Design and Implementation of an IoT System for Enhancing Proprioception Training

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ABSTRACT

One of the major issues relating to medical concern is, 'weakness and injuries in joints'. To facilitate proper correction for speedy recovery from damage caused at joints, specially the knee, we propose a system which uses wearable sensors. Whenever the bends around the joints is more and when the pressure at ankle exceeds the prescribed limit a feedback is sent to the patient and hence he/she can make the necessary correction. Also a graphical representation of the patient position and pressure will be maintained on a web page. This graph can provide an insight to physician or doctor regarding the exercises/movements occurred around the joints. The generic requirements like physical exercises for curing of injured, low strain practices of games and sports and also for the elderly people, movement can be effectively tracked and remotely controlled for better service and support by healthcare assistant. The primary function of this system is to enable high risk patients to be timely monitored and medicated to enhance the quality of their lifestyle.

Keywords— proprioception, wearable sensors, feedback

I. INTRODUCTION

Among the panoply of applications enabled by the IoT, smart and connected health care is a particularly important one. Networked sensors, either worn on the body or embedded in our living environments, make possible the gathering of information indicative of our physical and mental health. Captured on a continual basis effectively mined, such information can bring about a positive transformative change in the health care.

Proprioception is one of the most important sense also known as position sense. Proprioception allows us to accomplish complex tasks such as controlling our limbs without having to look at them for example, while driving. It can be impaired by diseases or injuries, and the patients will have difficulty with balance and coordination. This mostly affects elderly people and athletes.

Proprioceptive training involves exercises and the patients can record their improvement using wearable devices. In exercise therapy, the early rehabilitation stages, during which the patient works with the physical therapist several times each week. The patient is afterwards given instructions for continuing rehabilitation exercise by him/herself at home. This study develops a rehabilitation exercise assessment mechanism using wearable sensors in order to enable the patients with knee osteoarthritis to manage their own rehabilitation progress.

Using the available data, that has access to a large corpus of observation data for other individuals, the doctor can make a much better prognosis for your health and recommend treatment, early intervention, and life-style choices that are particularly effective in improving the quality of your health

II. CURRENT PRACTICES

The health parameters of the patient were measured and sent through Zigbee Communication protocol. The ZigBee technology provides a resolution for transmitting sensors data by wireless communication. Wearable sensor unit, attached to the patient's body, reads and transmits the patient's data to a portable ZigBee-based receiver carried around by a nurse or doctor or to a hospital server. The system is designed and built using the ZigBee modules (Nodes), sensors attached to the patient's body are interfaced to these Nodes. The complete Node is packaged in a light form and carried by the patient. Sensed data is transmitted to a ZigBee coordinator (Z-Coor) with a wide LCD display that is carried by the supervisor nurse or doctor on the hospital floor.

The XBee gateway shown in Figure1 is used to provide gateway functionality between the ZigBee network and the Ethernet. This gateway device collect data from the coordinator packetize it and via the TCP/IP layer, data is sent and stored in the main server where a database is used to keep records of the patient's history.

A Database is created that stores data such as threshold values for sensed data, these values are determined by the patient's physician and if the patient's readings exceed these values the system will automatically send an alarm SMS using the GSM network to the doctor. The patient's records or history of readings of the various signs are maintained and an Apache webserver was used in the experimental set up.

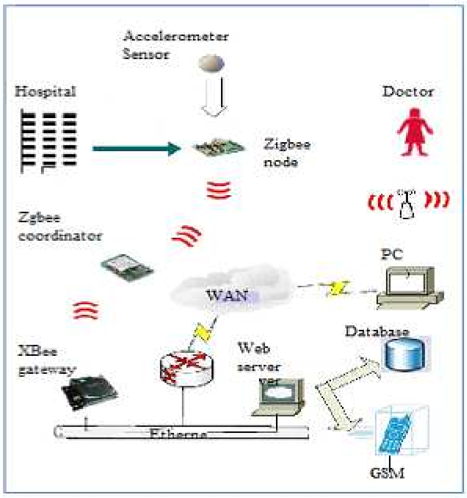

Figure 2.1: Patient health monitoring using Zigbee technology

III. BASIC ARCHITECTURE OF THE PROPOSED SYSTEM

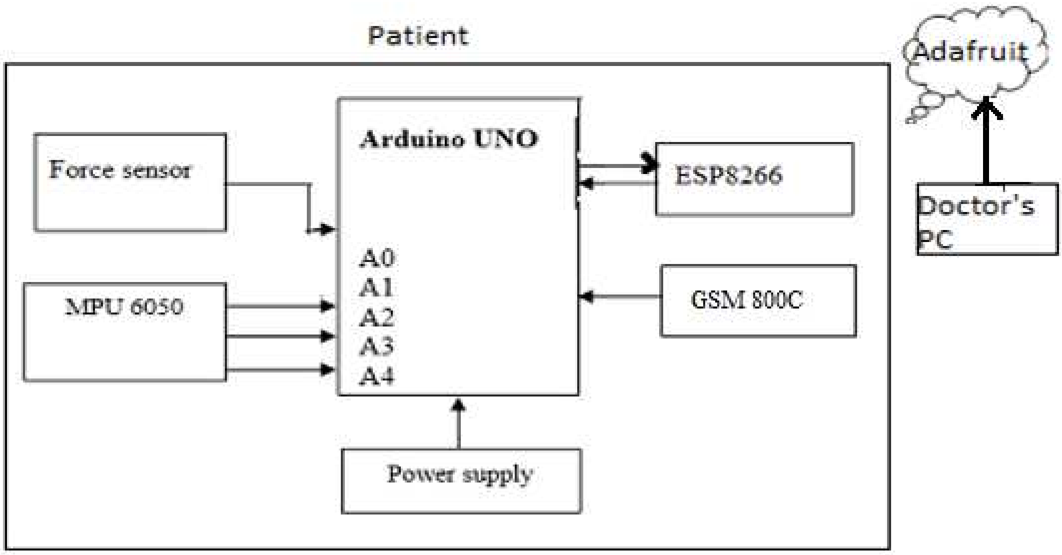

Figure 3.1: Block diagram for proposed system

We develop a healthcare monitoring system for both inpatients and outpatients for enhancing **proprioception training**, considering the cost, ease of application,accuracy and data security. The main idea of the designed system is continuous monitoring of the patients, over mobile phone and internet using wireless technologies. There are a number of exercises that can be performed to help train the proprioception such as balancing exercises, exercises while closing the eyes, strengthening exercises, squats, vertical jumps, are examples of ways that can help establish the connection between muscle fibers by building strength. The real-time monitoring system incorporates wearable sensors to extract medical information which helps finding out multiple parameters such as pressure, movement of the knee at the same time. The system has two interfaces, one for the patient and one for the doctor.

The patient interface is compromised of wearable sensors which extract medical information of the patient and transmit to the IoT server (Adafruit IO) via Wi-Fi. The doctor is provided with a unique user name and password to access the data obtained from the patient. The necessary feedback is sent via a SMS to the patient using GSM 800C module involving doctor's advice for fast recovery.

The model consists of Arduino UNO board with microcontroller ATMEGA 328, accelerometer sensor with gyroscope features (MPU 6050), force sensors and Wi-Fi module. In this system for outpatients monitoring, ESP8266 wi-fi module collects the data from the sensors and sends the data to IoT server(Adafruit IO) for storage and further analysis through the website. The Protected data stored can be accessed anytime by the doctors.

IV. FEATURES OF THE PROPOSED SYSTEM

The proposed idea is a remote health monitoring system over mobile phone and internet using wireless technologies. The real-time monitoring system incorporates wearable sensors to extract medical information which helps finding out multiple parameters such as pressure, movement of the knee at the same time.
The system architecture is two tier 1) a patient interface that is wearable sensors 2) a web portal.
The patient interface is compromised of wearable sensors which extract medical information of the patient and transmit to the IoT server (Adafruit IO) via Wi-Fi. The doctor is provided with a unique user name and password to access the data obtained from the patient. The necessary feedback is sent via a SMS to the patient using GSM 800C module involving doctor's advice for fast recovery. The proposed system has the ability to use multiple sensors which enables simultaneous monitoring of several parameters.

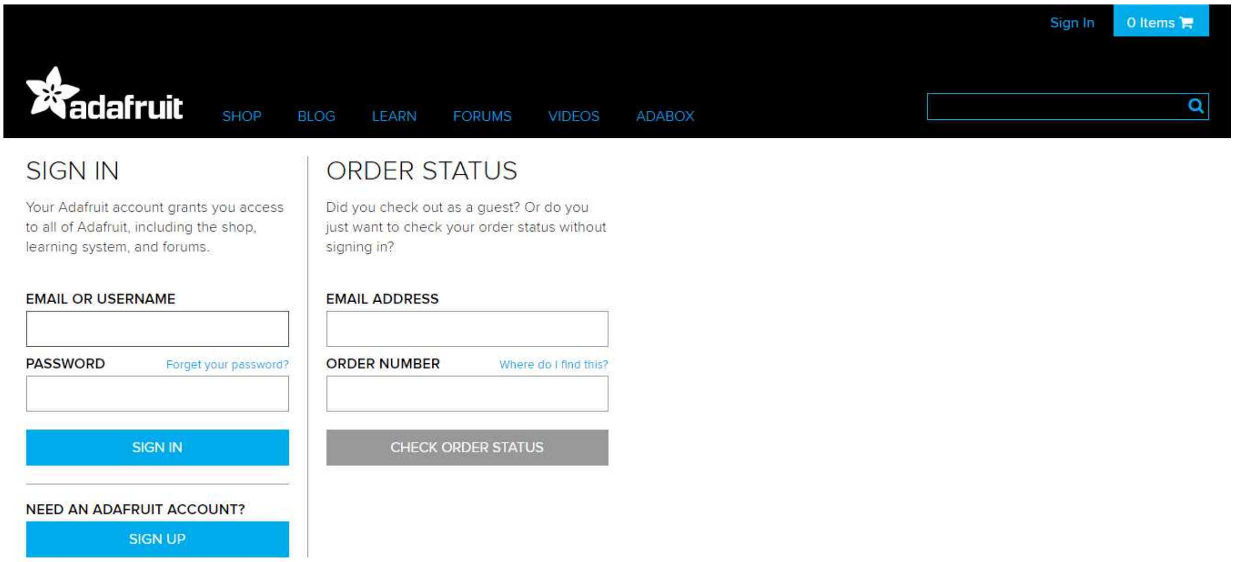

Figure 4.1: Adafruit login page

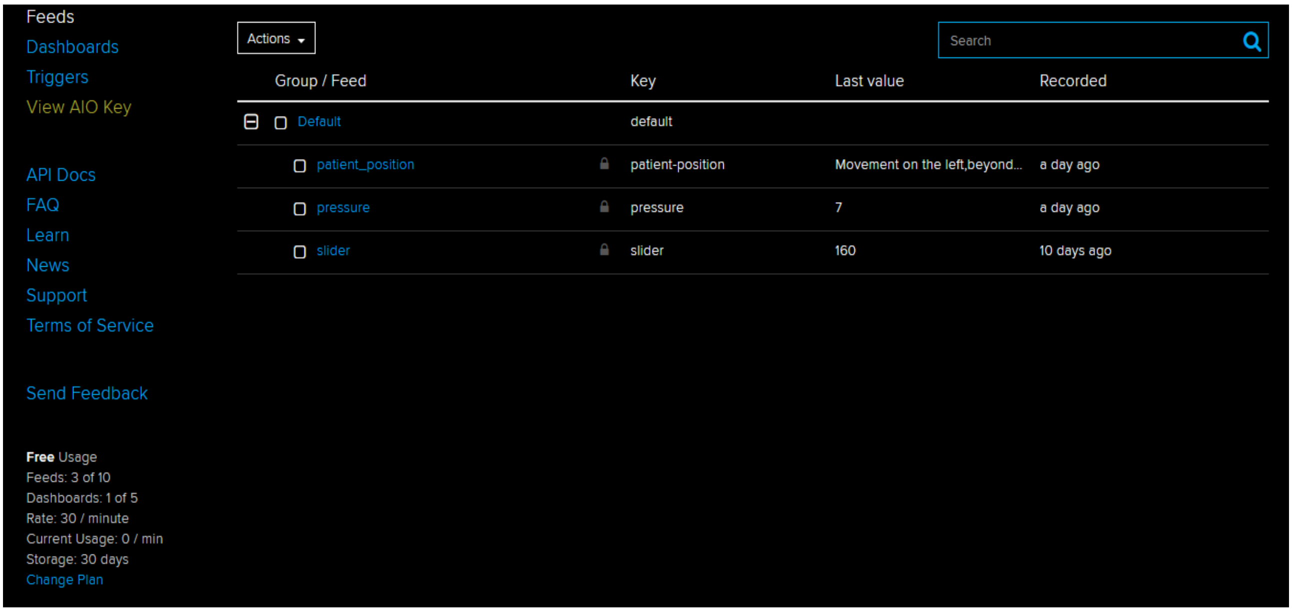

Figure 4.2: Adafruit Feeds with the sensed data

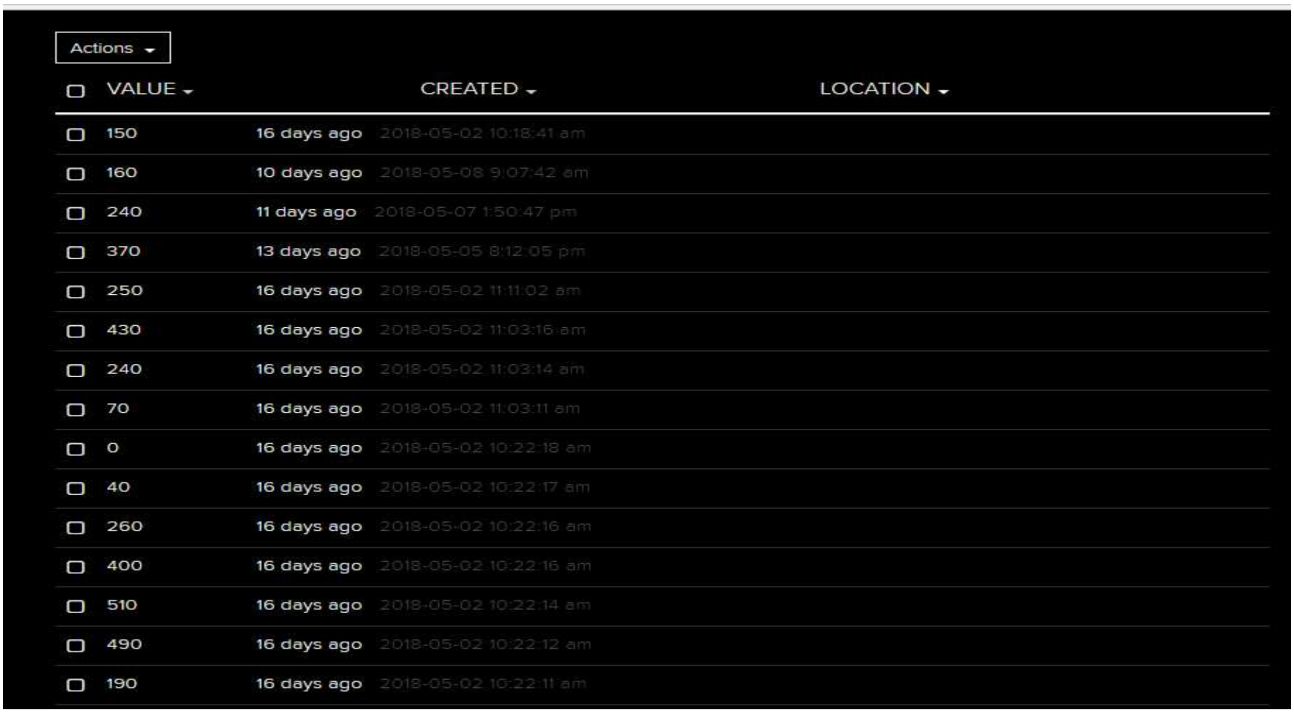

Figure 4.3: Adafruit feeds with sensed Pressure data

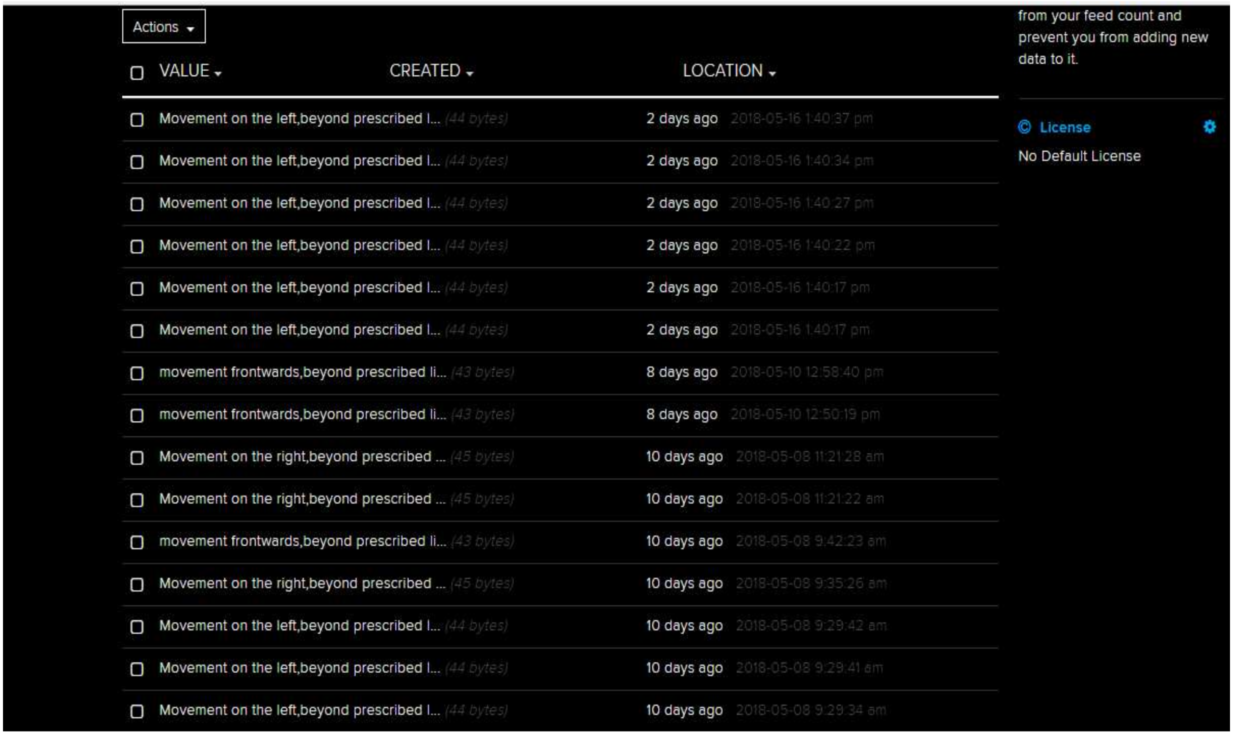

Figure 4.4: Adafruit feeds with patient position details

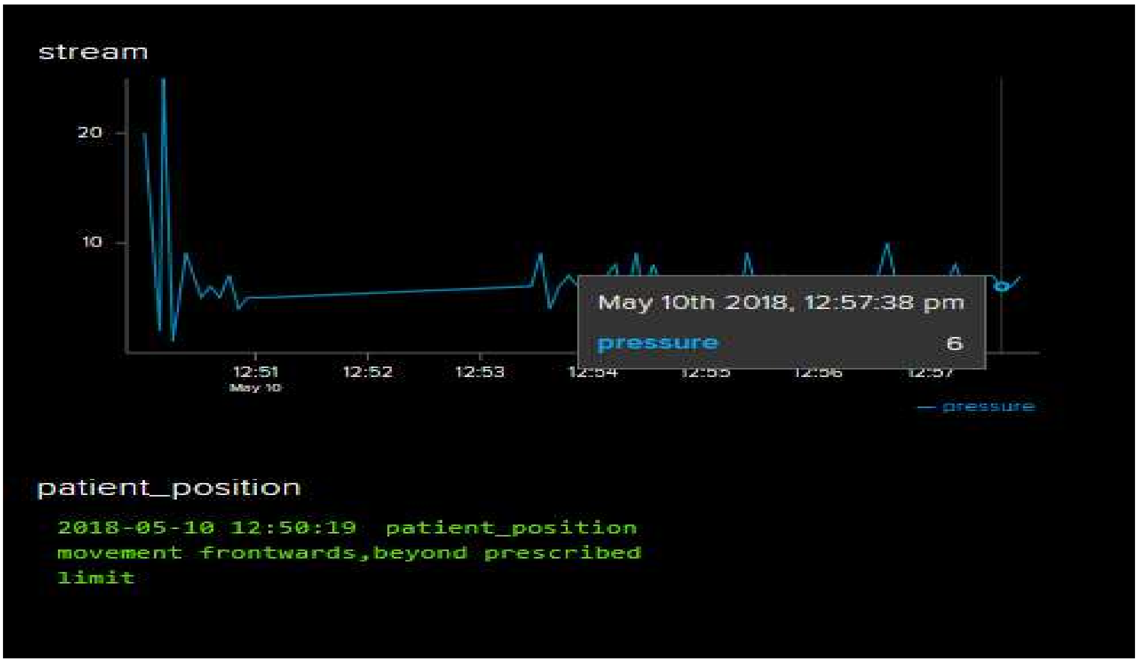

Figure 4.5: Adafruit Dashboard

The model consists of Arduino UNO board with microcontroller ATMEGA 328, accelerometer sensor with gyroscope features (MPU 6050), force sensors and Wi-Fi module. In this system for outpatients monitoring, ESP8266 wi-fi module collects the data from the sensors and sends the data to IoT server (Adafruit IO) for storage and further analysis through the website. The Protected data stored can be accessed anytime by the doctors.

MPU-6050: It has the ability to precisely and accurately track user motions, Motion Tracking technology can be used in applications ranging from health and fitness monitoring to location-based services.

Key features for this technology are small package size, low power consumption, high accuracy and repeatability, high shock tolerance, and application specific performance programmability – all at a low consumer price point. The MPU-6050 collects gyroscope and accelerometer data while synchronizing data sampling at a user defined rate.
FSR- Its key features are small size. It is capable of micro-force detection and high sensitivity, high sensitivity, high precision and high durability.

Data transmission from wearable sensors to IoT server

Data transmission process from sensors to IoT server via ESP-8266 Wi-Fi networks.
The sensors collect the data and transfer it to the IoT server (Adafruit IO) through ESP8266 Wi-Fi module.
The doctor is provided with a unique user id and password, where they can monitor multiple patients' health simultaneously by creating different dashboards and also observe the improvement of each patient from the stored data.

Feedback: The feedback is not only from the doctor after analysing the data in the IoT server, but also the patient is provided with immediate alert messages when there is any anomaly with reference to the predefined threshold values or the sensed parameters which vary based on the patients' age and condition using GSM 800C.
GSM 800C can transmit voice, SMS and data information with low power consumption. With the tiny size of 17.6*15.7*2.3mm, it can smoothly fit into slim and compact demands of customer design.
The alarming mechanism basically consists of data visualization, statistical pre-processing, and notifications.
The proposed alarming system is a generalized monitoring model that works on the principle of threshold values. It can be customized for individual monitoring due to the fact that the threshold values aren't the same for different age groups. The customized monitoring helps in setting adaptive boundary limits which keeps changing throughout the monitoring phase.

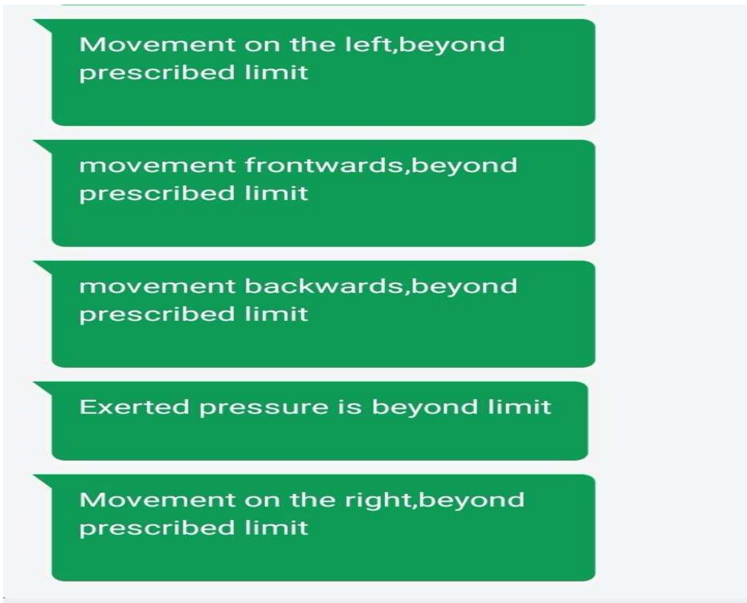

Figure 4.6: Feedback to patient via SMS

V. SPECIFIC HEALTHCARE APPLICATIONS

For people living with osteoarthritis (age range 45-65 years) rehabilitation based on exercise therapy is recommended, this model is useful to keep track of their movements which can enhance their joint function.

This model also helps the injured people specially the athletes who undergo a lot of physical and fitness training to ensure that they recover soon or have an easy going post-operative assessment by wearing the device and monitor their position so as to help him/her to do the exercises as prescribed.

For the physically disabled people if there are chances of improvement, this can help them to the take the process slowly and gradually by monitoring movement and pressure exerted at ankle continuously.

VI. RESULTS AND CONCLUSION

The health care services are important part of our society and automating these services lessen the burden on humans and eases the measuring process. Also the transparency of this system helps patients to trust it. The sensors measure the required parameters and provide the data to the web server. When threshold value is reached, an alert message is sent to the user via SMS using GSM 800C and he/she can act more quickly. The ESP-8266 Wi-Fi module helps the server to update the patient data on website.

The development of low-cost, low-power, multifunctional wireless sensor nodes that are small in size and communicate untethered in short distances are used in our project. These tiny wireless sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on the collaborative effort of a large number of *nodes. Issues* such as long-term patient care in hospitals, support for elderly people at home can be resolved using this. The implemented real-time patient monitoring system, enables doctors to monitor the patients' health on a remote site, and provide timely advice according to their improvement. The system prevents the patients from re-hospitalization and monitoring multiple patients' health status simultaneously. The data are available for review on the central server, and can be accessed remotely by means of Adafruit Feeds. The system developed automatically alerts the patient when an anomaly is detected through SMS services. Besides bringing comfort to patients, there are commercial benefits in the area of reducing costs, rehospitalisation, and improving equipment and patient management.

VII. REFERENCES

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