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Parking Governing System: A Cost-Effective Modular Approach

Kasiviswanathan Srikant Iyer

Assistant System Engineer at Tata Consultancy Services, Noida, Uttar Pradesh, India

Abstract: In the 21st century, we have observed a boom in the number of vehicles owned by people, but this sudden surge of automobiles led to the challenge of creating suitable parking and their maintenance. Although the parking of these vehicles was managed initially by manual labour, at this point of time it is a daunting task especially when the parking of these vehicles spans over multiple floors and every nook and cranny needs to be allocated specifically for the vehicles types and needs.

With the emergence of electric vehicle all around the word in an effort to save the planet parking lots are being modified to accommodate charging ports for such vehicles and this would be a great time to inculcate additional features and controls to the parking to greatly reduce the reliance of humans and have a record of every activity happening inside the parking area.

Although some limited number of parking lots have basic levels of electronic governance, an upgrade to fully monitored system is a much-needed change. As we have a responsibility to reduce wastage, it would also be wise to add on more features on top of the existing system without compromising efficiency while reducing the cost of products significantly. Therefore, choosing a modular approach is the wisest decision as when required more features could be added and older features could be removed from it without the need to remake the whole system.

The main objective of this study is shed some light on the possibilities of improving such a system by adding more features and exploring possibilities for specified needs. The above mentioned would be aimed for while keeping in conditions like energy efficiency, cost efficiency and feasibility. In this study, the application would consider multiple real life factors using sensors like PIR(Passive infrared), Ultra-Sonic sensor, cameras etc and the compiled result would be used to help run the setup while notifying drives when needed using actuators like buzzer, lights etc. As the functionality of the application is unlimited, it would greatly benefit if it is connected to the internet, but even without the connectivity, it could be a self-reliant system which is able to perform its tasks in real time.

Keywords: Parking automation, IOT, Raspberry Pi, Grid System, Arduino, Modular.

I. INTRODUCTION

A Parking lot management system is a system designed such that the human effort in managing the issues related to parking and maintenance are reduced substantially. This type of system may exist offline as well as online. An electronic version of such a system will enable us to automate the process with minimal human intervention. This experiment will be using commonplace IOT devices to demonstrate how such a system could be constructed without the need to overcomplicate the system. The signals of the sensors will be compiled and processed by a computer system which will allow it to efficiently manage cars parking. There are many components of parking that are to be taken into consideration like number of vehicles, duration of stay, malicious intent of driver etc. All these data may be derived directly or indirectly from the sensors present in the system.

II. MATERIAL AND METHORD

To carry out this study, any computer with basic computational power of handling a GUI would be enough to be an effective centre of command. To demonstrate this, we would be using an older version of the cheapest system available in the market. A Raspberry Pi with Ultrasonic sensor, PIR, Photoresistor and camera module would be used to observe, while LED lights and buzzers would be the outputs of the system. Although this study is using only one of these to demonstrate the functionalities, a grid of all the above-mentioned sensors and actuators would comprise of the system and that data can be interpreted by an Arduino before being conveyed to the Raspberry Pi. It is to be noted that as this is an expandable idea, many more features could be added along with many more hardware upgrades, some of them would be considered here, but the potential is endless.

Raspberry Pi:

Raspberry Pi a product of the Raspberry Pi Foundation in England was initially designed to provide cheap and usable computers to developing countries for teaching and learning basic computer sciences. Due to its versatile features along

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with cheap price and strong processor for its budget, it has quickly become a favourite among hobby builders and IOT enthusiast. The Raspberry Pi 3B+ is one such product which has all the required features to build a system for our purposes. Although there are newer models available in the market, this would be a good place to start as it is a very well-known board and has been in use for a longer period of time which in turn has created a large community of Raspberry Pi 3B+ users online who come together to solve problems when presented, along with the vast amount of resources available to its users. A Raspberry Pi 3 B+ is shown in Fig 1 below. No other peripherals are required to run this credit card sized board, but many of them could be added as per the requirement of its user. The specifications of the Raspberry Pi 3 B+ are as follows:

- A 1.4GHz Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoCi
- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2 and BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- 40 GPIO pin headers
- 4 USB 2.0 ports
- Micro SD port for loading your operating system and storing data

Fig. 1 Raspberry Pi

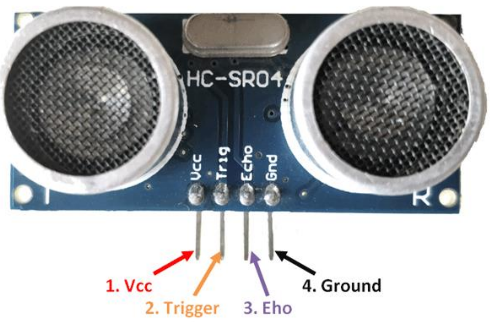

Fig. 2 Ultrasonic Sensor

Ultrasonic Sensor: An Ultrasonic sensor (as shown in Fig 2) is a device which may be used to measure the proximity of any object from the sensor itself. The working of the device may be simplified by breaking it down it into 3 main parts:

- The transmitter uses a piezoelectric crystal to produce sound waves that are directed towards the object to be measured
- A receiver which receives the sound waves that has bounced off the object
- The sensors internal calculator which calculates the time taken between transmission and receiving of the sound wave

As we know the speed of sound the sensor is able to calculate the distance travel by the sound waves by the formula D=1/2 T * C (Where D is the distance, T is the time taken and C is the speed of sound assuming the speed of sound to be ~343 m/s). Although we might not be to calculate the distance perfectly, it will give us an approximation on how far the vehicle might be. An ultrasonic sensor can produce analogue or digital signals and can be triggered when necessary. As this sensor used to check if the vehicle is parked in its position, we would not require its analogue signals.

PIR Sensor: IR sensors or "Passive Infrared" sensors are a cheap and effective way of checking if an object has moved in and out of its range. Due to its long life it can be found in countless home automation appliances like smart bulbs and home security systems. The sensor is made of pyroelectric sensor which can be observed as the rectangular piece on the centre of the dome in Fig 3. There are 2 layers which cancel each other out, so when some object enters its range, it can detect the difference between the 2 layers and alert us. The difference in the 2 layers is observable as the layers detect IR rays. Every object emits some level of IR frequencies, specially heat like the heat produced by a human body. Sensitivity of such a sensor can be individually set as per the use of it. The output signal of such a device is always digital as it is unable to provide additional details like detecting the direction or size of the object.

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Fig. 3 PIR sensor

Fig. 4 Camera Module

Camera: Although a well-known sensor, a camera may come in different shape and forms to perform different tasks like the one shown in Fig 4. The working of the camera is by accepting light through a convex lens before capturing the image onto a photosensitive medium. The task of capturing an image usually of the visual spectrum can be performed by the camera module, but camera with additional features like IR camera, heat vision and night vison are also available. The image captures by the camera is electronically stored and processed either on the sensor or externally depending on the complexity of the camera. A continuous stream of photos may be stored onto the memory to form a video feed, but as a continuous video feed requires multiple pictures the camera and processing modules need to be fast enough to write and read data at the same time to make it happen. As the data from the camera requires a lot of memory, usually only the important images are stored, but as memory in recent years have gotten cheaper and efficient it is quite common to store large number of images or continuous videos for security reasons.

Photoresistor: A photoresistor module (shown in Fig 5) also known as “light sensitive resistor” is a sensor which detects the presence of light in front of it. It works on the principal of photoconductivity. The photoresistor’s sensitive surface is able to detect light and reduces the resistance with respect to the amount of light in front of it. As a photoresistor is a passive component, it does not waste energy when not in use. The material used in the photoresistor may be an intrinsic or an extrinsic semiconductor. In both conditions, the photos from the light needs to have enough energy to excite the electrons across the band gap. As the resistance changes with respect to lumens, the photoresistor produces analogue output, but we could predefine a value above which the light is considered on or off thereby using it as a digital sensor.

Fig. 5 Photoresistor

Fig. 6 LED

LED: A LED or “Light Emitting Diode” is a semiconductor which can produce light when a current pass through it. The current that passes through the LED releases photos when the electrons are recombined with the electron holes in the semiconductor. The energy required for the electrons to cross the band gap determines the colour outputted by the led. The wavelength of light emitted for the led may range from 360 to 950 nm and can be used to produce lights in UV, visible and IR ranges. Led like the one shown in Fig 6 are common and are used extensively in IOT projects.

Buzzer: A buzzer, also known as a beeper (Fig 7), is a device that can produce an audio output when current is run through it. The buzzer is often used to notify the user of some occurrence. A common example of a buzzer is an alarm. The buzzer works by being attracted and repelled from its magnet pole created by an oscillating magnetic field. The vibrations are at such a frequency that a sound is produced.

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Fig. 7 Buzzer

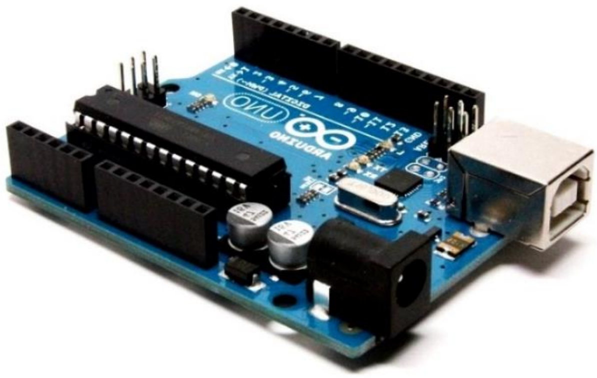

Fig. 8 Arduino

Arduino: An opensource single board microcontroller which is used in countless IOT projects. It can be programmed to perform a task along with receiving signals from sensors and sending information to its actuators. Its code is pretty like C and Arduino IDE can be used to include many libraries made specifically for every possible combinations of devices attached to it. Arduino (Fig 8) can be paired with multiple shields to extend the uses beyond its hardware capabilities. Although an Arduino is an open source design and there are many multiple designs available in the marker, these are a few features that can be found on a board:

- A ATmega328 microcontroller
- 14 digital IO pins
- 6 analogue pins
- 5V to operate

As this design depends heavily on the hardware components along with the basic software components, the placement and connections of the hardware will be of utmost importance. The system is designed to eliminate the presence of human assistance as much as possible, so that would include all the tasks from assisting in parking to identifying potential issues that may lead to accidents inside the parking lot. Along with this, this system would need to save energy.

A. Hardware Placement

The placement of the sensors along with their uses will be as follows:

i. Photoresistor- The photoresistor would be placed on the ground, facing the sealing (Green dot on Fig 9). Thereby if any object like a car could cast a shadow on it. Thereby when there is a shadow on the parking spot the system can assume that a car is parked on it.

ii. Ultrasonic Sensor- An ultrasonic sensor would be placed on the wall 2 feet from the ground (Purple dot on Fig 9), at which level it would be able to see the distance of the car from the wall. It would be of concern if the car is parked too far away from the wall, as it would lead to potential accidents and if the car is brought too near the wall, there is a possibility of the driver damaging their own vehicle.

iii. PIR- As the parking lot is not a social location and would not be in used all the time. So, it is unwise to use all the lights of the parking space. To save energy a PIR grid would be placed on the grid corners to detect movement, and when the lot is in use by someone, the lights would turn themselves on.

iv. Camera- Cameras would be placed at strategic point so that every vehicle is in sight, along with all entrances and exits to have a record of comings and goings of vehicles. While the cameras do not need to be fancy, the entrance and exit cameras need to be sharp enough to uniquely identify the vehicle, and if need be, sharp enough to perform image recognition.

v. LED: Bright red LEDs should be placed over every parking spot (Red spot on Fig 9) to notify the driver if there is an empty space for them to park in. This would reduce the need for the user to drive around, looking for a free space.

vi. Buzzer- Will be placed next to the Ultrasonic sensor (Pink dot on Fig 9) to notify the user if he is too close or too far from the desired spot. Along with this there shall also be a buzzer present with the attendant to notify him of any issues that the system cannot handle or understand.

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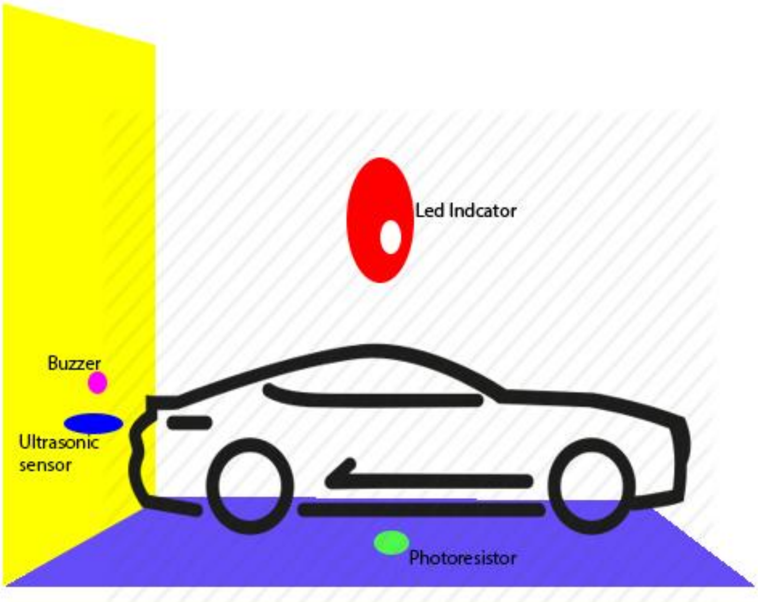

Fig. 9 Hardware placement

The other hardwires may be located at any location if the data is transmittable and thereby do not warrant a specific location.

B. Connections to system

As mentioned, the sensors are the same for every parking location and thereby need to be arranged in a grid system like in Fig 10. As connecting each sensor to the system is not feasible, the sensors will be connected to an Arduino and Arduinos working in pairs will determine the location of the lot and pass on that data to the system (in this case the Raspberry Pi). Similarly, the actuators will be triggered by the system through the Arduinos. It is a wise decision to use a WIFI module like an ESP8266 to transfer data between the system and Arduino which would prevent clusters of wires going to and from the system from each Arduino. In the figure below the data from 2 Arduinos will help the Raspberry Pi determine the location of the notification or changes to be made. Each intersection of Arduinos is a parking space and is automated to manage a parked car. For example, if the space represented by the circle is to send information, Arduino 4 and Arduino C will receive the signal, this would help us identify the spot as no other place activates both Arduinos. Similarly, if D2 is being called the space marked with a square will be activates as it is uniquely identified by the 2 Arduinos.

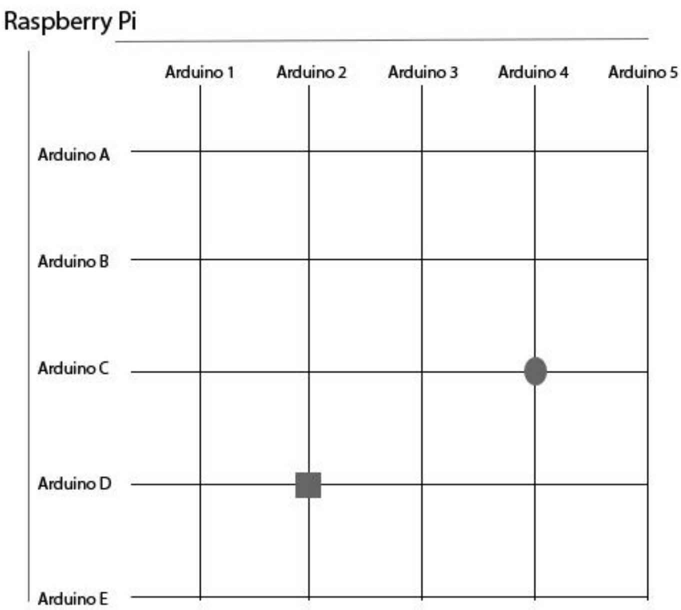

Fig. 10 Connections

C. Actions

For every scenario of sensors different action might need to be taken into consideration so as to most efficiently make this system work. Every sensor is followed by the tasks it would trigger.

1) Ultrasonic sensor- once the distance is measured if the distance is
    a) Too far: This means the vehicle is outside the bounds of the designated parking area and might hit the moving vehicles so
        i) The buzzer will keep buzzing
        ii) The LED above will blink
        iii) If the car has not been moved correctly in 1 minute, the on-duty staff will be alerted
    b) Too close: This means the vehicle might hit the wall and
        i) Buzzer will beep to alert the closeness and the frequency of the beeping will increase as the vehicle comes dangerously close
        ii) If the distance is 0 ie the vehicle has hit the wall, the cameras will store the data permanently for liability
        iii) The on-duty staff will be notified.
2) The Photo resistor will be in shade when a vehicle is over it so
    a) If the photoresistor does not get any light
        i) The LED above will turn off to indicate occupied
        ii) The location will be marked as in use to tally the counter between entry and parked cars
    b) If the light re appears
        i) The LED above will turn back on to notify that the space is vacant fpr further cars to park
        ii) A car would be expected to leave the lot
3) The PIR would be triggered as soon as there is movement detected so
    a) If there is no movement the PIR would return false
        i) All the lights of the parking lot would be turned off
        ii) Only the important cameras would keep recording to save memory
        iii) The sensors can be inactive during this time
    b) If there is movement detected the PIR would return true
        i) The lights of 2 rows and columns surrounding the PIR would be turned on
        ii) All the sensors in this area would also be triggered on
        iii) All the cameras facing this direction would be active
4) When the number of vehicles increase or decrease
    a) During entry
        i) The vehicle count is increased
        ii) A parking spot needs to be in use within 5 mins or an alarm is triggered
        iii) If the lot is at full entry will be not allowed
    b) During exit
        i) The vehicle count is decreased
        ii) A parking spot is expected to be emptied just before this, if not, an alarm will be triggered
        iii) If the lot is empty, no vehicle should exit.

III. RESULTS AND DISCUSSIONS

Even though the system contains 2 parts, namely hardware and software they are so directly related that they work in pairs. These are some points to be considered with this system.

- This is a 24*7 system so the system needs to be taken offline in parts for maintenance
- As the system has no closed ends it can be extended on all directions
- As the grid has many more ports available in the form of physical as well as online connections other features like speed checker and image recognition can be added later
- More effective modes of grid system can be achieved through designated hardware instead of multiple arduous.

The circuit diagram of the system can be represented as below

Use Case Diagram: As observed in Figure 11, almost every component is connected to the Arduino, but it's important to realize that although all the data is passes through the multiple Arduinos the data is being sent to and processed at the Raspberry Pi. Still calling Arduino just a repeater would be an understatement as it adds its unique identifier to the data to and from the sensors which enables us to determine the location of the sensors. As mentioned before the raspberry pi should be able to attach itself to preexisting system and work along with it. If any sensors are not to be used, they can simply be removed without the need to modify the complete system. In the figure below the user (in this case the driver) would directly affect the output of the sensors which pass on the data to the raspberry pi through Arduino. A manual

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overwrite switch will be given to the on-duty staff if any decision made by the system needs a human intervention. The details of the decisions taken along with the camera feed would be visible to the on-duty staff through the screen provided.

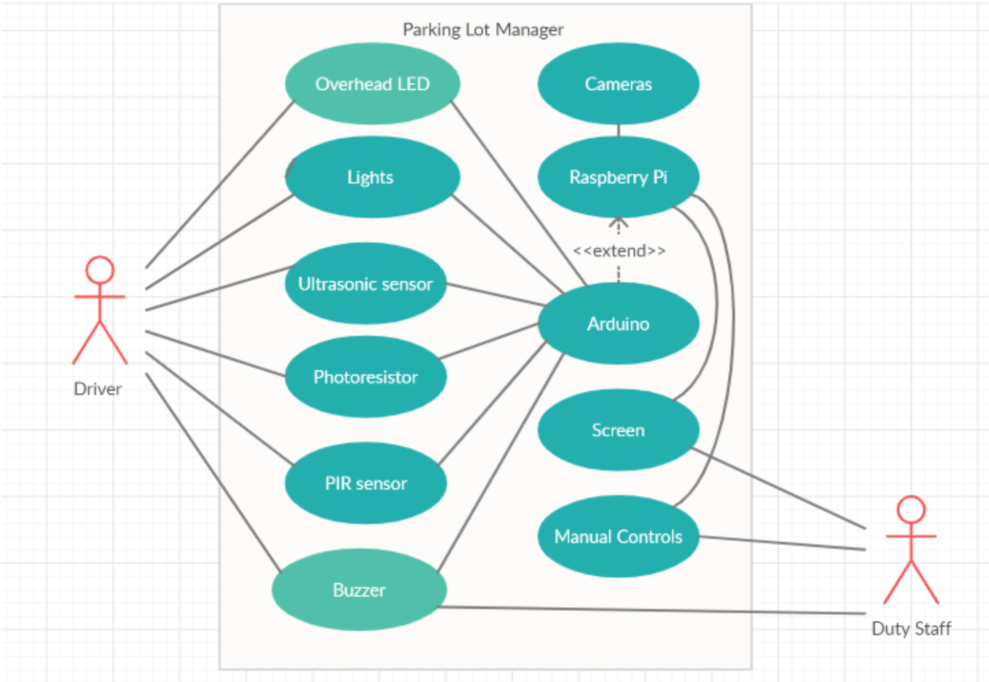

Fig. 11 Use Case Diagram

Component diagram: The component diagram (Fig 12) shows the connections between the systems and how many devices are connected to each other. As seen below, there are multiple sensors connected to multiple Arduino as they form the grid, but all the Arduinos connect to only 1 raspberry (abcee) Pi as 1 system is enough to study the data and compile them to give instructions on how to run the grid. The multiple cameras are also connected to the Raspberry Pi and 1 or more screen may be attached to the Raspberry Pi to observe the workings through a GUI for the system.

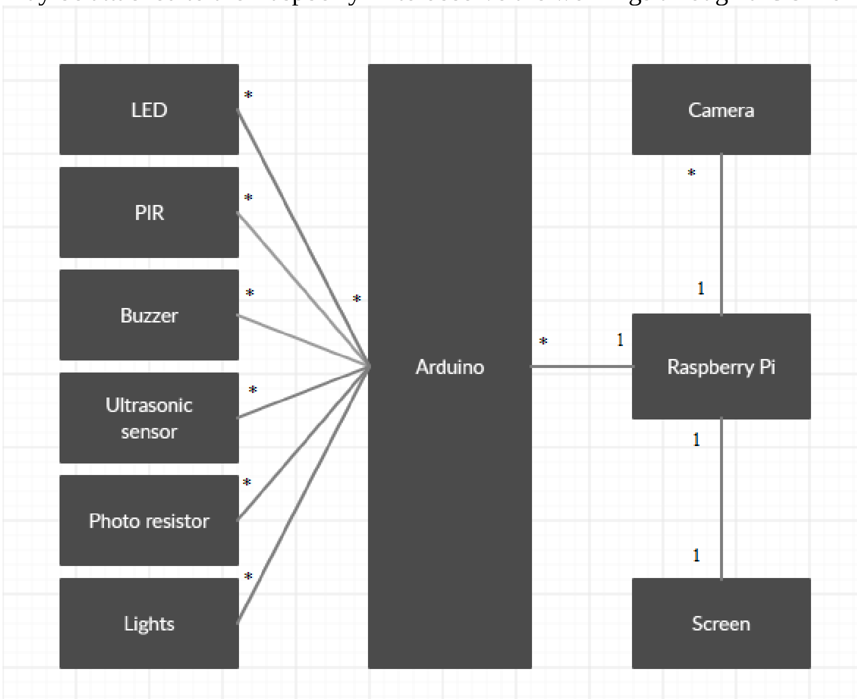

Fig. 12 Component Diagram

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IV. CONCLUSION

The system presented is quick to response and reliable due to its dependence on offline and hardware components, but a system with online connectivity would be able to get additional advantages like predicting the rush hours and accommodating for weather conditions for example priorities scheduling indoor parking on rainy or snowy days. Along with this the addition of all the other components talked about in this project may be done over a local area network or the internet instead of relying on physical GRIO pins being available on the Raspberry Pi. These are some of the points that are of importance that needs to be discussed about this project.

- This system indicated how a complicated system can be simplified down to basics.
- Although the components in this project are basic and how to connect is explained, such many devices may need a more professional approach.
- Although the software aspects of the paper were not discussed in this paper, it would be a very important part of the system.
- The software for this system may be minimalistic, but also has the potential to include many more features from the information received from the sensors.
- Due to being mostly passive and only activated by PIR this system will save a lot of energy as compared to existing system.
- This system can be made very cost effectively due to the face that most of the parts are relatively cheap due to them being favorites of hobbyists.
- Any future design would greatly benefit due to its modular nature and careful design.

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BIOGRAPHY

Kasiviswanathan Srikant Iyer B. Tech in Computer Science and Engineering (2015-2019) from SRM Institute of Science and Technology, Chennai, India. Currently working as Assistant system engineer at Tata Consultancy Services. A hard worker with a thirst for learning and understand of the world around. With an aptitude for coding and a passion for building working things, his projects maily revolved around IOT and machine learning.