Open Sesame
High Level Design

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1 Introduction

The original purpose for garage doors was to secure cars or tools during the night. Over time, attached garages have become a standard of building design leading to garage doors now serving the additional purpose of a front door for many families. Open Sesame will be working to merge features found in a variety of openers on the market to present a convenient solution to forgetfulness and security. The Open Sesame team consists of Denise Garcia, Ka Hin Lee, Veronica Martinez, Jane McGuinness, and Angela Savela.

2 Problem Statement and Proposed Solution

Many homeowners across the world are plagued with the common problem of forgetfulness or absent-mindedness. One of the largest issues that forgetful homeowners have to deal with is whether or not they remembered to close the garage door. This concern, however, is not limited to the chronically forgetful. It can affect anyone who is simply not paying attention or is distracted momentarily thus leading to a wide-open garage door. Forgetting to close the garage door is a mistake that can easily be made when leaving or even entering the home. An unattended, open garage door can lead to many dangers such as burglary, trespassing, or a small child escaping. There are even minor annoyances that can come from an opened garage door such as a pet running away or unwanted weather damage to cars or homes. It is almost impossible to determine whether or not the door was opened or closed once one has left their residence. Lack of control from a distance not only means the door may be left open, but also that it cannot be opened to allow entry to permitted visitors—such as maintenance workers.

Although many people fall victim to a gaping garage door, it does not mean the problem cannot be remedied. The headache of the many will be answered and that answer is “Open Sesame.” In an attempt to tackle these problems, the team will develop the next-generation garage door system. The system is meant to interface with an existing garage door and include the traditional controls while incorporating the capabilities of the new features. Using a network of sensors, the garage door would automatically open as the user’s car approaches, and close upon their departure, thus eliminating the need to search for a remote. For the user’s convenience, there will be a cell phone application that allows for the user to check on the status of their garage door remotely and send a command to open or close the door from any location, provided their cell phone with the application is connected to a wireless network. The system would be able to relay the state of the garage door by sending a message, or taking and sending a picture of the door to the user in the event that the user requests visual confirmation. They could both close a door when it is left open and open it for permitted guest while at work. Additionally, the system will inform the user through the cell phone application if the door was supposed to open or close, but did not, which the user could conveniently follow up with by requesting an image of the garage door to further assess the situation.

3 System Requirements

3.1 Embedded Intelligence

The microcontroller must be able to interface with an existing garage door system, so that signals may be sent from the microcontroller to the main circuit of the garage door opener

system. This connection will allow for the microcontroller to transmit open/close signals for the door and on/off signals for the light. The microcontroller will also be connected to external sensors, which relay the status of the door and light. From this information given, the user can then proceed to change the status of the light or door if necessary.

3.2 Device Power

The microprocessor circuit board and the electric imp connecting circuit board must be powered by some kind of continuous power source, which can connect to a USB cable. Batteries will power the additional sensor that is meant to be in the user's car in order to determine the distance of the vehicle from the garage. These batteries must have a lifespan of at least a couple of months for the user's convenience.

3.3 Wireless Interface

A wireless router with WPA2 security will be used to provide the system with protected access Wi-Fi, which is the typical wireless network protocol for most modern homes. The only device that will need to be supported from the system is the Electric Imp, which is what will allow the user to communicate with the system using the Internet. Although the Electric Imp must be within the range of the wireless router providing Wi-Fi, there is no required range for the user to be able to remotely access or control the entire system from the Android application on their phones.

3.4 User Interfaces

There will be three main user interfaces: the cell phone application for Androids, the existing button panel, and the existing remote control devices. The cell phone application will be the primary focus, as the latter two interfaces do not need to be changed. The cell phone interface will serve to allow the user to communicate with the system, by receiving images of the garage door area and signals determining the status of the door, as well as sending the commands to perform these functions and the commands to open or close the door as desired.

3.5 System Installation, Use, and Safety

The system will be installed by connecting the microprocessor circuit board to the existing garage door system circuit, most likely by hardwiring it, however there is also the possibility of a wireless connection. The new system will not be interfering with existing functions of the original garage door opener system, as it will be designed to be as least invasive as possible. The new system will use external sensors to detect the status of the garage door, so the connection between the new system and the previous system is one way with the microcontroller sending open/close and light on/light off signals to the garage door opener circuit. A primary motivation for making the system as noninvasive as possible is to avoid conflicting with the safety features and protocols of the existing garage door opener system.

4 System Block Diagram

4.1 Overall System

In order to address the problem and demonstrate the proposed features, multiple engineering tasks will have to be accomplished. These will be required to not only create the prototype, but also to ensure that it functions as expected. Figure 1 illustrates the connections between the various components of the system.

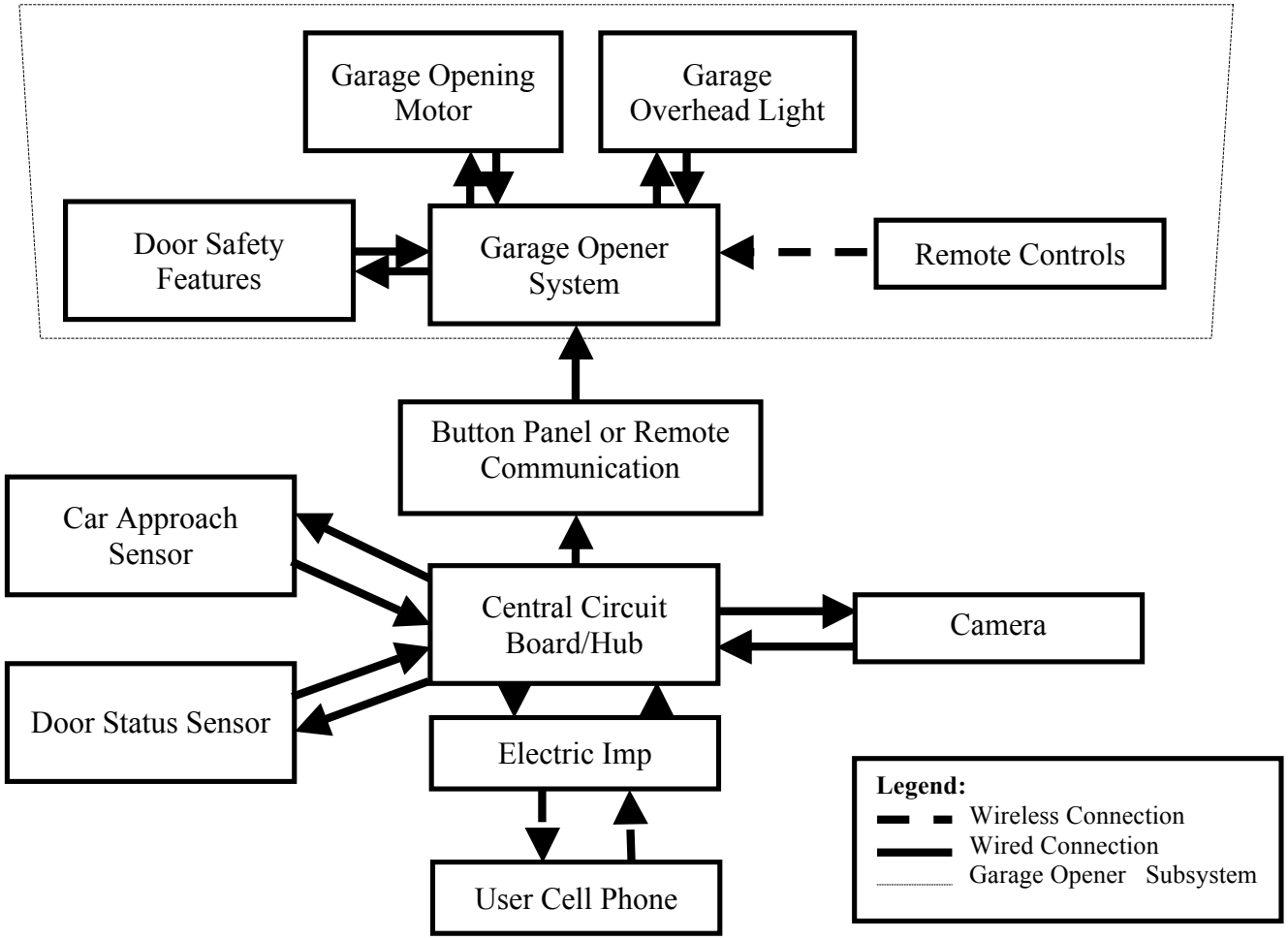

Figure 1. Proposed Block Diagram for the Open Sesame System Using Hardwire Interface

4.2 Subsystem and Interface Requirements

Table 1. Subsystem and Interface Requirements

Car motion sensor	Will be located within the car Must communicate with exterior sensor (on driveway) Exterior sensor receives signal and sends signal to main hub
Camera	Will be located on the ceiling of garage Must receive signal from app to take picture Must send picture wirelessly to app (using imp cloud)
Main hub	Will attach to existing garage door opener Circuit will include (most importantly) microcontroller hardwired to imp (April board) Communicates with imp via UART on microcontroller Must control door open/close, send signal to camera, and receive wireless (imp cloud) signal from car motion sensors Must maintain existing safety controls (on original opener)
User interface	App will control door open/close, the camera Must communicate with hub, using wifi/imp cloud Will transmit images to user Will update door status
Power Supply	Must provide power to our added circuit board
Door Status Sensors	Must detect whether the garage door has closed Must communicate with hub Will be hardwired to main circuit

4.3 Future Enhancement Requirements

Table 2. Future Enhancements

Completely Wireless System	Instead of having a hardwired panel, all sensors would be wireless and battery powered.
Live Video Stream	Upon request, a video stream could be accessed by the user.
Complete Integration with Garage Door	Receive information from garage door about status as well as when auto-reverse is active.
Intelligent Programming	Using knowledge about the user, such at work hours or vacations, the controller would send updates after any unusual activity occurs.

5 High Level Design Decisions

5.1 Garage Door System

The team will not be designing a garage door opener, as this would be outside the scope of the project. Existing communications will instead be interfaced within the controller. This will allow all of the garage door safety features to continue to operate as normal. The Open Sesame system will not override, change or interfere with existing sensors and signals that determine the status of the door, the presence of an object under the door and the autoreverse action. This will retain any of the original safety features. The design should allow for normal operation of the garage door at any time, as well as upon startup, or after a power outage. Possible connections to the garage door system would be a wired connection that would replace an existing button panel, or a radio connection using a cloned garage door remote. Either method would perform the same task of sending an on/off signal to the motor and light. This signal would have the same priority as any normal signal between either the button panel or remote control and the motor and therefore would not interfere with safety features.

5.2 Microcontroller

The microcontroller is the central hub for all communications within our system. There will be direct connections from the circuit board to the garage door system to control the state of the garage door. Additional connections will exist to the Electric Imp, digital camera, and any of the additional sensors added to improve the functionality. The microcontroller will have to be able to handle UART or SPI communications to interface with the Electric Imp for WiFi connectivity and to obtain and send images from the camera. If a USB camera is selected, a microcontroller capable of handing USB communication will be necessary. To interact with the car approach and door status sensors, the microcontroller could be required to use analog to digital communication.

5.3 Wireless Interface

The Electric Imp will be directly connected to the circuit board, and sit inside an SD card mount. Through the ports on the SD card mount, UART or SPI signals can be sent to the microcontroller and the Electric Imp will receive the power necessary for its operation. UART will likely be used for this feature as functionality between the Electric Imp and microcontroller has already been confirmed. Additionally the Electric Imp connects via WiFi to an online cloud. This cloud communicates with a web address assigned to the individual imp, which is accessible to anyone with the web address. For security reasons this web address should be kept confidential to prevent unwanted users accessing and operating the system.

5.4 Electric Imp Website

A website is assigned for the Electric Imp by the company. It is a basic web address, and the website itself is not interactive, merely an address to open. The Electric Imp has the ability to wait until this address is reached, and send a signal to the imp. Based on modifications to the

web address, in this case adding “?led=0”, it is possible to set values and send them to the Electric Imp. The smartphone application will access this website and the Electric Imp will carry out further computations and communications.

5.5 Camera

In order to send photographs to the user’s smartphone, it will be necessary to setup a camera. It is only required to have a low quality image that effectively shows the status, eliminating the need to use the fast clock signals used for large amounts of data processing. Communication between the camera and the user would go first through the microcontroller continuing through the Electric Imp. The Electric Imp could then send the information to the cloud, and finally to a webpage or the user’s smartphone. This communication can be accomplished through either serial or parallel ports or USB (on the camera to microcontroller end). In order to take useable pictures, the system will turn on the garage door light by sending a signal through the remote for the duration of the picture.

5.6 Smartphone Application

This application will be the source of communication between the user and the Electric Imp, and by extension, and garage door. By pressing buttons to select options a weblink will be activated, and communication with the Electric Imp will begin. Based on the current state of the garage door, and the selected inputs, the microcontroller will perform appropriately and send any signals to the garage door. The basis behind the application is redundancy, with real-time updates to the user, including images upon request and during any possibly function failures.

5.7 Door Status Sensor

The status of the garage door must be reliably communicated to the user’s cell phone upon request. Because interfacing with the garage door directly would pose difficulties as well as safety concerns, a remote connection may be used instead. Without this direct connection, an additional pressure sensor will be used to sense the position of the garage door. This sensor would be hardwired to our main circuit board and communicate through the microcontroller to the Electric Imp. The Electric Imp would then be able to provide updates to the user through their smartphone

5.8 Car Approach Sensor

A major part of the project’s functionality relies on sensors to open the garage door on the approach of the vehicle. A solution will be to use a radio transmitter in the car, similar to a wireless dog collar, and a radio receiver on the control board.

6 Open Questions

6.1 Android Application

Next semester, the team will have to learn how to develop an Android application that provides the user with feedback and information from the garage door opener. The application development will include front-end and back-end design. The main challenge will be in the back-end where communication will have to be established with the microcontroller, more specifically, the Electric Imp, which provides the wireless connection. The application will act as a client that receives information such as the status of the garage door and a picture message from the web camera.

6.2 Garage Door Opener System and Demonstration

There are several open questions revolving around the features of and communication with the existing garage door system. Since the product will function as a module to add onto a garage door opening system, not be included with and sold in a garage door package, the product will have to be somewhat universal in its ability to interface with common door openers on the market. A decision must be made on the most effective way to communicate with the system. The best option will be minimally invasive to the opener (particularly with respect to the safety features and to the hardware) in order to meet the customer requirements. A choice must be made between hardwiring the Open Sesame product in place of the original button panel or having the device communicate with the opener like one of the remotes. Using the hardwire approach would be more physically invasive, but easier to power and establish communication. The remote system will be less universal and more difficult to implement because of the security and technology garage door opening companies use in their remote controls. However, it would not require changes to the hardware of the opener and could be placed at a location convenient to sensor communication. Ultimately, compatibility will have to be ensured between Open Sesame and the opener.

A second question raised in this area is how to demonstrate the functionality of the product without purchasing a garage door. One method would be to make the project compatible with an installed garage door system that the team has permission to test on. Alternatively, a computer simulation could be built to ensure that the product produces the expected open and close signals as a result of receiving input from the smartphone application, camera, or sensors.

6.3 Sensors

The exact sensors that will be used to detect an approaching vehicle are still unknown. It will most likely require a radio frequency emitter in the car that will transmit a signal received and recognized by a module connected to the microcontroller. A sensor will also have to be chosen to detect the current status of the garage door to determine if it has failed to close or has unexpectedly opened. A pressure sensor installed by the corner of the door or an accelerometer installed on the door will allow this data to be collected. With all sensors, there are open questions about how to best power the device and whether wireless or wired communication with the microcontroller should be established. The need for reliable, long-lasting power, convenience of installing the wiring, and maintaining a low price will help to dictate these choices.

6.4 Camera Options

The main user requirement affecting the choice of camera will be cost. The image does not have to be in color or have high resolution to allow the user to determine the status of the door. In addition, the wireless method of communication that has been chosen is compatible with several protocols for transmitting images. One option is a web camera. The challenge of using a web camera is figuring out how to interface it with the microcontroller. A majority of web cameras today communicate using a Universal Serial Bus (USB) connection. And the USB communication protocols are not trivial. An alternative to using a USB connection would be to use a camera that communicates through parallel or serial ports. An example would be the serial JPEG camera sold by Adafruit (see cost table for reference). A low quality security camera may also be an option. Whichever technology is chosen, the team will have to learn the required protocol to send the images taken by the camera to the user's android application. Power to the camera will also have to be established most likely through its connection to the microcontroller.

7 Major Component Costs

Table 2. Required Technologies, Purpose and Estimated Costs

Part	Use	Estimated Cost
Distance Sensors	To detect objects in the line of view of the garage door	Ultrasonic Range Finder[1] $45 Infrared Proximity Sensor[2] $20
Camera	To take images of the garage door	Webcam[3] $30 Surveillance Camera[4] $20 Serial JPEG Camera[5] $40
Door Status Sensor(s)	To detect whether the garage door is open or closed	Pressure Sensor[6] $11 Accelerometer[7] $12
Batteries	To power the sensors, camera, remote control	AA Lithium[8] $4/battery

[1] "MB1200 XL-MaxSonar-EZ0 High Performance Ultrasonic Range Finder"
[2] "IR Distance Sensor"
[3] "Shop for Webcams"
[4] "Security Cameras and Security Camera Surveillance"
[5] "TTL Serial JPEG Camera with NTSC Video"
[6] "NBPLANN150PAUNV"
[7] "Accelerometers"
[8] "Energizer Ultimate High Energy AA Lithium Battery"

8 Conclusions

The aim of this project is to modernize a garage door system by taking advantage of today's technologies. Open Sesame will bundle the convenience of a smartphone with this system to create a powerful tool for absent-minded and security-conscious homeowners. The primary goal is to improve total home security through quick sensor status updates and visual picture notifications. The overall effectiveness of the product will be determined by how well the system will be able to notify the user and if the product was able to successfully operate the garage door through sensors input, phone signals, and traditional controls.

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