].

4 Healthcare Projects Based on Arduino

The author in[5] improves a personal health diagnosis according to a patients symptoms. A massive amount of gathered data is applied to analyze the infection and risk incurred in patients. Franca states that current generation systems innovations represent the improvement of continuous monitoring characteristics of a patient and the development of different productivities and workflows of medical personnel. Furthermore, the author in [20] highlights many different wireless technologies and benefits when applying such technologies. The authors in [4] improve a wearable sensor system to track patients' actions. The system is standardized to a threshold level that is lower than 5%, where the notion is to reduce the error rate incurred in the gathered data by producing a detection system for track-ing patients movements that identifies a fall and repeatedly directs a request for assisting caretakers.

The authors in [4] develop a method for maintaining healthcare data of a patient that is gathered within various geographical regions. The data is made accessible to physicians, medical centres, laboratories, hospitals, etc., to track patients medical history. Intelligent systems detect the disinfected articles and alert the medical staff to wash hands after contacting the disinfectant articles. The author in [37], IoT techniques are applied to enhance and support healthcare efficiently. The health-based information is inter-related with particular physicians involved in emergency cases within hospitals, regardless of the physicians absence, who should be close to the patient or interact with doctors in an emergency. Despite the physicians lack, who should be close to the patient or the hospital, they should be aware of their patient's conditions to consider the advice coming along from the involved physicians around patients severe conditions. Brian Blake state that human users are previously forewarned according to their fitness and ge-netics or medical history.

The authors in [20] the sensed and delivered data within different wireless devices are obtained at the local system, which allows entering data through other heterogeneous formats that are beneficial when constructing real-time applications. Additionally, this transferred data is modified through the physicians mobile application, including the user (caregiver or patients).

The authors in [24] introduce the IoT-based system to enhance various services in the emergency medical system where such ser-vices are enhanced by indicating how IoT data is being gathered and joined for interoperability.

The authors in[38] study healthcare software's significant and detailed needs and produce an architecture for healthcare and IoT systems. Several parameters, such as ECG, blood oxygen, respiration, temperature, etc., are considered by Long.

The authors in [39] are based on the increase of interrelated health issues and the lack of a suitable solution in healthcare for track-ing patients. When a physician is absent, patients are likely to face severe problems and lose lives according to severe cases. Subsequently, to solve the issue of encountering absent physicians, patients would be exposed to many different severe problems and lose lives based on extreme cases and would assess the status of every patient according to their physicians regardless of their absences from the hospital or near the patient.

Table 1: Comparative study on Raspberry Pi medical and health-care IoT projects

No.	Name	Describtion
1	NU Health embedded: HIS/ EMR on Raspberry Pi [40]	It is an open source electronic medical record (EMR) and hospital information system (HIS), It gives a total coordinated framework to run emergency clinics as it incorporates understanding therapeutic records the board, charging, and fund the board, research center administration, stock administration, and more highlights.
2	OpenEMR on Raspberry Pi [41]	It is an open source electronic medicinal record (EMR), It is a self-facilitated cloud-based EMR arrangement. OpenEMR was created utilizing PHP and MySQL, It gives a completely useful secure EMR arrangement with numerous coordination alternatives".
3	OrthancPi: Mini DICOM/ PACS server [40]	It is an open source developer-friendly DICOM server, We have audited it here and it was over our rundown of open source DICOM/PACS servers.
4	Pumpkin PACS/ Pumpkin Pi [42]	"It is a model undertaking that changes over Raspberry Pi to a little PACS/DICOM workstation, It utilizes Aeskulap open source DICOM watcher to show the medicinal pictures".
5	IRM Sandwich: Mini PACS server[43]	"It is a business PACS server with "Zero Impression" DICOM Watcher that associated with the IRM Wellbeing Motor which is the result of a similar organization. IRM Sandwich was intended to be exceptionally lightweight so it can run easily with Raspberry Pi and some other SBC just as Smaller than normal PCs".
6	GNU LIMS: LIMS on Raspberry Pi [44]	"It is an open source research center data the board framework which coordinates with GNU Well-being. GNU LIMS additionally works inside Raspberry Pi which makes it the main open source LIMS that is boxed and prepared with Raspberry Pi".
7	MySignals e-Health Sensor Platform for Raspberry Pi/ Arduino [26]	"It is a stage for engineers to make IoT medicinal checking and warning applications, It was once called "eHealth Sensor Stage" as it furnishes designer amicable therapeutic sensors perfect with Raspberry Pi/Arduino".
8	HealthyPi[45]	"It is An open-source, multi-parameter, undeniable human body essential sign checking Cap for Raspberry Pi just as independent use. It goes for designers with an enthusiasm to make minimal effort fundamental sign screens".
9	Raspberry Pi Patient Monitor [46]	"It is to make an ease compelling patient checking framework. With the Raspberry Pi perfect screen it screens ECG, Pulse, SPO2, Breath, Temperature, and Circulatory strain".
10	Smart Health Kit [47]	"It is meaning to make an exceedingly compelling warning and alarming framework utilizing Raspberry Pi. It gives continuous observing and moment notice framework to guarantee a viable opportune reaction".
11	PatientCare-wearable: Patient monitor[48]	"PatientCare is a model for continuous patient observing execution utilizing Raspberry Pi and a lot of therapeutic sensors to send constant checking information to Samsung IoT cloud stage".
12	Nurse Presence Detection [49]	"It is utilized to send a notice if there is somebody goes into the patient's room just as recognize whether that individual is the alloted nurture or not".
13	Raspberry Pi Electrocardiogram [50]	"It is an effective usage of Raspberry Pi as ECG gadget, despite the fact that it accompanies a notice".
14	Heart Rate Pulses [51]	"It is a model with a far reaching instructional exercise about how to utilize Pulse Heartbeat Sensor with Raspberry Pi, however it's not normal for different activities it utilizes Windows 10 IoT Cen-ter".
15	Emergency Button for Elderly with Serious Illnesses [52]	"It is utilized Raspberry Pi Zero Remote model to make a crisis warning catch for patients, particu-larly patients with genuine ailment or older, It utilizes Pushbullet.com a notice framework to send the notice to the consideration group or specialists".

Table 2: Comparative study on health-care IoT and Arduino projects

Ref.	TECH.	Description	Limitations
Smart Human Health Monitoring System by using IoT	Bluetooth and Wifi	The produced method provides a plat-form for fall detection.	Preserving a database server is significant due to the track availability of former medical records related to the patient, which provides more efficient and enhanced testing.
Pervasive communications in healthcare	Bluetooth and Wifi3G, GPRS, Blue-tooth, Wifi, and Zigbee	The produced method provides infor-mation regarding the EMG, GSR-sweating ECG and SPO2.	The system is generated for long-term storage of the biomedical information related to patients and supporting healthcare specialists with the diagnostic Information.
Personal Health System architecture for stress monitoring and support to clinical decisions	GPS / GPRS/ GSM	The produced method is based on providing temperature, heart rate, patients location at any provided time.	The user interfaces HTML webpage is automatically refreshed every 15 seconds.
Design of Iot Based Smart Health Monitoring and Alert System	Body sensor	The produced method standardizes med-ical data, accesses and maintains data in an organized way.	IOT involves an embedded technology that permits them to interchange necessary information with each other or with the Internet.
Patient Monitoring System Based on Internet of Things using Rasperripy	BSN Technology 3G/ CDMA/GPRS Across hospitals.	A method is produced in order to under-stand and obtain IOT data emergency data control and data sharing	Consists of a massive quantity of intelligent object and intelligent devices that are linked to the internet in order to communicate with each other.
Patient Monitoring Sys-tem Based on Internet of Things	GPR, Wifi, 3G	A system provides suitable and adequate medical facilities by gathering and linking data within health status monitors.	To obtain information regarding human health in real-time based on an IoT wearable device.

5 Comparative Study

Patient contacts with physicians were confined prior to the Internet of Things to in-person visits, telephonic and textual conversa-tions, etc. There was no mechanism for physicians or hospitals to continually evaluate the health of their patients and offer sugges-tions based on such information.

Remote monitoring in the healthcare industry is now feasible thanks to Internet of Things (IoT)-enabled devices, which can keep patients safe and healthy while also enabling doctors to provide superior treatment. Due to the simplicity and efficiency with which contacts with physicians have developed, it has also resulted in improved patient participation and satisfaction. Furthermore, remote monitoring of a patient's health may assist to reduce the duration of a patient's hospital stay as well as the likelihood of re-admissions. In addition, the Internet of Things has a substantial influence on lowering healthcare expenses and increasing treatment results.

The Internet of Things (IoT) is unquestionably changing the healthcare business by rethinking the area of devices and human con-tact in the delivery of healthcare solutions. The Internet of Things offers applications in healthcare that are beneficial to patients, their families, doctors, hospitals, and insurance companies.

The Internet of Things for Patients - Patients have access to individualized attention via the use of wearable gadgets such as fitness bands and other wirelessly linked equipment such as blood pressure and heart rate monitoring cuffs, glucometers, and other similar devices. These devices may be programmed to remind users of calorie counting, activity monitoring, appointments, blood pressure fluctuations, and a variety of other tasks.

In this article we do a comparative study on Raspberry Pi Medical and Healthcare IoT Projects table 1 and Healthcare IoT and Arduino Projects table2.

6 Results and Discussion

A current healthcare system should provide improved healthcare facilities to people wherever and whenever they need them cost-effectively and patient friendly. The healthcare system is transforming from a conventional to an efficient patient positioning ap-proach. In the typical model, doctors play a central role. They are expected to visit their concerned patients to do the appropriate analysis and direction. There are two significant drawbacks to this strategy. To begin with, healthcare providers should always be present and accessible to patients. Second, ensuring that the patient is admitted to the hospital and is prepared to use bedside bio-medical devices for an extended period.

Given the importance of healthcare facilities in our surroundings, automating them minimizes the burden on humans and stream-lines the measurement procedure. Additionally, the system's transparency enables patients to place their trust in it. The purpose of enhancing monitoring systems is to reduce healthcare costs by lowering physician office visits, hospitalizations, and diagnostic tests. Numerous improvements are anticipated to the suggested approach to achieve a more efficient and fluidly adaptive system, includ-ing improved sensors. Due to the wireless data transmission through the Internet, physicians' devices or mobile phones receive health-related data. As a result, the requirement for each patient to continue to the hospital and transmit messages to physicians is seen to be immediately remedial considering the patient's health situation.

7 Conclusion

As healthcare facilities are considered significant in our environment, automating such facilities reduces the load on humans and simplifies the measuring procedure.

Additionally, the transparency of the system assists patients in relying on it. Improving monitor-ing systems aims to minimize healthcare expenses by minimizing physicians office visits, hospitalizations, and diagnostic testing processes. Several developments are likely to be performed through the proposed system to obtain a more efficient and seamlessly adaptive system, such as providing further developed sensors. Due to the wireless data being transmitted throughout the Internet, health-related data is delivered to physicians devices or mobile phones. Consequently, the demand for proceeding to the hospital each time and sending messages to physicians is considered directly remedying according to a patients health care

References

[1] M. Figueroa, A. K. Jarmusch, H. A. Raja, T. El-Elimat, J. S. Kavanaugh, A. R. Horswill, R. G. Cooks, N. B. Cech, and N. H. Oberlies, "Polyhydroxyanthraquinones as quorum sensing inhibitors from the guttates of penicillium restrictum and their analysis by desorption electrospray ionization mass spectrometry," *J. Nat*, vol. 77, no. 6, pp. 1351–1358, 2014.

[2] S. Saminathan, K. Geetha, and P. G. Student, "A survey on health care monitoring system using iot," *Int. J. Pure Appl. Math*, vol. 117, no. 17, pp. 249–254, 2017.

[3] Y. N. Yergaliyev, R. I. Mukhamediyev, and A. M. Kairbekov, "Ways of using internet of things (iot) for health monitoring," vol. 16, pp. 105–106, 2018.

[4] S. D. M. S. N. Malokar, "Patient monitoring system based on internet of things using rasperripy: Key features, application and open issues," *Comput. Networks*, vol. 54, pp. 2787–2805, 2016.

[5] J. Gómez, B. Oviedo, and E. Zhuma, "Patient monitoring system based on internet of things," *Procedia Comput. Sci*, vol. 83, pp. 90–97, June 2016.

[6] A. D. S and G. W. S, "Patient health monitoring system (phms) using iot devices," *vol.*, vol. 7, pp. 68–73, 2016.

[7] and M. L. Mobyen Uddin Ahmed(B), "Mats bjorkman, aida causevic, hossein fotouhi, "an overview on the internet of things for health monitoring systems," icst inst," *Comput. Sci*, vol. 170, pp. 429–436, 2016.

[8] S. Francesca, C. G. Carlo, D. N. Luca, F. Rocco, and R. Marco, "Comparison of low-complexity algorithms for real-time qrs detection using standard ecg database," *Int. J. Adv*, vol. 8, no. 2, pp. 307–314, 2018.

[9] Arduino.cc. https://www.arduino.cc/en/guide/introduction.

[10] D.Kushner, *The Making of Arduino - IEEE Spectrum*, spectrum.ieee [Online]. Available, 2011. [Online]. Available: https://spectrum.ieee.org/geek-life/hands-on/the-making-of-arduino

[11] H. Barragan, "The untold history of arduino," github. [Online]. Available: https://arduinohistory.github.io/

[12] M. Banzi, "How many arduinos are in the wild." [Online]. Available: https://blog.adafruit.com/

[13] M. University, "Arduino faq – with david cuartielles." [Online]. Available: http://medea.mah.se

[14] D. Dougherty and D. Dougherty, "Free arduino." [Online]. Available: https://makezine.com2017

[15] Hackaday, "The arduino foundation: What's up." [Online]. Available: https://hackaday.com/2017/06/19/the-arduino-foundation-whats-up/

[16] J. Biggs and J. Biggs, "Ceo controversy mars arduinos open future." [Online]. Available: https://techcrunch.com,2017

[17] R. Wilson and R. Wilson, "Arduino reborn partners with arm." [Online]. Available: https://www.electronicsweekly.com,2017

[18] M. Heron, "Deaths: Final data for 2016," *Natl. Vital Stat*, vol. 67, p. 5, 2018.

[19] K. A. Ms.Nithya, R. Rajaduari, and M. Ganesan, "A survey on structural health monitoring based on internet of things," *Int. J. Pure Appl. Math*, vol. 117, no. 19, pp. 389–393, 2017.

[20] F. Delmastro, "Pervasive communications in healthcare," *Comput. Commun.*, vol. 35, no. 11, pp. 1284–1295, 2012.

[21] M. Hassanalieragh, A. Page, T. Soyata, G. Sharma, M. Aktas, G. Mateos, B. Kantarci, and S. Andreescu, "Health monitoring and management using internet-of-things (iot) sensing with cloud-based processing: Opportunities and challenges," in *Proc. - 2015 IEEE Int*. Conf. Serv. Comput. SCC 2015, 2015, pp. 285–292.

[22] T. Sivakanth and S. Kolangiammal, "Design of iot based smart health monitoring and alert system," *Int. J. Control Theory Appl.*, vol. 9, no. 15, pp. 7655–7661, 2016.

[23] P. W. Digarse and S. L. Patil, "Arduino uno and gsm based wireless health monitoring system for patients," in *Proceedings of the 2017 International Conference on Intelligent Computing and Control Systems*. ICICCS 2017 vol. 2018–Janua, 2018, pp. 583–588.

[24] B. N. Karthik, L. D. Parameswari, R. Harshini, and A. Akshaya, "Survey on iot arduino based patient health monitoring system," *Int. J. Sci*, vol. 1, no. 3, pp. 1414–1417, 2018.

[25] S. D. Ravani, B. V. I. N. Aik, and R. A. B. A. B. U. J, "Iot based patient health monitoring system," *Int. J. Eng*, vol. 4, no. 3, pp. 2316–2319, 2016.

[26] [Online]. Available: http://www.my-signals.com/

[27] M. Condoluci, M. A. Lema, T. Mahmoodi, and M. Dohler, "5g iot industry verticals and network requirements," *no.*, vol. 2010, pp. 148–175, 2017.

[28] M. A. M. Albreem, A. A. El-Saleh, M. Isa, W. Salah, M. Jusoh, M. M. Azizan, and A. Ali, "Green internet of things (iot): An overview," in *2017 IEEE International Conference on Smart Instrumentation*. ICSIMA 2017, 2018, vol. 2017–Novem, no: Measurement and Applications, March 2018, pp. 1–6.

[29] C. Xu, L. Yang, and P. Zhang, "Practical backscatter communication systems for battery-free internet of things: A tutorial and survey of recent research," *IEEE Signal Process*, vol. 35, no. 5, pp. 16–27, 2018.

[30] M. A., A. Mohammed, and M. Yamani, "A brief survey on 5g wireless mobile network," *Int. J. Adv*, vol. 8, no. 11, pp. 52–59, 2017.

[31] W. I. T. Matters, I. T. Runs, and O. N. Wind, *Going Green with the Internet of Things*. Events.Windriver.Com.

[32] Y. Yu, H. Lin, J. Meng, and Z. Zhao, "Visual and textual sentiment analysis of a microblog using deep convolutional neural networks," *Algorithms*, vol. 9, p. 2, June 2016.

[33] J. Liu, H. Shen, H. S. Narman, W. Chung, and Z. Lin, "A survey of mobile crowdsensing techniques: A critical component for the internet of things," *ACM Transactions on Cyber-Physical Systems*, vol. 2, no. 3, pp. 1–26, 2018.
[34] N. T. Le, M. A. Hossain, A. Islam, D. Y. Kim, Y. J. Choi, and Y. M. Jang, "Survey of promising technologies for 5g networks," *Mob*, vol. 2016, 2016.
[35] J. Dizdarevic, F. Carpio, A. Jukan, and X. Masip-Bruin, "Survey of communication protocols for internet-of-things and related challenges of fog and cloud computing integration," *vol.*, vol. 1, no. 1, pp. 1–27, 2018.
[36] F. Liang, X. He, W. G. Hatcher, C. Lu, J. Lin, X. Yang, and W. Yu, "A survey on the edge computing for the internet of things," *IEEE Access*, vol. 6, pp. 6900–6919, 2017.
[37] G. Pioggia, G. Tartarisco, G. Baldus, D. Corda, M. Ferro, R. Raso, A. Arnao, and A. Gaggioli, "Personal health system architecture for stress monitoring and support to clinical decisions," *Comput. Commun.*, vol. 35, no. 11, pp. 1296–1305, 2011.
[38] T. Thomas, N. T. Bhuvan, and A. Professor, "Study on distributed sdn controllers and failover mechanisms," *Int. J. Innov. Res*, vol. 5, no. 4, pp. 10 176–10 181, 2017.
[39] V. Sudha, S. B. A, M. Poojitha, and N. Taj, "Survey on patient health monitoring system using iot and arduino," *Int. J. Electr. Electron*, vol. 6, no. 1, pp. 172–174, 2018.
[40] [Online]. Available: https://medevel.com/orthanc-a-developer-friendly-free-and-open-source-dicom-server-for-medical-imaging/
[41] [Online]. Available: https://www.open-emr.org/
[42] [Online]. Available: https://projects-raspberry.com/pumpkin-pacspumpkin-pi/
[43] [Online]. Available: http://www.irm.kr/sandwich.html
[44] [Online]. Available: http://health.gnu.org/download/projects
[45] [Online]. Available: http://healthypi.protocentral.com/
[46] [Online]. Available: https://www.hackster.io/protocentral/build-your-own-patient-monitor-with-a-raspberry-pi-dab936
[47] [Online]. Available: https://www.hackster.io/akatsuki/smart-health-kit-4be597
[48] [Online]. Available: https://www.hackster.io/andri/patientcare-for-samsung-artik-cloud-9e68b9
[49] [Online]. Available: https://www.hackster.io/MarcelK/nurse-presence-detection-c4844a
[50] [Online]. Available: https://www.hackster.io/phantom_override/building-a-electrocardiogram-with-windows-iot-and-azure-8b2b44
[51] [Online]. Available: https://www.hackster.io/mohamedemam0/windows-10-iot-core-reading-heart-rate-pulses-e3af03
[52] [Online]. Available: https://www.hackster.io/phfbertoleti/emergency-button-for-elderly-and-people-w-serious-illnesses-501f4c