PARENTS OF THE FUTURE

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Abstract

Parents of the future (originally done in Spring 2019), is a project consisting of two subcomponents, an ultrasonic sensor-based device, and a wall mounted camera subsystem, both of which collect data about chore completion. The data is then sent to a computer that processes the data by running image processing algorithms to track how far along a chore is, and whether or not it has been completed, and posts the task status and data to the back-end server of a secure website in real time. The website can then be accessed by parents in order to track the respective chores, and to assign new ones.

Contents

1. INTRODUCTION

1.1 Updated Problem Statement

A lot of times, both parents (or the only parent, in case of single parents) of the household tend to be working for some number of hours a day, and have to leave their children alone at home. A study [1] commissioned by "Visit Anaheim", stated that families spend only about 37 minutes of quality time on weekdays and 2 hrs and 40 minutes of quality time on weekends, mainly due to parents' hectic work schedule. This time should be spent on emotional bonding, and should not be cut short by parents having to tell their children to do things that children can easily do while their parents are away, such as household chores. Hence, we decided to build something that would allow parents to track their children's progress on a set of household chores, namely doing the laundry, doing the dishes, and taking out the trash.

1.2 Updated Solution

Although there are several apps [2] that keep track of children doing their chores, most of them depend on the children logging completion of their chores on their smartphone apps, or parents having to check manually. Our solution employs sensors and algorithms that monitor chores in real time and themselves check for task progress and completion, which provides reliability and saves the parents' time.

There are also several home surveillance and security systems [3] available in today's market; however, none of them can decide whether or not tasks have been completed, but rather, can only record video data that the parents will have to manually track. Our solution overcomes the shortcomings of both the aforementioned pre-existing solutions.

The original project that we are referencing sought to build an IoT based system that would help parents monitor the chores done by their children, using pressure and ultrasonic sensors in the sink, the trash can and the laundry bin, and building a local network between the sensors and the parents' computers. We would like to implement the functionality of this project by removing the pressure sensors and adding visual surveillance to the already existing solution, by adding vision sensors or cameras, and placing them near the doors or rooms where the chores (laundry, trash and dishes) are to be carried, and transmitting their data to a computer, which would run computer vision algorithms to detect not only whether a task has been completed, but also how far along it is. This task data would then be posted to the backend of a secure website, which would then be accessed by the parents in order to check task progress and assign new tasks.

1.3 High Level Requirements

The high-level requirements of the system will be as follows:

1. The system should recognize the children as they enter the field of view of a video camera
2. The system should recognize that the task has been completed using the sensors and camera
3. The system should update the information to the parents' device apps every time a task is started or completed

1.4 Visual Aid

The visual aid shown below presents the placement of each component in the project. The laundry room layout, trash can room layout and sink room layout show the respective regions in which the chores are carried out the left, and an IP camera for each task plugging into the wall at the right of the room layout. The middle part of each layout contains a pictorial representation of the Wi-Fi router, the main computer and a client device; but these three components can be placed anywhere in the home (client devices can even be outside the home), since the internet connection does not require the devices to all be present in the same room. The diagram also shows the top view and side view of the physical device (including the sensors and microcontrollers) and how they will be plugged into the wall.

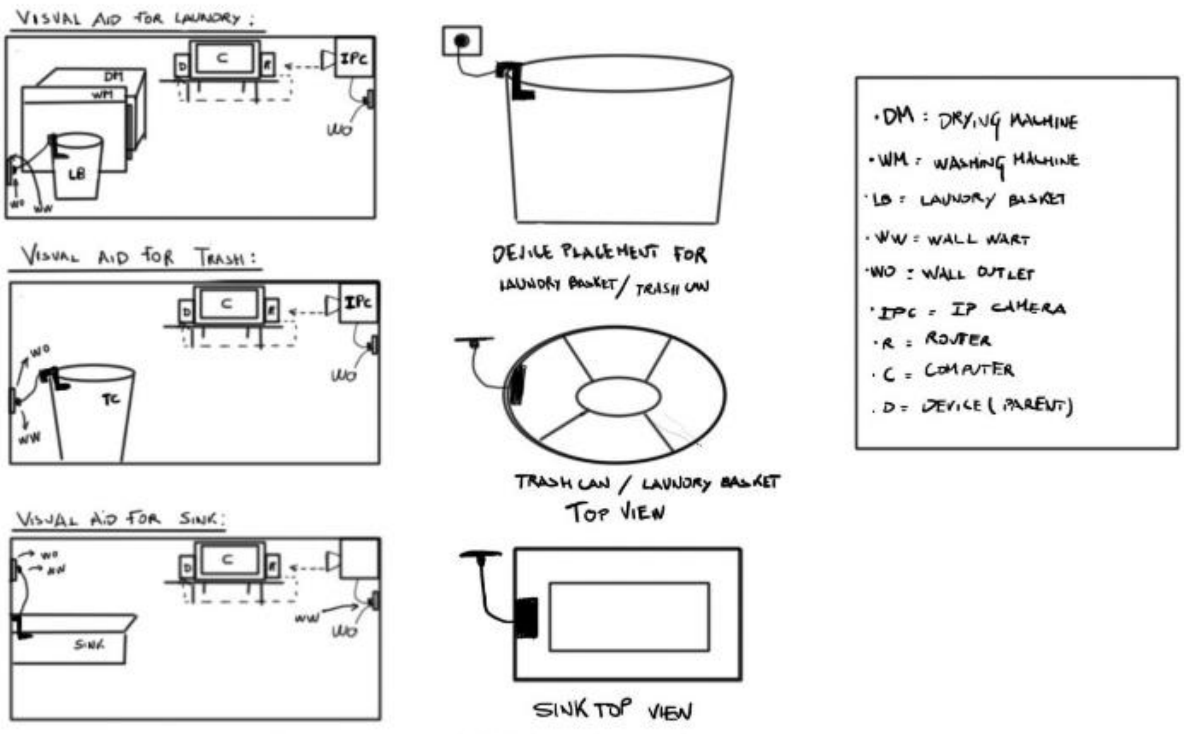

Figure 1: Visual Aid

1.5 Block Diagram

The block diagram shown on the next page contains the following modules:

(a) Power Module: this will consist of the home power outlets used to connect the system components to electricity, the wall wart and required connectors that will step down the main outlet voltage to 12 V, wires where required for electrical connections, and voltage regulators for stepping battery voltage down to 3.3V and 5V for the microcontrollers and the sensors respectively.

(b) Control Module: this will be made up of the microcontroller and the LEDs status. The microcontroller will receive data from the ultrasonic sensor using the PWM method, and transmit them to the processing module via the inbuilt Wi-Fi chip on the ESP32 microcontroller. This module will fit on the PCB.

(c) Sensor Module: this will consist of three ultrasonic sensors, in the same rooms as the cameras, and will be used to collect data such as the amount of clothes or garbage or dishes collected in the laundry basket or trash can or kitchen sink respectively. They will be placed on the top of the containers, pointing down to it.

(d) Wireless Camera Module: this will consist of 3 wireless cameras placed at certain locations in the home, such as in the kitchen, in the laundry room, and the room containing the trash, which will collect video data that will then be processed by the computer. This data will be transmitted to the processing subsystem directly by the camera over Wi-Fi (the Xiaomi IP camera has built in Wi-Fi capabilities.

(e) Wi-Fi Module: this will consist of the Wi-Fi the router for sending information from the Wi-Fi chip for each of the PCBs, as well as the cameras to the main computer, and for providing internet connectivity between the computer and client devices when present inside the home.

(f) Processing Module: this will consist of the main computer present in the home which will run video and image processing algorithms to detect objects and people in the apartment, and track task completion. The main computer will take in camera input via Wi-Fi, and will also generate the signals to be updated on the apps on the parents' laptops, tablets or smartphones (complete and incomplete chores, and chore progress). It will also have a server, which will have a database (MySQL DB) to store all the processed data. The software module running on the computer will contain a main python program to extract data from the database, to run the Python-OpenCV library to make use of computer vision algorithms to generate data, and to print out HTML, CSS and JavaScript code to update the website that will be accessed by the client devices.

This is the actual "brain" of the project, and will be used to fulfil all the high-level requirements of the project. However, the system will also rely on the other components of the project to get the job done.

(g) Client Module: this pertains to every parent device that the parents would like to use to access the chore monitoring system app.

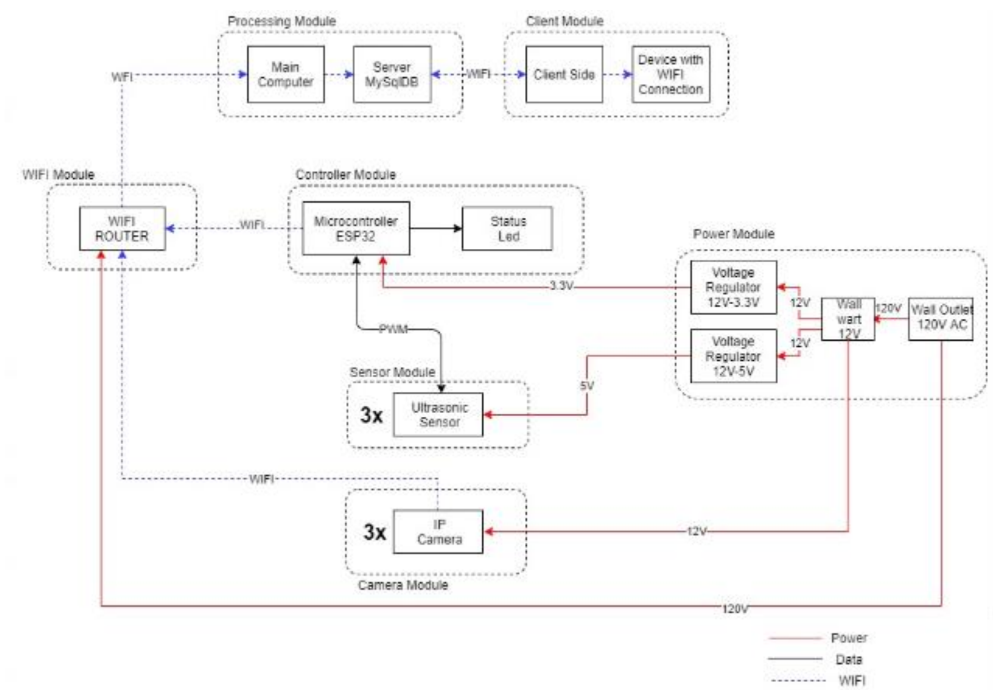

Figure 2: Block Diagram

2 Design

2.1 Software Implementation

The software component of our project contains two parts, namely the computer vision algorithms to track task progress, and the website backend. We could write wrapper code in Python, which would be able to complete both of the above parts by doing the following tasks:

- The camera and sensor data would be placed into a mySQL database from the camera (we were not able to figure out how to store the camera data in the database directly, since we were unable to find data about it on the website, and would need for it to arrive in order to test it and come up with a way to do this), and from the Arduino based microcontrollers present on the ultrasonic sensor device boards. We would write SQL code (embedded inside Python) to query the database and access the required sensor data.
- We could write Python code to compute whether or not the task is complete based on the data from the ultrasonic sensors.
- We could write python code to integrate the "Online Realtime Action Recognition based on OpenPose library" (henceforth referred to as "OpenPoseExtended", which would be used to implement the computer vision component of the project as follows:
    1. The camera data would be obtained at the database via wifi, at a rate of 18-20 frames per second
    2. OpenPoseExtended would then make a call to the OpenPose library to assign "key points" or "skeletal dots" to each image frame as detailed in the OpenPose github documentation
    3. OpenPoseExtended would then use the Deep Sort Algorithm to perform real-time human tracking
    4. OpenPoseExtended would then perform action recognition using deep neural networks to assign an action label to each person in the frame image based on single framewise joints detected by OpenPose
    5. We would then take these action labels, and check for sequences for task completion. For example, the task of laundry completion can be broken down into washing and drying. Washing can further be decomposed into 3 poses, bending down on top of the laundry basket, picking up clothes from the laundry basket, and placing them into the washing machine. Drying can be decomposed into similar poses, namely bending down in front of the washing machine, picking up clothes from the washing machine, standing/bending in front of the dryer, and placing clothes in the washing machine. Once a given pose sequence would be detected, the algorithm would mark the related subtask as complete; and once both subtasks would be completed, the wrapper python code would mark the task of "doing laundry" as complete.
    6. We also intended to train the algorithm on our own dataset in order to better detect the tasks, and also to assign better labels to each pose, which would have led to more streamlined task progress tracking.
    7. We would also use the OpenCV objectdetect module to detect whether the laundry basket, the trash can and the sink were empty, full or in between, and run a loop to continue tracking pose sequences until the basket would be empty, to mark a task as complete. When this module would recognizes the laundry basket, the trash can or the sink to be full, a task would be marked as "ready to assign", so that the parents could assign the chore to one of the children.
- We would then use our results from the sensor code and vision code to decide whether or not a task was complete, and how far along a task was, in another python module. We would track the following things: subtask completion, task completion, task ready to be assigned.

- Every time a subtask or task was marked as complete, a mySQL script embedded in python, running on the main computer would update the back-end database with the new values.
- We would write the website front end using HTML and JavaScript, which would read the data from the back-end and render it on the user devices. The parents would then be able to use this website to assign tasks to the children.

2.2 Circuit Schematics

Our project has two different mechanisms to gather data from the home environment, namely the ultrasonic sensor, and the camera. The ultrasonic sensor and the voltage regulator are the only components that would go on the PCB, along with the microcontroller. The schematics for the 3.3V voltage regulator, the 5V voltage regulator and the ultrasonic sensor can be found in Figures 3, 4 and 5.

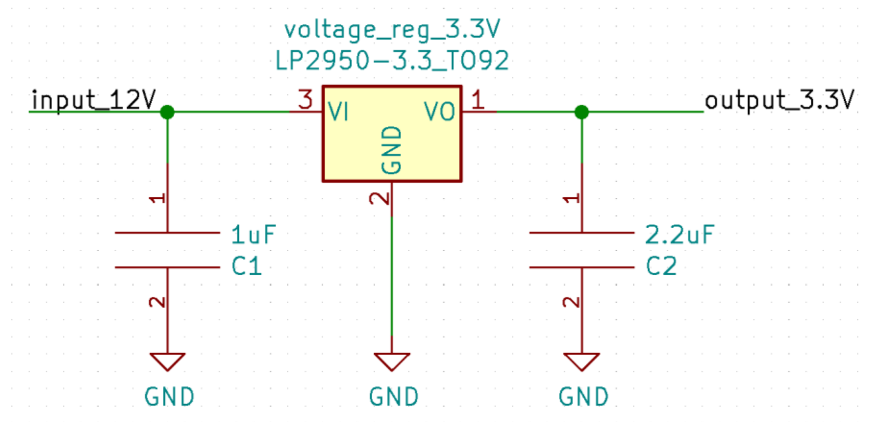

Figure 3: Schematic for Voltage regulator 3.3V

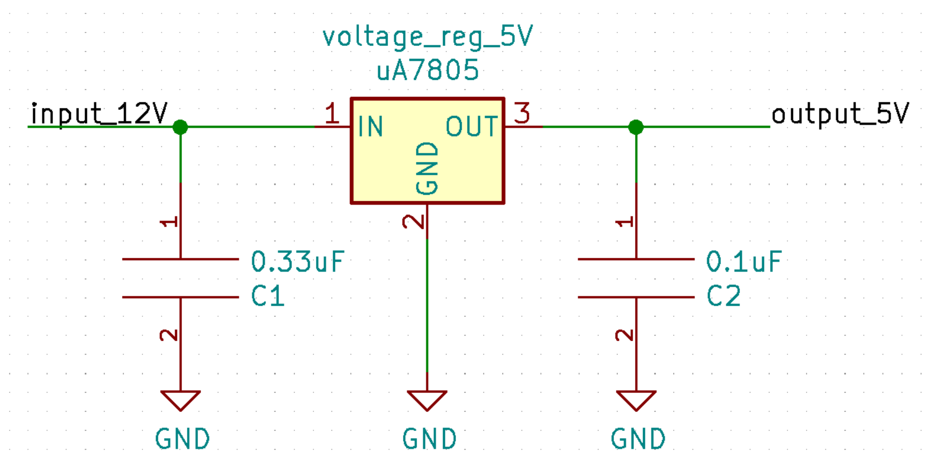

Figure 4: Schematic for Voltage regulator 5V

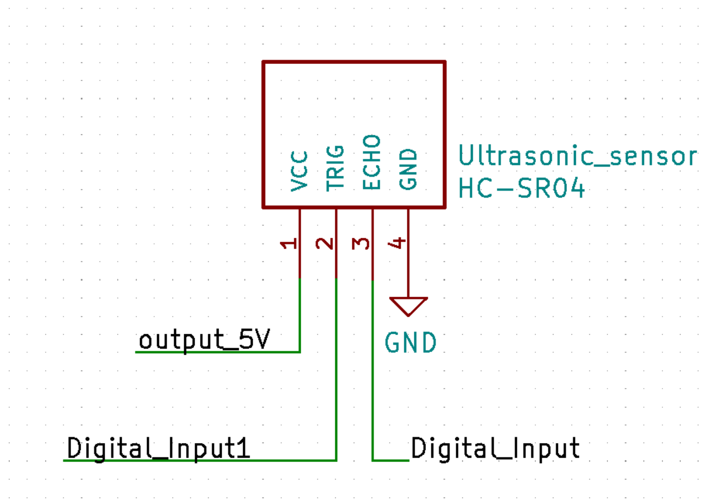

Figure 5: Schematic for Ultrasonic Sensor

2.3 Physical Diagram

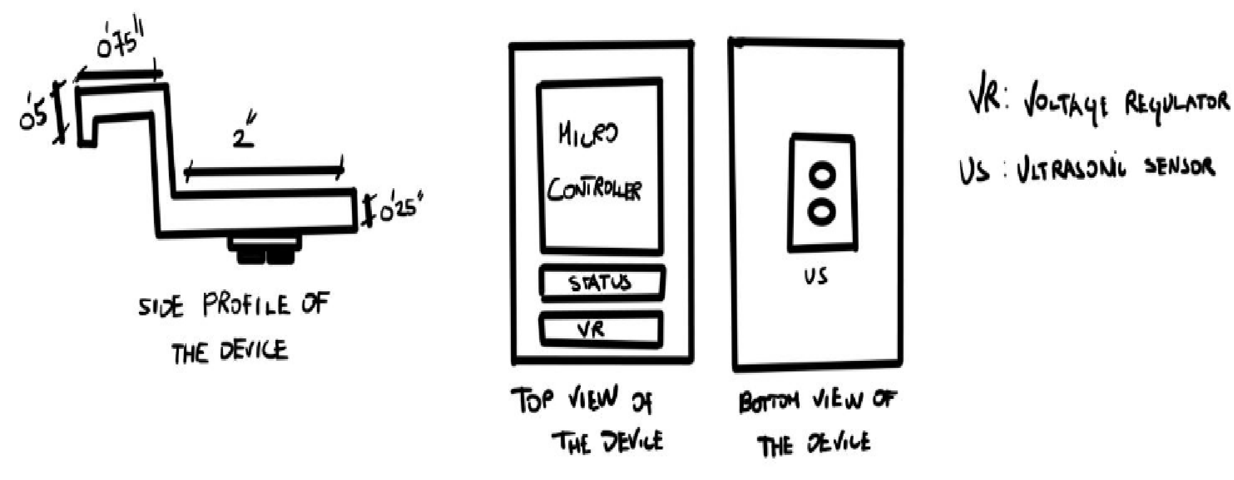

Figure 6: Physical Design

We designed he sensor-based devices to be built on a small metallic plate-like body, with dimensions as shown in the left part of Figure 6. All the components of the control module and sensor module would be placed on it, as well as the voltage regulators. Since the ultrasonic sensor would only be required to detect how full or empty the sink/garbage can/laundry basket, we decided to place it at the bottom of the device to give it better access to the contents of the aforementioned chore sites.

2.4 Cost Analysis

The cost for our project can be divided into the cost for the labor, and the cost for the parts.

- Labour: our goal was that we would all work the same number of hours and optimize the time in the best possible way. We assumed that for this project, we worked as engineers without experience, for a reasonable salary of 30$/hour. We assumed that we worked for a total of 14 weeks, for 15 hours per week. The total cost has been computed in Equation 1.

Total cost = 3 *2.5*14*30*15 = **47,250 $**

Equation 1: Total Labor Cost of the Project

- Parts: The table below includes all the parts that need to be bought to build the robot. We are assuming that the user family will have a computer with an i7 or i9 processor.

Description	Manufacturer	Quantity	Cost/unit ($)	Total cost ($)
Microcontroller ESP32	Espressif Systems	3	2.20	6.60
Ultrasonic Ranging Module	Sparkfun	3	3.84	11.52
Voltage regulator 5V (UA7805CKCT)	Texas instrument	3	0.58	1.74
Voltage regulator 3.3V (LP2950-3.3_T092)	Texas Instrument	3	1.08	3.24
Wall Wart 12V	Jameco Valuepro	3	7.95	23.85
Mi Home Security Camera Basic 1080P	Xiaomi	3	20	60
RTX 2080 Ti GPU	NVIDIA	1	1,199	1,199
TOTAL				$1305.95

Table 1: Total Cost for the Parts

- Sum of costs:

Total for the Labor	$47,250
Total for the Parts	$106.95
Overall cost	**$47,356.95**

Table 2: Total Cost Analysis

3. Project Conclusions

3.1 Implementation Summary

Overall, our project is a culmination of three major subtasks, namely, collecting sensor data from the environment, collecting video data from the environment, and collecting and running algorithms on the data, and posting the results to the backend of a website, where it can be accessed by the members of the household.

We have designed the sensor submodule such that it contains an ultrasonic sensor, a wifi enabled Arduino based microcontroller, status LED's, and two voltage regulators for 3.3 V and 5V each, which are used to supply power of the appropriate voltages to each component. We have also designed a physical body for this module, which has been detailed in section 2.3, and is supposed to be placed at the top edge of a sink, a laundry basket, or a trash can, and can detect how far away the contents of each are from the top at any given instant. The distance data would then be transmitted by the microcontroller over wifi, and would be stored in the database of the main computer. Thee status LED's would be turned on while the device would be plugged into the wall.

We decided to use an IP camera, which would be mounted at a strategic location in the respective rooms in the family's household, and would be able to record video of the environment, and send the data to the database on the main computer over the wifi. The IP camera would also draw power from the wall outlet.

Once the data is present in the computer's database, the algorithms compute whether the tasks are complete, and if not, how far along to completion they are, and posts the relevant data to the backend of a website, which can then be accessed by the members of the household. The details for how this was to be implemented are found in section 2.1.

We also performed a tolerance analysis for our design, which can be found in the next section.

3.2 Unknowns, Uncertainties and Required Testing

Our project has a camera submodule, a sensor submodule, a computer submodule, and a Wi-Fi submodule. Since we did not have access to the lab, we were unable to test and assemble the sensor submodule, and were also unable to unit test all of our individual parts to see whether they were functioning properly electrically and whether all their input and output pins were working. In addition to that, we were also unable to test the Wall warts.

If we were to complete these tasks, we would begin by unit testing all of our electronic components to make sure that they worked. We would then assemble our components along with the PCB that would be provided to us based on our implemented by the design. We would then test the whole sensor module in its entirety, to see if it were able to detect distances correctly.

Next, we would have worked on integrating the sensor module with the wifi module and the computer module. That would have required trying to transmit dummy data from the sensor module over the wifi module to the computer and ensuring that the data was received by the computer module and stored in the assigned spaces in the database.

We have however, been able to analyze our system in theory by performing tolerance analysis on our project design, and believe that the most critical features of our project are the camera module, the computer and the GPU. This is because the main task of detecting the completion of the task will be carried out by the Vision algorithms on the computer and GPU, with the data that is collected from the cameras set up for each task. This data needs to be sent over Wi-Fi. In order to prove that our design will be able to function despite the limited accuracy of the sensors, we need to show that our current requirements will be satisfied even if there are fluctuations in the given data within the tolerance ranges of the components involved. The requirements for the camera and computer can be found in Appendix A.

Beginning with the camera, we see that it is required to have a 120-degree field of vision, as well as be able to generate data of at least 18 frames per second. The camera that we have chosen is a commercial camera, and we do not have access to its data sheet since it is a commercial product and not a sensor; we will have to test it when we get the device delivered in order to measure the tolerance range. For now, we will assume an error of 5%, because we are using a well-developed commercial product, from which we can expect good quality. Our camera has a listed field of view of 130 degrees, and so we will get 130 degrees+/-6.5 degrees, which will be somewhere between 123.5 degrees to 136.5 degrees, which will ensure that the vision angle parameter is met.

We can also assume a 5% error in frame rate, which will put the camera frame rate within the range of 19-21 frames per second. However this will not be a problem either, since we are planning to use vision algorithms for OpenCV, on an i7 processor, and also using an NVIDIA GPU, which will be able to handle this frame rate, in terms of computational performance (the GPU will be able to process the data and generate results to be updated on the back end of the server.)

Since this system is to be deployed in the USA, where there is reliable electricity and internet in most places; therefore, the components of the power module and the Wi-Fi module have not been taken into consideration in the tolerance analysis.

Since all the above requirements were expected to have been met, the project would have been able to operate successfully.

3.3 Ethics and Safety

One major issue that this project could face is that the video data could be intercepted by malicious third-party content, which would be a violation of sections 1.2 and 1.6 of the ACM code of ethics [5], titled "Avoid Harm" and "Privacy" respectively. To avoid this, we could encrypt the data from end to end, so that it cannot be used maliciously even if the system is intercepted.

Moreover, if intercepted, this data could be used to determine whether the children are home alone or not, which could cause a lot of damage. In order to effectively deal with this, all the cameras should be kept out of places in the home where privacy is expected, such as bedrooms, bathrooms and changing rooms. Also, the field of view of the camera should be limited to the bare necessary minimum required to assess whether or not the task has been completed.

Although there are not many codes and laws for camera surveillance, every state in USA has their own laws about what is and isn't legal to do, and customers can contact their attorney to confirm them [6].

Since this project is heavily reliant on electricity, several electric safety measures will have to be followed, to avoid causing injury or harm to the members of the household or guests who may come in contact with it, in order to be in line with the IEEE code of ethics [7], entry 9. We will make sure to ground each electrical component, and also place it on rubber or wood in order to insulate it.

Since we were unfortunately unable to implement the project, we did not face any new concerns from it. We also did not encounter any additional concerns in the design review either.

3.4 Project Improvements

If we were to work on this project for a year instead of four weeks, we would like to add three additional features, namely camera data security, website security, and portability and robustness for the sensor-based devices.

Since we are making use of an IP camera, which sends data over wifi, we would like to prevent malicious access to the data. In general, anyone who would know the IP address of the IP camera would be able to connect to it and access its video data. We would like to add an extra layer of software protection to authenticate any user who tried to connect to the camera. Another option would be to make out IP camera a part of the user family's LAN network with a correctly implemented firewall, so that no third party would be able to access the camera externally.

Secondly, we would like to assure that no one other than the parents would have access to the data located in the database. Hence, we would like to add software authentication to the webpage, which we would like to do using a "user account" system, which would enable parents and children to create accounts on the website, and use the user ID's and respective passwords logged as a part of these accounts, to log into the website.

Lastly, we would like to make our sensor-based devices wireless, by replacing the wall warts, so that they would become more portable and easier to use, and would not need to be plugged into a wall outlet. We would also like to design stronger, tougher encasings for the sensor-based devices, to make them more robust and fall, break and damage resistant, as well as easier to clean.

References

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Appendix A: Requirements and Verification Table

A.1 Power module

Our project is going to be connected to the wall outlet, and this is how all the PCBs, router and cameras are going to be powered. The cameras that we are going to use already have their plug in with their own wall wart, Each PCB will be powered at 12 V, but it will have two Voltage Regulators inside each PCB so it can match 3.3V needed for the microcontroller and 5V needed for the sensors.

A.1.1 Wall Wart

We made the decision of using wall warts to power the PCB because they are more environmentally friendly as compared to lithium batteries and because they are more convenient for clients in case of a long term set up, since they do not have to be recharged, like Lithium batteries would have to be.

Requirements	Verification
The output should be 12V +/0.6 V	With a voltmeter connected to the output of the voltage regulator in parallel, the voltage should be between 11.4V and 12.6V.

Table 3: R&V Wall Wart

A.1.2 Voltage regulator 3.3V

This voltage regulator is going to be connected exclusively to the microcontroller, which needs at least 0.5mA and 3.3V+/-0.3V to work.

Requirements	Verification
The 12V from the wall wart should reach 3.3V+/-0.3V	With a voltmeter connected in parallel to the output of the voltage regulator, the voltage should be between 3V and 3.6V.
There should be at least 0.5 mA for the microcontroller to work	An ohm resistor will be connected at the output. An ammeter will be connected in series to the output terminal, and the output current measured should be more than 0.5mA

Table 4: R&V Voltage regulator 3.3V

A.1.3 Voltage regulator 5V

This voltage regulator is going to be connected to the sensor and the microcontroller. The minimum current through each of them is 15mA (ultrasonic sensor).

Requirements	Verification
The 12V from the wall wart should reach 5V+/-0.5V There should be at least 15 mA for the ultrasonic sensor and microcontroller to work	With a voltmeter connected to the output of the voltage regulator, the voltage should be between 4.5V and 5.5V. An ohm resistor will be connected at the output. An ammeter will be connected in series to the output terminal, so the outputted current measured is greater than or equal to 15mA

Table 5: R&V Voltage regulator 5V

A.2 Control Module

This module is made up of two parts, namely the microcontroller and the status LED's. The microcontroller will be powered with the 3.3 V from the 3.3 V voltage regulator and LEDs will work with signals provided by the microcontroller. The ESP32 will be responsible for processing the data from the ultrasonic sensors and transfer the data to the main computer over Wi-Fi using the inbuilt Wi-Fi chip.

A.2.1 Microcontroller

For this project, the microcontrollers that are going to be used are going to be the ESP32, which will be low cost and enough for the devices that we need to connect to the microcontroller. We were looking for a cheap microcontroller, because we are going to use three of them and with the wireless cameras our project price is going to rise. This microcontroller also has Bluetooth and Wi-Fi connections integrated.

The microcontroller will be powered with a 3.3V voltage regulator. The ultrasonic sensor will be connected to the ESP32 through the Digital PWM input pins, as well as the Analog Input pins.

Requirements	Verification
When providing an input voltage of 3.3 V and the frequency being 20 MHz, the supply current should be approximately around 12 mA with a percent error of 10% Wi-fi pin must correctly receive and send 5 bytes of data from the microcontroller to the database.	With an ammeter connected in series a resistor and the output terminal, so the outputted current measured is around 12mA (10% error) This can be verified using dummy tests by transmitting random data over Wi-Fi once the PCB with microcontroller is connected.

Table 6: R&V Microcontroller

A.2.2 LEDs status

These LEDs will be located on the PCB and their aim is to indicate the user if the microcontroller is currently being powered or not. the children if they have to work on it or not. The LED will be connected to a standard PWM Digital Input pin and depending on whether the device is powered, it will be on or off.

Requirements	Verification
When the ESP-32 is correctly powered with an input voltage of 3.3V and receiving data from the Ultrasonic sensor the LED should power on.	When the power module is connected to the PCB, the sensors are connected to ESP-32, the LED should be held in the high position. This will be verified through the use of a multimeter.

Table 7: R&V LEDs status

A.3 Sensor Module

A.3.1 Ultrasonic Sensor

The sensor that will be used is HC-SR04 ultrasonic sensor. It will be used for determining in the container is full. When a container is full, the distance between the top and bottom part of the container is detected as less, because there are obstacles in the middle. The sensor should be able to send a signal indicating the container is full when the measure is 7 inches.

This sensor works by emitting a 40kHz ultrasound wave which will bounce on the object and come back to the sensor. The sensor will measure the time that it takes for the wave to come back, and depending on the time, the obstacle is closer or further. We will send 10 signals in order to make sure that the object is not falling, but it is staying in the pile of stuff. In Figure X there's an explanation of how it works internally.

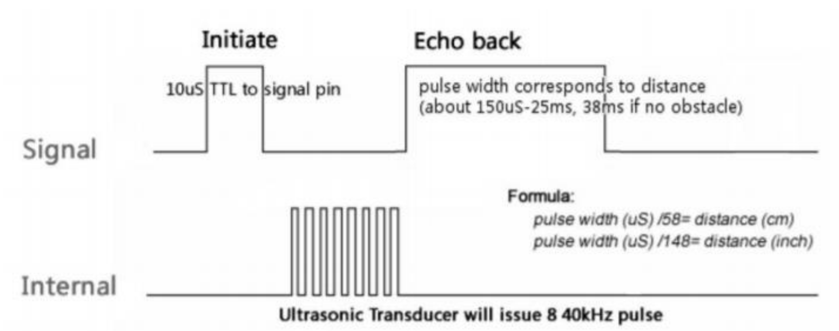

Figure 7: Ultrasonic Sensor Timing Diagram

The sensor will be receiving power from the voltage regulator and the TRIG and ECHO pins on the sensor will be connected to the PWM (Pulse Width Modulation) pins on the ESP32 [4] .

Requirements	Verification

The sensor must be able to measure the distance from 1.5 feet to 7 inches.	The sensor will be tried by measuring distances that are already measured with a measuring tape.

Table 8: R&V Ultrasonic sensor

The sensor must be able to work with the measures, but what we really want from the sensor is to be able to detect whenever the distance is 7 inches or less. For that purpose, the algorithm used will be as shown in Figure 6:

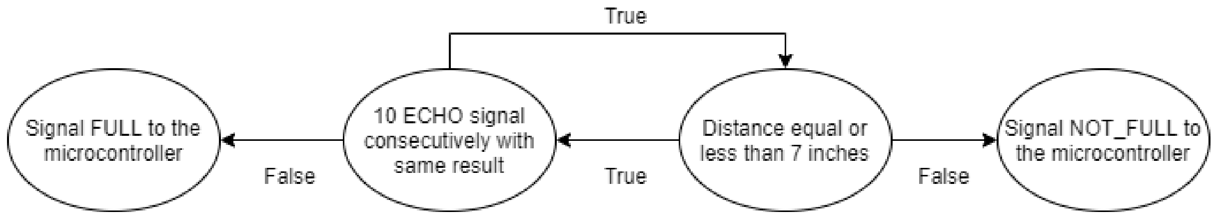

Figure 8: Ultrasonic Sensor Algorithm Flowchart

A.4 Camera Module

A.4.1. IP Camera

The cameras that are going to be used need to be IP cameras. They don't necessarily need to be wireless, because they don't have to be moved, but they must be able to connect via Wi-Fi to the computer (with a router). These cameras need to have enough quality so our code can successfully identify a person.

Requirements	Verification
The camera must be capable of recording at an angle of at least 120 degrees	Once the camera is working, two different objects will be placed within 120 degrees, and we will prove that both objects are detected by the camera by sending video data to the computer over Wi-Fi and viewing it on the computer screen.
2. The camera must send data at a rate of at least 20 fps	To test the camera, we will set it up to connect with the power and Wi-Fi, and

Table 9: R&V IP Camera

A.5 Wi-Fi Module

A.5.1 Router

The router will be used to connect the IP cameras and the microcontroller to the main computer, and send information back and forth between them. This won't have to be bought, because the camera should work with the router device in any apartment. This router must be able to receive 6 different signals.

Requirements	Verification
It must be able to receive 6 different signals (3 from the sensors and 3 from the cameras) and send them to the computer.	This can be verified with test runs by sending dummy data from the 3 sensors and 3 cameras to the computer and verifying that they are received after everything is settled up.

Table 10: R&V Router

A.6 Processing Module

A.6.1 Main Computer

The computer will be responsible for processing all the data coming from the camera, via Wi-Fi, and all the sensor information, that is also transmitted via Wi-Fi. It will run video and image processing algorithms to detect the unwanted objects, happenings or people in the apartment. This computer will be also responsible for running the script (HTML, CSS, JavaScript) which will hold all the Client-Server communications, acting as a back end.

Requirements	Verification
1. The computer must have enough processing power to run and process all the video data by running image processing algorithms (4.9 GHz frequency and 8 GB RAM minimum) 2. The computer must be able to connect to the internet so it can receive all the data from the microcontroller and the video from the IP Cameras.	1. Check if our main PC components have enough processing power and RAM available by checking the specifications on a laptop running a reliable processor, such as Intel i7 2. Check if our main PC is able to connect to the internet by connecting to different webpages, after completing the required Wi-Fi setup.

Table 11: R&V Main Computer

A.6.2 Server

The server will hold all the database access and handle all the database requestss from the client side. The database will be updated every time a task is completed, and it will be updated from the main computer we talked before

Requirements	Verification
Minimum disk space of 2GB The server should be secure and all information should be protected	1. Buy enough memory or verify that the computer has it already. Use passwords in order to access the server.

Table 12: R&V Server

A.6.3 MySQL Database

The database acts as storage for all of the data coming from the sensors. Via Wi-Fi, an Arduino based microcontroller can directly push data to a database. Databases are a method of organizing data records and SQL is an implementation of the former that allows a user to obtain many records with a single command. SQL is attractive to a large array of problems due to this functionality, and is essential for our goal of visualizing statistical information.

Requirements	Verification
The database must be able to either receive or send at least 15 bytes (mean length of a human name 15 chars)	1. We will test this with a computer by sending requests to the server.

Table 13: R&V MySQL Database

A.7 Client Module

A.7.1 User Device (Client Side)

This will consist of every device with an internet connection that will access the web page. The updates will be made on the back-end side, and will be shown on this side (front-end).

Requirements	Verification
The devices need to have Wi-Fi on them and they have to be able to connect to the internet.	1. We will check this by loading a simple web page (eg: google.com) on the devices

Table 14: R&V User device