



Mini Rover-Object Detecting Ground Vehicle (UGV)

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Abstract—This paper proposes the multipurpose, wirelessly controlled UGV which can move across the surface, detect objects and classify them. It can also monitor and inspect object under interest, if detects any undesirable condition then inform corresponding authority for further immediate actions. The Mini Rover is a programmable machine with built in capability of executing certain set of predefined actions automatically. It can interact and get perception of environment via certain set of sensors and actuators. UGV will be able to go to places that human cannot reach for the sack of exploration and observation without an onboard human presence. UGVs are used for the purpose of search and rescue, security and surveillance, terrain and forest monitoring because it is inconvenient, inefficient, dangerous, and sometimes impossible to have a human operator present in such environments. Major problems faced by UGV in natural terrain environment are reliable sensing, route finding, and object detection and identification. We combine a set of sensors and image processing techniques to counter these problems by getting a more extensive perception of the environment.

Index Terms—Object tracking, Classification and recognition, GSM based Alarm, Live Video Streaming

I. INTRODUCTION

The UGV is an exploration vehicle designed to move on the ground that can detect objects, characterize them and send feedback to the remote station wirelessly without any human interference. They are gaining popularity due to their versatile applications in various fields such as in military, domestic and industrial zones. The UGV operating in natural terrain environment face lots of problems that reduce the overall reliability and may cause failure in operation. In general, these challenges can be categorized, according to Reliable sensing, environment, technology, and operation [1].

An engineering study was carried out at World Trade Center (WTC) to analyze the performance of UGVs and to find out most frequently occurring cause of failure. The showed that while getting perception of environment, most commonly failed sensor was camera [2]. On average 24% of total search time was lost due to lightning effects and obstacles in front of camera [3]. The lighting effects included states in which the lights were completely off or were in transition between intensities. This failure was less common, occurring 6%, on average, of the total time the robots spent searching [4]. The environment also play a major role in the operation of UGV. The UGV may not operate in extreme environmental conditions such as in the presence of heavy rain or heat [5]. In terms of technology reliable communication link and battery timing are most demanding challenges. Among all major problems faced by UGV in natural terrain environment are reliable sensing, route finding, object detection and obstacle avoidance [6, 7].

In this paper, we combine a set of sensors and image processing techniques to counter these problems by getting a more extensive perception of the environment. In the UGV

Arduino is used as a central computing device, when connected to sensors and actuators make human-like decisions based on what it can sense. Communication is an integral part of any robotic system, here in this we create a wireless communication link between the UGV and the Control Station (such as Laptop) by using ZigBee Protocol. The UGV also have an integrated Global System for Mobile Communication (GSM) module, the purpose of this module is to messages-based alarms when it detects an unfavorable condition such as a fire or very high temperature. To get more extensive, accurate and real-time perception of the environment a Vision System is added to the UGV.

In this Vision System, Raspberry Pi and ordinary Pi-Camera are utilized to get real-time video streaming of area under interest by creating Wireless LAN (WLAN) between the UGV and control station. Then, on control station, this video streaming fed into MATLAB and image processing techniques are applied to detect, classify and track object under interest.

The remaining paper is organized as follows; in section II, a brief description of the Design Methodology of the system. Section III is about Object Tracking, Classification and Recognition, and in section IV is about the Results And Discussion of the derided system model and section V contains the Conclusion.

II. DESIGN METHODOLOGY

A. UGV-To-Control Station

In teleoperation mode the UGV requires a Control Station which controls the movements of the UGV remotely. In order to send commands to the UGV a dedicated wireless communication link is created between the UGV and Control Station, in which control station

send commands to the UGV and UGV execute the commands by carrying out certain predefined actions or tasks show in Figure 1.

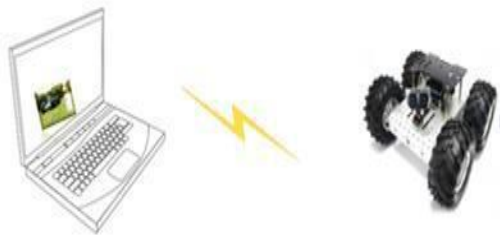


Figure 1: Communication between the UGV and Control Station

B. UGV-To-Control Station Communication Link

This communication link consists of two ZigBee's, one on Control Station side which as configured a coordinator and other configured as router is integrated in the UGV creating a point-to-point link show in Figure 2.

In this wireless link control station is the laptop and xbee is connected to via USB port.

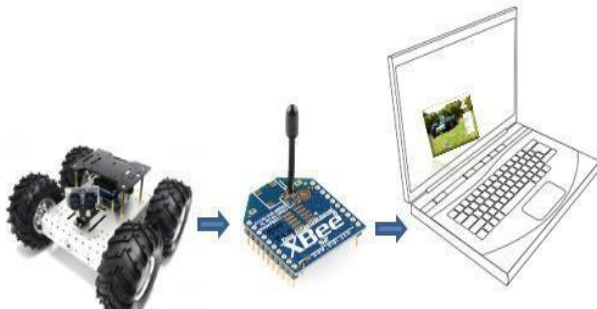


Figure 2: Communication Link between the UGV and Control Station

C. GSM Based Alarms

The UGV contain set of sensors such as fire, humidity, temperature and smoke sensor to monitor the environment. UGV moves across the surface and continuously monitor the area under the interest. In the UGV Arduino is acting as main computational and decision-making device which is connected to the sensors, actuators and communication device. So, when UGV detects an unfavorable condition such as fire or hire very temperature then it notifies the corresponding authorities via GSM messages.

D. Live Video Streaming Via WLAN

Interface of Raspberry Pi with Matlab and Access of video from raspberry pi to Matlab the purpose of using raspberry is to get live streaming from raspberry pi camera into control station i.e. Laptop. Once the live video streaming is accessed to laptop we need to process that video into Matlab at the control stations.

Connecting Raspberry Pi Camera with Raspberry Pi

To get live video streaming following hardware is required.

- a) Raspberry Pi camera
- b) Raspberry Pi
- c) Power Supply 3.3 V (Q Mobile charger)
- d) LCD Monitor

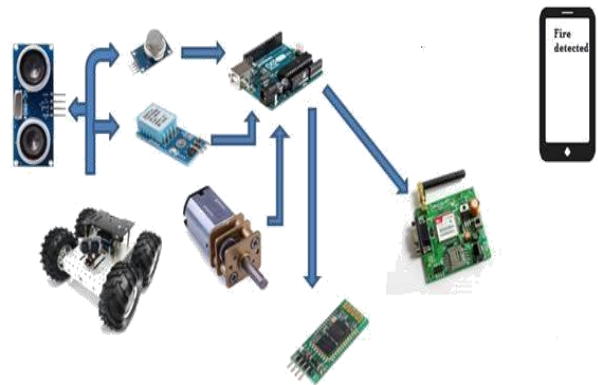


Figure 3: GSM Communication Link

1. HARDWARE SETUP

- i. Connect raspberry pi with monitor through VGA-HDMI cable
- ii. Connect raspberry pi camera with raspberry pi
- iii. Power up raspberry pi and LCD monitor
- iv. In prompt window, run "*sudo raspi-config*". If camera is not present. Run "*sudo apt-get update*" and "*sudo apt-get upgrade*"

```
pi@raspberrypi ~$ sudo apt-get update
pi@raspberrypi ~$ sudo apt-get upgrade
```

- vii. Run "*sudo raspi-config*" again - you should now see the "camera" option and enable it.
- viii. Select "Finish" and reboot your Raspberry Pi.
- ix. Now Raspberry pi camera is configured and is ready to be used for live streaming.

To do so Matlab needs a hardware support package for the raspberry pi. So, it is necessary to install MATLAB. This package provides the facility of communication between a Raspberry Pi and a computer running MATLAB. This package creates a WLAN or LAN between Raspberry Pi and the computer. The type of network configuration depends on setting that is to be configuration at the time of installing MATLAB hardware support package for Raspberry Pi.

III. OBJECT TRACKING AND CLASSIFICATION

Image processing is a method of performing operations on an image to get desired output, like detection of objects, identification of objects, compression of the image, and different other operations. This type of processing takes the image as input and produces an output which may be input or characteristics

corresponding to the image. It may include filtering of image i.e. converting color image to grayscale image, smoothing, sharpening, removing noise, and edge detection. The basic example of image processing is the use of low pass filter for smoothing of image i.e. to reduce noise within an image or to produce a less pixelated image.

Nowadays automation in robotics is becoming essential in most of the environments like industries and research. The robots have to be autonomous in real-time environments like a firefighter robot in an industry, moving unwanted objects from a particular place and etc. In such environments dependency on other sensors increases. As the environment and application become more serious than the accuracy of robots has to be more perfect. And merely sensor does not provide every information, for example, a fire sensor sense fire but it does not tell that on how much area the fire has affected, how much distance is there between affected area and robot and etc. In such cases, real-time observation is needed.

The induction of image processing in robots overcomes all above described problems. In image processing, the detection of fire does not tell merely the presence of fire but the information like, how much area is affected at what distance and its intensity.

Object detection is the process in which objects of the interest are detected in images or video streaming. There is wide range of objects such as persons, automotive, bicycles, and buildings in images or videos. Object detection techniques normally use feature extraction and certain learning algorithms detect specific objects and put them in a category. It is commonly used in applications such as image retrieval, security, surveillance, and automated vehicle parking systems [11].

There are several algorithms used for object detection in an image. Some of them are described below.

The process in which foreground is separated from the background in a series of video frames. It is fundamental technique used for detecting moving objects from a stationary camera. Basic process involved to detect moving objects is to find out the difference between the current frame and a reference frame, called "background model". [12-14]

Following are the steps involved in Background Subtraction

- 1) Get Video Stream
- 2) Take snapshots
- 3) Background Model
- 4) Compute difference between background and current frame
- 5) Apply Thresholding

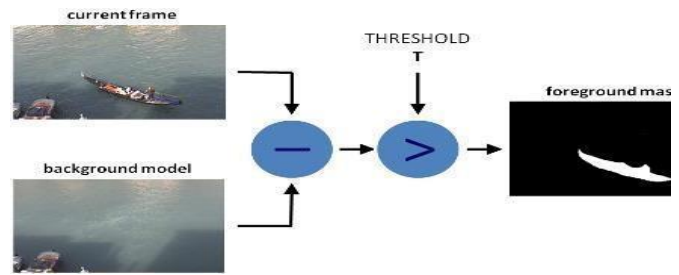


Figure 4:Background Subtraction [6]

These operations are related to the shape of objects. It applies a structuring element to an image at the input and creates an image of the same size. Figure. 4 operation, the content of each picture element in the output image is based on a comparison of that picture element in the input image with pixels in its neighborhood. The sensitivity morphological operations to specific shapes depend upon the size and shape of picture elements in the vicinity,

The two fundamental morphological operations are erosion and dilation. Erosion means to remove or reduce, this process removes the pixels from the boundaries of an object while dilation means to increase, in this process pixels are added at the boundaries of an object.

The number of pixels dilated in the object or eroded from the object in an image depends on the size and shape of the structuring element used to process the image.

The rules for the dilation and erosion are described below:

1) Dilation

The value of output pixel is greatest is greatest among the all pixels in neighborhood of input pixels. In a binary image, if any of the pixels is set to 1, the output pixel is set to 1. As shown in Figure 6, the neighborhood of pixel of interest is defined by the structuring, which is circled. The dilation function applies the appropriate rule to the pixels in the neighborhood and assigns a value to the corresponding pixel in the output image.

2) Erosion

The value of the output pixel is the smallest of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0. Figure 7 shows the realization of erosion.

The region of an image having some features that are static or approximately static is known as a blob. Every point in a blob can be considered as similar to one another. Blob analysis detects set of joint pixels that correspond to moving objects. The most common method for blob detection is convolution.

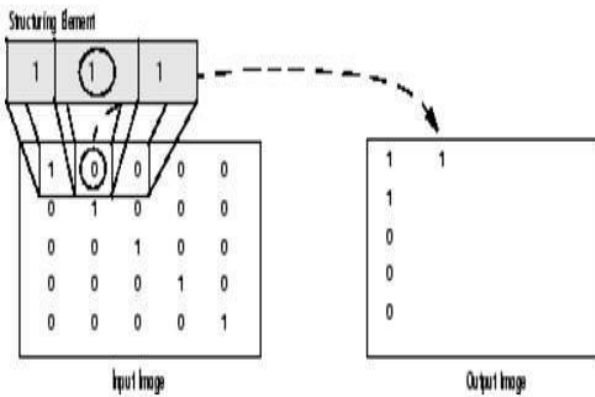


Figure 6: Dilation of Image

Once the object has been detected then it can be tracked along its path. It is used for the estimation of future states, these are certain mathematical models that gives an efficient estimation of the state of a process in numerous aspects. This filter is useful in tracking different type's objects that are in motion.



Figure 7: Erosion

In this method, noisy measurements are combined with the prediction of the state for getting the true estimation of the next state. After estimation object existence is verified at estimated position.

IV. RESULTS AND DISCUSSION

The UGV is controlled wirelessly. The wireless communication link between UGV and control station is Xbee network. The whole process of communication link is already described in this paper. The sensor system consists of three sensors those are smoke sensor, fire sensor and temperature sensor. The sensor is connected to Arduino. And GSM is also connected to the Arduino. When the smoke sensor senses the smoke, it generated the alarm and values of smoke, fire and temperature are sent to particular mobile numbers. The results are shown in Figure 7.

The basic image processing methods are applied to the live video streaming like face tracking, object detection, sending email, and video recording. These all functions are comprised in one graphical user interface.

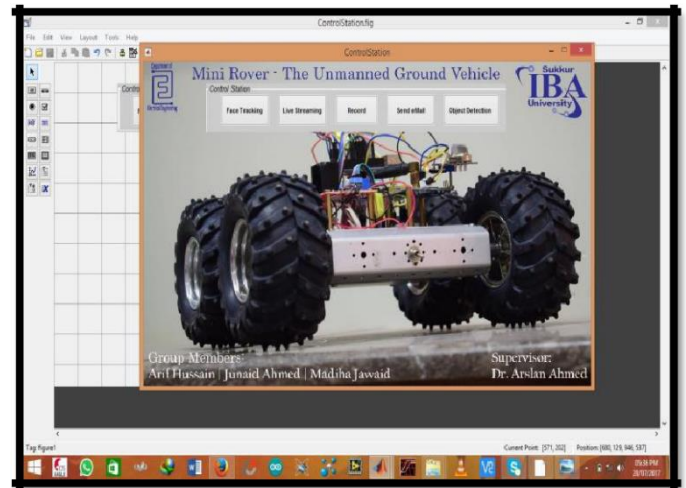


Figure 8: GUI of Different Function at Control Station

Live Video Streaming from UGV to Matlab at Control Station In GUI, when **live streaming** button is pressed, the live video streaming will start. That live video streaming is coming wirelessly from UGV to MATLAB in control station. Following are the results show in Figure 8.



Figure 9: Live Video From Raspberry Pi Camera to MATLAB

The **face tracking** button is pressed than, if any human is there its face will be tracked. As he/she move its face it will be tracked. This video processing is done live video streaming show in Figure 9. This feature allows the recording of live video streaming. It saves the recorded file in the specified folder. We can send recorded video via email to authority. The email addresses diction are specified show in the code.

In this feature slow moving objects are detected using image Processing algorithms such as background subtraction. morphological operations and blob analysis. In this paper we have taken human as a sample, both are result show in Figure 10.

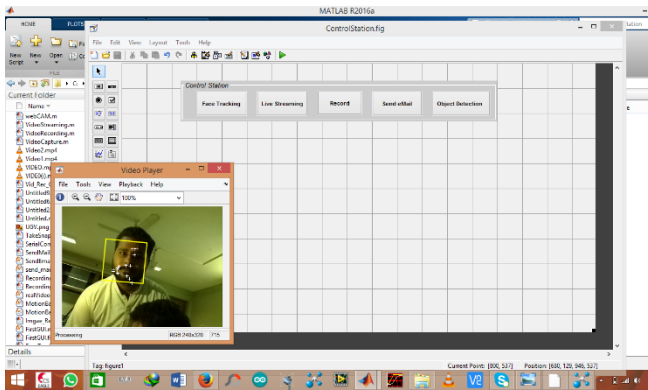


Figure 10:Face Tracking From Live Video

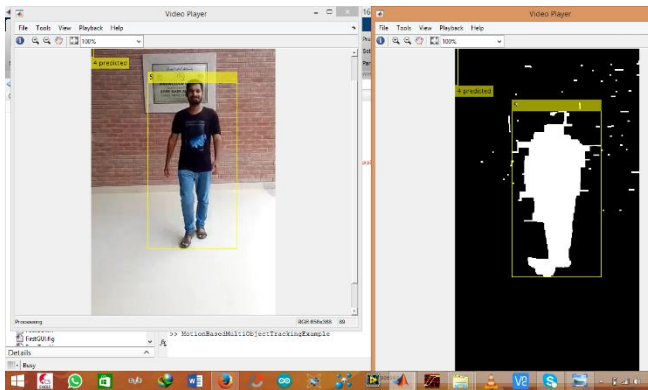


Figure 11:Moving Objects (Human)

V. CONCLUSION

In this project, a wirelessly controlled Unmanned Ground Vehicle (UGV) has been developed for remote applications. The UGV uses a combination of ultrasonic, temperature and gas sensors along with a built-in camera and therefore can be used for multiple applications which includes fire detection, smoke detection and object detection. Once the sensors sense anything then camera becomes active and track the object under observation. The camera differentiates whether the object is a fire, a smoke or moving object. This UGV can be used in industrial processes for surveillance purposes or to identify unwanted movements.

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