Mobile and Pervasive Computing

CNT5517 - Section 1G92. CIS4930 - Section 015E

Mobile & Pervasive Computing

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Term Project Report

Group 15

iROAM

Intelligent Real-time Observation & Analysis of Movement

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Google site link to this report online	https://drive.google.com/open?id=0B-cIKH7K2_XIU05BRXhsU082SGM
Google site link to the Final Presentation of your project	https://drive.google.com/open?id=1xTpst2dcHAKfgFw0C3JcknD7VHLGD7_XgAnzcHprS6s
Google site or YouTube link to your 1 min video	https://youtu.be/nwuy0WTobYA

CONTENTS

1. The Problem and its Significance

Assistive devices - such as canes, crutches, and walkers - are effective ways to alleviate the impact of mobility limitations for many people, allowing improved ambulation and independence. Approximately 6.5 million people use these devices to assist with their mobility. Patients and health insurance funds are burdened, the cure is often lengthy and difficult. Physical therapists cannot monitor users in real time during recovery. What makes this more complicated is that the amount of pressure needed varies according to the injury. Some patients are told to apply roughly 10 per cent of their body weight; for others, it can be 50 per cent.

Additionally, not all seniors feel comfortable using wearables, either because they don't trust it or don't understand how to use it. Old people are not really familiar with technology. Also, it is difficult for family members to monitor the elderly with respect to their day to day activities when they are alone.

2. The Solution Approach

Smart health products can help people get healthy, stay healthy, and prevent illness in new and dynamic ways. Internet of Things (IoT) can turn standard products into connected ones, making it easy to track health, help loved ones, and share important data with doctors.

To solve the problems stated above we made crutches and walkers an IoT device. We developed smart crutches that make a difference in recovery time. iROAM works by monitoring how much weight the patient is putting on the crutches. Physical therapists and other health professionals can analyze the data to easily assess the user's movement and expedite the recovery process. A physician can track the patient's recovery and better understand what he or she needs for rehabilitation.

Smart crutches/walkers is also helpful to look after elderly people. Design and easy usability are critical factors for assistive devices for seniors. Smart walkers are great for these reasons, there are no additional wearables and force and pulse sensors are attached to existing devices. These can detect if a senior hasn't walked for a longer period of time and provide their heart rate at any given time in a remote terminal. Pulse sensor tracks heart-rate of the users and sends an alarm to caretakers if heart rate and pressure go below or above defined threshold. Additionally, a red LED blinks on the device if heart rate change is abnormal.

The solution starts with periodic data collection using multiple sensors attached on the assistive device, then sending it to a server which stores the data and performs data-

analytics to glean useful information and form daily/weekly/monthly patterns. All this is then available to the doctor (who is in-charge of the patient) through multiple graphs as part of a consolidated dashboard. The dashboard also updates in near real-time by taking into account the activity being done by the patient at that moment.

Fig 1: Solution Diagram

3. Design

3.1 **Arduino UNO**:

- Mqtt
- Wifi-shield
- Bluetooth shield
- Force Sensitive Resistor
- Pulse Sensor

3.2 **Server**:

- Is based on Node.js.
- Uses Meteor as an integrated Javascript stack to tie everything together.
- Uses MongoDB to store data received from the Arduino board.
- Makes use of React framework to create a dynamic web app and provide client side routing.
- Connects with 'Initial State' to provide data-driven visualizations.

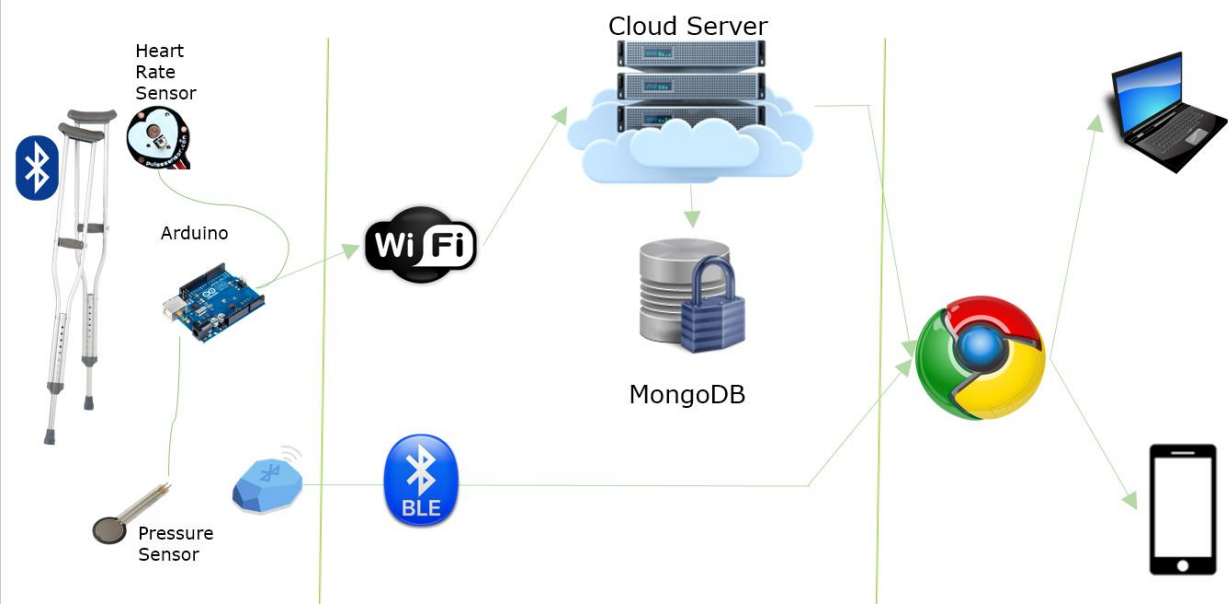

Fig 2: System architecture design

4. Implementation

Arduino:

- **Mqtt** - PubSubClient library is used for transmitting the monitored set of vitals to the server using MQTT protocol. The monitored parameters viz pulse and the force applied on left and right crutches/cane are sent as messages on topics “iROAM/pulse”, “iROAM/lForce” and “iROAM/rForce” respectively to the public MQTT broker “broker.mqttdashboard.com”.
- **Wifi-shield** - Arduino WiFi library is used for supporting wireless communication using Arduino WiFi shield on top of Arduino UNO board. The WiFi shield connects to the predefined network and facilitates the transmission of MQTT messages from Arduino board to MQTT broker.
- **Bluetooth** - HC 05 (Master) and HC 06 (Slave) sub modules are used on two Arduino boards to provide for Bluetooth enabled communication. By this, we can make use of only one WiFi shield to wirelessly transmit MQTT messages from both the Arduino boards (One sends messages to the other connected to the WiFi shield via Bluetooth). Serial port communication is used between the sub modules after pairing them manually using AT commands.

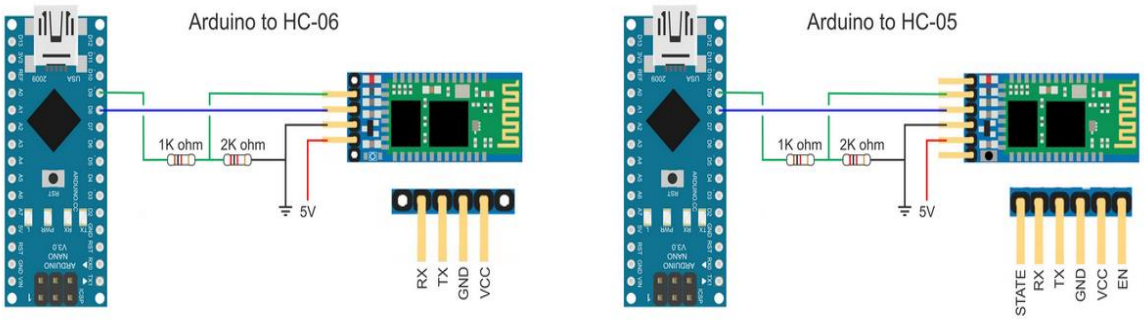

Fig 3: Bluetooth Pin Diagram

- **Force Sensitive Resistor** - A piezoresistive force sensor on which the harder you press, the lower the sensor’s resistance. Pressing hard, the resistance changes from infinite to ~300k. Used as a presence sensor that is calibrated to transmit the amount of force (in lbs.) applied using crutches/walking cane. The sensor is connected to the Arduino board using a breadboard. The sensors are calibrated by measuring weights and checking the resultant resistance value and a graph is plot and the corresponding equation is obtained using the service WolframAlpha. The sensor is placed under the crutches/walking cane to get the maximum pressure applied for every step taken and the same is sent to the server

using MQTT protocol (Arduino to public broker and to the server) under the topic “iROAM/rForce” and “iROAM/lForce”.

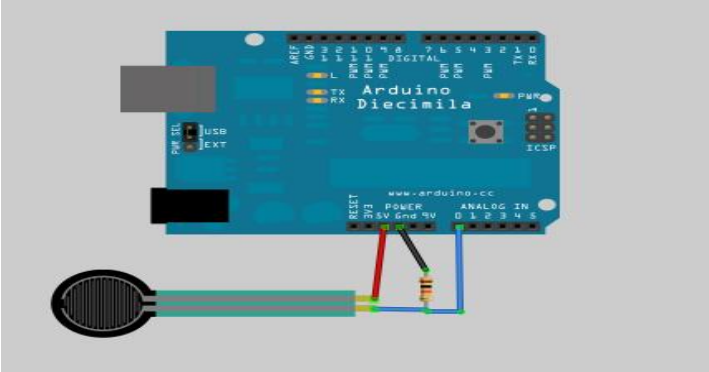

Fig 4: FSR Pin Diagram

- **Pulse sensor** - a plug-and-play heart-rate sensor for Arduino that is used with the Arduino to monitor the user’s heart beat per minute (BPM). The sensor outputs analog signal and we use an algorithm that calculates the BPM using the output of the pulse sensor. The calculated BPM is sent to the server using MQTT under the topic “iROAM/pulse”.

Fig 5: Pulse Sensor Pin Diagram

Server:

- Cloud9 was chosen to host a collaborative development environment and the node server.
- Node.js is used as the server on which backend is hosted. Some other npm modules used in the app are:
    - Mqtt - used to receive data from hive mqtt broker.
    - Request - make GET calls to InitialState platform.
    - Moment - data/time formatter.
    - React - to display client side dynamic webapp.
    - BCrypt - used as part of authentication functionality.
- Meteor
    - Manages node server.
    - Provides easy integration with hosted MongoDB database.

Beacon

- A Beacon is fitted on the crutches/walker and a custom URL is set for a particular user and it broadcasts the same so that anyone with valid credentials can pull up the iROAM dashboard. This eliminates the need for remembering URL or to download and install any specific applications.

4.1 Implementation Effort Map

Task	**Time taken**	**Subtasks**
Hardware (setup, coding & calibration)	9 days	Coding, Bluetooth + Wifi Shield + FSR sensors + led + pulse sensor, MQTT
Nodejs	3 days	Publish client-side web pages, server-side logic, MongoDB, integration with hive MQTT and InitialState.
Front-end (React + dashboard)	3 days	Login, authentication and real-time dashboard which use InitialState graphs.
Integration test with hardware mounted on crutches	2 days	Sync both Arduino boards using bluetooth, final testing and bug fixing
Report, Presentation, Video	2 days	

5. Project Status and Challenges

The aim of the project has been successfully **achieved**. In the current version of our project we have completed the following features:

Objective	Achieved?
Get force applied on left and right crutches.	✓
Monitor heart rate using pulse sensor.	✓
Count number of steps a person take during the day.	✓
Emergency alert if there is a spike or dip in heart rate	✓

6. Demonstration

Our idea serves as a solution for remote monitoring of data of the injured patients who are using crutches for recovery and for activity tracking of the elderly who use any form of walking aid. The patient is given crutches that are fitted with the FSR sensors, pulse sensor and a beacon which broadcasts a custom URL. All the peripherals are connected to a central computational device - Arduino UNO.

Once, the patient starts using the crutches, the Doctor and the patient themselves can monitor their activities on a day to day basis in their respective dashboard (remote terminal). The medical personnel get better idea with respect to patient's recovery phase and how they are coping with it like,

- Is the force applied on crutches is high or low?
- Walking activity - number of steps covered with the crutches on a given period of time
- Is the pulse of the patient normal on specific period of days and during specific activities like resting or walking with the crutches?

The Doctors use their dashboard to get the list of patients and select particular patient's record to monitor their vitals and activities. If any abnormalities are found or if any suggestions to be made, the Doctor can directly inform the patients instead of waiting for the feedback from patient themselves.

In case of the elderly people using the walker/walking cane fitted with our sensors, their family members and caretakers can monitor their activity like pulse rate and number of steps walked along with the walking cane.

7. Business Model

iROAM adds business values to the following sectors:

1. **Healthcare service** - The hospitals and Doctors can practice better treatment strategies based on the data gathered as it gives more credible information related to patient's recovery instead of relying on conventional feedbacks. This improves the efficiency of treatment strategies and thereby building confidence and increasing the customer base

2. **Walking Aid provider** - Manufacturers can fit the modular set of board and sensors to any of the walking aids and provide for customization as per the user/patient/medical personnel requirement

3. **Data Analytics** - The data gathered across all age groups and all medical conditions provides crucial information related to the recovery speed and user/patient activities (movement related) during the rehabilitation period which is of great value in health care community

4. **Cloud services** - Cloud service for storing and managing health related data requires HIPPA (Health Insurance Portability and Accountability Act) compliance and data needs to persist throughout the rehabilitation period (relatively long period of time) depending on the medical condition

8. Materialized Team Effort

Name	Problem/ solution	Design / Architecture	Implementation	Reporting
1.Siddharth Gupta	20%	23%	21%	14%
2.Akhil Sharma	20%	18%	18%	26%
3.Kartik Chaturvedi	20%	21%	21%	15%
4.Yuvaraj Sripathi	20%	19%	20%	16%
5.Tanu Gupta	20%	19%	20%	26%

9. Video

https://youtu.be/nwuy0WTobYA

10. References

[1] https://www.nichd.nih.gov/health/topics/rehabtech/conditioninfo/Pages/people.aspx
[2]http://www.dailymail.co.uk/health/article-1207256/The-smart-crutch-calculates-heal-bones-quicker.html
[3] https://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr
[4] https://pulsesensor.com/
[5] https://github.com/WorldFamousElectronics/PulseSensor_Amped_Arduino
[6]http://www.martyncurrey.com/connecting-2-arduinos-by-bluetooth-using-a-hc-05-and-a-hc-06-pair-bind-and-link/
[7] https://www.arduino.cc/en/Reference/WiFi
[8] http://pubsubclient.knolleary.net/
[9] https://www.wolframalpha.com/