UEE693

Capstone Project

Remoulding an existing house into a Smart Home

Investigating Group

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Contents

1 Aim

The project aims to increase the energy efficiency of a household by converting primitive devices into smart devices and managing them using a self-evolving deep learning model.

2 Literature Survey

2.1 National Status Review

- Archana N. Shewale, **"Renewable Energy Based Home Automation System Using ZigBee"**, International Journal of Computer Technology and Electronics Engineering (IJCTEE), 2015

  Archana N. Shewale describes the methodology of renewable energy based home automation in which two things are consider one is energy consumption and another is energy generation. In this, ZigBee is used for monitoring energy consumption of home equipment and power line communication (PLC) is used to monitoring energy generation.

- S. Anusha, **"Home Automation using ATmega328 Microcontroller and Android application"**, International Research Journal of Engineering and Technology(IRJET), 2015

  S. Anusha describes the design and development of a remote household appliance control system using ATmega328 microcontroller and android mobile through GSM technology.

- J. Chandramohan, **"Intelligent Smart Home Automation and Security System Using Arduino and Wi-Fi"**, International Journal of Engineering and Computer Science, 2017

  J. Chandramohan provides a low cost-effective and flexible home control and monitoring system with the aid of an integrated micro-web server with internet protocol (IP) connectivity for access and to control of equipment and devices remotely using Android-based smartphone application. generation.

2.2 International Status Review

- Debraj Basu, **"Wireless Sensor Network Based Smart Home: Sensor Selection, Deployment and Monitoring"**, IEEE, 2013

  Debraj Basu details the installation and configuration of unobtrusive sensors in an elderly person?s house - a smart home in the making - in a small city in New Zealand. The overall system is envisaged to use machine learning to analyze the data generated by the sensor nodes.

- Byeongkwan Kang, **IoT-based monitoring system using tri-level context making model for smart home services"**, IEEE International Conference, 2015

Kang discusses about acquisition and analysis of sensor data which are going to be used across smart homes. It proposed an architecture for extracting contextual information by analysing the data acquired from various sensors and provide context aware services.

- Jeya Jeya Padmini, **"Effective Power Utilization and Conservation in Smart Home Using IoT"**, IEEE International Conference, 2015

  Jeya Jeya Padmini discusses about effective power utilization and conservation in smart homes using IoT. It uses cameras for recognizing human activities through image processing techniques.

- Pranay P. Gaikwad, **"A Survey based on Smart Home System Using Internet of Things"**, IEEE International Conference, 2015

  Pranay P.Gaikwad discusses about challenges and problems arise in smart home systems using IoT and propose possible solutions.

3 Need Analysis

The currently available solution and research exhibit these features

- The existing market solutions provide on/off switching of the devices. The available solutions provide comparatively lower energy efficiency and also require human intervention to achieve desired conditioning of the environment.
- Some of them also use unsuitable technologies like Power Line Communications, Bluetooth and Ethernet etc. From the present analysis of the existing solutions for automating a room environment, the technologies used suffer from a number of drawbacks. So, these protocols are limited in functionalities when used by an end user in real life.

4 Objectives

- To detect changes in the environment of rooms using different sensors.
- To develop plug and play device control techniques to manage home appliances.
- To optimize energy consumption to increase the efficiency of the household.
- To design a central processing hub for management of modules and execution of control algorithms.

5 Novelty

Higher levels of controllability can be achieved through individual device level control such as for an AC the temperature, modes, swing, fan speed etc. can be controlled.

Load optimization will be carried out from the evaluation of the usage patterns of the individual devices thus increasing the energy efficiency.

6 Methodology

6.1 Sensor aggregator module development

Sensors are collected in a single unit to form an interconnection among the sensors for efficient analysis and evaluation of aggregated data by the controlling unit.

6.1.1 Selection of sensors

As a first step, we need to figure out all the environment variables relevant to home automation system. These are the conceived energy based equipments which will be optimized :

- Lights
- Fans
- Air Conditioners

Now based upon the above identified appliances, the environment variables under observation will be

- Infrared Radiations - To detect the presence of human being in or around the target area.
- Temperature - To detect the temperature of the surrounding room environment.
- Illumination - The information provided by this sensor will be used by the system to, adjust the illumination accordingly to the desired level.

The choice of sensors based on the identified parameters will be done considering the room specifications and the accuracy and range provided by the sensor unit.

6.1.2 Aggregation of sensors

Based upon the appliances present inside a particular room, specific sensors will be aggregated to form a module of sensors and it will be installed inside every room. This will help in collecting optimum data and reduce complexity in the installation as well.

The module formulated will be a combined unit containing sensors and circuitry for controlling an entire room. All such modules will form a network through the Home Automation Unit. This module will act as a local control placed centrally on the ceiling providing ease of access to every part of the room through a single unit.

6.2 Plug and Play actuator development

To introduce software based control, microcontroller based actuators modules are to be attached either in the power supply lines of the devices (fan and lighting system control) or must be directly attached to the device itself (Air Conditioner control).

6.2.1 Study of control methodology

The development of actuator modules designed for each device to be automated will be using plug and play methods so as to convert existing devices into smart ones. The actuators will operate and automate the appliances based on the commands received from the microprocessor.

6.2.2 Actuator circuit design

1. Air Conditioner The plug and play module of the air conditioner will be equipped with IR blasters. It will then receive the signal and relay this to the receiving end to automate the air conditioner accordingly.

2. LED Lights The use of pulse width modulated signals that drives a control switch (say MOSFET) to switch the LEDs accordingly thereby altering the intensity.

3. Fans Speed regulation of fans will be done using the combination of Diac and Triac to reduce the energy losses that were occurring by the use of conventional voltage controller.

Now the designed circuit of actuator modules is designed in such a way that there would be no need to interfere with the existing circuitry of the appliances with a number of iteration done, we will achieve the most desired place of installation of the actuator modules.

6.3 Energy optimization algorithm formulation

6.3.1 Study of decision influencing parameters

6.3.2 Design of a deep learning model

6.4 Home Automation Unit design

6.4.1 Design of the software for the Home Automation System

All the sensor aggregator modules and the retrofit modules need a central hub for their communication and management. The HAS will receive the inputs from the sensors and give an optimized output to the modules after processing it using the aforementioned algorithms. The HAS will run atop it providing functionalities like adding new devices, removing devices, defining rooms, adding sensor aggregator units and plug and play smart device conversion modules.

6.4.2 Development of a user interface to enable user interaction with the system

Applications will be deployed on the market places for the most common mobile platforms, App Store for iOS and Play Store for Android. A cloud-based web app will also be deployed for users to operate from laptops and desktops. The user will be able to use these apps to connect directly to the server hosted on the Home Automation Unit in their homes without any middleware services ensuring their security and privacy.

7 Deliverables

- Sensor modules to collect room environment parameters.
- Plug and Play actuator modules to control household devices.
- Load Optimization Algorithm based on deep reinforcement learning models
- Home Automation Unit to manage the devices and execute control algorithms and associated mobile applications.

8 Associated Subjects

UTA007 Computer Programming-I Fundamentals of functional programming

UTA009 Computer Programming-II Fundamentals of object oriented programming

UTA011 Engineering Design-III Embedded system design using sensors and micro-controllers

UEE301 Direct Current Machines and Transformers Study of transformers

UEE505 Analog and Digital Systems Study of analog and digital systems and their interoperability.

UEE401 Alternating Current Machines Study of the single phase induction motors

UEE504 Power Electronics Use of switches to control device output in an efficient manner

UEI404 Digital Signal Processing Fundamentals Use of DSP techniques to process signal from sensors and other devices

UEI609 Fundamentals of Microprocessors and Microcontrollers Fundamentals of Assembly Programming and Embedded system design using micro-controllers

UEI501 Control Systems Use of closed loop systems to eliminate errors in a system

UEE801 Electric Drives Application of Power electronics to control AC Drives

9 Interdisciplinary Works

This project consists of extensive multidisciplinary efforts. The Load Optimization algorithm will be generated using a Deep Reinforcement Learning model which is primarily a topic of interest in Computer Science. The wireless communication among the sensors, devices and the HAU are subjects of Electronics and Communication Engineering.

10 Software Used

Provided by college

- MATLAB
- LabVIEW
- Multisim and Ultiboard

Open Source

- Tensorflow
- Node.js

11 Hardware Used

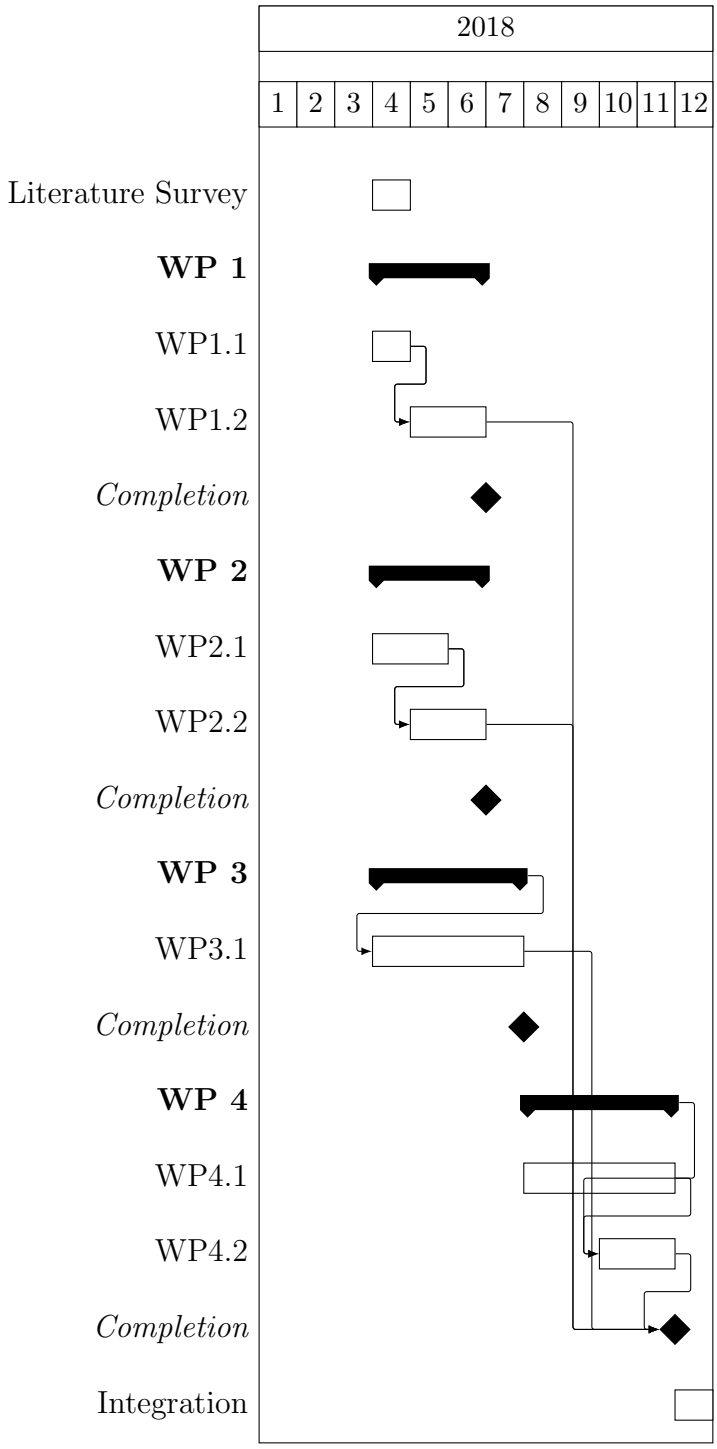
- PCB Prototyping Machine
- Digital Storage Oscilloscope
- Function Generator
- Multimeter
- Soldering station
- Mobile Phone

12 Real-world compliance

12.1 Engineering Standards

12.2 Realistic Constraints

13 Work Schedule



14 Proposed Budget

Item	Specification	Quantity	Amount	Manufacturer	Justification
Raspberry Pi 3 Model B	64-bit ARM-v8 processor 1.2GHz 1GB RAM	3	7,185	Raspberry Pi Foundation	Central Processing Hub
TP-Link Archer C20 AC750 Wireless Dual Band Router		1	1,499	TP-Link	Wifi Router to establish the network around the house
esp8266 Wifi Board	GPIO SPI SDIO I2C	5	1,045	Espressif Systems	Wifi Board for wireless modular connectivity
ATTiny Microcontroller	1 timer 2 PWM Channel 4 Channel ADC inputs Watchdog	10	540	Microchip Technology	Microcontroller for controlling the PnP Devices
ATMega328P Microcontroller	8 Bit 32 KB Flash Advanced RISC Architecture 20 MHz CPU Clock 3 Timers 6 PWM	10	1,240	Microchip Technology	
Relay	Current: 16A Coil Voltage: 5V	20	1,440	Amazon*	Switching the primitive devices
DHT11 Humidity and Temperature Sensor	Voltage: DC 5V Digital Output Humidity Range: 20-90RH Temperature range: 0-60	10	860	Evelta*	Sensors for developing Sensor Aggregator modules
HC-SR501 PIR Sensor		2	858	Evelta*	
GY-30 Light Intensity Sensor		10	1,150	Evelta*	
Jumper Wires		5	1,160	Amazon*	Prototyping
Breadboard		10	1290	Amazon*	

Printed Circuit Boards		20	400	J. B. Electronics	
Philips Base B22 9-Watt LED Bulb		1	669	Philips	Consumables for developing control methodology for PnP Modules
Crompton Hill Briz 1200mm Ceiling Fan	Sweep: 1200mm Bearing: Double ball bearing Blades: 3 Speed: 370 RPM	3	4,347	Crompton Greaves	
Circuit Components			2,500	J. B. Electronics	Capacitors, MOSFETS etc. required to develop driver circuitry for PnP and Sensor Aggregator modules
Miscellaneous Expenses			5,000		Contingency reserve expenses
Total			**30,034**		