# Self-Sufficient Surveillance System

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelors of Engineering in Mechanical Engineering

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## FINAL YEAR PROJECT REPORT

We hereby recommend that the dissertation prepared under our supervision by: { Jawad Ahmad 2011-NUST-SMME-BE-ME-30; Muhammad Qayyum NUST201200980; Saram Ali NUST201201348} Titled: Self-Sufficient Surveillance System be accepted in partial fulfillment of the requirements for the award of Bachelors of Engineering in Mechanical Engineering degree with ( B+ grade)

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# Declaration

I/We certify that this research work titled "*Self-Sufficient Surveillance System*" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.


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# Copyright Statement

*Dedicated to our parents*

# Acknowledgments

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# Abstract

Our design was to develop a Sustainable Standalone surveillance system which will be able to produce its own power through renewable source and able to process and perform different operations in real time (Pattern recognition, abnormal behaviour detection etc.) as required by the user and relay that information back to the customer remotely using the principle for Internet of Thing devices.

To Make Tomorrow Better for a Pakistani, It’s essential they could feel more secure about life & property. Developed countries have made this possible through a network of security and easily available home surveillance systems but they could not be applied in Pakistan due to their high cost, complexities and the frequent outages of power in Pakistan.

As of June 2016, the shortfall of Electricity generation has exceeded 4000MW which renders the 24/7 operating condition for surveillance system ineffective; whereas The average Solar Insolation 6 kwh/m$^2$/day exists in the region with persistence factor of about 90%. Most of the parts of the region are extraordinary places for harnessing Solar power with more than 2200 hrs per annum. [1]

The most important task was to develop a system which could be standalone and sustainable at the same time, with the processing power to analyse the feed able to differentiate between different picture frames and send the abnormal detections to the user remotely.

Keywords: Solar, Raspberry Pi, Motion detection

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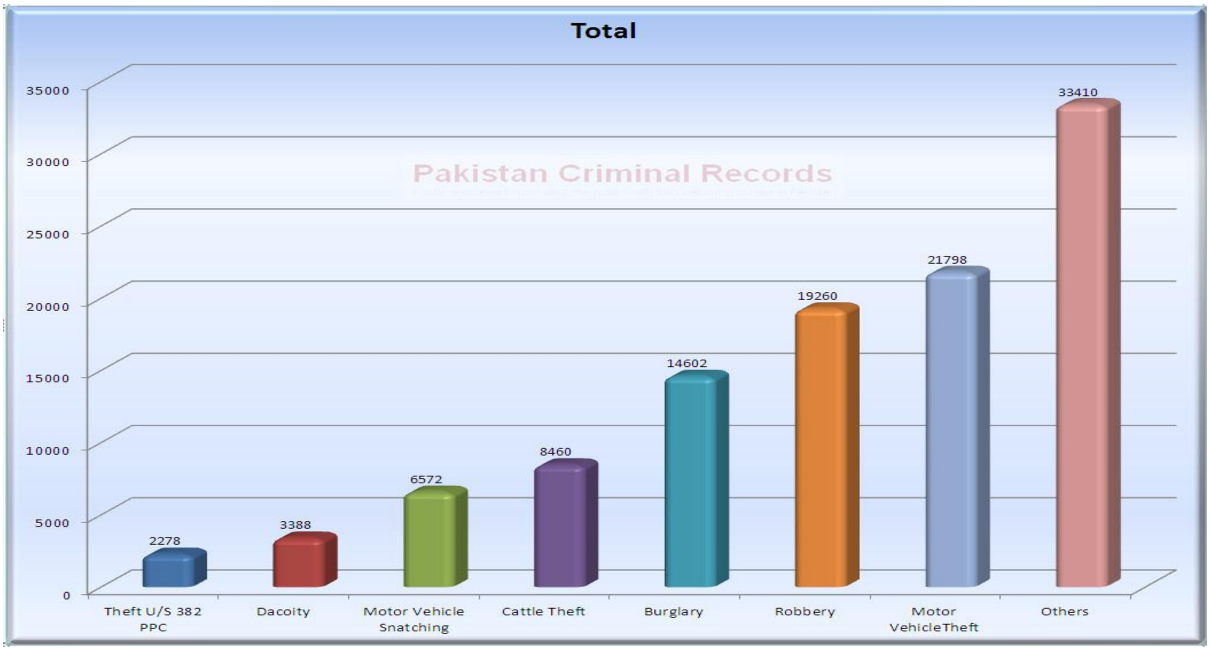
# Chapter 1 Introduction

## 1.1 Brief Background

Pakistan's precarious security and energy conditions have left hundreds of thousands of people affected with many millions in a state of distress. Security & Surveillance have become the most important tasks to ensure the safety of the life & property of citizens of any country. With the difficulty of finding evidences against the culprits, any smart surveillance is able to provide the material able to find the justice for the victims.

Security of Human life and property have always been of utmost importance in every age, and every age has played its part in bringing more secure life to the human beings and their properties. But as the times are changing the burglars, terrorist, cheaters etc. have found new and challenging ways to bypass the established system. As the contemporary way to stop these acts have been by applying a digital video recording (DVR) systems, but as these systems require long hours of labor to monitor and provide loopholes to the cheat actors to do their job, they are rendered to be helpless in these times. Thus, we need to develop a system which is not only automated but also sustainable and standalone.

Now a days Pakistan have different type of security risks ranging from cattle theft to burglaries, motor thefts terrorists sneak out etc. So we need a system that could effectively tackle all these activities and provide solutions to the customers. For Example cattle theft could be easily reduced by creating a no man's area around the cattle by employing our system and the customer would be alerted if there's someone present who shouldn't be. Following is a table showing different crimes and their frequencies.




(Fig 1-1- Statistical Crime Chart)

From the above criminal records of the graph it can be observed easily that the major share of crimes is of Burglary , Robbery & Motor Vehicle Theft. By installing a video surveillance system these crimes can be reduced significantly.

Machine learning and understanding of human actions is a challenging area that has received much attention within the past years. Video Surveillance is one of the active research topics in Image Processing. Video Surveillance started with analogue CCTV systems, to gather information and to monitor people, events and activities. Existing digital video surveillance systems provide the infrastructure only to capture, store and distribute video, while leaving the task of threat detection exclusively to human operators. Human monitoring of surveillance video is a very labor-intensive task. Detecting multiple activities in real-time video is difficult in manual analysis. Thus the Intelligent video surveillance system is emerged. The analytics software processes video flow images to automatically detect objects (peoples, equipments, vehicles) and event of interest for security purposes. In real time, video surveillance systems detect situations in video flow that represent a security threat and trigger an alarm. Observing or analyzing a particular site for safety and business purposes is known as video surveillance. Security and crime control concerns are the motivating factors for the deployment of video surveillance cameras. Video surveillance cameras are used in shopping centres, public places, banking institutions, companies and ATM machines. Nowadays, researches experience continuous growth in network surveillance. The reason being is the instability incidents that are happening all around the world. Therefore, there is a need of a smart surveillance system for intelligent monitoring that captures data in real time, transmits, processes and understands the information related to those monitored. The video data can be used as a forensic tool for after-crime inspection. Hence, these systems ensure high level of security at public places which is usually an extremely complex challenge. As video cameras are available at good price in the market, hence video surveillance systems have become more popular. Video surveillance systems have wide range of applications like traffic monitoring and human activity understanding. In video surveillance system we demonstrate a system which analyses activity in the monitored space in real time, and makes the events available for generating real time alerts and content based searching in real time.

## 1.1 Objective:

The main purpose of this system is to improve the awareness of security personal and decision makers by collecting real-time information automatically. The system raises an alarm whenever unacceptable movements are detected. Hence, the system has the ability to detect mobile objects in the scene and to classify their movements (as allowed or disallowed). Wann-Yun Shieh(Wann-Yun Shiehet al., 2009) proposed a human-shape-based falling algorithm and this algorithm was implemented in a multicamera video surveillance system. The algorithm is implemented in real world environment for functionality proof. In this algorithm, multiple cameras are used to fetch the images from different regions required to monitor. A falling-pattern recognition approach is used to determine if an accidental falling has occurred. Also, in that case a short message will be sent to someone who needs to be alerted. Hae-Min Moon(Hae-Min Moonet al.,2010) [2 ]proposed the system on human identification method that uses height and clothing-colour information appropriate for the intelligent video surveillance system based on smartcard. Reliable feature information can be obtained using the smartcard. It uses octree-based colour quantization technique to the clothing region for colour extraction and height is extracted from the geometrical information of the images. The similarities between the two images are compared based on the Euclidean distance.

## 1.2 Applications:

Here are some benefits/uses of video surveillance for your business.

- Increase overall security and safety – Security cameras positioned throughout a business help to prevent crimes and break-ins.
- Improve worker productivity – The presence of surveillance cameras on the premises can improve communication between departments or buildings, allowing for heightened productivity.
- Prevent dishonest claims – In instances where employees or visitors falsely attest to injuring themselves on your property, visual evidence from the facility's security cameras can disprove such assertions, saving the hospital from pricey unwarranted insurance claims.
- Resolve employee disputes – Employee disputes are easily resolved when clear visual proof is available. Surveillance cameras can shed light on incidents in question.
- Continuous real-time monitoring – IP surveillance allows authorized employees to monitor critical areas continuously, in real time, from their personal computers.
- Digital storage – Business that chooses to install IP-based video surveillance systems can take advantage of the benefits of digital storage. IP systems enable the user to store recorded footage digitally on network servers, hard-drives or NVRs, where the surveillance video is easily accessible to authorized users, and offers improved searching capabilities.
- Visual evidence for investigations – Surveillance cameras can provide invaluable visual evidence for investigations of criminal activity and other specific events that have taken place within or around facilities.
- Remote video monitoring – Remote monitoring is an extremely helpful tool. IP surveillance allows your employees to view security camera footage remotely from any PC with network access. Multiple sites can even communicate over the same network with all of the camera views accessible online via the Internet.
- Prevent theft – Prominently placed security cameras can help deter potential thieves and identify those who do steal.
- Improve image – The presence of a security system shows your customers that you care about their security and can improve their shopping experience.
- Safety – Not only do cameras help you maintain safety around your business, they also discourage misbehavior. Conspicuously placed cameras have been shown to reduce threats of violence and vandalism drastically.
- Visitor monitoring – One problem many business continually struggle with is proper access control for visitors. Security cameras at entrance doors can help your administrative staff monitor visitors and make sure they are properly signed in.
- Crowd control – Large crowds can get testy. It takes a strong security effort to maintain order so the spirit of an event isn't overshadowed by violence and disruptive behavior. A video surveillance network can play a significant role by providing

security workers with clear views of the action, and the ability to focus in on specific scenes and individuals.

- Safe entry and exit – When a hefty mass of people gets together for an event, entrances and exits can get bottled up with everyone trying to get to the same place at the same time. Video surveillance around these areas helps in lessening the impact of interruptions and disturbances for those coming and going.
- Building/venue security – Surveillance cameras monitoring restricted access areas can help to ensure that only registered guests and staff members gain entry to specific areas of a facility.

# Chapter 2 Literature Review

## 2.1 Prevalent surveillance systems

In the first part of this overview a number of the most popular commercial intelligent surveillance systems is described. Main solutions which were identified in extensive research of the market as well as systems developed by ADDPRIV Partners in the past, are included. Subsequently, several so called smart surveillance cameras with integrated visual processing modules are presented. This description is followed by an introduction to similar security related projects. The specifications which are discussed in the following sections contain a number of quotations from producer's technical specifications, advertising materials and other descriptions. To improve clarity of this document, the quotation marks were omitted, thus the paragraphs containing a significant number of citations are shaded with grey background. However, it is assumed that all copyrights for the used descriptions are still owned by the companies or consortia related to the products and research projects named at the beginning of each subsection.

## 2.2 Commercial system solutions analysis

The solutions described in this section are devoted to commercial systems which involve automatic detection of defined events on the basis of video processing. This could be acquired either by supplied software or supporting it with some hardware. In general, such systems include several basic devices i.e. for data acquisition, conversion and storage. Additionally the end user software is delivered either as a web interface or more typically as a dedicated application simplifying the system maintenance and/or management. The video processing is implemented based on the advanced technologies which were developed by each company. In some cases, black box devices are offered where each camera (one or more) is plugged in. Alternatively, dedicated high performance servers are delivered to support multiple video streams analysis. The descriptions for several chosen products are shown in the following subsections. They include general system features as well as various system configurations.

### 2.2.1 GeoVision

Company website: http://www.geovision.com.tw

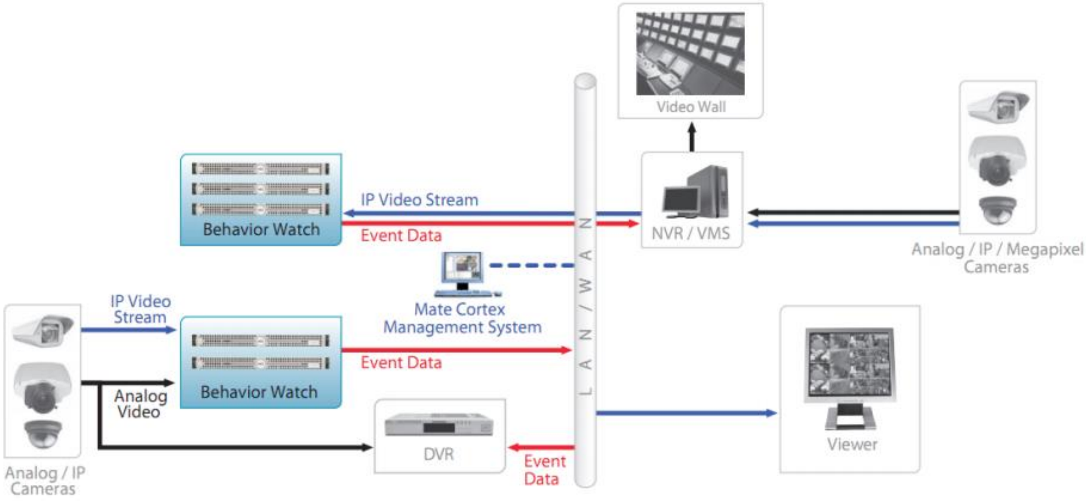

(Figure 2-1- Geovision module)

GeoVision offers a diverse product line with industry-leading technologies:

- Digital Surveillance Systems ranging from the cost-effective 20 fps to the leading-edge 480 fps models, choices ranging from BNC to DSub, built-in to standalone I/O modules
- Continuous improvement of S/W, H/W compression technology to keep competition edge
- IP surveillance product line
- Integration of IT technology into surveillance system
- Video analysis features for surveillance system
- Digital Surveillance Systems with expandable supports to POS, Central Monitoring Station
- License Plate Recognition Systems
- Access control system
- A complete lineup of security accessories that help security professionals to deliver customized services to users as to the video analytics a wide range of functionality is introduced, including the following:
- Face detection
- People counting
- Unattended object detection
- Missing object detection
- Camera tampering detection
- Video stabilization
- Crowd detection

### 2.2.2 Mate

Company website: http://www.mate.co.il/




(Figure 2-2- Mate Flow chart)

A comprehensive package of integrated and highly scalable products that individually and together provide timely answers to the most pressing security issues:

- Ensuring that review time focuses on highly relevant, real-time events
- Overcoming human tendency toward losing vigilance over time
- Giving security personnel the means to deliver greater value
- Using highly automated and reliable technology
- Applying a system architecture with easy growth potential
- Transferring bi-directional data between remote sites and Control Center There are many places where an existing security infrastructure cannot be upgraded with smart on-site devices. The answer is to add this capability within the Control Center. The Behavior Watch collects all video surveillance content inputs and analyses it for potential access violations and other specified behaviors. Only those events of security value are then passed for human intervention. The Behavior Watch is equipped to handle a range of surveillance tasks. It detects the difference between video objects and tracks suspect human behavior. It provides a new level of intelligence that makes alerts more precise and relevant.

## 2.3 Commercial Solutions Analysis

Another approach to application of video analytics to surveillance systems is the employment of so called smart cameras. A smart camera is usually a regular camera equipped with an additional DSP module where video processing is performed. These two elements are typically integrated inside one enclosure. Such cameras can be used within already existing surveillance systems offering the human operator an additional information acquired from the video analytics module. Often, along with this solution producers deliver a dedicated software for the cameras, with an interface allowing communication with the user. In this way the operator can be adequately alerted by displaying additional information about current video stream.

### 2.3.1 Samsung Techwin

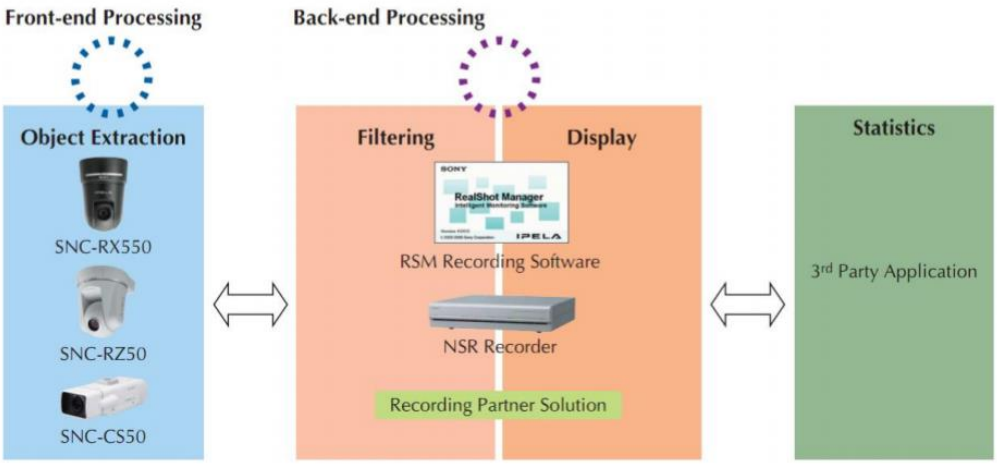
Company website: http://www.samsungtechwin.com/


(Figure 2-3- Samsung Techwin tracking module)

Samsung Techwin, world leading imaging technology plays an important role in protecting the safety and happiness of people by providing a comprehensive range of products and complete solutions ranging from city surveillance to the protection of streets, airports, ports, industrial facilities Military installations and B2C. Samsung Techwin sets a new benchmark in the domestic and international security market by providing higher quality, cleaner images and cutting edge network functions. Samsung Techwin aims to provide a one-stop security solution that meets the needs of users both now, and into the future, and is committed to becoming the world leading provider of professional security solutions.

### 2.3.2 Sony Distributed Enhanced Processing Architecture (DEPA)

Company website: oct09-sony-E_DEPA_whitepaper_Ver10_061221.pdf




(Figure 2-4- Sony DEPA proposed solutions)

Sony's distributed video analytics is named DEPA, Distributed Enhanced Processing Architecture. The DEPA design divides traditional processing into two separate tasks. Front-end processing is distributed to the endpoints of systems within cameras while back-end processing takes place at the recorder. Features: DEPA's Front-End Processing

- Distinguishes objects from environmental noise
- Detects moving and/or stationary objects
- Object information is converted into metadata and then transferred over the network.
- Receives and stores pre-processed object data from cameras
- Extracts objects that match the filtering condition set in recorder
- Displays information; creates alarm responses appropriate to specific conditions

## 2.4 Different System analysis Summary

Available and known commercial solutions from the area of smart video surveillance were presented in the previous sections. However, without direct access to trial version of systems, the detailed evaluation of their performances is out of the scope of this document. For this reason, these solutions are only briefly described to highlight some of the key characteristics of current state of the art solutions. The same methodology was applied for describing security related projects. Many of these projects are still ongoing, therefore most of their results are not available yet .Even if the results are available, the utilized methods efficiency is commonly assessed using different criteria to those that will concern the ADDPRIV project. Therefore, this overview is tending mainly to screen the concepts, researched during other security related projects.

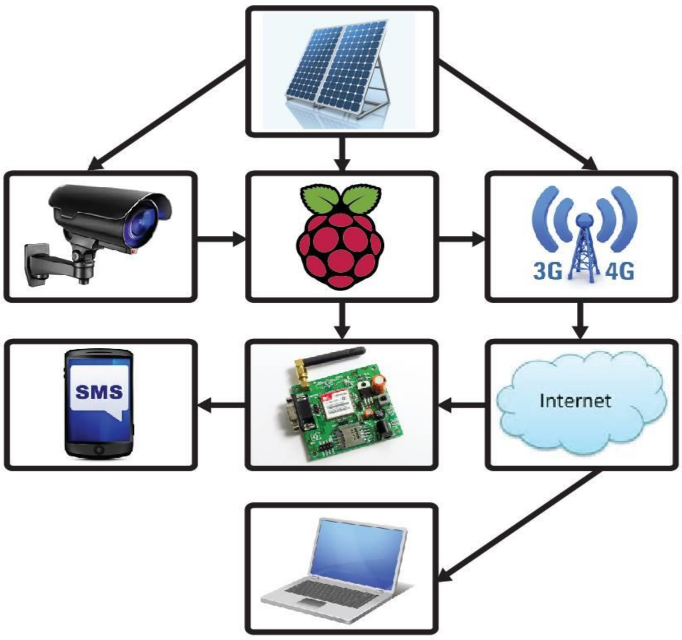
All of these mentioned projects are smart to an extent and all of them are not self-sufficient in terms of Power However there are some products in the market which are self-sufficient but those products are not smart you have to monitor all the coverage manually by man labor. So we need to design a System which is capable of some extra features like intelligent and self-sufficient etc.

# Chapter 3 Functionality, Design Components

As our aim is to design a surveillance system which is self-sufficient i.e. powered by solar means and smart enough to detect any unusual activity. So the very basic block diagram of our system is as follows

## 3.1 Basic Block Diagram

Following is a block diagram of the system.




(Figure 3-1- Block Diagram of the system)

The Diagram shows that a solar panel is used to power up Raspberry pi which is further connected to camera and Wi-Fi modules. Then the video feed is uploaded to an internet database which can be accessed from any smart device laptop or mobile.

The flow Chart of the system is as follows:

## 3.2 Flow Chart


(Figure 3-2- Flow Chart of the system)

We have further divided our system into 2 sub-systems.

- Self-Sufficient System
- Surveillance System

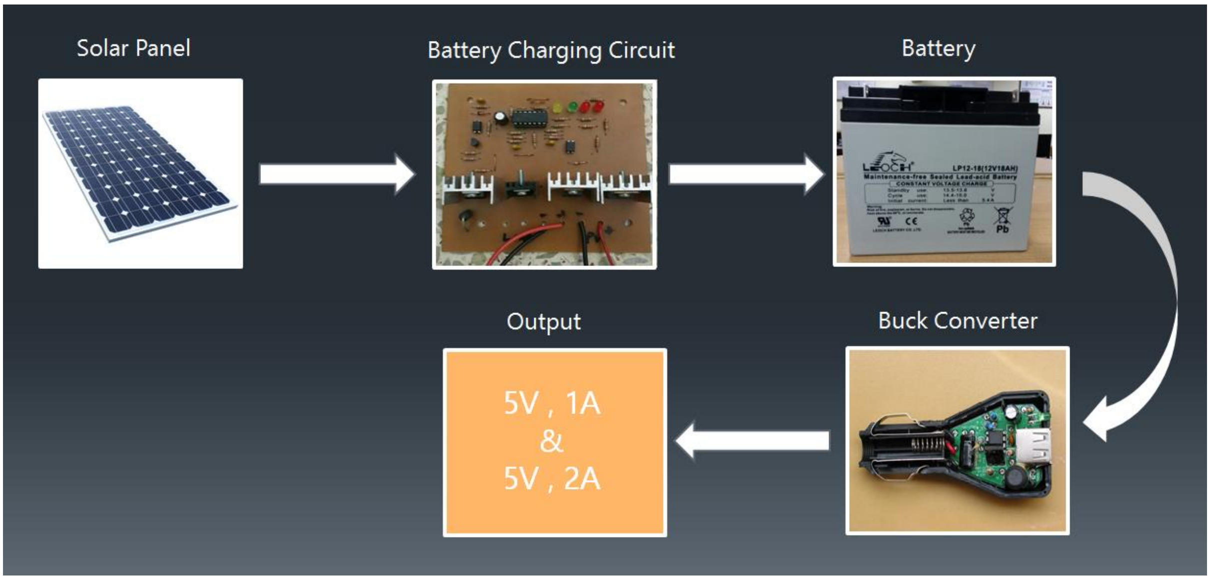
Self-Sufficient System includes that how the whole system is powered with the help of solar panel whereas the heart of surveillance part is raspberry pi which use a camera and Wi-Fi adapter to monitor and upload the data on internet and which can be accessed from anywhere.

## 3.3 Selected Hardware

| **Self-Sufficient System** | **Surveillance System** |
|---|---|
| Solar Panel | Raspberry Pi |
| Lead Acid Battery | Raspberry Pi Camera |
| Battery Charging Circuit | Wi-Fi USB Adapter |
| Buck Converter | GSM Module |

## 3.4 Self-Sufficient System

The Basic block diagram of our self-sufficient system is as following



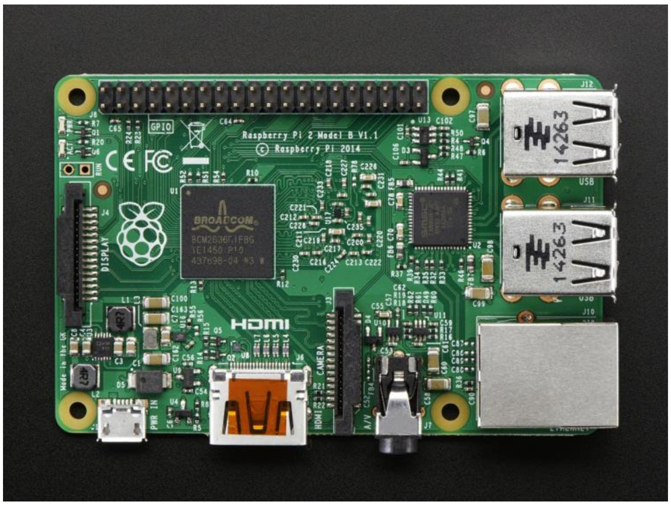

(Figure 3-3- Block Diagram of the Self-sufficient System)

The basic blocks of the above diagram are explained in the next section. The explanation includes why we used this hardware and how we managed to design them to get desired output.

## 3.5 Components Used (Surveillance)

- Raspberry Pi Model 2 B
- Pi Camera
- WiFi USB Adapter
- Zong 4G dongle

### 3.5.1 Raspberry Pi Model 2 B



(Figure 3-4- Raspberry Pi)

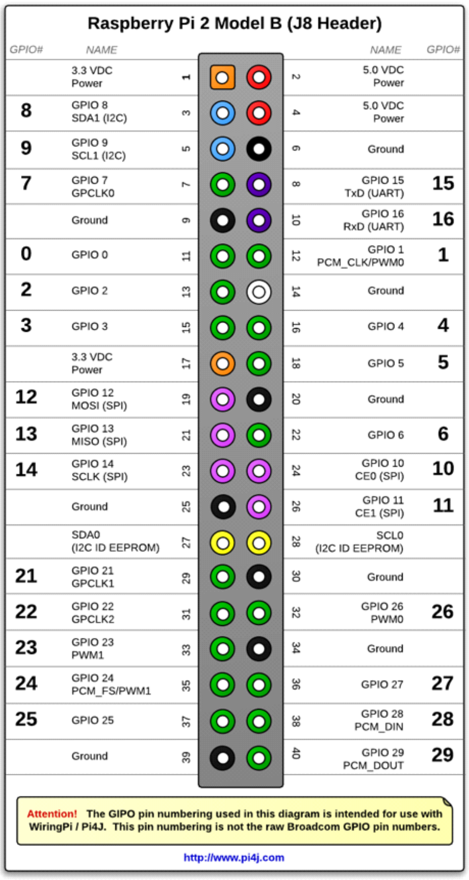
The Raspberry Pi is a series of credit card–sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation[3]

Technical Specifications

- Broadcom BCM2836 Arm7 Quad Core Processor powered Single Board Computer running at 900MHz
- 1GB RAM
- 40pin extended GPIO
- x USB 2 ports
- pole Stereo output and Composite video port
- Full size HDMI
- CSI camera port for connecting the Raspberry Pi camera
- DSI display port for connecting the Raspberry Pi touch screen display
- Micro SD port for loading your operating system and storing data
- Micro USB power source
- Raspberry Pi 2 Model B Features
- Broadcom BCM2836 Arm7 Quad Core Processor powered Single Board Computer running at 900MHz
- 1GB RAM so you can now run bigger and more powerful applications
- Identical board layout and footprint as the Model B+, so all cases and 3rd party add-on boards designed for the Model B+ will be fully compatible.
- 40pin extended GPIO to enhance your "real world" projects. GPIO is 100% compatible with the Model B+ and A+ boards. First 26 pins are identical to the Model A and Model B boards to provide full backward compatibility across all boards.
- Connect a Raspberry Pi camera and touch screen display (each sold separately)
- Stream and watch Hi-definition video output at 1080P
- Micro SD slot for storing information and loading your operating systems.
- You can now provide up to 1.2 AMP to the USB port – enabling you to connect more power hungry USB devices directly to the Raspberry PI. (This feature requires a 2Amp micro USB Power Supply)
- 10/100 Ethernet Port to quickly connect the Raspberry Pi to the Internet
- Combined 4-pole jack for connecting your stereo audio out and composite video out.

Pinout

40 General Purpose input output pins are available with special pins also included like UART, Serial Communication, SPI, and PWM etc.




(Figure 3-5- Raspberry Pi Chart)

<u>IO Pins</u>

All IO pins are 3.3V, not 1.8V. Pins are not 5V tolerant.

<u>Power-up State</u>

All pins are set as inputs on power up (TBC).I2C pins (e.g. Pj-3 and P8-5) are therefore high due to the pull up resistors on these pins.

<u>I2C</u>

Pull up resistors are included on the RPi board so are not needed externally (true for RPi1 Model B so presumably true for RPi 2 Model B, but not confirmed as full schematic not yet available).

<u>SPI</u>

The Chip Select signals are for up to two independent slave devices. It seems that with the SPI port enabled in Raspbian both the CS0 and CS1 pins are assigned to it and therefore can't be used as IO

### 3.5.2. Raspberry Pi Camera

(Figure 3-6- Raspberry Pi Camera)

<u>General Specifications</u>

| | |
|---|---|
| Size | around 25 x 24 x 9 mm |
| Weight | 3g |
| Still resolution | 5 Megapixels |
| Video modes | 1080p30, 720p60 and 640x480p60/90 |
| Linux integration | V4L2 driver available |
| C programming API | OpenMAX IL and others available |
| Sensor | OmniVision OV5647 |
| Sensor resolution | 2592 x 1944 pixels |
| Sensor image area | 3.76 x 2.74 mm |
| Pixel size | 1.4 µm x 1.4 µm |
| Optical size | 1/4" |
| Full-frame SLR lens | 35 mm |
| S/N ratio | 36 dB |
| Dynamic range | 67 dB @ 8x gain |

| | |
|---|---|
| Sensitivity | 680 mV/lux-sec |
| Dark current | 16 mV/sec @ 60 C |
| Well capacity | 4.3 Ke- |
| Fixed focus | 1 m to infinity |
| Focal length | 3.60 mm +/- 0.01 |
| Horizontal field of view | 53.50 +/- 0.13 degrees |
| Vertical field of view | 41.41 +/- 0.11 degress |
| Focal ratio (F-Stop) | 2.9 |

<u>HARDWARE FEATURES</u>

| Available | Implemented |
|---|---|
| Chief ray angle correction | Yes |
| Global and rolling shutter | Rolling shutter |
| Automatic exposure control (AEC) | No - done by ISP instead |
| Automatic white balance (AWB) | No - done by ISP instead |
| Automatic black level calibration (ABLC) | No - done by ISP instead |
| Automatic 50/60 Hz luminance detection | No - done by ISP instead |
| Frame rate up to 120 fps | max 90fps. Limitations on frame size for the higher frame rates (VGA only for above 47fps) |
| AEC/AGC 16-zone size/position/weight control | No - done by ISP instead |
| Mirror and flip | Yes |
| Cropping | No - done by ISP instead (except 1080p mode) |
| Lens correction | No - done by ISP instead |
| Defective pixel cancelling | No - done by ISP instead |
| 10-bit RAW RGB data | Yes - format conversions available via |

| | |
|---|---|
| | GPU |
| Support for LED and flash strobe mode | LED flash |
| Support for internal and external frame synchronisation for frame exposure mode | No |
| Support for 2x2 binning for better SNR in low light conditions | Anything output res below 1296x976 will use the 2x2 binned mode |
| Support for horizontal and vertical sub-sampling | Yes, via binning and skipping |
| On-chip phase lock loop (PLL) | Yes |
| Standard serial SCCB interface | Yes |
| Digital video port (DVP) parallel output interface | No |
| MIPI interface (two lanes) | Yes |
| 32 bytes of embedded one-time programmable (OTP) memory | No |
| Embedded 1.5V regulator for core power | Yes |

Software Features

| | |
|---|---|
| Picture formats | JPEG (accelerated), JPEG + RAW, GIF, BMP, PNG, YUV420, RGB888 |
| Video formats | raw h.264 (accelerated) |
| Effects | negative, solarise, posterize, whiteboard, blackboard, sketch, denoise, emboss, oilpaint, hatch, gpen, pastel, watercolour, film, blur, saturation |
| Exposure modes | auto, night, nightpreview, backlight, spotlight, sports, snow, beach, verylong, fixedfps, antishake, fireworks |
| Metering modes | average, spot, backlit, matrix |
| Automatic white | off, auto, sun, cloud, shade, tungsten, fluorescent, |

| | |
|---|---|
| balance modes | incandescent, flash, horizon |
| Triggers | Keypress, UNIX signal, timeout |
| Extra modes | demo, burst/timelapse, circular buffer, video with motion vectors, segmented video, live preview on 3D models |

### 3.5.3 Wi-Fi USB Adapter

For the accessibility of Wi-Fi to Raspberry Pi we have used a Wi-Fi USB Adapter. It's a small device which works as a Wi-Fi receiver antenna and can access any 3G and 4g internet signal just like an internet chip.

(Figure 3-7- Wi-Fi USB Adapter)

The Hardware and Performance features of the USB Adapter are given below

<u>Hardware</u>

| | |
|---|---|
| Antenna Configuration | 1x1:1 (TxR:S) |
| Bus Type | USB 2.0 |
| Chipset ID | Realtek - RTL8188EUS |
| Industry Standards | IEEE 802.11b, IEEE 802.11g, IEEE 802.11n |
| Interface | Wireless Ethernet |

Performance

| | |
|---|---|
| Frequency | 2.4 GHz |
| Full Duplex Support | Yes |
| Maximum Data | |
| Transfer Rate | 150 Mbps |

| | |
|---|---|
| MTBF | 44,000 Hours |
| Security Features | TKIP/AES |
| WEP Data Encryption | WPA and WPA2-PSK Data Encryption |

# Chapter 4 Sustainability Standalone System

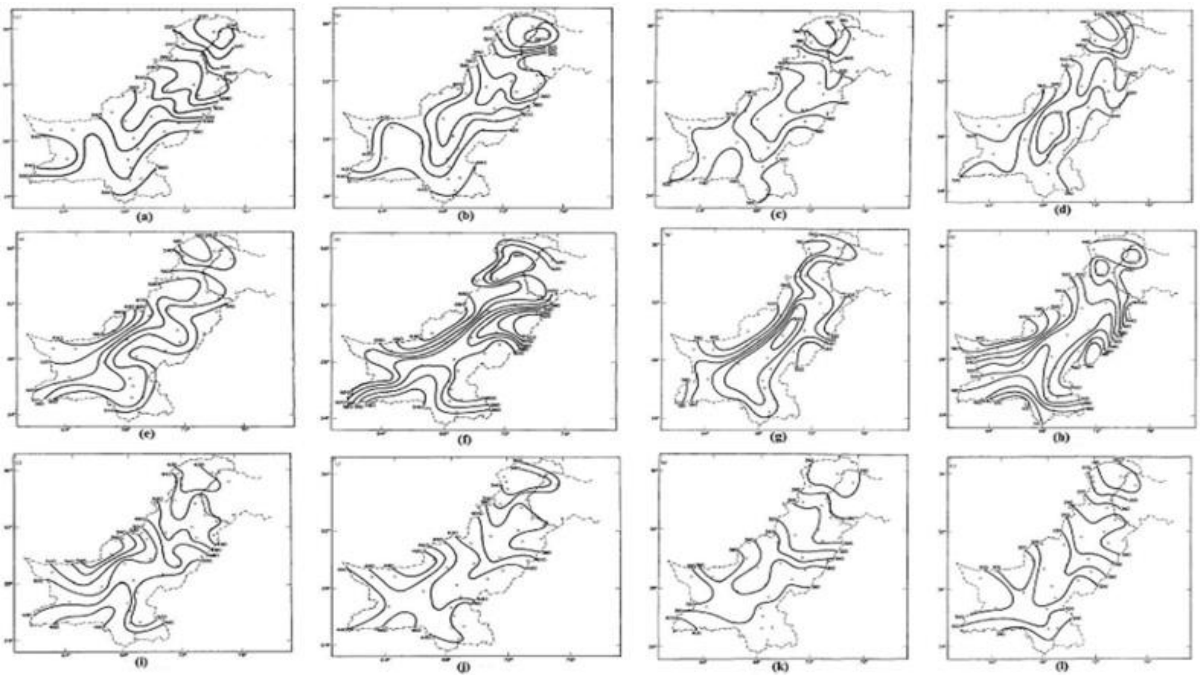
## 4.1 Solar Power

In the developing world, the availability and the cost of power can play a vital role in the economic development and humans well-being. As country become wealthier and their population grow, demand for energy increases. Traditional sources of energy are often too expensive to satisfy this demand.  They are also decreasing day by day and time will come when they will be eliminated. The trend will change from these conventional methods to alternative sources like solar energy.

Solar energy can prove to have an immense amount of constructive and helpful impact on you and on the environment as a whole. Contrasting to the fossil fuels that we consume and use on a daily basis, solar energy does not fabricate the excessively injurious pollutants that are liable for the greenhouse effect which is known to lead to global warming. Solar power use reduces the quantity of contamination and toxic waste, not to forget pollution that the engendering plants have to produce.

Solar energy is ultra clean, natural and a sustainable source of energy that you can utilize in the use of making solar electricity, solar heating appliances, solar cooling appliances and also solar lighting appliances.

Pakistan covers 796,095 sq kilometer of land b/w latitudes 24 and 36 North and Longitudes 61 and 76 East. At present, it really faces the energy problems. 33.4% of its electricity generation comes from hydel power[4] which becomes less productive during driest, hottest months and therefore we face mega fall of electricity. Most of electricity generation is from thermal which is very expensive. Fortunately, Pakistan location on earth is in such a place that it receives more radiations from sun directly and Pakistan comes in the solar belt and the solar energy intensity in the Sun Belt is approximately 1800-2200 KWh per square meter." The maximum amount of solar radiation in the country is received in and around Quetta. Sind and Blochistan provinces are receiving more than 440 cal/cm2 day, Punjab and Khyber Pakhtunkhwa (KPK) province is receiving between 400 and 440 cal/cm2 day and the northern areas and Kashmir are receiving less than 400 cal/cm2 day.[4]



(Figure -4-1-Mean daily solar radiation in Pakistan (cal/cm2/day) during: (a) January, (b) February, (c) March, (d) April, (e) May, (f) June, (g) July, (h) August, (i) September, (j) October, (k) November and (l) December) [4].

## 4.2 Advantages of Solar Energy

- Need no fuel
- The power source i.e. “Sun” is absolutely free
- The production of solar energy produces no pollution
- Solar power is a Renewable and Natural resource
- The technological advancements in solar energy systems have made them extremely cost effective
- Solar systems do not require any maintenance during their lifespan, which saves the maintenance cost
- Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid
- Solar cells require little maintenance

## 4.3 Application of Solar power in Standalone Surveillance System

As one of our objective of developing of sustainable system, that it must be a standalone device i.e. it must be able to meet all its need for effective surveillance. For that it must be able to produce energy to power the Raspberry pi, rotating mount, buck converter etc. As for the Solar technology’s efficiency is increasing as currently a Standard commercial solar PV panel can convert 12–18% of the energy of sunlight into useable electricity whereas high-end models come in above 20% efficiency.[5]

Our day's consumption is not exceeding 150W and a small panel would be able to produce that much amount of power to keep running the surveillance for the whole day and also maintain a backup for unforeseen circumstances.

As mentioned, each part of Pakistan gets a healthy sunlight all around the year, and therefore our device would be free of any requirement from the grid power. It could be deployed to any remote location, as it would be able to function from its own generated power source.

## 4.4 Power Requirement

As mentioned above the hardware components that our system is using, we can deduce the following use of watts per each device per day.

Raspberry Pi = 5W*24hrs

= 120W/day (approximately)

Servo motors = 6W*1hr

Assumption that user is going to employ the rotating mount for not more than 1 Hour in a day.

Servo motors = 6W/day

Total = 126W/day

= 126W/12V =10.5 A

Now, Watts Required/Hours of sunshine = Panel Size

To be on safer side, considering that our specified region is getting 6 hours of concentrated sunlight

126/6 = 21W

So, this means that we needed a solar panel of rating 21W, but as there were 2 Servo motors and the user could employ them for as long as they wanted. So for on the safer side, we chose a Solar panel of rating 30 W.

## 4.5 Backup Requirement

As explained earlier, solar power is produced directly from the energy generated from the Sun reaching the specified area, and our devices have to work 24/7, but Pakistan's demographic is such that it has approximately 13-15 hours of daylight. So to run our system, we will have to store energy so that could be used when there is no sunlight.

We have already learned that our system requires 126W/day and have chosen a 30W panel for a 6 hours concentrated light.

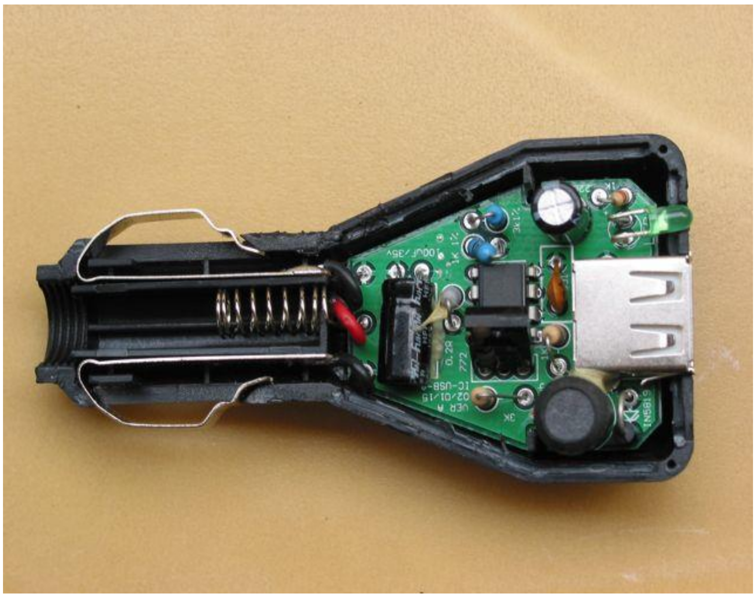
The battery we used for our system is LP12-18. It is lead acid battery which is maintenance free that you don't need to change electrolyte after a specific duration. The output of the battery is 12 Volts and it is 18Ah battery i.e. if the load is of 1 Ampere then it can be derived for 18 hours. In our case on average our load is of 1.5 Amperes so it can easily be derived up to 12 hours in case of dim light our in nights. So by using this battery our system can provide a 24/7 surveillance. Moreover a 24Ah battery can also be used for longer duration. As the solar panel output is not constant it is directly proportional to the sunlight intensity so we need a circuit to charge our battery continuously on varying input. We need a solar charge controller which can provide us a voltage slightly greater than 12 volts to charge the battery on variable input.

| | |
|---|---|
| Standby use: | 13.5-13.8 Volts |
| Cycle use: | 14.4-15.0 Volts |
| Initial current: | Less than 5.4 Amperes |

(Table 4-1- Battery Specification)[7]

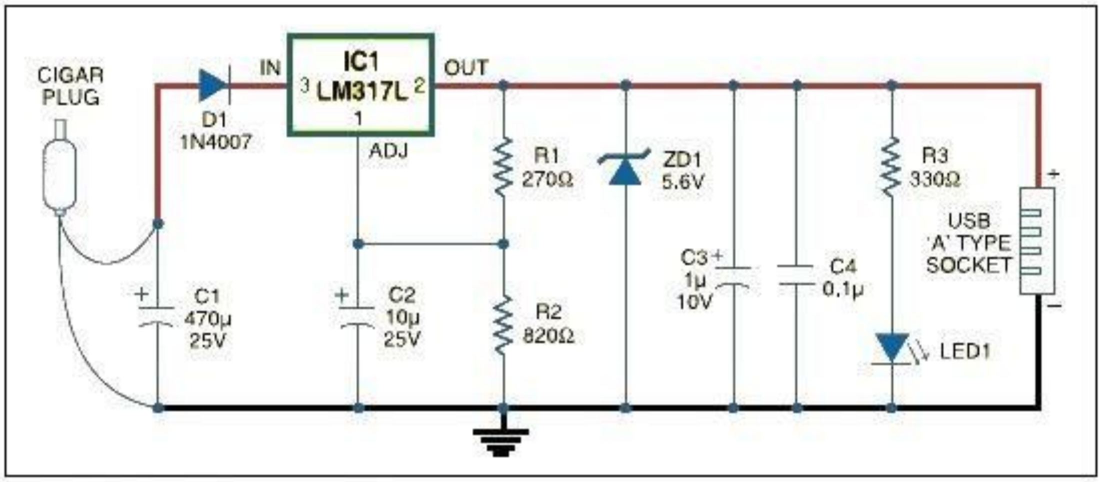
## 4.6 Buck Converter

The Raspberry pi operates on 5 Volts and 1-2 Amperes but the output of our battery is 12 volts so we need to convert the 12 volts to 5 volts. Buck converter can be used to get the required voltage. We have used the car charger instead of simple buck converter. It was cheap and it also converts 12 volts input to 5 volts and we don't need to connect any USB port to facilitate the connections as in car charger the USB ports are already integrated.



(Figure 4-2- Car Charger as Buck Converter)

The IC used in car charger for regulating the voltage is LM317L. The schematic of the charger circuit is as follows:

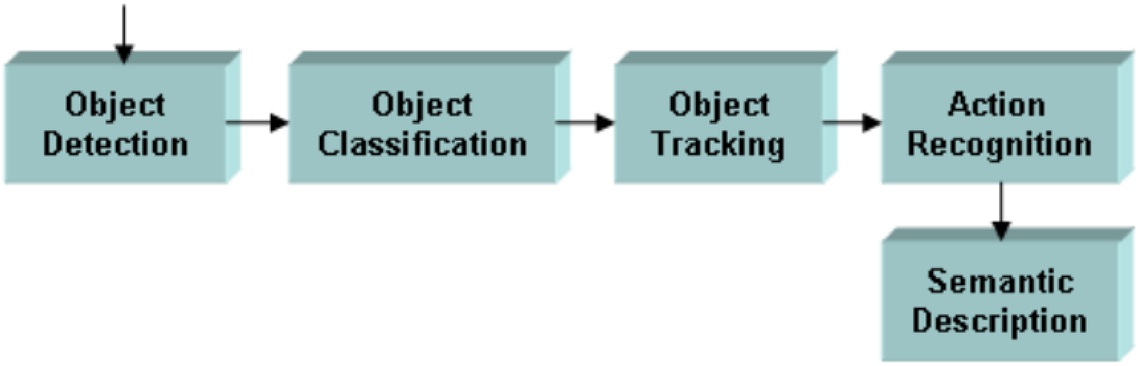



(Figure 4-3- Car Charger Circuit Diagram)

After connecting this car charger at the output of the battery, now we have our desired 2 outputs, one is of 5 Volts and 1 ampere and the other is of 5 Volts and 2 amperes. Raspberry Pi and module can be connected easily at the output port of the car charger.

# Chapter 5 Motion Detection

Each application that benefit from smart video processing has different needs, thus requires different treatment. However, they have something in common: moving objects. Thus, detecting regions that correspond to moving objects such as people and vehicles in video is the first basic step of almost every vision system.

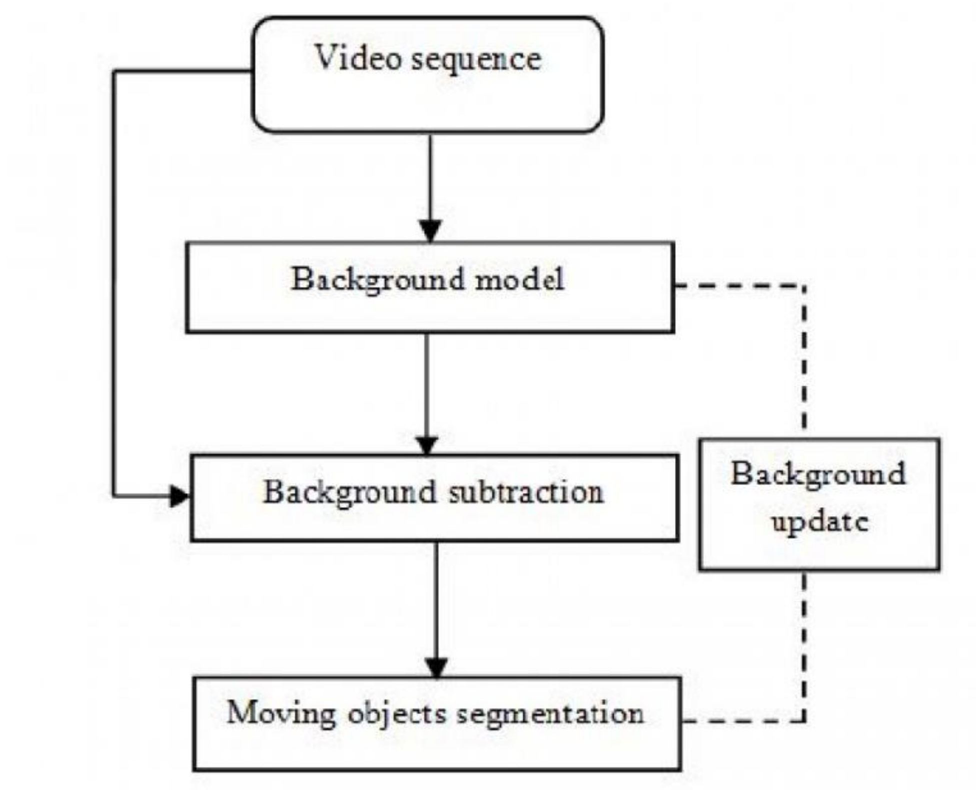



(Figure 5-1- Block Diagram of Motion Detection)

Since it provides a focus of attention and simplifies the processing on subsequent analysis steps. Due to dynamic changes in natural scenes such as sudden illumination and weather changes, repetitive motions that cause clutter (tree leaves moving in blowing wind), motion detection is a difficult problem to process reliably. Frequently used techniques for moving object detection are background subtraction, statistical methods, temporal differencing and optical flow whose descriptions are given below.

## 5.1 Background Subtraction

Background subtraction is particularly a commonly used technique for motion segmentation in static scenes. It attempts to detect moving regions by subtracting the current image pixel-by-pixel from a reference background image that is created by averaging images over time in an initialization period. The pixels where the difference is above a threshold are classified as foreground. After creating a foreground pixel map, some morphological post processing operations such as erosion, dilation and closing are performed to reduce the effects of noise and enhance the detected regions. The reference background is updated with new images over time to adapt to dynamic scene changes[8].




(Figure 5-2- Block Diagram of Motion Detection 2)

There are different approaches to this basic scheme of background subtraction in terms of foreground region detection, background maintenance and post processing. In Heikkila and Silven uses the simple version of this scheme where a pixel at location (x, y) in the current image It is marked as foreground if

$$|I_t(x, y) - B_t(x, y)| > \tau$$

is satisfied where $\tau$ is a predefined threshold. The background image BT is updated by the use of an Infinite Impulse Response (IIR) filter as follows:

$$B_{t+1} = \alpha I_t + (1 - \alpha) B_t$$

The foreground pixel map creation is followed by morphological closing and the elimination of small-sized regions. Although background subtraction techniques perform well at extracting most of the relevant pixels of moving regions even they stop, they are usually sensitive to dynamic changes when, for instance, stationary objects uncover the background (e.g. a parked car moves out of the parking lot) or sudden illumination changes occur.

## 5.2 Statistical Methods

More advanced methods that make use of the statistical characteristics of individual pixels have been developed to overcome the shortcomings of basic background subtraction methods. These statistical methods are mainly inspired by the background subtraction methods in terms of keeping and dynamically updating statistics of the pixels that belong to the background image process. Foreground pixels are identified by comparing each pixel's statistics with that of the background model. This approach is becoming more popular due to its reliability in scenes that contain noise, illumination changes and shadow. The W4 system uses a statistical background model where each pixel is represented with its minimum (M) and maximum (N) intensity values and maximum intensity difference (D) between any consecutive frames observed during initial training period where the scene contains no moving objects. A pixel in the current image it is classified as foreground if it satisfies:

$$|M(x, y) - It(x, y)| > D(x, y) \text{ or } |N(x, y) - It(x, y)| > D(x, y)$$

After thresholding, a single iteration of morphological erosion is applied to the detected foreground pixels to remove one-pixel thick noise. In order to grow the eroded regions to their original sizes, a sequence of erosion and dilation is performed on the foreground pixel map. Also, small-sized regions are eliminated after applying connected component labeling to find the regions. The statistics of the background pixels that belong to the non-moving regions of current image are updated with new image data. As another example of statistical methods, Stauffer and Grimson [8]described an adaptive background mixture model for real-time tracking. In their work, every pixel is separately modeled by a mixture of Gaussians which are updated online by incoming image data. In order to detect whether a pixel belongs to a foreground or background process, the Gaussian distributions of the mixture model for that pixel are evaluated.

## 5.3 Temporal Differencing

Temporal differencing attempts to detect moving regions by making use of the pixel-by-pixel difference of consecutive frames (two or three) in a video sequence. This method is highly adaptive to dynamic scene changes; however, it generally fails in detecting whole relevant pixels of some types of moving objects. A sample object for inaccurate motion detection is shown in Figure below. The mono colored region of the human on the left hand side makes the temporal differencing algorithm to fail in extracting all pixels of the human's moving region. Also, this method fails to detect stopped objects in the scene. Additional methods need to be adopted in order to detect stopped objects for the success of higher level processing.

(a) (b)

(Figure 5-3- Temporal Differencing)

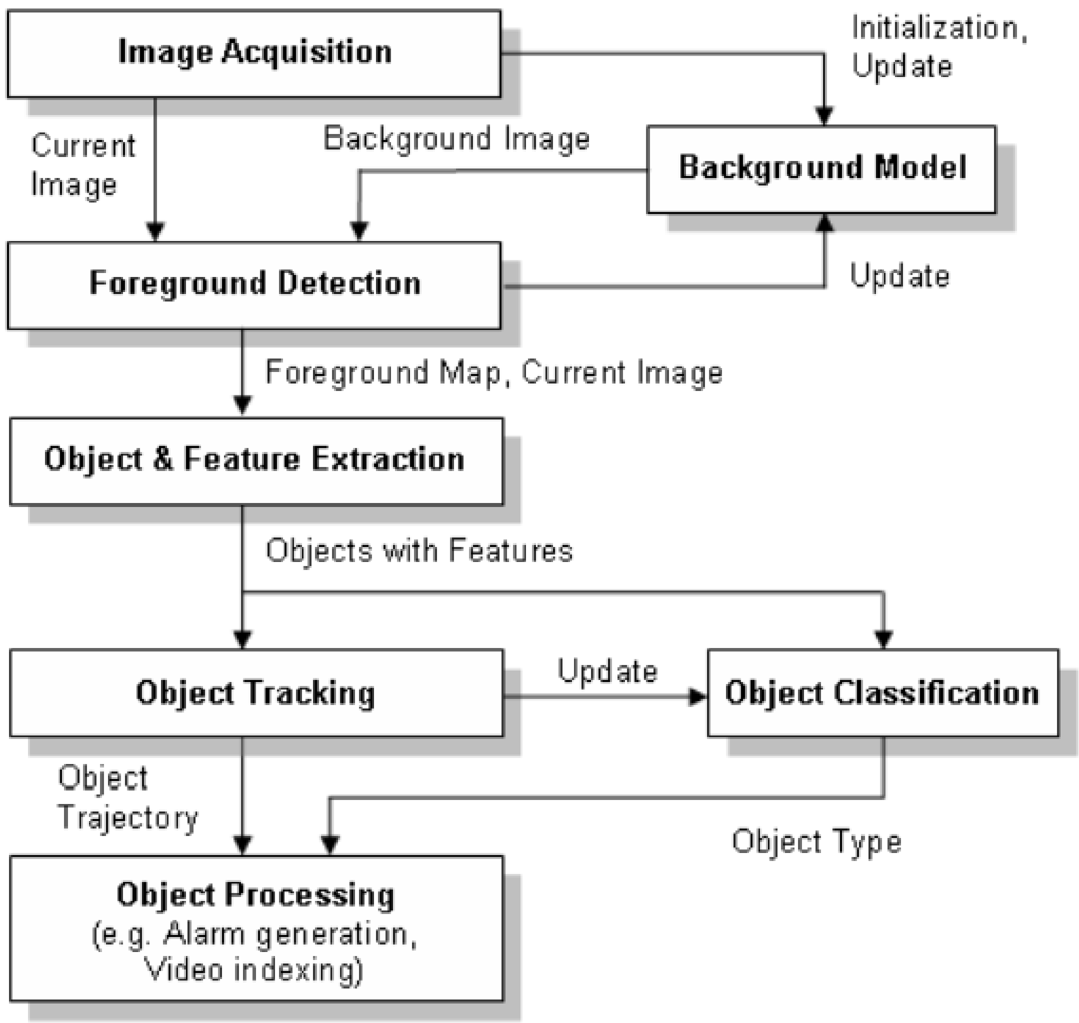
## 5.4 Object Detection & tracking

The overview of our real time video object detection, classification and tracking system is shown in Figure below. The proposed system is able to distinguish transitory and stopped foreground objects from static background objects in dynamic scenes; detect and distinguish left and removed objects; classify detected objects into different groups such as human, human group and vehicle; track objects and generate trajectory information even in multi-occlusion cases and detect fire in video imagery. In this and following chapters we describe the computational models employed in our approach to reach the goals specified above. Our system is assumed to work real time as a part of a video-based surveillance system. The computational complexity and even the constant factors of the algorithms we use are important for real time performance. Hence, our decisions on selecting the computer vision algorithms for various problems are affected by their computational run time performance as well as quality. Furthermore, our system's use is limited only to stationary cameras and video inputs from Pan/Tilt/Zoom cameras where the view frustum may change arbitrarily are not supported. The system is initialized by feeding video imagery from a static camera monitoring a site. Most of the methods are able to work on both color and monochrome video imagery. The first step of our approach is distinguishing foreground objects from stationary background. To achieve this, we use a combination of adaptive background subtraction and low-level image post-processing methods to create a foreground pixel map at every frame. We then group the connected regions in the foreground map to extract individual object features such as bounding box, area, center of mass and color histogram.

Our novel object classification algorithm makes use of the foreground pixel map belonging to each individual connected region to create a silhouette for the object. The silhouette and center of mass of an object are used to generate a distance signal. This signal is scaled, normalized and compared with pre-labeled signals in a template database to decide on the type of the object. The output of the tracking step is used to attain temporal consistency in the classification step.

The object tracking algorithm utilizes extracted object features together with a correspondence matching scheme to track objects from frame to frame. The color histogram of an object produced in previous step is used to match the correspondences of objects after an occlusion event. The output of the tracking step is object trajectory information which is used to calculate direction and speed of the objects in the scene.

After gathering information on objects' features such as type, trajectory, size and speed various high level processing can be applied on these data. A possible use is real-time alarm generation by pre-defining event predicates such as "A human moving in direction d at speed more than s causes alarm a1." or "A vehicle staying at location l more than t seconds causes alarm a2." Another opportunity we may make use of the produced video object data is to create an index on stored video data for offline smart search. Both alarm generation and video indexing are critical requirements of a visual surveillance system to increase response time to forensic events.




(Figure 5-4- Flow Chart of Motion Detection and Tracking)

# Chapter 6 Structure & Pan Tilt Mechanism

For a standalone system, it is a necessary requirement for the system to be sustainable, and can be applied to remote locations, be able to bear the loads with minimum vibrations and at the same time be portable. Provide the necessary constraints to the solar panel and also able to give the pan tilt mechanisms the necessary degree of freedoms to circumvent the entire premises.

## 6.1 Structure

### 6.1.1 Structural Properties

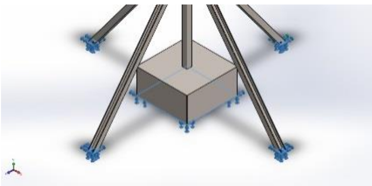
Following is the analysis of our structure using Pro-Engineer.

Material properties:

| Model Reference | Properties | Components |
|---|---|---|
|  | Name: **Alloy Steel**<br>Model type: **Linear Elastic Isotropic**<br>Default failure criterion: **Max von Mises Stress**<br>Yield strength: **6.20422e+008 N/m^2**<br>Tensile strength: **7.23826e+008 N/m^2**<br>Elastic modulus: **2.1e+011 N/m^2**<br>Poisson's ratio: **0.28**<br>Mass density: **7700 kg/m^3**<br>Shear modulus: **7.9e+010 N/m^2** | **SolidBody 1(Boss-Extrude5)(Part1-1),**<br>**SolidBody 1(Boss-Extrude7)(Part3-1),**<br>**SolidBody 1(Boss-Extrude7)(Part3-2),**<br>**SolidBody 1(Boss-Extrude7)(Part3-3),**<br>**SolidBody 1(Boss-Extrude7)(Part3-4)** |

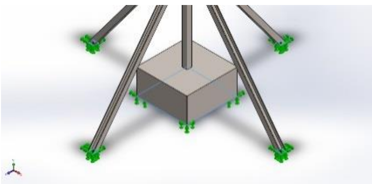
| | | |
|---|---|---|
| | Thermal expansion coefficient: **1.3e-005 /Kelvin** | |
| Curve Data:N/A | | |

Loads And Fixtures:

| Fixture name | Fixture Image | Fixture Details | |
|---|---|---|---|
| **Fixed-1** |  | **Entities:** | **5 face(s)** |
| | | **Type:** | **Fixed Geometry** |

**Resultant Forces**

| **Components** | **X** | **Y** | **Z** | **Resultant** |
|---|---|---|---|---|
| **Reaction force(N)** | **-0.0546157** | **104.933** | **-0.042888** | **104.933** |
| **Reaction Moment(N.m)** | **0** | **0** | **0** | **0** |

| | | | |
|---|---|---|---|
| **Fixed-2** |  | **Entities:** | **5 face(s)** |
| | | **Type:** | **Fixed Geometry** |

| Fixture name | Fixture Image | Fixture Details |
|---|---|---|

**Resultant Forces**

| Components | X | Y | Z | Resultant |
|---|---|---|---|---|
| Reaction force(N) | -0.0546157 | 104.933 | -0.042888 | 104.933 |
| Reaction Moment(N.m) | 0 | 0 | 0 | 0 |

### 6.1.2 Results

Reaction Forces

| Selection set | Units | Sum X | Sum Y | Sum Z | Resultant |
|---|---|---|---|---|---|
| Entire Model | N | -0.0546157 | 104.933 | -0.042888 | 104.933 |

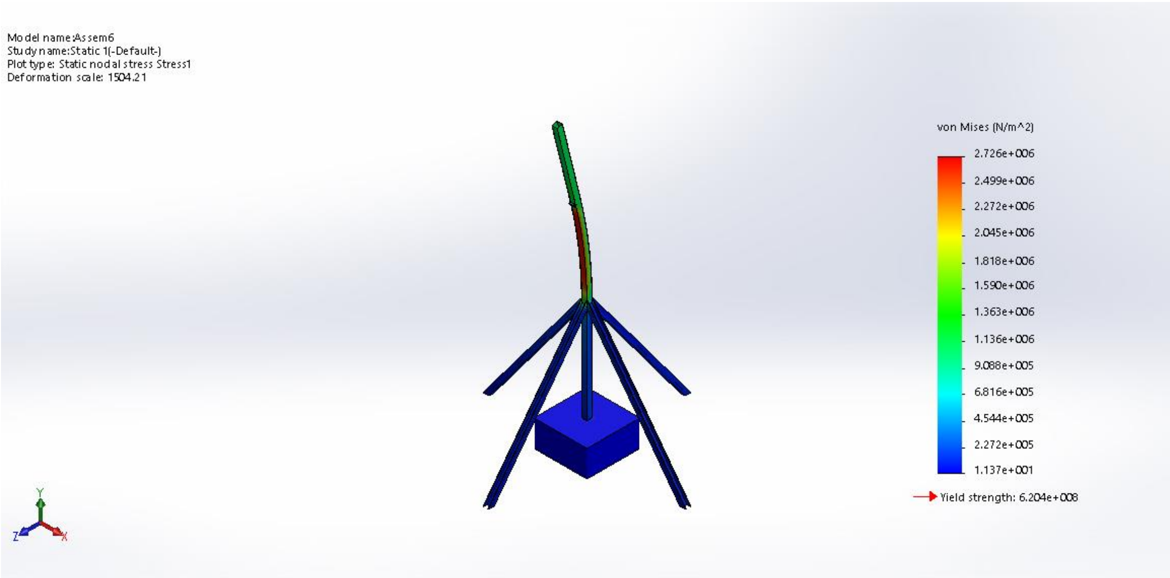
Reaction Moments

| Selection set | Units | Sum X | Sum Y | Sum Z | Resultant |
|---|---|---|---|---|---|
| Entire Model | N.m | 0 | 0 | 0 | 0 |

Results:

| Name | Type | Min | Max |
|---|---|---|---|

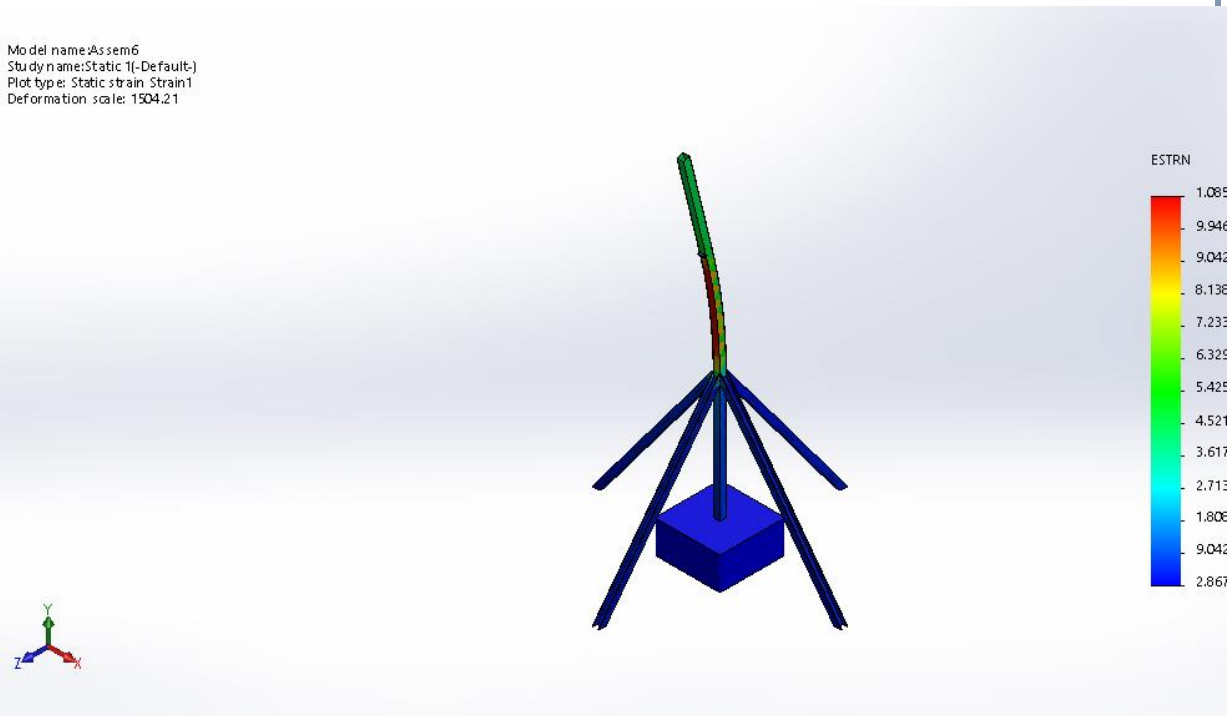
| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Stress1 | VON: von Mises Stress | 11.3726 N/m^2<br><br>Node: 3159 | 2.7264e+006 N/m^2<br><br>Node: 313 |




Assem6-Static 1-Stress-Stress1

| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Displacement1 | URES: Resultant Displacement | 0 mm<br><br>Node: 53 | 0.0951432 mm<br><br>Node: 71 |

| Name | Type | Min | Max |
| --- | --- | --- | --- |
| Strain1 | ESTRN: Equivalent Strain | 2.86692e-011<br><br>Element: 2779 | 1.08502e-005<br><br>Element: 3341 |




Assem6-Static 1-Strain-Strain1

**(**Figure 6-1- Structural analysis**)**

## 6.2 Pan Tilt Mechanisms

It is a major requirement for any surveillance system that feed could be collected from a larger pan area, which could be done by giving the user the control of the pan and tilt mechanisms, so that the user may define the area which he wants the system to scan.

### 6.2.1 Pan Tilt Design

There are different ways to design Pan tilt mechanisms, the most easy are the readily available gimbals that are attached to the camera base and could be operated remotely, but as our system was already employing Raspberry pi system, We decided to design a pan tilt mechanical structure and rotated by servo motors, which were controlled through the Raspberry pi.

Following is the mechanical design of our pan tilt mechanisms with servo motors attached.

(Figure 6-2- Pan Tilt Mechanism)

### 6.2.2 Servo Motors

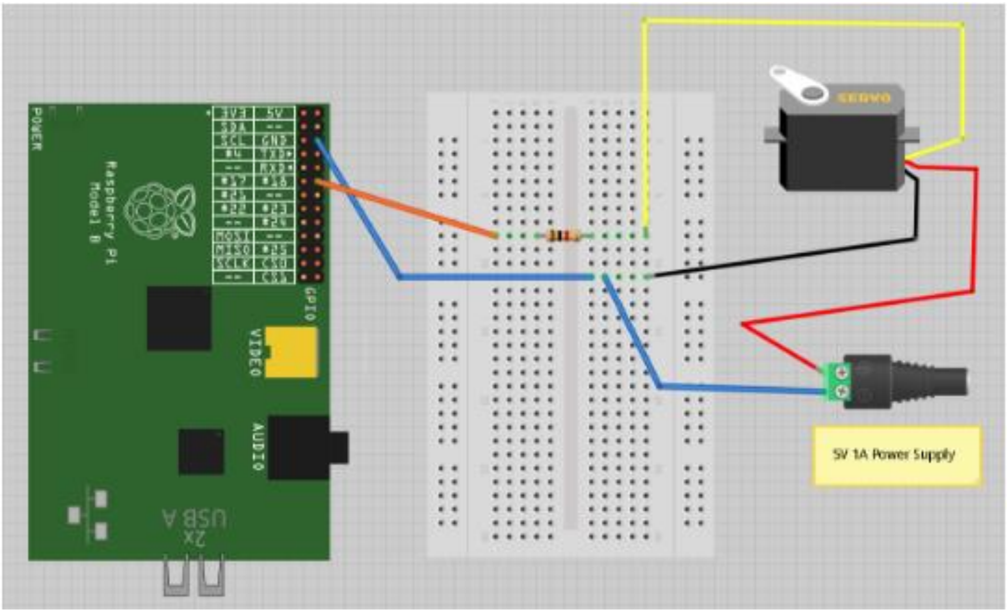
Most of the servo motors could be employed but we chose the MG996R [9]due to its readily availability and it's easy to use functionality. It is an upgradation of the famed MG995 servo. It could approximately rotate120 degrees (60 in each direction), and it also give the user to control them with any servo code, hardware and library so to control the motors.

- Specifications
- Weight: 55 g
- Dimension: 40.7 x 19.7 x 42.9 mm approx.
- Stall torque: 9.4 kgf·cm (4.8 V ), 11 kgf·cm (6 V)
- Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
- Operating voltage: 4.8 V a 7.2 V
- Running Current 500 mA –
- Stall Current 2.5 A (6V)
- Dead band width: 5 µs
- Stable and shock proof double ball bearing design
- Temperature range: 0 ºC – 55 ºC

## 6.3 Servo control

For controlling a servo motor, we need the following essential components

- Servo motors
- Jumper wires and Breadboard
- 1 Kohm Resistor
- Power supply




(Figure 6-3 Controlling Servo)

We have also created a user interface for controlling a servo motor, so that user could easily change the angle of the pan and tilt both servos.


(Figure 6-4-User interface for servo control)

```
from Tkinter import *
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
GPIO.setup(18, GPIO.OUT)
pwm = GPIO.PWM(18, 100)
pwm.start(5)

class App:

  def __init__(self, master):
    frame = Frame(master)
    frame.pack()
    scale = Scale(frame, from_=0, to=180,
       orient=HORIZONTAL, command=self.update)
    scale.grid(row=0)



 def update(self, angle):
   duty = float(angle) / 10.0 + 2.5
   pwm.ChangeDutyCycle(duty)

root = Tk()
root.wm_title('Servo Control')
```

```
app = App(root)

root.geometry("200x50+0+0")

root.mainloop()
```

# Chapter 7 RESULTS

After Implementation of the whole system we have found these following results:

## 7.1 Solar Panel Output

The solar panel is giving a DC voltage of output of 12-20 Volts. It depends upon the intensity of sunlight. And this power is further given to the battery charging circuit to charge the battery.

## 7.2 Pan and Tilt Mechanism

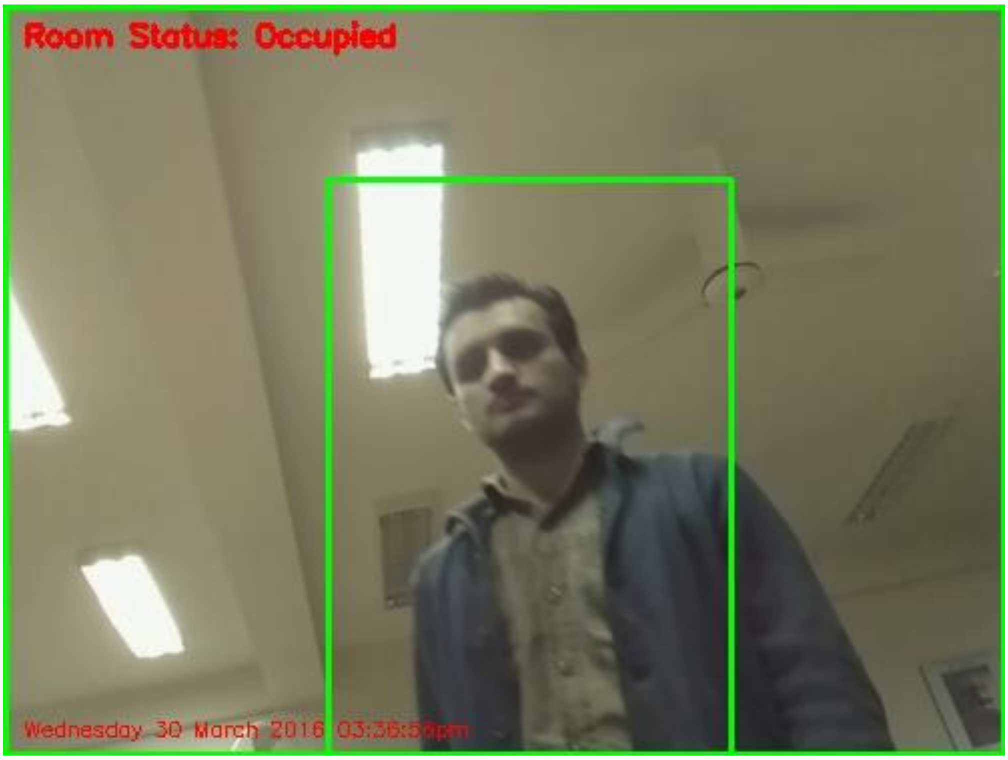
Our design was able to give 120 degress rotation in both x & y axis, and was able to be controlled remotely by the user through the developed user interface.

## 7.3 Buck Converter Output

The input of the Buck Convertor is 12 Volts from the battery and the output measured is 5 Volts, 1 Ampere and 5 Volts, 2 Amperes, GSM Module and Raspberry Pi is connected to these both outputs respectively.

## 7.4 Motion detection

- Done using Background Subtraction.
- OpenCV and Python are used for this purpose.
- The system is detecting any kind of motion successfully.
- The Screenshot of output of our system is shown below.



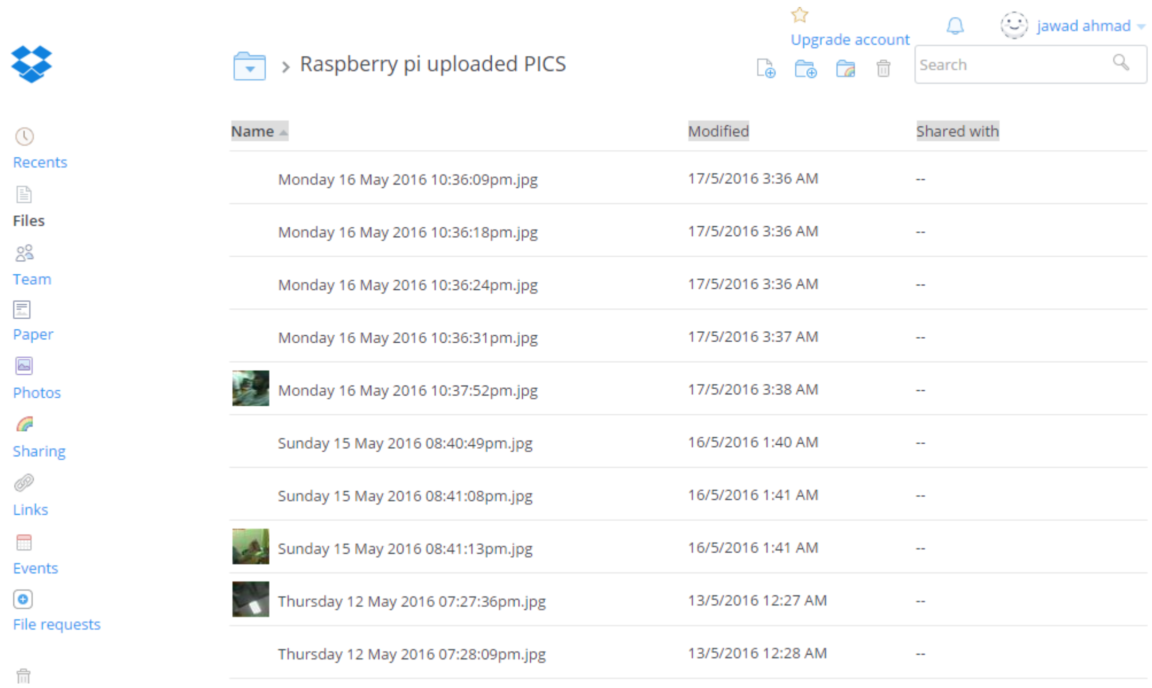

(Figure 7-1- Motion detection)

## 7.5 Cloud Storing

One of the most better alternative that have been given through this project is that we should be applying the cloud technologies to store the feed and its analysis, because saving it through any other means i.e. DVR storage or others would always be in the reach of the culprits. We must accept that cloud technologies are in their developing phase but the type of risks that are prone to prevalent systems, are not applicable to the cloud technologies.

For these benefits we incorporated the Dropbox API[10] in our code so that any anomaly detected should be automatically uploaded to the user’s dropbox and notification given to the user.

Now even if the culprit moves ahead to break the system, his last photo would be sent to the customer’s database (Dropbox) and he could take action as soon as possible.




(Figure 7-2- Dropbox Interface)

## 7.6 Product's functions

We have succeeded to design a System which has the following features:

- Self-Sufficient System
- 24/7 Monitoring
- Live/Real time streaming
- Smart System
- Images storage in Drop box
- Notify the Rational persons

### 7.6.1 Sustainability

This system is in accordance with the rules of sustainability i.e It is a scocially beneficial product for the customers, as they will feel secure with the installation of this product, secondly, This product has a zero carbon foot print while even producing its own power with the help of Solar technology and thirdly with the employment of Raspberry pi and Dropbox API, this device is economically very feasible for the customers.

### 7.6.2 Real time Analysis:

This system allows the user to be notified through Dropbox if any anomaly appears in the specified area, whereas the user can also view the feed real time though any browser by the system IP and a working Internet connection.

# Chapter 8 Future Recommendations

In future we can work further in to improve efficiency and accessibility of the product. Some future recommendations are as follows:

- Database
- Face Recognition
- Multiple Cameras Network

## 8.1 Database

For any advance ment first we must have to compile a database of the faces or objects that could be encountered by the system, as any action to be taken by the system depends upon the successful identification of the objects.

## 8.2 Face Recognition

We can add the feature of face recognition in the system. By the help of this feature, whenever a motion is detected the system will first try to recognize the face of the person if it matches with some known person then it will not create any alarm but on the other hand it will notify the rational persons on detecting some unknown face.

## 8.3 Multiple Cameras Network

We can develop a network of multiple cameras to monitor a whole building or institution. All cameras will be connected to a central database which will further capable of sending the video feed on internet cloud and will centrally control the whole system.

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[9] (MG996R Tower Pro- Electronic Caldas, 2016)

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