Senior Design I

Initial Project and Group Identification Document

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Plug and Play Home Automation with Alternative Control

Group 23

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INTRODUCTION

Motivation

As a place where people live, sleep, eat, and work a home is arguably considered the most important place for a human. Many people cater their lifestyles to their home but we aim to reverse this and enable a person's home to cater to their ever changing lifestyle. We plan on achieving this by creating an intelligent home system that goes beyond simple timers and is able to adapt and learn a person's habits and needs. In addition, this system would be able to focus on energy efficiency by filling the gaps where humans have frequent errors. It would function as a plug and play system that requires less installation and more customizability.

What sets our automation system apart is its user interface and control system. We want the user to have the ability to control their house from the palm of their hand. A custom glove will allow the user to use intuitive gestures in order to change settings, turn items on and off, and gain status information about their home. This glove will have the capability to interface with multiple types of hardware and can have additional uses outside the scope of a home automation system. Not only would they be able to interface to the system via the glove—but also in a secure application accessible from one's phone, computer, or tablet in any location with internet.

Goals and Objectives

Our goals for the home automation system are to make it affordable, easy to customize, adaptable to a person's habits and energy efficient. We want it to be very user friendly and have plug and play functionality for an easier set up.

The objective for the glove is to ultimately enhance the home automation system control process. It will do this by having a sleek system design and a low latency response. In addition to this, it will interface to other outside hardware such as the Oculus Rift through the creation of special API libraries.

Functions of Project

Ultimately our system will be a fully functional home controller that can take user input via a wireless glove or through an application interface. It will make smart decisions based on past user habits to save energy and to enhance home safety. This project will further the research on using power line communication and aim to find efficient, reliable messaging protocols for this communication. It will also further the research and usage of wearable electronics as a means of control and communication.

REQUIREMENTS AND SPECIFICATIONS

Requirements

Home Automation System

The Home Automation System will have 2 main controller boards. The Central Manager and the Load Controller. The Home Automation System will also have "Smart Switches" which are devices that will gather sensor data for the rest of the system to help the system adapt to the user's lifestyle. All three of these devices will communicate with each other through Power Line Communication (PLC) where the Central Manager will be the master.

The Central Manager's controller board will hold an ARM processor. This processor will be embedded with a Linux environment. The processor will be responsible for processing and interpreting sensor data, composing messages to the Load Controller to control household devices, making this data available online through Ethernet communication, provide a graphic user interface on an LCD screen for the user to program their home, and communicate with the Wireless Glove System to provide alternative home control.

The Load Controller board will be responsible for controlling multiple household devices with triacs and switches. The Smart Switch will be responsible for taking in sensor data that includes but is not limited to temperature, humidity, energy usage, capacitive touch, and infrared. The Smart Switch will send this data to the Central Manager.

Wireless Glove System

The glove shall record kinesthetic data from an inertial measurement unit giving the main orientation of the hand, and flex sensors on each finger to record the position of each finger. Along with that the glove will have other sensors not dealing with kinesthetic data but with user input. This will include contact switches made from conductive thread, and buttons.

Data from all sensors will be fed into a microcontroller. The microcontroller will control feedback sensors including haptic feedback and an LCD screen. The microcontroller will also deal with packaging the data and sending it serially to a serial to Bluetooth module. This device will communicate with a PC with Bluetooth capabilities in order to use data from all these sensors to control multiple PC devices like a mouse and keyboard. This device will also communicate with the main controller board from the home automation system in order to control home devices. The glove system will be powered by a battery in order to keep the system portable.
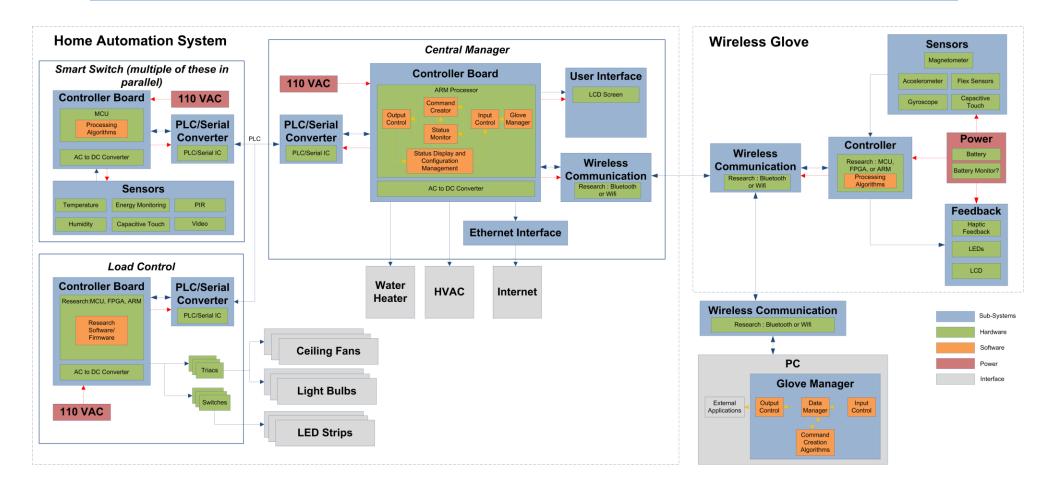
Specifications

Home Automation System

- Smart Switch will send messages to the Central Manager only when an event is triggered (i.e. temperature changes by 3 degrees, capacitive touch is activated, etc.)
- Smart Switch will collect data 5 times per second
- Temperature will be accurate to the tenth of a degree
- Humidity will be accurate to tenth of a percent
- All devices will be powered from wall outlets
- All devices shall use power line communication
- Graphic User Interface will update data 10 times a second

Wireless Glove System

- Position of hand will be accurate to a tenth of a degree
- Glove will update kinesthetic data 20 times a second
- Glove battery will last a minimum of 5 hours
- Glove shall be wearable during everyday activities
- Battery shall be removable and therefore replaceable
- Glove shall be compatible with Windows PC with Bluetooth capabilities

BLOCK DIAGRAM

Home Automation System

Smart Switch (multiple of these in parallel)

Controller Board
- MCU
  - Processing Algorithms
- AC to DC Converter

110 VAC

PLC/Serial Converter
- PLC/Serial IC

Sensors
- Temperature
- Energy Monitoring
- PIR
- Humidity
- Capacitive Touch
- Video

Load Control

Controller Board
- Research:MCU, FPGA, ARM
  - Research Software/ Firmware
- AC to DC Converter

PLC/Serial Converter
- PLC/Serial IC

110 VAC

- Triacs
- Switches

- Ceiling Fans
- Light Bulbs
- LED Strips

PLC

Central Manager

110 VAC

PLC/Serial Converter
- PLC/Serial IC

Controller Board

ARM Processor
- Output Control
- Command Creator
- Input Control
- Glove Manager
- Status Monitor
- Status Display and Configuration Management

AC to DC Converter

User Interface
- LCD Screen

Wireless Communication
- Research : Bluetooth or Wifi

Ethernet Interface

- Water Heater
- HVAC
- Internet

Wireless Glove

Sensors
- Magnetometer
- Accelerometer
- Flex Sensors
- Gyroscope
- Capacitive Touch

Wireless Communication
- Research : Bluetooth or Wifi

Controller
- Research : MCU, FPGA, or ARM
  - Processing Algorithms

Power
- Battery
- Battery Monitor?

Feedback
- Haptic Feedback
- LEDs
- LCD

Wireless Communication
- Research : Bluetooth or Wifi

PC

Glove Manager
- External Applications
- Output Control
- Data Manager
- Input Control
- Command Creation Algorithms

Legend
- Sub-Systems
- Hardware
- Software
- Power
- Interface

FINANCING

Budget

Financing

Our project does require a significant monetary contribution in order to fully develop. We plan on submitting a proposal to SoarTech, Duke Energy and Oculus Rift to possibly become sponsored by them. If we are unable to obtain any sponsorship, our team is able and willing to pay for all costs associated with the full development of our project.

MILESTONES

Milestones	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Research Phase								
PLC Communication	■							
Embedded Linux	■							
Home Device Control Protocols	■							
Wireless Communication	■							
Glove Sensors	■							
Glove Power Source	■							
Glove Feedback System	■							
Glove Interfacing Manager	■							
AI Home Adaptive Control Algorithms	■	■						
ARM Processor	■							
AC Control	■							
Power/Engery Monitoring	■							
DBMS for Home Control and Status Data	■							
Design and Documentation Phase								
Glove Interface	■	■						
PLC Communication Protocols		■						
Home Control Sensors		■						
Smart Switch Hardware System		■	■					
Glove Hardware System		■						
Home Control Manager PCB		■	■					
Home Control Manager Software System		■						
Home Control Power System		■	■					
Smart Switch PCB		■						
Home Control and Status DBMS		■	■					
Load Control PCB			■					
Home Control UI			■					
Glove PCB			■					
Implementation Phase								
Glove Hardware		■						
Glove Software			■					
Smart Switch Hardware			■					
Home Automation Control Software				■	■			
Home Automation Control Hardware				■	■			
Smart Switch Software					■			
Load Control Firmware				■	■			
Load Control Hardware					■	■		
Integration and Testing Phase								
Complete Glove System Integration					■			
Glove System Testing						■		
Smart Switch Testing						■		
Complete Home Automation Integration						■		
Load Control Testing						■		
Home Automation Control Testing							■	
Complete Home Automation Testing							■	■
Home Automation and Glove Integration							■	
Entire System Testing							■	■

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All