Video Doorbell

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High Level Design

1 Introduction

Home security has always been a vitally important part of domestic life. Given recent advances in technology and decreasing prices for connectivity, it is now easier than ever for individuals to protect their houses and improve their quality of living. The goal of our project will be to create a video doorbell. Similar devices include the Ring doorbell and the Nest Hello doorbell from Google. Overall, the goal of the device will be to create a doorbell system that simultaneously acts as a video security system as described in the problem description and solution section.

2 Problem Description and Solution

The problem facing the target user is twofold. First, they should be alerted of any motion and potential danger on their front porch. Second, they should be able to monitor their porch at any time from any location. Our video doorbell system will allow the user to remotely monitor their front door using a WiFi enabled camera. The system should be able to detect motion in front of the door, notify the user through an app that motion has been detected, and allow the user to view the video stream from the doorbell.

Furthermore, the device should be able to be turned on using the same app regardless of motion detection.

In this section, we will list the functional groups of our design. We give more detail on the design and interaction between groups in later sections.

1. Motion Sensing: the device will need to have a motion sensing system.
2. Video Input: the device will need to be able to interface with a video camera and take in video data.
3. Communication with mobile app: the device will need to both send and receive information from a mobile app. This information includes sending a video stream to the app when the motion sensor activates and turning on the video stream/transmitting to the app when the user commands.
4. Mobile App: we will create a mobile app to control the device and send notifications to the user.
5. Power: the device will likely need to be powered by replaceable battery or seamlessly integrate with the 120V in-home wiring.
6. Mounting: the device will need to be mountable on the average front door area, constraining the maximum product size.

3 System Requirements

Our overall system requirements are as follows:

1. Ability to mount the device on a wall or door frame.
2. When something approaches the device, the motion sensor will cause the system to notify a mobile app and allow the user to view a video stream.
3. The mobile app user will be able to turn on and view the video stream through commands on the app regardless of a lack of motion-sensing input.

These principal goals will be accomplished through the implementation of lower level features. One such critical feature is WiFi compatibility. We showed-off a version of this in our end-of-semester demonstration, but it will require additional work to embed this intelligence in our custom Printed Circuit Board and ensure its compatibility with the camera we select.

In our initial design proposal we thought the best user experience would be to run the device off batteries such that it could be installed in any location. However, as nearly all porches are already wired for a regular doorbell, we believe it will be best in the long run for our device to run off standard house wiring so that it will operate virtually maintenance-free for many years. Now, instead of choosing the proper batteries our only concern will be adding the correct voltage/power dividing scheme to our board so as to not fry the logic chip or any other components.

Because the doorbell itself is not mobile it will not require any sort of extended range on its WiFi connection. It will simply connect to the user’s home network to upload all video

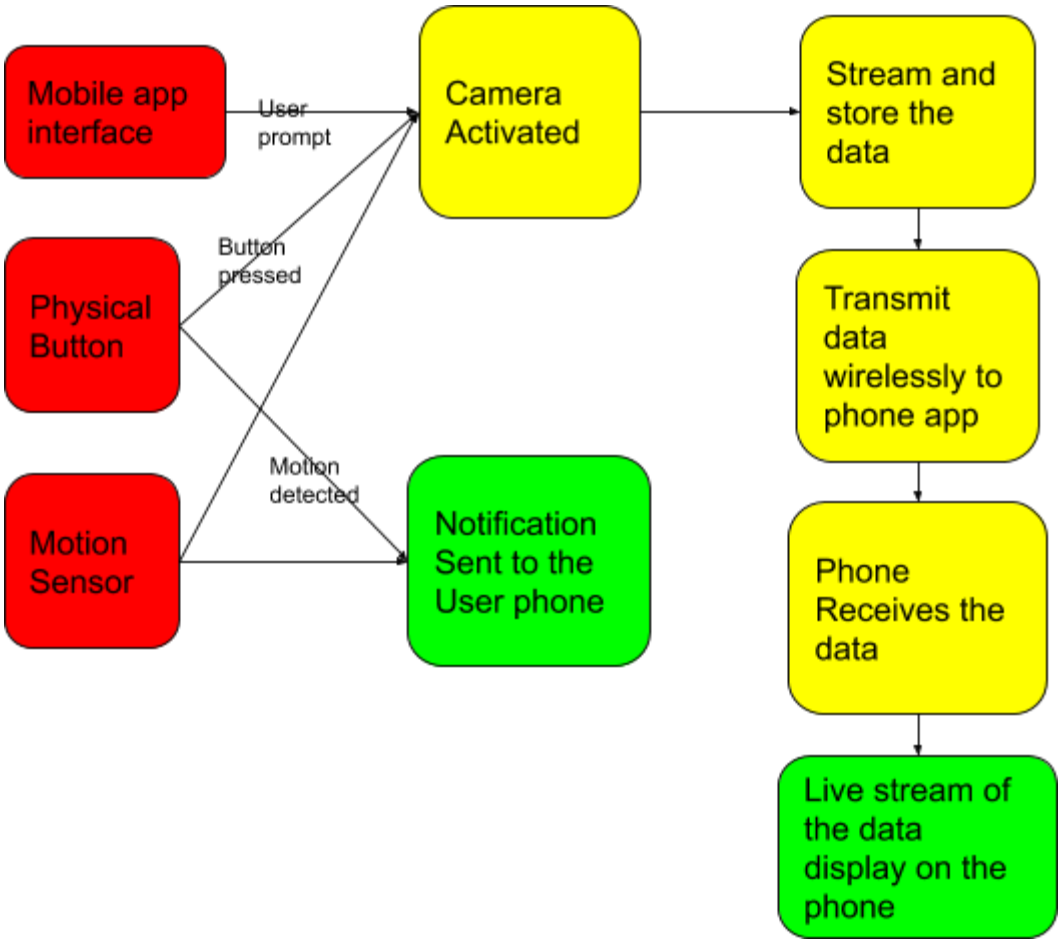
data. At that point any device with the correct login credentials and internet access will be able to view the recording or activate the live feed by remoting into the cloud-based storage location.

Installation of the device will be very similar to a “traditional” non-video doorbell. Safety will be ensured by disabling the flow of electricity to the wiring on the porch through the circuit breaker during installation. Power will only be restored after the device has been securely screwed into the outer wall of the home.

The device is not carried during day-to-day use, so weight will not be a concern. Size should be minimized because some doorbells are mounted in a fairly narrow area between a door and perpendicular wall on the exterior of the home. Additionally, the more the device looks like a normal doorbell, the more comfortable the user experience will be, and less confused guests will be when experiencing it for the first time.

4 System Block Diagram

4.1 Overall System:



There are three major activation subsystems (red) that will be developed independently to cover all use cases of our device. The first is a way to trigger the camera to begin recording via a mobile app. The second is a button that turns on the camera when a

visitor presses it like a traditional doorbell. The last is a motion detector that automatically activates the camera when someone is detected near the porch. There is then an internal subsystem (yellow) that will be handled via software and deals with uploading the video stream over the home WiFi network and sending it to the user's device. The final section is the output subsystem (green). This involves sending push notifications to the user's device and facilitating a continuous video stream.

4.2 Subsystem and Interface Requirements:

Major activation requirements specify that the mobile app and button press should be able to turn on the camera within seconds of triggering. Also, the motion detector should have a range that covers the entirety of the porch and some of the front yard, but will not be fooled by cars in the streets or pedestrians on the sidewalk. The main internal requirement is that a WiFi connection should be established and maintained strong enough to stream video. Additionally, some sort of local or cloud storage solution must be developed so that old film can be reviewed in cases of robbery of vandalism. Finally, on the output end, the app should be user-friendly and reliable such that it does not unexpectedly crash or lose video connection.

4.3 Future Enhancement Requirements

Like any good device, our doorbell has room for improvement. For example, as a prototype it is unlikely our device will be fully waterproof but this is something customers will want if their porch is not sheltered from the elements. Another enhancement we have heard about is that other video doorbells can connect with each other to help law enforcement track criminals. It would be a good selling point if our device could also interface with this network to help the police. We could further implement facial recognition to let the user know if an expected guest has arrived or if the visitor is a stranger.

5 High Level Design Decisions

We will need a camera for video capture with resolution high enough to identify visitors. It should also work in low light or have an external flash. The main component of the motion detection system is the motion detector itself. It should be an infrared based device so it uses less power and will still detect even in near darkness. We will also need a large physical button to take the place of the actual doorbell. All of these inputs will be fed into a single microcontroller than then outputs the alerts and video feed over WiFi. We have decided to use the pic33 because it was one of the devices we were introduced to this semester and it will accomplish everything we demand for this project. It will be powered off house wiring and needs a power divider to safely provide electricity to our circuit.

6 Open Questions

The most critical remaining tasks for this project include an integrated, always-on motion detection system and the mobile user interface, as we have already done a proof-of-concept with the WiFi video transmission. For the motion detection we need to keep power usage at a minimum while the sensor only turns on the actual camera when there is action to film within a specified area (the front porch). Second, the user must be able to access the video feed quickly and remotely to see it live, but also have some clips of interest stored for later. We will have to research secure cloud hosting options such as Google Drive or Dropbox.

7 Major Component Costs

After producing our PCB for $50, we will have $450 remaining to spend on various electronic components and elements of the physical interface. This is significantly more than we plan to spend on our device, which may allow some room in the budget to drop-in and compare similar parts. The principal elements of our design solution can be accomplished by integrating the following existing technologies:

1. Microchip. We will be using ESP32 Microship Controller. It is very convenient for its wide range of temperature tolerance (–40°C to +125°C), ultra-low power consumption, and its feature to provide Wi-Fi and Bluetooth functionality through SPI / SDIO or I2C / UART interfaces.
    - https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf
2. Motion Sensor. Our design requires a PIR sensor that can interface with a ESP32 chip. This will allow the ESP32 to turn on the camera and begin wireless transmission when someone approaches the video doorbell.
    - https://www.mouser.com/ProductDetail/Adafruit/189?qs=GURawfaeGuDSOVYhJqJicw%3D%3D&gclid=Cj0KCQiAtf_tBRDtARIsAIbAKe25DsLJsM0rUMy42Io1k2FiJdns74yvthPxN9-ddxd8ZvhQjkN5WNQaAgvYEALw_wcB outputs a digital high for $9.95
3. Wireless transmitter. The doorbell should be able to reliably send detection alerts and video data to the user on their computer or mobile app. ESP32 has this feature.

4. Camera interface. Our device should incorporate a wide-angle camera to capture video of the user's front porch after motion has been detected. This component should be high resolution such that intruders can be discerned from postal workers or other welcome visitors. The camera we are using is the ESP32-CAM, which is a camera that interfaces with ESP32 microcontroller.

5. Power source. Most parts we're using require 3-5 V to operate. If we opt for the battery operated design, we will choose a long-lasting component that has power

output closely matched to the draw of our other electronic components such as the camera, transmitter, and subparts of the PCB.

- https://www.sparkfun.com/products/13855?_ga=2.164561535.1126498413.1572929608-815174334.1572929608

Part:	Operating Voltage (V)	Cost ($)	Notes
ESP32 Thing	2.2 - 3.6	21.9	- You can power it by plugging in a usb power adapter and simultaneously recharge the battery while connected - Will power the chip at 3.3 V
ESP32-CAM	3.3 or 5	10	
Adafruit PIR Sensor	3.3 or 5-12	9.95	- In order to operate with 3.3 V, we need to bypass the regulator, that means doing a bit of soldering
Lithium Ion Battery-2Ah	Supplies nominal 3.7	12.9	

8 Conclusions

Every engineer dreams of developing a product that makes the world a better and safer place. Video doorbells check these boxes by defending the user's greatest investment against the ever-prevalent dangers of the modern world. We are attempting to design a product in the currently hot smart home sector. Our video doorbell will replicate many popular features from systems currently on the market while looking for opportunities to optimize or expand the existing technology along the way. Important milestones in the device design are low-level circuit design, video processing and storage, mobile app development, and product external fit-and-finish. Once these tasks have been

accomplished, we will have created a video doorbell worthy of integration in any smart home.

References

Device capabilities and pricing researched at:
-https://www.mouser.com/ProductDetail/Adafruit/189?qs=GURawfaeGuDSOVYhJqJicw%3D%3D&gclid=Cj0KCQiAtf_tBRDtARIsAIbAKe25DsLJsM0rUMy42Io1k2FiJdns74yvthPxN9-ddxd8ZvhQjkN5WNQaAgvYEALw_wcB
-https://www.microchip.com/wwwproducts/en/ATWILC3000
-https://www.robotshop.com/en/ov7670-camera-module.html?gclid=Cj0KCQiAtf_tBRDtARIsAIbAKe2cJief5xO4YMbjE-XqS4SDub0GQLVaQwFECPN8YFGqZRL5ju_bHWUaAtWxEALw_wcB
-https://www.sparkfun.com/products/13855?_ga=2.164561535.1126498413.1572929608-815174334.1572929608