MSc Project - Reflective Essay

Project Title:	An Ultra-Low-Power IoT-based Remote Monitoring System for COVID-19 Patients
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To begin with, the process of conducting research, developing new ideas and writing the paper entitled 'An Ultra-Low-Power IoT-based Remote Monitoring System for COVID-19 Patients' gave me the chance to learn about healthcare applications while also contributing to the area by offering a solution for remote patient monitoring.

This paper presents an actual development of an IoT-based system for monitoring the health condition of COVID-19 patients remotely in real-time. To conduct this paper, I have done extensive research on existing systems and designs. I have also, carefully studied the specifications of different protocols (e.g. Wi-Fi, Message Queuing Telemetry Transport (MQTT)), hardware components (e.g. microcontrollers, sensors), platforms, software (processing algorithms) and selected the ones that were accessible and would make my system effective to monitor the patients with ultra-low power consumption and low implementation cost. Furthermore, it provides the development of a smartphone application and cloud environment to allow clinicians to monitor, process, aggregate and visualise the health status of patients in real-time to minimise the need for physical diagnosis.

<u>Further applications of the proposed system</u>

This paper currently focuses on the effective remote monitoring of the health status of COVID-19 patients in real-time. The current outputs of the system are various biomedical values of the individuals being monitored It could be further extended to various sectors as well, such as agricultural, chemical and food industries, where it is also crucial to monitor and analyse different values in real-time.

<u>Assumptions</u>

The commercial monitoring devices and systems may produce slightly different results and consider other limitations as well. However, the proposed prototype can serve as the foundation. The assumptions of the proposed system are:

1. The sensors are working properly all the time.
2. The sensors require calibration to show accurate data.
3. No downtime or maintenance updates in the Internet Service provider and ThingSpeak Cloud.
4. No internet disconnections from the microcontroller.

<u>Limitations of the proposed system</u>

One of the limitations of the current paper is that it does not consider secure communication between the MQTT broker and the MQTT clients, and insecure communication puts the business at risk of cyberattack and sensitive data leakage. Another limitation is that data obtained from remote monitoring devices cannot inform the clinicians anything about the patients' mental or emotional condition or the circumstances in which the data was collected. Therefore, an overdependence on data may encourage reductionism. The advantage of less time-consuming face-to-face engagement with the healthcare services may come at the expense of obtaining.

contextual data and not barely noticeable indicators that can be derived only during consultations. For example, a doctor may observe the patient is untidy and inquire about their mood and welfare [1]. Finally, based on the application requirements, users have to buy the corresponding ThingSpeak units to get the capacity and features needed.

Connections of hardware parts and sensors

There are four major components in the hardware. The first is the microcontroller (NodeMCU), and the others are the sensors (AD8232, MAX30100 and LM35). The sensor AD8232 is the ECG sensor which has six pins (ground, input voltage (Vin), two comparator pins, output and one shutdown pin). The ground and Vin pins are connected to the respective ground and voltage pin of the microcontroller. The voltage provided to the sensor is 3.3v. The comparator pins are connected to the two digital pins of the microcontroller. In our case, the shutdown pin is not used. Next is MAX30100, which gives the values of heart rate and SPO2(oxygen saturation in the blood). This sensor contains six pins that are Vin, serial clock (SCL), SDA (serial data), Interrupt (INT), IR Led (IRD), Red led (RD) and ground. The Vin is connected to the 3.3v pin of the microcontroller. The SCL and SDA are connected to the digital pins of the controller. The INT, IRD and RD are not used in our circuit. The last sensor is the LM35 temperature sensor which has three pins, two are the Vin and ground, which are connected to the respected pins of the NodeMCU, and the third is the input pin which is connected to the analog pin of the NodeMCU.

Challenges

The main challenge which was faced during the project was to connect the inbuilt Wi-Fi module (ESP8266) of NodeMCU with the cloud so that everything will be viewed on the runtime. There were number of ESP8266 Wi-Fi disconnection problems which were successfully tackled and now data is being updated on the screen after every 2 seconds. The next big challenge was to send the data to both ThingSpeak Cloud and Blynk app. The complex part was the connection to two different servers with the same runtime values in real-time. The third important issue that was faced was to find the compatible libraries for the Blynk, ThingSpeak and sensors to compile the code successfully on the Arduino IDE. The last challenge was the calibration of the LM35 body temperature sensor in order to give accurate measurement results.

Future work

To improve the current work, further research would allow to integrate a fuzzy neural classifier to make the system more autonomous in a way that prediction and identification of an emergent medical condition would be completely done in the cloud without requiring doctors' monitoring and diagnosis. The future work will include an implementation of a special mechanism in the sensor node to reduce the number of data transmissions to the cloud. The objective is to reduce the number of sample transmissions while preserving data accuracy when there is no or little variation in the measured biological data. Thus, keeping resource utilisation and energy consumption as low as possible. Furthermore, I would implement an alert mechanism, which would send a message to doctors and patients in case of an unusually low or high sensor value measurement. In addition to the current experimental study, if I had more time, I would have investigated other performance measures as well, such as energy consumption and latency of the proposed system rather than accuracy. Also, I would compare the proposed algorithms to others in the field of machine and deep learning.

Legal awareness and ethical issues

While remote patient monitoring has many advantages, some possible harms could emerge. In IoT and remote healthcare provision, cognizance of legal, social, and ethical concerns, as well as sustainability, are important. Data privacy issues concerning real-time data exchange between patients and healthcare service providers have been raised in legal awareness. The first is that there is a great chance that this exchange of sensitive data can be the centre of attention for many intruders for data analysis and statistical purposes. So, that is why anonymity is preserved in the experimental analysis.

Social awareness

Concerning social awareness, there are both positive and negative effects on job opportunities. Remote monitoring in healthcare requires some technical skills (electronic engineering and Information Technology (IT)). As a result, this reduces the opportunities for the older generation of doctors and clinicians, who do not have experience on how to use such digital technologies. In order to minimize this gap, the government and other organisations have to collaborate for the education of low-technical skilled doctors.

Over-relying on data

Overvaluing device capabilities may lead to patients and/or healthcare workers placing too much reliance on data and technology, perhaps leading to a false sense of reassurance even though the technology fails to detect an issue. As a result, diagnoses may be overlooked, and treatment may be delayed. Overdiagnosis, on the other hand, may cause the patient undue health worry, for example, in the case that monitoring equipment identifies changes that are not a reason for concern. There is a lack of clarity in terms of professional obligations [1].

Health disparities

Remote patient monitoring has the potential to exacerbate health disparities. These applications necessitate the utilisation of digital technology and will likely favour individuals who are more health activated, prioritize their health, and have the motivation, competence, and knowledge required to engage with such applications. It is a fact that not all individuals will be agreeable and able to utilise such digital gadgets [2]. Lack of dependable internet or mobile technology access, lack of interest in one's own health, or discomfort dealing with modern technologies are some of the causes behind this. Patients who are not able or not willing to participate may deny the opportunity to gain medically important insights from the data, resulting in the requirement for more regular encounters with healthcare providers, more hospitalisations, recurrences of diseases, and unpleasant events over the course of their lives [1].

Data privacy

When evaluating the balance between access and data privacy, the ownership of health data is a vital but complex topic. Doctors should take into account that the patient is the ethical owner of his or her own data, not a healthcare service provider or a business. Patients must be allowed to choose the boundaries for data usage, storage, and distribution of their own medical information, and these concerns should be covered in the context of approval process. The status of people as proprietors of their own health data is recognised in most countries [3].

Conclusions

This reflective essay addresses the paper's strengths and weaknesses, analysis of the current implementation, as well as certain assumptions, and details about future work and research. Remote monitoring brings technological advancement in the healthcare industry. However, this reflective essay also examines ethical and social-legal awareness concerns, and it is concluded that a balancing point between technology and its influence on the larger community should be discovered.

References

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