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Mine Warfare and Surveillance Rover

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Abstract: ***Landmines are a legacy of war, insurrection, and guerrilla activity. Landmines kill and maim approximately 26,000 people annually. This paper will review the development and applications of collective use of sensors to address the challenges of reliably detecting landmines. It emphasizes the relevance of mechanical technique in landmine detection process as compared to civilian or humanitarian minesweeping programs and use of camera for surveillance. In this project, we will concentrate on detection of landmines and documenting the co-ordinates of the detected mines on maps as well as use of a camera for real time video surveillance. Landmine detection and removal is a critical problem faced by many countries around the world, and the situation can be compounded by natural disasters or land development. Therefore, it is critical to detect landmines in the ground and remove them safely. The process of landmine removal starts with the detection of landmines in the ground. Metal detector is used to detect the presence of sub surface mines and camera is used to detect the presence of surface mines in its proximity. Whenever any of these devices detects a landmine in its proximity, the co-ordinates of that instant are transmitted wirelessly along with a message to the base station (controller).***

I. INTRODUCTION

A landmine is an explosive device that is hidden under the ground and is designed to destroy enemy resources ranging from vehicles to tank and combatants, when they pass over or near it.

These landmines typically get detonated automatically because of the pressure as one steps or drives over it, although some other mechanism for detonation might also be used.

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These landmines typically get detonated automatically because of the pressure as one steps or drives over it, although some other mechanism for detonation might also be used. The name comes from the ancient practice of military mining, where tunnels were dug under enemy fortifications or military formations.

These "mines" were initially collapsed to destroy overhead targets, but later they were filled with explosives and detonated to cause even greater devastation. Nowadays there are two types of landmines named Anti-Personnel (AP) and Anti-Tank (AT) mines. The use of landmines is controversial because of their potential as indiscriminate weapons. Landmines could remain harmful after several years after the conflict has ended.

In 20th century, 80% of the victims were military personnel but today most of the casualties are faced by civilians. Day to day life of civilians staying near areas contaminated by landmines is majorly affected.

The correct disposal & clearing of landmines gives life back to the local community living there. In short it restores human dignity and promotes human security.

The economic impact includes reduction in migration to larger towns and cities due to fear of mines. Surveillance provides tactical advantage in crucial situations.

Most of the landmine detecting methods involve human interference. This creates a high risk to the experts involved in the process of minesweeping. All the technologies at present involve human interference up to some extent. Thus to reduce the chances of loss of lives due to accidental triggering of land mines and to increase the speed of detection of land mines, we can use Mine warfare and Surveillance Rover.

This rover can be controlled by a controller who is away from the mine field, thus reducing the risk of damaging human life due to accidental triggering. The rover will also help in surveillance where soldiers cannot go.

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I. CURRENT TECHNOLOGIES FOR LANDMINE DETECTION

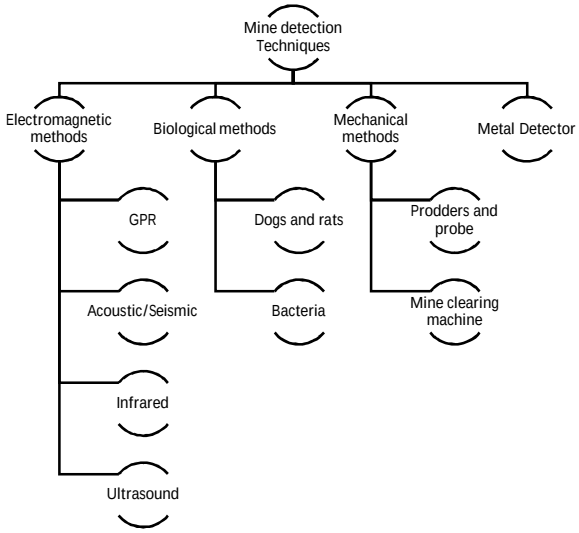

Fig 2.1 Detection Techniques

Many sensors are being used to detect the presence of landmines, but separately. Every sensor which is used for landmine detection can fail in certain surroundings or environmental conditions.

1) *Metal Detectors* – The metal detector which has been used to detect landmines works on the principle of measuring the disturbance generated due to electromagnetic field generated because of metallic objects present beneath the coil. This method of detection has good success rate while detecting the mines which are in metallic in nature but now a days most of the mines are nonmetallic in nature hence making this method of detection little incompetent.
2) *Ground Penetrating Radar* - The ground penetrating radars works by emitting the radio waves into the ground and analyzing the reflected signals at the boundaries of materials having non identical indexes of refraction generated because of differences in electrical i.e. dielectric properties. Ground Penetrating Radars have ability to sense changes in dielectric constant hence detecting the landmines of all type of materials. This is possible due to because the required radar wavelength is generally smaller than most mines at frequencies that still have reasonable penetration depth. The abnormal changes in subsurface due to natural inhomogeneity caused due to excess roots, water pockets and rocks may sometimes give false alarms. The Ground Penetrating Radars could be very unproductive when the soils holds moisture hence making performance highly variable and difficult to predict.
3) *Infrared / Hyperspectral Systems* - This method works by detecting an atypical contrast in electromagnetic radiation either reflected or emitted from the surface of the landmine or the soil which is dead above the buried landmine. The technology covers various modes by which it is possible to take action, it also includes active and passive irradiation using a wide range of electromagnetic wavelengths. As this method does not requires physical contact hence it can be used from distant. An airborne system deployed with this sensor could effectively detect surfaced landmines. Though this system is matured enough to be deployed but the complexity of processing the signals are still rudimentary.
4) *Ultrasound* - The ultrasound works on creating high pitched soundwaves to create image of hidden anatomy. Generally ultrasound works by emitting the sound waves of frequencies higher than 20 kHz in the ground. These emitted soundwaves gets reflected over the boundaries having different acoustical properties. These strong ultrasound signals can generate the signatures of landmines buried beneath the ground. The advantage with this system is that it has ability to work seamlessly even on wet grounds but as these sound waves are mostly to get attenuated because of air – ground interface it is ideal when sensors are touching the ground.

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	GPR	MD	IR	US
Sand	O	O	O	×
Clay	△	△	×	×
Water	×	×	×	O
Deep Earth	O	O	×	×
APM	O	△	△	O
ATM	O	O	O	O
Price	×	O	△	O

Table 2.1 Sensor performance in various conditions **O good, △ not bad, × bad**

Sensing Technique	Cost	Energy Consumption	Quality of Images	Usability under various weather conditions	Ground Penetration	Object material independency
Camera	✓	✓	✓	✓	×	✓
Infra Red	✓	✓	×	×	✓	×
Ultrasound	✓	✓	×	✓	✓	✓
Ground Penetrating Radar	×	×	×	×	✓	✓

Table 2.2 Comparison of various sensing techniques

II. SYSTEM ARCHITECTURE

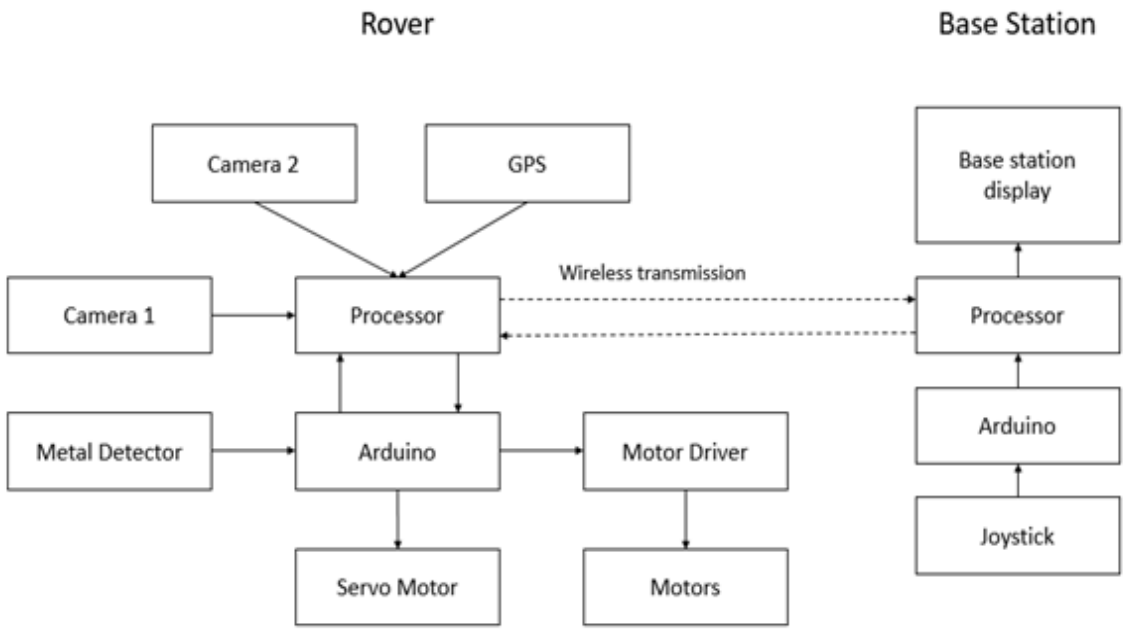

Fig. 3.1 System block diagram.

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The system block diagram of Mine warfare and Surveillance Rover consists of the following major blocks and their functions are stated as:s

A. Rover

1) *Camera* - Two cameras (webcams) are used on rover. First camera is used for Surveillance and another camera is used for landmine detection. Camera used for object detection has resolution of 5 MP and the resolution of surveillance camera is 3 MP.

2) *GPS* - A GPS module (receiver) is mounted on rover to obtain real time co-ordinates (location) of the rover. The coordinates received from this modules are updated on maps at runtime using Google Maps APIs

3) *Metal Detector* - A metal detector based on the principle of bit frequency oscillator is interfaces with the microcontroller onboard. The frequency response of this is analyzed and proper interrupt are generated to notify system for possible presence of landmine.

4) *Atmel Atmega 2560* – This microcontroller is specifically chosen because of presence of multiple onboard pins for UART communication and PWM pins to generate signals and also to read the frequency response of metal detector.

5) *Servo motor* – This motor is used to rotate the arm on which the detector coil of metal detector is mounted. A rotating arm covering 180 degrees of field improves the coverage area for single rover.

6) *Motor driver* – These are used to interface the motors with the control unit. Using this circuitry it is possible to control pace & the direction of the rover.

7) *Motors* - The motors used are square geared DC motors of 25 kg-cm torque. Square geared DC motor is a very high torque motor. Gear box is built to handle the stall torque produced by the motor. Drive shaft is supported from with metal bushes.

8) *Processor* – It is used to collect the data from the microcontroller onboard, take proper decision and to send that to base station. It also has to execute the commands sent from the base station.

B. Base Station

a) *Display at base station* - To display the map and video feeds at base station

b) *Joystick* – It is a controlling input device interfaced at base station to control the movements of rover.

c) *Rover*

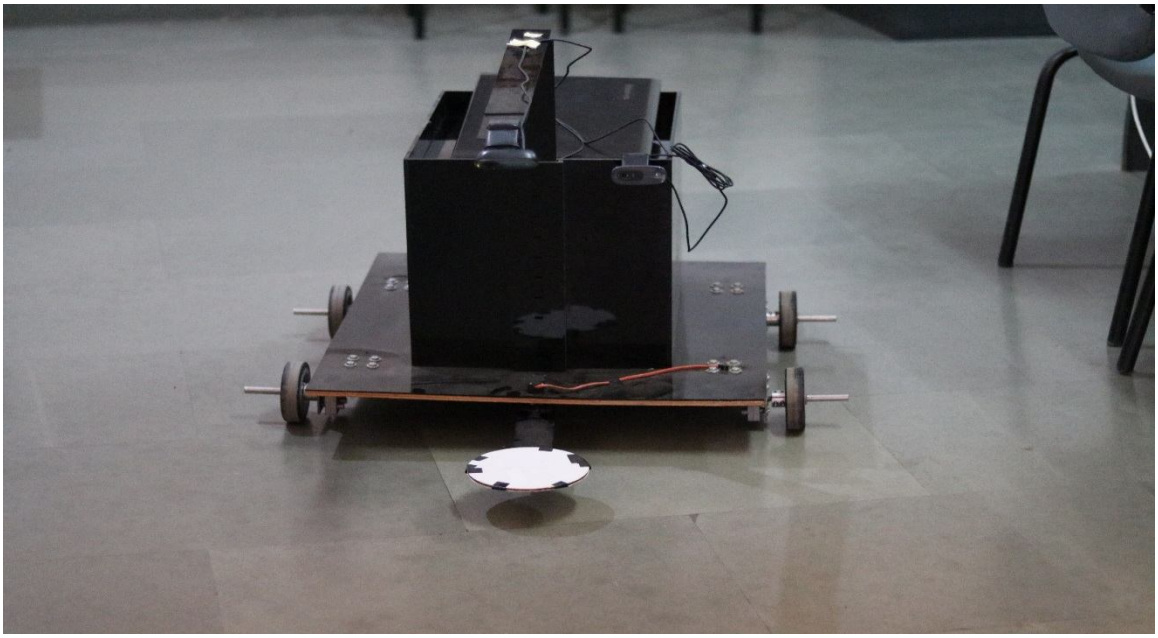

Fig. 3.2 Rover

As shown in figure, Mine warfare and Surveillance rover has two cameras mounted at top. The camera which is used for mine detection is extended so as to detect mines at a safe distance from rover, so as to avoid accidental triggering. The second camera is used only for surveillance. The search coil of metal detector is rotated in front of rover using a servo motor. Due to the movement of search coil, more search area is covered and accidental triggering of mines is avoided. The system uses high torque wheels which

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are connected to the motor through a coupling and shaft. All the other components required i.e. motor drivers, battery, metal detector circuit and reference coil, Arduino are kept inside the box. Laptop which is used as a processor is kept on the top of this box.

C. Base Station

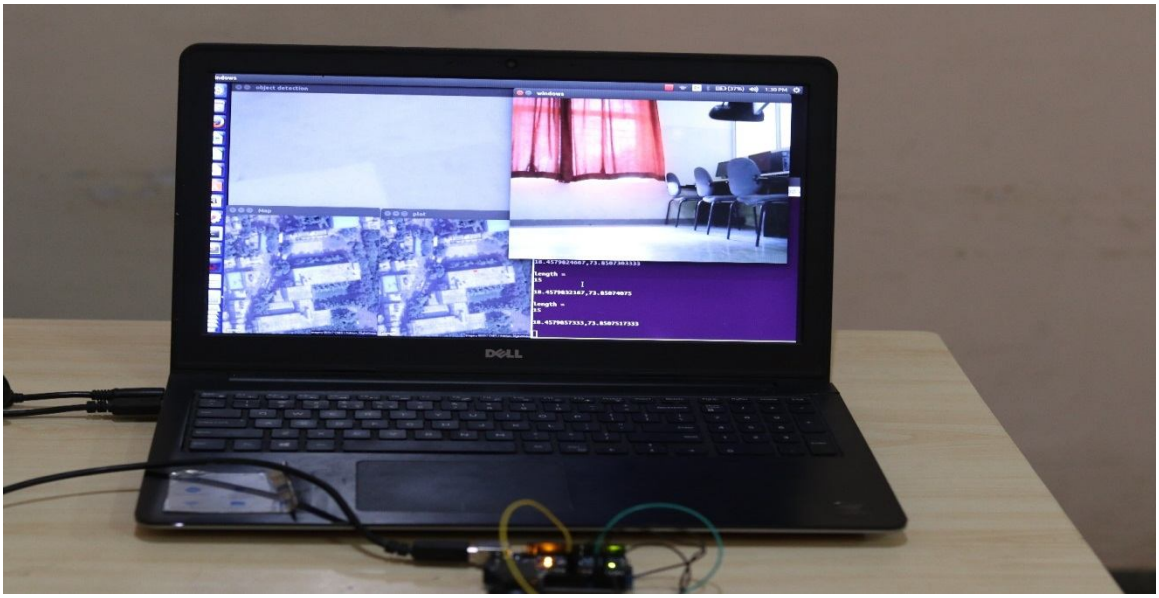

Fig. 3.3 Base station

At the base station, a laptop, joystick and an Arduino is used. Joystick controls the movement of rover. The display of laptop shows 5 windows. Two windows give the live video feed received from the rover. Out of these two windows, one window displays a message whenever mine is detected by camera. One window displays the co-ordinates of current location of the rover and whenever a mine is detected by metal detector it displays a message “mine detected” along with the co-ordinates. The remaining two windows display the map plots. One window displays the path followed by the rover while the other window displays the points where mine was detected by metal detector.

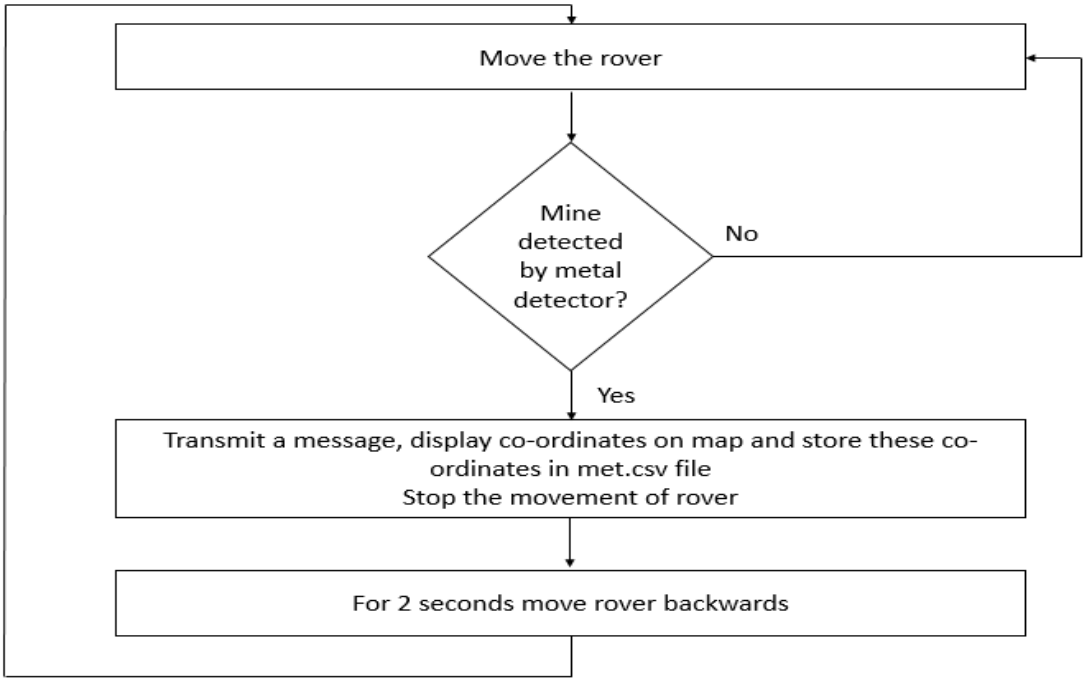

Fig 4.1 System flowchart – I

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The movement of rover is controlled using a joystick at the base station. This joystick is interfaced to Arduino which is connected to a laptop. Thus movement of rover is controlled by the joystick. Whenever a mine is detected by metal detector, the co-ordinates of that instant and a message are transmitted to the base station where the co-ordinates are stored in a separate file and displayed on a map. Also at the same time the rover halts and moves in reverse direction for 2 seconds. During these 2 seconds the joystick control does not work. After 2 seconds, the movement of rover can again be controlled by joystick.

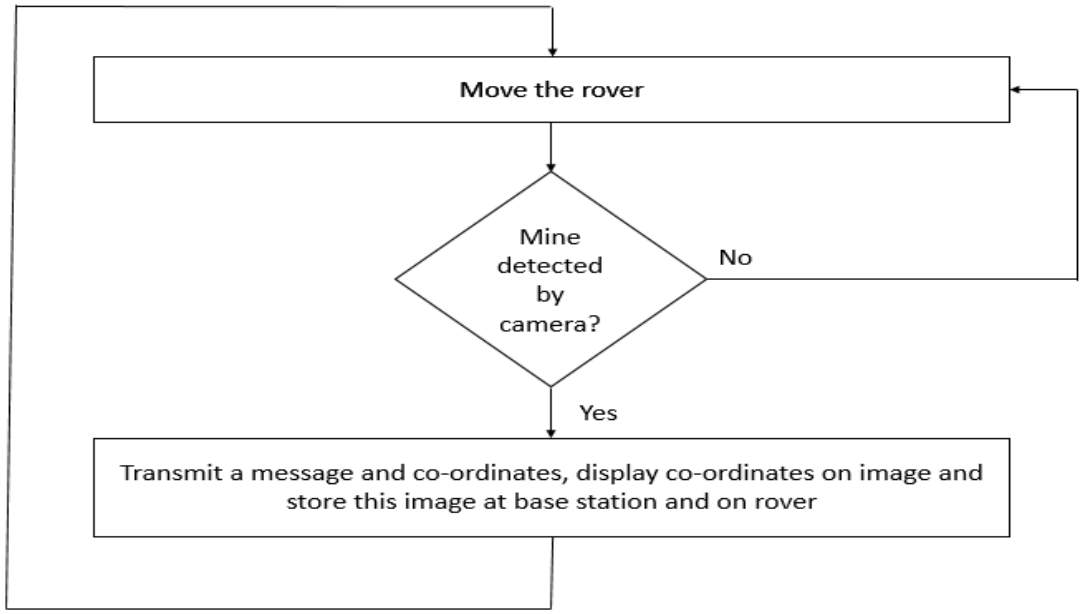

Fig 4.2 System flowchart – II

Whenever camera detects the presence of a mine, the co-ordinates of that instant are transmitted along with the image frame. These co-ordinates are printed on the image and displayed at the base station. Also this image is stored at base station.
Surface mine detection using Camera Detection of surface mines is carried out by using image processing. The classifier used for object detection is Haar classifier.

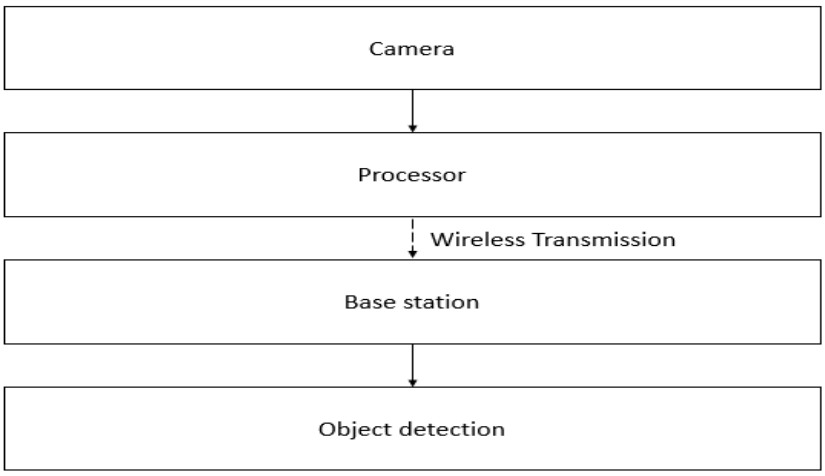

Fig 4.3 Surface mine detection flowchart

For detection of surface mine, we are using haar cascade. The above flow chart shows the steps involved in capturing the video and then detecting the presence of land mines. A webcam is used for capturing the video feed. This video feed is passed on to the processor present on rover. This processor transmits the video feed wirelessly to the base station using TCP/IP protocol. At the base

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station using a haar cascade a particular type of object (mine) is detected. If along with the camera any other sensor detects the presence of land mine, then it is considered to be correct. This location is then recorded

III. RESULTS

A. The system uses metal detector and camera as sensors for detecting the presence of mines. The location of mines is then stored in an ".xml" file and displayed on a GUI.

B. The range of this metal detector is around 10 cm. The mine will be detected even if there is no direct contact of search coil (of metal detector) and the mine.

C. For detection using camera, the angle of camera should be parallel to the mine or an angle of 45º with the camera.

D. The distance between rover and base station can be upto 100 metres.

IV. OUTPUT IMAGES

These images show the output obtained at base station after data is transmitted wirelessly from rover.

A. GPS Plot

Fig. 6.1 GPS plot

The above figure shows the plot obtained from GPS co-ordinates. The left window shows the path traced by rover with green markers. The right window shows the plot of places where mine was detected by red markers.

Output of camera used for object detection

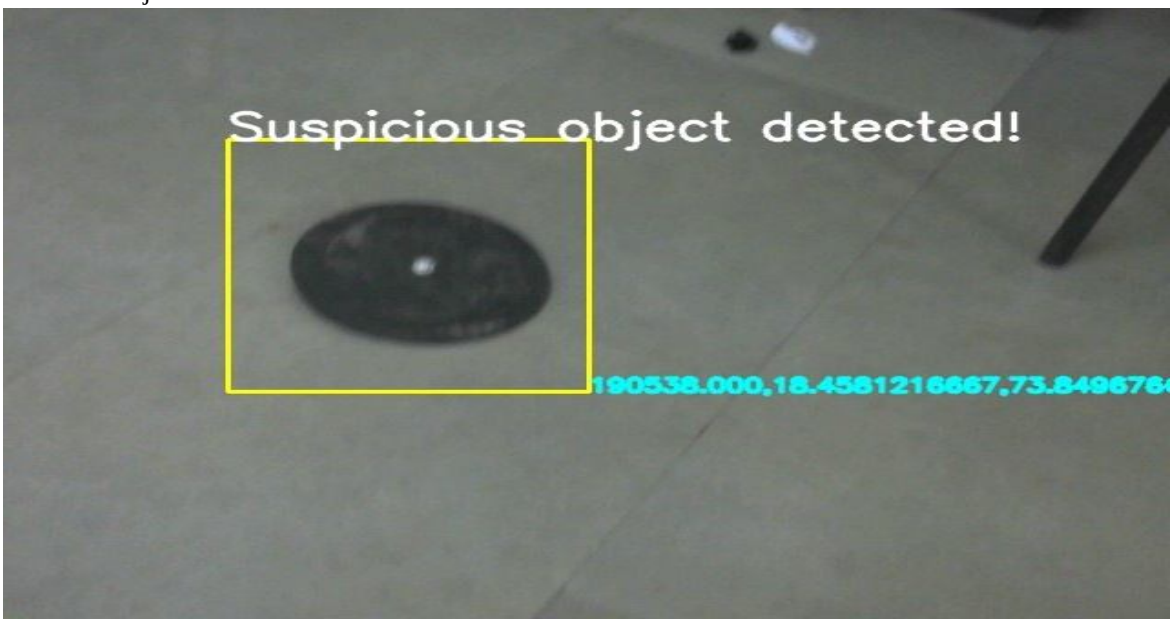

Fig.6.2 Object detection using camera (when rover is stationary)

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Fig. 6.3 Object detection using camera (when rover is moving)

Above images show object detection using camera. Whenever object is detected, a warning “Suspicious object detected” is displayed and the co-ordinates of that instant are displayed on that image. This image is then stored at the base station. The stored images at base station are shown in following Fig.

Output obtained after mine is detected by metal detector

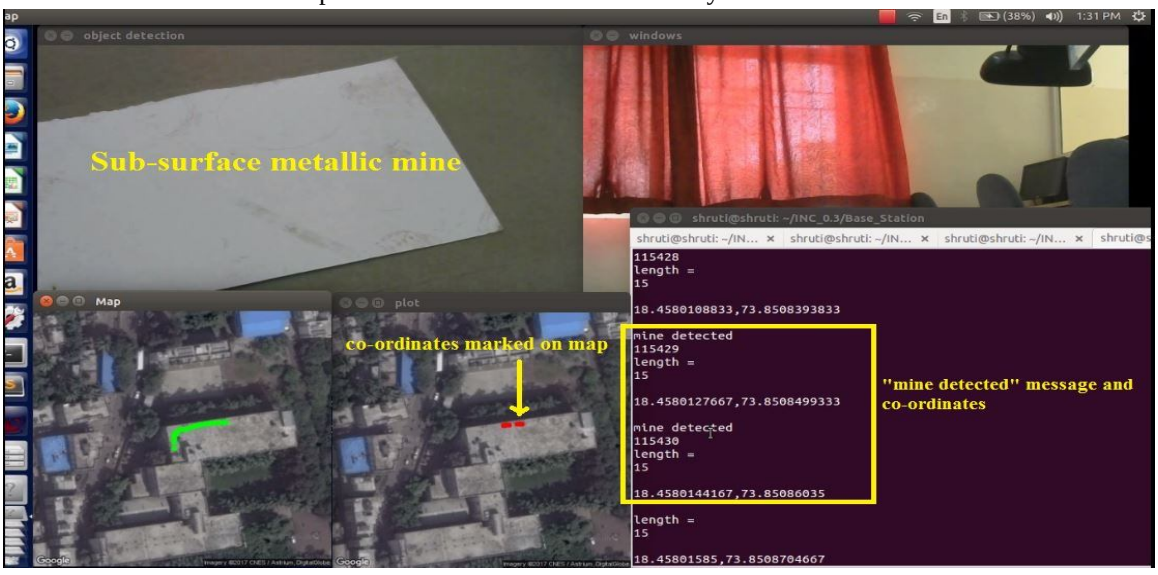

Fig. 6.4 Sub-surface mine detection using metal detector

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When a mine is detected by metal detector, its co-ordinates are marked on map using a red marker. Along with this, a message "mine detected" and its co-ordinates are displayed.

Data obtained after mine detection

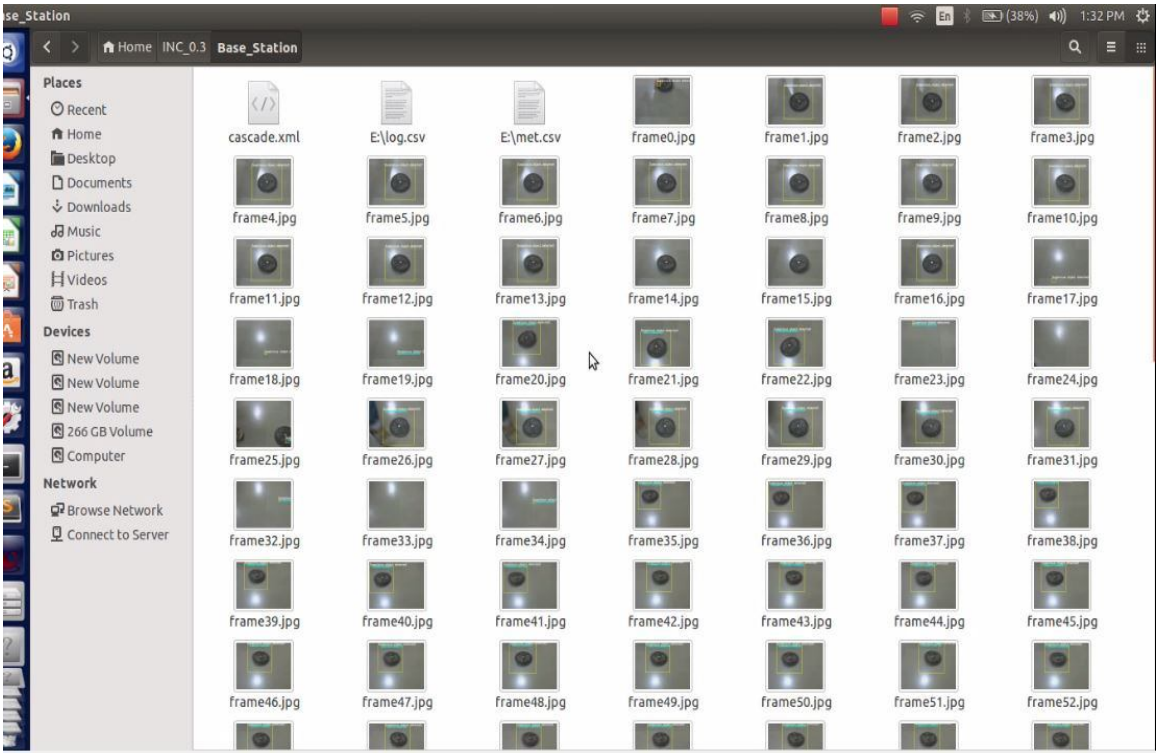

Fig. 6.5 Object detection images and .csv files stored at base station

Figure shows the output obtained after mine detection using camera and metal detector. The images stored after mine was detected by camera are stored at base station.

V. CONCLUSION

This project is implemented using two sensors i.e. metal detector and camera to independently detect the presence of surface and sub-surface metallic mines. Different sensor technologies which can be used for mine detection have been studied and the above two sensors are selected. A servo motor is used to rotate the search coil in front of the rover. Due to this, more search area is covered by metal detector. Wi-Fi is used for wireless communication between rover and base station. To achieve this wireless communication, socket programming is used. Different ports are created so as to enable simultaneous communication of various components between rover and base station. Based on the torque calculations square geared motors are selected for locomotion of rover. The body of rover is made from acrylic sheet so as to avoid false triggering from metal detector.

This rover helps in detecting the presence of landmines and documenting its location. Due to this data, the speed of process of mine removal increases as the location of mines is already known. Many such rovers can be used simultaneously to further increase the speed of minesweeping.

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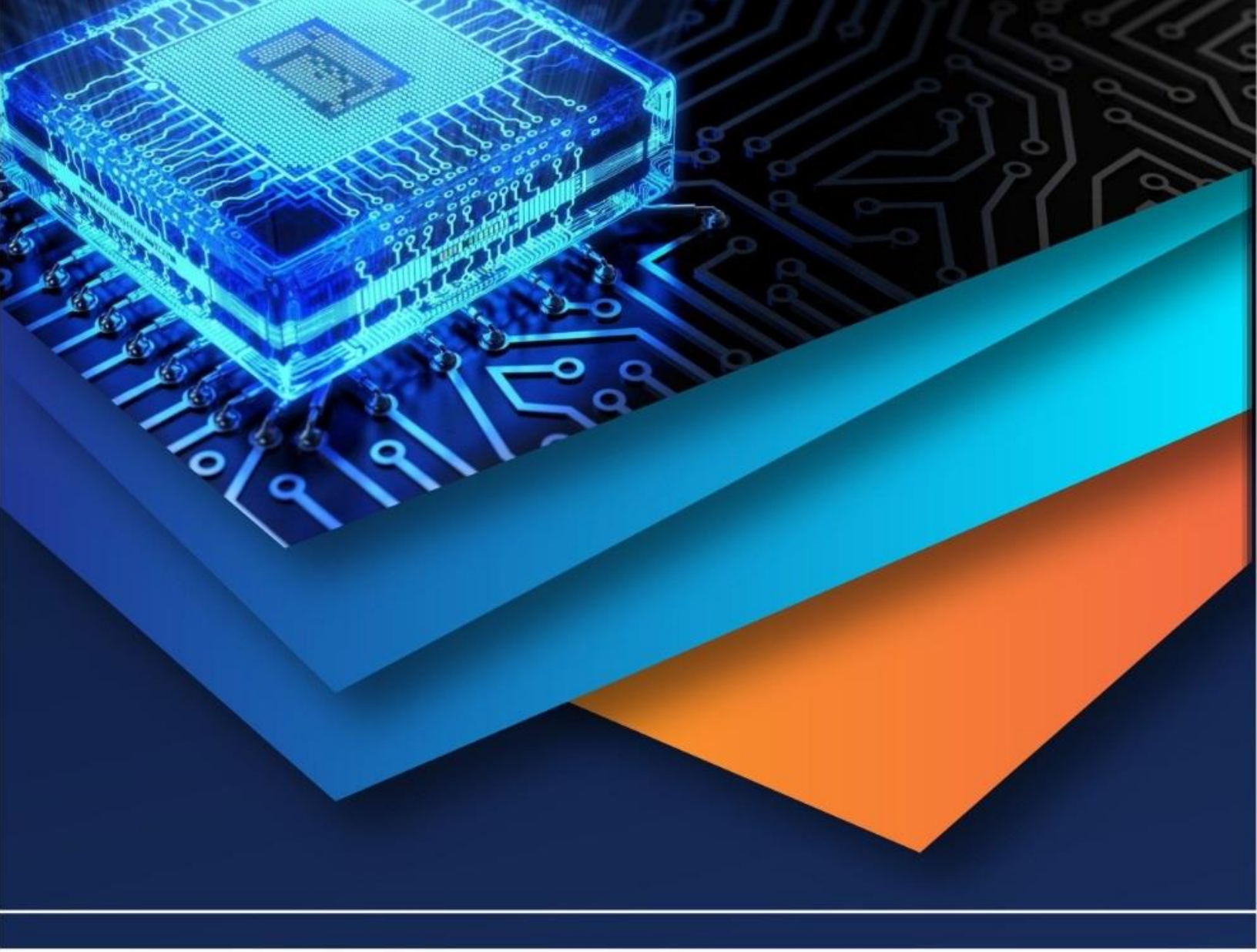

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