READING ASSIGNMENT

Smart Irrigation System, IoT Smart Power Socket, IoT Health Monitoring System, and IoT Smart Workout System

By: Alan Biju Palayil

Instructors: Dr. Jafar Saniie and Dr. Won-Jae Yi

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Acknowledgment: I acknowledge all the work (including figures and codes) belongs to me and/or persons who are referenced.

Signature: ___________Alan Palayil_________

Smart Irrigation System by Salih Usta was developed like the IoT Smart Farming Architecture for Agricultural Automation which was developed by Adrián Sánchez-Mompó, Heloise Barbier, Won-Jae Yi, and Jafar Saniie from the ECAPS Research Laboratory. The project is built on IoT and Wireless Sensor and Actuator Networks (WSAN) to provide an ideal condition for growing crops. The system is created to detect the moisture level of the soil around the crop. This is achieved by using a series of sensors which monitor the soil's moisture and nutrients. The project is developed to automate the watering of water which can be reducing labor work, can help monitor the water consumption, help obtain an accelerated growth and higher production yields. The system comprises of two stages which uses low-power sensor and microcontroller that reads the data from the sensor and after feedback from the gateway, it would actuate the solenoid to distribute water. The communication between the microcontroller and gateway using a bespoke LoRa. Using the LoRa WAN architecture, the system can be flexible for deployment size ranging from personal farms to commercial-level farms.

The system discussed in the reference is focusing on the irrigation of the crops and the following parts are used:

- 12V DC Solenoid
- Soil Moisture Module
- Flex Pipes
- Diode
- Arduino Uno
- Cables
- Relay
- Raspberry Pi
- 5V Power Supply
- HopeRF RFM95W modules

The system is designed to be two-staged gateway and nodes instead of single handling nodes connected directly to the internet as it increases the modularity of the system to have additional nodes for larger fields and reduces the power consumption since the actuators nodes can be deployed with battery or solar powered with a centralized decision-making system if the internet connectivity is unstable.

The system is using custom communication protocol through LoRa radio. It provides a robust long-range communication which allows simultaneous interference-free co-channel transmission. The sensor and actuator send the data to the gateway where the data is processed and instructions from the gateway are sent back to the actuators. An acknowledge of receipt is returned by the node. The algorithm detects changes in the sensory nodes and sends the data to the microcontroller (actuators) which then relays it to the raspberry pi (gateway). The gateway checks the node's value and if the soil is dry or moist. If the soil is dry, the gateway sends a command to the actuator which turns the solenoid which then dispenses the water to the crop until the soil becomes moisten.

For this project, there is an immense potential within the IoT for agriculture. The system can be designed for a greenhouse with inclusion of a few more sensors can completely automate the irrigation system. With the addition of light sensors, the system can have the crops a required amount of UV lights, a gas module like MG811 can be used to monitor the CO_2 levels all of which can improve the growth of the crops. This project has a great scope since the agricultural industry is booming and innovative ideas are being implemented daily to improve the farming culture. The estimated cost of this project I believe is around $120 and can be implemented on from an individual/ personal level to an industrial/commercial level.

IoT Smart Power Socket is a project developed in the ECAPS Research Laboratory in the ECE department by Carlos Mateo, Fernando Almagro, Won-Jae Yi, and Jafar Saniie. The project is implemented to provide the functions of electrical protection, monitoring, automation, and remote control to a power socket with the help of mobile application. The project is designed to support complex tools such as time scheduling which can be used for automation, power usage management for a group of sockets, and operation management for remote access. The Smart Power Socket (SS) is developed to have simple manual control using the ultrasonic sensor, has a surge protection to protect the electric appliances and make it affordable. It includes the following components:

- Arduino Uno
- Ultrasonic Sensor
- Light Sensor
- Temperature and Humidity Sensor
- Relay
- HC-06 Bluetooth module
- LED Lights
- Resistors
- Wires

The device uses the power source adapter attached in parallel to the actual plug. To include a surge protection and reduce overflow, the input power is less than standard outlets. A fault detection which checks the electrical safety, blockage and switch state is also implemented along with power consumption monitor. The Smart Socket's local node is primarily coded using C++ language to ensure fast execution from the algorithm and react promptly to user interactions and the Arduino which acts as the Hub is developed using Python considering its flexibility. The Socket is divided into three main modules:

- SS Hub Management
- SS Local to Hub
- SS Local to Cloud

The cloud is implemented using MBaaS software from Firebase Authentication and Firestore. The mobile application is developed using Android Studio as the IDE and coded in Java. The app is designed to connect the user to the device via cloud and the user can use the app to automate the socket by adding parameters of timers to turn on/off the socket at particular times, the light threshold to activate the socket at a given luminance along with modularity of sockets to add them in groups to have enable group control.

The project is based on the commonly smart plug which is an addition of a device to the male/female electric plug and socket. The product is made to combat the expensive commercial solutions with the inclusion of features. The product is well developed with the use of light sensor to turn on/off a particular device and my recommendations would be to add exterior housing/ design the final housing along with the display the role of the temperature and humidity sensors to the product so that it can be made marketable. This project looks to be a great boon for both the home and industrial automation. Looking over the parts used in this project I believe the cost of this smart plug system to be around $50 excluding the Raspberry Pi as I expect the system to connect to the cloud directly also it is not mentioned in the paper.

IoT Health Monitoring System by David Arnold and Andrew Mustea was a project developed on an existing ECAPS project. The original project made by Won-Jae Yi, Boyang Wang, Bruno Fernandes dos Santos, Eduardo Fonseca Carvalho, and Jafar Saniie from the ECE department of Illinois Tech was an application for IoT based fall detection system. The system is designed to analyze the users' status and during irregularities, such as a fall would be detected using sensors like accelerometers and a gyroscope and transmit to the Raspberry Pi which acts like a central node. It is used as a W-iPCN and uses WiFi or Bluetooth with the device. Using a smartphone application, the device can be connected to the central node or the database server using WiFi, Bluetooth, or Cellular. The project is further developed by the addition of vital sign detection.

The project is divided into four main components: Chest sensor, thigh sensor, vital sign detection, and central W-iPCN. The following are the parts used to create each component:

- The chest sensor includes an accelerometer, gyroscope, Arduino pro mini, Zigbee module, battery, and a rest button.
- The thigh sensor has an accelerometer, gyroscope, Arduino pro mini, battery, and a Zigbee module.
- The vital sign detection houses maxim integrated microcontroller along with temperature, ECG module, and a XV module.
- The central coordinator was made up using a Raspberry Pi 3b+ and a XV module. The XV modules are used to transmit data between the vital sign device and central coordinator.

The project is designed to be a low-power utilization IoT device which is developed using C++ and python. The Raspberry Pi is used as the W-iPCN central node and is used to receive and analyze data. The data is transmitted to the database using API method. The database is created using the XAMPP platform on which the central server and PHP application is built on. This enables the project to have its own database server and smartphone application. The smartphone application contains the Users' name, last timestamp update from the server, and a graph which displays the data from the device's sensors.

The vital sign device contains the ECG module and temperature sensor. The ECG device is used to collect the raw data using the five lead ECG cable and transmits the data to the central node via the XV module. The temperature sensor also transmits the data through the XV module to the central node. The central node collects the data from both the sensors through the receiver XV module. The data is analyzed by the central node using the sample data collected. The data is then sent to the database server. Using the Zigbee transceiver. The fall detection works by collecting the data from the accelerometer and gyroscope from both the components and is transmitted to the central node. The central node compares the data to the existing constraints and values to detect the fall criteria. The constraints included help the device differentiate between a fall and sitting/lying down posture. Using an email module connected via a python script, a message is transposed into a text if a fall occurs.

Looking over this project, the project is developed well enough with my recommendation to make the project more modular and have pre-registered data to help user defined profiles. After looking over the similar projects, there are similar projects which only have fall detection either on wheelchair or some other sorts. I have not seen a device that can register users' sitting or lying down in comparison to alerting on every swift movement along with capabilities of temperature and heart monitoring. The estimated price of this project is around $300 with the just the parts list. The device has an enormous potential within the nursing community for both toddlers and elderly which can be used to alert family and medical personals.

IoT Smart Workout System was developed by Jose Toledo Monsalve with the guidance of David Arnold, Won-Jae Yi, and Jafar Saniie. It is a project developed for athletes to track their workout and analyze their activities. It is an automated system to track the movements during a workout session in real-time. It was designed to record and store precise workout data which can be used to access and improve the trainings. The project is developed to be modular for user defined functionality. With the use of Wireless Body Sensor Networks (WBSN) and IoT, the Smart Workout system was developed. The WBSNs is used for its lightweight and low-power wearable sensors which are used to monitor the users' motion patterns. With the implementation of IoT, the system's usability and productivity are increased as computing resources can run via the cloud. The system comprises of the following component: two sensor nodes on the user's thigh and chest, a PCN for collecting and processing data from sensor nodes, a central server for receiving, storing, and analyzing data from the PCN along a web application and smartphone application to view and control the system.

The parts used for each of the following components are:

- The sensor nodes are made up of a Zigbee module, ultrasonic sensor, accelerometer, and an Arduino Uno which is strapped to the thigh.
- The PCN includes a Raspberry Pi 3b+ and a XV module which is coded to receive the data from the Zigbee module and using an algorithm detects squats and push-ups.

Th-e processed data from the PCN is transmitted using a REST API via WiFi or Ethernet to the central cloud server. The data received via the Zigbee transceiver from the sensor nodes is processed using a python script algorithm which distributes the data from the accelerometer and ultrasonic modules to the constraints to determine the users' position into four categories. The

PCN also includes a rep detection algorithm, the user can accurately determine the reps within a workout session by the current and previous position. The WebSocket also provides charting tools like Google Charts which are used for graphical representation.

The mobile application retrieves data in the form of JSON format and is available for the user to view. It includes the summary information about the workout session with a time frame. The REST API implemented on the central server is utilized to customize the messages between the PCN and Android application. During the demonstration, the sensor node is attached to the thigh and records the four postures: standing, squat, plank-high, and plank-low. With new positions being recorded on the top.

The project is overall a good approach with a lot of future modularity for additions of sensors. The system has a wide area of use being in the sports and medical fields. The system can be used to monitor and record athletes' trainings and be viewed by the trainer or coach. In the medical field, the system can be used by patients in rehabilitation centers. There are activity tracers currently available in the market that can measure like the Apple Watch and iPhone but without the same accuracy. According to the parts list, the estimated cost of this project is around $200 including the server maintenance. This project has already predicted its market with the focus on fitness industry. With the addition of sensors like ECG, SpO2 modules can improve the scope and value of the project. The project seems like the Fall Detection project and one recommendation would be to combine the two projects into one. Another suggestion is to develop a training application that can has routines for users so that they can follow workout routines.

References:

Internet of Things Smart Farming Architecture for Agricultural Automation by Adrián Sánchez-Mompó, Heloise Barbier, Won-Jae Yi, and Jafar Saniie

Design Flow and Implementation of an IoT Smart Power Socket by Carlos Mateo, Fernando Almagro, Won-Jae Yi, and Jafar Saniie

Design Flow of Neural Network Application for IoT based Fall Detection System by Won-Jae Yi, Boyang Wang, Bruno Fernandes dos Santos, Eduardo Fonseca Carvalho, and Jafar Saniie

Design Flow of Wearable Internet of Things (IoT) Smart Workout Tracking System by Jose Toledo Monsalve, David Arnold, Won-Jae Yi, and Jafar Saniie