EEE 495

Electrical and Electronics Engineering Design II

Project Title: Multifunctional Smart Home using IoT Technology

Product Specifications Document

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1.0 INTRODUCTION

1.1 Purpose of the Product

The aim to be accomplished by this product is to develop a smart home that provides multiple features for the sake of both security and quality of life improvement, allowing the residents with more time to spend more productively elsewhere.

1.2 Scope of the Product

For the purpose of collecting data about the surroundings, the light sensors will gather data on light levels and the cameras will be checking for people and licence plates respectively. There are connections by use of wires between these devices and the Raspberry Pi 3 Model B+. The microprocessor then sends the data which has been collected by the devices to Google Firebase and then further on to the application in the smartphone through a WiFi connection on the Raspberry Pi 3 Model B+. This may be seen and interacted with by the user through a Graphical User Interface (GUI) on the smartphone application which would have a remote connection.

The Light Sensors will be used for two purposes. The first is for the solar tracking system, and the second is for the automatic lights. The light sensors are connected to the microprocessor and together they have the following functions. For the Solar Tracking System, the light sensors will be placed around the solar panel, and depending on which sensor gives the highest reading for light level, the solar panel will be moved to face that direction by using a servo motor. For the Automatic Lights, the light sensors will detect light coming into the house through the windows, and if the light level falls below a certain point, then the LED lights will automatically turn on; the lights may also be manually turned on and off using the smartphone app, and the app may also have fixed times set to turn the lights on and off.

The Camera Modules will be used for two purposes, one for each camera. The first of the two is face detection and identification, and the second is licence plate detection and identification. The camera is connected to the microprocessor and together they have the following functions. For the Door Camera, when a registered person enters the field of view, the door opens with the motion of the servo motor; if a dangerous person shows up then the owner is sent both a notification in the smartphone app and a phone call; if an unknown guest comes, then the owner is sent a notification; in all cases, the owner may see a video feed from the smartphone application. For the Gate Camera, when a car with a registered licence plate enters the field of view, the gate opens with the motion of the servo motor; if an unknown car comes, then the owner is sent a notification on the smartphone application; in an emergency case such as multiple cars showing up, the owner is sent both a notification and a phone call; in all cases, the owner may see a video feed from the smartphone application.

The Smartphone Application will be connected to the microprocessor wirelessly through a WiFi connection. It will show some data collected by the other devices, such as a video feed from the cameras. It will send notifications to the user based on what the cameras detect. All the systems can be activated and deactivated from the app. The app can be used to register faces and licence plates through the smartphone camera.

The house itself will be powered by a battery, with no external power source such as energy from a wall socket being provided. The Raspberry Pi 3 Model B+ has specific conditions

under which it operates optimally, as will be explained in a later section, so there should be no modifications made to the electrical working of the product. No major changes in placement of the components in the product should be made in order to have the desired outcomes.

In the case that an unknown person is detected by the camera, while the user will be notified, the person may physically damage the camera, or simply break it. This would mean that there is no information if the person is still in front of the camera or if they have broken into the house, making for a security risk.

2.0 GENERAL PRODUCT DESCRIPTION

2.1 Context About the Product

The key components of the main product are as follows:

- Camera Modules (PI Camera)
- Servo Motors (MG90S)
- Light Sensors (4 Pin LDR)
- SMD LED Lights (5mm RGB LED)
- Solar Panel (21V 170mA)
- Battery (12 V, 7 A)

Data gathered from what the devices read or detect is sent to the Raspberry Pi 3 Model B+ microprocessor, which functions as the central processing unit. Commands are sent along with the data from the microprocessor to Google Firebase, and in the end, sent through to the application in the smartphone.

2.2 Functionality of the Product

The product will have a multitude of features all accessible by the user through the smartphone application. The features are as follows:

- Solar Tracking System
    - A solar panel will move automatically using a servo motor to face the direction which has the most sunlight.
    - Light sensors will be used to track the light levels.
- A Door Cam (Door Camera) System
    - A camera will recognise faces of people entering the house.
    - The people living in the house will have their faces registered and a face identification method will let them in with no issues, done so by the servo motor.
    - When an unwelcome visitor such as a thief is identified, the owner is immediately sent a notification and a phone call.
    - If unknown guests show up, the owner is given a notification, and can check a video feed of the camera and can decide to let the visitors in or not.
- A Gate Cam (Gate Camera) System
    - A camera will read licence numbers of cars approaching the house’s gate.

    - It will have the owner's licence plate number registered and will let the car in, done so by the servo motor.
    - If an unknown car shows up, then the owner will be sent a notification on a smartphone app, and can check a video feed to decide to open the gate or not.
    - In emergency cases, such as detecting multiple cars at the gate the owner is sent both a notification and a phone call.
- Automatic Lights
    - The lights in the house will work with an automation feature as when sensors detect low light levels, the lights will turn on.
    - The smartphone app can also be used to turn the lights off and on.
    - Times can be manually set in the app to have the lights turn on and off.
- Smartphone Application
    - The hub for all systems in the smart home.
    - It will be able to activate and deactivate the systems in the house.
    - The app can be used to register faces and licence plates through the smartphone camera.

2.3 Constraints of the Product

The components listed function as normal under the following constraints:

Component	Constraint
Microcontroller	All wiring to be connected as designed Temperature range between 0ºC to 85ºC
Camera	To be mounted in such a way that there is a clear view of the target (face or licence plate) Temperature range between -30ºC to 70ºC
Servo Motor	To be checked for any defects in the turning mechanism of the motor Temperature range between 0ºC to 55ºC
Light Sensors	To be situated where sunlight would strike them throughout the time the sun is up Temperature range between -60ºC to 75ºC
Solar Panel	To be protected from the elements such as harsh snowfall or hailing Temperature range between 15ºC to 65ºC
SMD LED Lights	Temperature range between -30ºC to 85ºC
Battery (12 V, 7 A)	To be recharged on consumption To be replaced on deterioration Temperature range between -15ºC to 60ºC

2.4 User Base for the Product

The main customer base for this product are homeowners, or people living in a rented home; hence the main application of the product is in domestic use. The users are required to have a stable internet connection to be able to use the product properly. The application itself will have a login system, so the user will need to make an account with a username and password to be able to use it for the smart home. Furthermore, for both the door camera and gate camera systems, the user will need to register to the system the faces of the people living in the house and the licence plates of the cars they use respectively. The solar tracking and automatic lights will need to be manually turned on from the smartphone application for them to have functionality as intended. The user will also need to register a phone number to which calls will be placed in emergency situations. The goal of the product is to provide the user with both security and comfort in the sense that there is time saved using these automated systems to be used productively elsewhere.

2.5 Dependencies of the Product

When the product is working there are some dependencies required to be met for it to work optimally, and they are as follows:

- The cameras are positioned optimally such that they capture the faces of people and licence plates of cars within a good field of view such that identifications are made even in most edge case scenarios.
- The light sensors for the solar tracking and automatic lighting are all placed in such a manner that there is no light, other than the light they are meant to detect, leaking in their range of detection.

2.6 Use Case Scenarios of the Product

The cameras should be mounted at appropriate heights such that they have a maximised field of view. The gate camera should be low enough to easily detect number plates but high enough to be able to capture an overall picture of the car from a small distance, roughly a metre or so. The door camera should be high enough to read the faces of adults, but low enough to be able to read children's faces and make out what the visitors' hands. The light sensors in the solar tracking system should be placed around the cardinal directions of the solar panel to be able to effectively determine which direction is getting the most light, furthermore, care should be taken that light from another one direction is not also falling on a sensor meant for another direction. Light sensors for the automatic lighting should be placed at the window sills to effectively determine whether the light coming from outside the house is sufficiently low to turn on the LED lights or not. There should also be lights by both cameras in case of low light situations such as night time.

3.0 PRODUCT FUNCTIONALITY AND CONSTRAINTS

3.1 Details on the Product

3.1.1 Product Construction

The structure of the product is basically a replica of a house with 98 cm×55 cm×55 cm dimensions and two main parts:1. a building which includes two spaces, a room and a living room. 2. A garden which has a gate for entrance. The materials used for construction of the house are cardboard (walls, ground, roof, and doors) and metal(skeleton frame). The rest of the other components are two cameras, sensors, battery ,solar panel, and Microprocessor. A close approximation of weights of the product is listed below:

Name of Component	Count	Weight(g)	Size(mm)
House replica	1	2200	980×550×550
Raspberry Pi Model 3b+	1	50	85×56×17
Pi Cameras	2	8	25 ×24×11.5
Servo motors	3	36	22.9×12.2×32.5
Solar panel	1	200	120×194×2
Battery	1	1700	151×65×94
Light sensor	10	150	4.5×2×1
SMD LED lights	5	15	2×2×1
USB fan	2	400	18×15×6
Temperature sensor	2	30	3×3×1
Extra materials (wires,glues,etc.)	-	100	-
Total	27	4889g	-

3.1.2 ***Product Durability***

For durability of the product, the metallic skeleton was chosen for the house replica. For wiring of the whole system between sensors, camera, voltage suppliers and raspberry pi board, direct soldering will be done as much as possible. The solar panel wiring will be done in a manner such that it will be in-built to be waterproof, Similarly the wiring of the gate camera and door camera will be in-built and waterproof designed. The Battery will be placed in the house. Also, the battery is a replica of a house generator that is getting charged during the day by the solar panel which helps the energy durability of the house.

3.1.3 Environmental Conditions on the Product

A house is always prone to natural disasters such as earthquakes, floods, and bad weather conditions. Moreover, internet connection and voltage supplier connection, which are the fundamentals of this system, are prone to disconnection. The cameras can get damaged or get covered during the mentioned environmental conditions. The servo motors can disfunction and the voltage suppliers' way through the system can get damaged through those conditions.

3.2 Performance Characteristics of the Product

The performance of the components and the entire system may differ due to noises, as electrical components are always prone to noises. Also, in real life many of the performance characteristics can differ due to wiring, internal ,and external factors. But since the entire system's response to the user is based on raspberry pi's speed in response, it is logical to assume that other components will perform with a speed near to their specific speed mentioned in their datasheets. In the following table, approximate speed of components to respond to the user is mentioned :

Name of Component	Speed Based on Response Time
Raspberry Pi 3B+	1.2GHz
Pi Camera	30 fps
Light sensor	2-50 ms
Temperature sensor	3°C/s

Also, the speed of the internet and type of phone will affect the system's overall performance, but since the project is in testing phase, these matters will be experimented in a real time and real environment to find the optimal performance conditions.

3.3 Security of the Product

The security of the product is one of the most crucial parts of smart house technology. There are many components which are in need of high security protocols such as the application, cameras, and Microprocessor. And all of these devices are endangered by thieves, and functional error or noises. A one time error or miss detection in cameras can cause a wrong person to get in the house or a person hacking the application and registering in the database can allow him/her to control all the devices.

3.4 Information Management

All the information gathered by sensors and cameras are stored in a database via wifi connection. The user can have access to all of the information using his phone and can change some of the settings and have control on the cameras and sensors. The chosen database is Google firebase which is very secure and efficient for the testing phase. All the necessary files such as face datasets, car plates datasets, pre-trained models, and outputs of the sensors are all stored in this database.The user can access to this database via phone application to register or delete a person or a car plate.

3.5 Product Operations

3.5.1 Human Factors

Although the system is able to identify the presence of threats to the house and there are two layers of security as gate camera and door camera, the system cannot take immediate action and stop the unknown person who is in front of the door. It can only send a notification to the user and contact the police station. Also, if there is a malfunction in the system or caused by someone, there is no immediate back up, and the user must contact the support office.

3.5.2 Maintainability

The maintainability of the system must only be in the hands of the group of experts who has developed the system or taught by them to be in charge of supporting the system. Any external or self debugging and maintenance may cause dysfunctionality and jeopardise the main features and abilities of the IoT system.

3.5.3 Reliability

The system is guaranteed to perform without any problem for a long term use (minimum 5 years). All the devices, integrations, and systems in the product are designed to provide reliability. However, it is recommended to get annual technical testing for durability and reliability by the product's support team.

3.6 Sustainable Lifetime of the Product

The primary component working for this product is the Raspberry Pi 3 Model B+, which has a working lifetime of about 7 years. Since the other components all work for longer than 5 years, it can be safely summarised that the overall working lifetime of the product in this case to also be 7 years per product. With good care being taken to maintain the system, it would also be appropriate to say that the product can last longer as well. Aside from this, the battery is a consumable and would need to be changed or recharged, so it is the only limitation on the overall lifetime of the product.

4.0 PRODUCT INTERFACING

Interfacing with the product is possible through both physical means as well as remotely. It is required for the product to be powered on manually and physically, however, after this the product may be controlled by the smartphone app so long as the user for the home is registered for the specific device being used.