Proposal for a Wearable Medical Monitor

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***Abstract*—This document describes a device that would be used to monitor a patient's health via wireless sensors embedded within an article of clothing.**

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I. Introduction

We are researching methods to create a small network of devices that will monitor a patient's health and other statistics during exercise. Specifically, there are three physical components involved: The first is a chip that reads incoming data from a set of gyroscope and accelerometer sensors attached to it. For the most part this device will not analyze much of its data; the chip will only process it enough to determine vital information—for example, if the patient has fallen down, a scenario that could require immediate medical attention. Otherwise, in the absence of such emergencies, it sends its raw collected data to a smart phone.

The smart phone, being significantly more powerful, will analyze and process the data to determine various statistics about the patient, such as body temperature and the motion of their arms, the latter of which can be used to determine what types of acts the patient is performing and in what quantities. The processing in this stage will need to be light enough in terms of computation that it does not use a substantial amount of electricity, yet accurate enough that there are no false positives. Once it has processed its data, it will simply store it. Later on, during the patient's next visit to his or her doctor, the data will be handled in whatever method best suits the purposes it may have.

II. Motivations

A system of this type could find use for almost anyone, but it would be especially beneficial to recovering patients whose physical strength may have yet to fully recover, or who risk blackouts or other potentially sudden and dangerous scenarios that would require immediate attention. As mentioned, the device contains gyroscope and accelerometer sensors, which can determine if a person is falling extremely quickly. Once this occurs, the device can immediately send a signal to a listening server that may then take the appropriate action as necessary. The thermal sensors can also serve a similar purpose: If they detect that a patient is experiencing hyperthermia or hypothermia notification can be sent to the same listening server. Finally, the last system we plan to implement on the device will be to measure arm movement while walking or running. By doing this we can closely monitor a patient's exercise habits to ensure safe practices and that they are giving themselves the optimal amount of exercise in relation to what is prescribed to them. This in and of itself has a variety of purposes. For example, it would allow doctors to make sure that the patient is staying healthy and active enough, especially if their treatment requires a certain amount of physical exercise. It could also do the opposite as well, ensuring that patients do not overexert themselves whether or not physical exercise is necessary. Such an example could be simply recording how active a patient has been during a day that they should have been spent resting in bed.

III. Related Work

This is an area that has had thorough research conducted into it. Jovanov et al. mention some of the main problems with this type of technology, which include unwieldiness of the device depending on its build and wireless interference between devices of the same type. The paper mentions that communication between two devices either would require intrusive wiring, which may negatively influence results by causing discomfort in the patient, or require wireless communication, which is vulnerable to interference [1]. However, our use of Bluetooth only requires a short-range connection to the patient's internet-enabled phone, which provides a convenient solution to both problems, as Bluetooth, once properly configured by the user, is secure against interference, whether accidental or intentional. As Fong and Chan also mention, another major advantage of these sorts of wearable devices is that they may be used outside of laboratory environments and often result in greatly improved power consumption. The same paper also, however, mentioned that "data logging, data processing and fixation methods are the areas to be improved in the near future" [2]. Because our device does not store any data beyond the buffer required for wireless transmission, this does not present itself as an issue, and in the worst-case scenario, any excess data can be stored on the patient's phone for later retrieval.

IV. Proposed Approach

The approach we are planning on taking for project is to start step-by-step. First we are going to use the Intel Galileo board which is a microcontroller to grab the raw data from the wearable sensors. The sensors are broadcasting their data through Bluetooth I assume in a fixed channel using RFCOMM and we can simply use the integrated blue-tooth capability of the microcontroller to connect to the sensors and grab the data we need.

Once we have developed the code for capturing the data from the sensors we can test establishing a wireless connection to a cell phone and forward the data to it for further processing. Forwarding the data through wireless might require we have a buffer for the data to be transmitted. After we have set up the wireless communication to the patient's cell phone it should the process should be similar for forwarding the information to the servers in the cloud.

After we have the Bluetooth and wireless connection set up, we can test the sensor data by actually simulating a fall by letting the wearable sensors fall on a soft surface and analyzing the data we obtain when this happens. Once we have tested it thoroughly we will have a sense of what data to expect in the situation a patient falls and we can start working on sending that critical data to the servers in the cloud via Wi-Fi directly instead of forwarding the data to the patient's cell phone. After that is working we can simulate a patient falling and have our code detect it and send the information directly to the cloud.

V. Evaluation

Once we complete this project we should be able to receive data from wearable sensors i.e.: gyroscope and accelerometer sensors and forward it to the Cloud if the patient is in a critical condition for example if we detect the person is falling or if the patient is healthy forward the data to the patient's cell phone for further processing. We will test our code for the board at different levels:

A. Data transmission

We need to make sure we are able to establish a reliable connection to both the patient's sensors and the patient's cell phone because we are need to be able to detect any sudden change in the patient's condition and it is critical that the data we get is accurate.

B. Fall detection/critical health condition detection

We will test the sensor data we get by simulating all the possible scenarios the patient could be in, that way we will have an idea of what data we should expect for each scenario and most importantly detect when the patient is in a critical condition and needs immediate attention.

C. Efficiency

We will test for efficiency of the code that determines if a patient is in a critical condition. We need this code to be very efficient because it is the most critical part of the system and it needs to be able to react to quick and drastic changes in the data to detect if a person is falling on the ground.

VI. Rough Timeline

We might need two weeks to familiarize ourselves with the board and all of its capabilities. After that we might need about two weeks to be able to figure out how to get the data from the sensors, since we have to learn about the Bluetooth standard and how to use it to connect to other Bluetooth devices and learn about the wireless standard to send data from the board to a cell phone. After we have learned those things the rest will be easy since all we need to do is a little processing of the data and then forward it to a cell phone or to a server, so after we have managed to set up both the wireless communication and the Bluetooth communication we should be able to finish the rest in one or two weeks. So in conclusion it might take us about two to three months to finish this project.

References

[1] Jovanov, Emil, et al. "A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation." Journal of NeuroEngineering and rehabilitation 2.1 (2005): 6.

[2] Fong, Daniel Tik-Pui, and Yue-Yan Chan. "The use of wearable inertial motion sensors in human lower limb biomechanics studies: A systematic review." Sensors 10.12 (2010): 11556-11565.