Mapping and Localization of Landmines by Heterogeneous Swarm Robot

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Abstract Swarm robotics is an emerging field of technology that uses the collective intelligence of groups of robots. To perform different kinds of complex tasks or the tasks unhealthy for human, swarm robots can be used. Detection of landmines is the important part of the humanitarian demining operation. Introduction of robots in the process of detecting landmines, that too, multiple simple robots reduces the human risk. In this research we are detecting the landmines, locating the position of landmines as well as robots and routing a path for the safe traveling of humans. Swarm robots reduce the time consumed for the detection process. We divide the entire plot equal to No of robots and starts mine detecting process. Robots are localized and tracked in the video using python OpenCV. The localization using the camera, data transmission using ZigBee and motor driving circuitry are controlled by the ARM LPC1769 microcontroller.

Keywords — Humanitarian demining, Localization, Python, OpenCV, ZIGBee, LPC1769

I. INTRODUCTION

As an emerging field of research, researchers attracted to swarm robotics since the 1980s. The members in a swarm are not highly intelligent, but they complete a complex task by coordination, cooperation, and division of work and that shows the high degree of autonomy [1]. The main applications of swarm robotics include the tasks require the large area, time and cost, and that are harmful to the human being such as disaster management, Warfield areas and target searching [1]-[2]. Our robotic swarm is specially designed for Warfield for the detection of landmines. Currently, there are several ongoing projects that aim to develop and control large numbers of physically embodied agents. Self-organizing and cooperative behaviours have been investigated for navigation, for pattern formation [3, 4,7], and for doing tasks too complex or impossible for a single robot to achieve [5], like cooperative pushing [6].

The prototype includes two types of robots, S-bots for searching landmines in the selected area and one Cam-bot. The field of inspection is determined by the central computer by using the images captured by the Cam-bot. searching for bots holds the sensors for landmine detection, obstacle avoidance, positioning, communication etc. The searching robots are communicating through the algorithm that was developed by the trial and error method. A hardware design of the swarm robot was built successfully and detected the landmine in a particular area.

A. Objective

For the localization and mapping of swarm robot, we have many objectives

1. To develop an autonomous robot that consists of different sensors gives data from which converts it into useful information and send via ZigBee
2. Mapping and localization of robots in the decided scenario

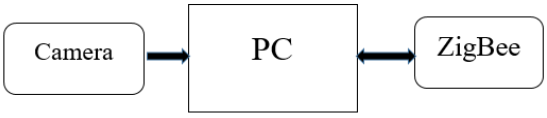
II. METHODOLOGY

A. Hardware Description

Hardware description can be explained as two setups,

- Cam-bot

This bot consists of ZigBee, camera, and PC. The main objective of this bot is to determine the boundary of inspection from the video that is captured by the camera. It constantly checks whether the s-bot has been reached a boundary or not. If s-bot reach left boundary cam-bot will notify to s-bot to turn right about 180-degree rotation. If s-bot reach right boundary cam-bot will notify s-bot to turn left.



- S-bot

This bot consists of ZigBee, ultrasonic sensor, LPC1769 microcontroller, motor driving circuit, metal detector buck

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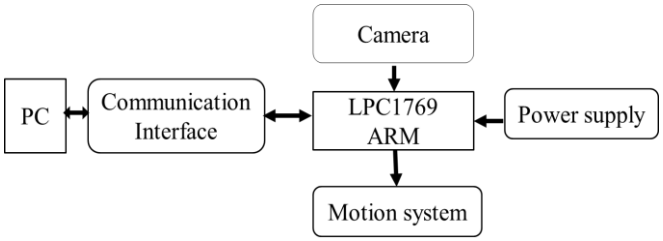
converter and battery of 12V. The 12V is converted to 5V with the help of a buck converter. As the commands are received over ZigBee the motor drives motor according to the commands.

We made this robot base in acrylic sheet. We designed it in the COREL DRAW software and cut it in the laser printer.



The block diagram of searching bot is shown in figure which is different from cam-bot. S-bot uses a number of sensory information for effective searching and positioning of mine locations. To detect the presence of landmines a metal detector sensor is used. If the detected metal is a landmine, the positional values of mine are again sent to the PC. Also, the current position of s-bots is determined by using inertial sensors.

The important messages about distance and the positions of the mines are broadcasted among the s-bots. After getting the X and Y coordinates of the mine location a safe route map can be built by avoiding all the mines.

B. Software Description

We did this project on the two platforms. Firstly, LPCEXPRESSO IDE in which we have given overall control of the S-bot which will be loaded with the help of a flash magic. Secondly, we use OpenCV Python for the tracking the robot and mapping its position.

Camera Setup: we use camera for the real-time

Operations**.** VideoCapture() if we pass 0 normal camera will be connected and if we sent 1 second camera will be connected and so on. This helps the device to capture frame-by-frame. But at the end, we have to release the capture. Moreover if anyone wants to apply this color detection technique on any image it can be done with little modifications in the code [8].

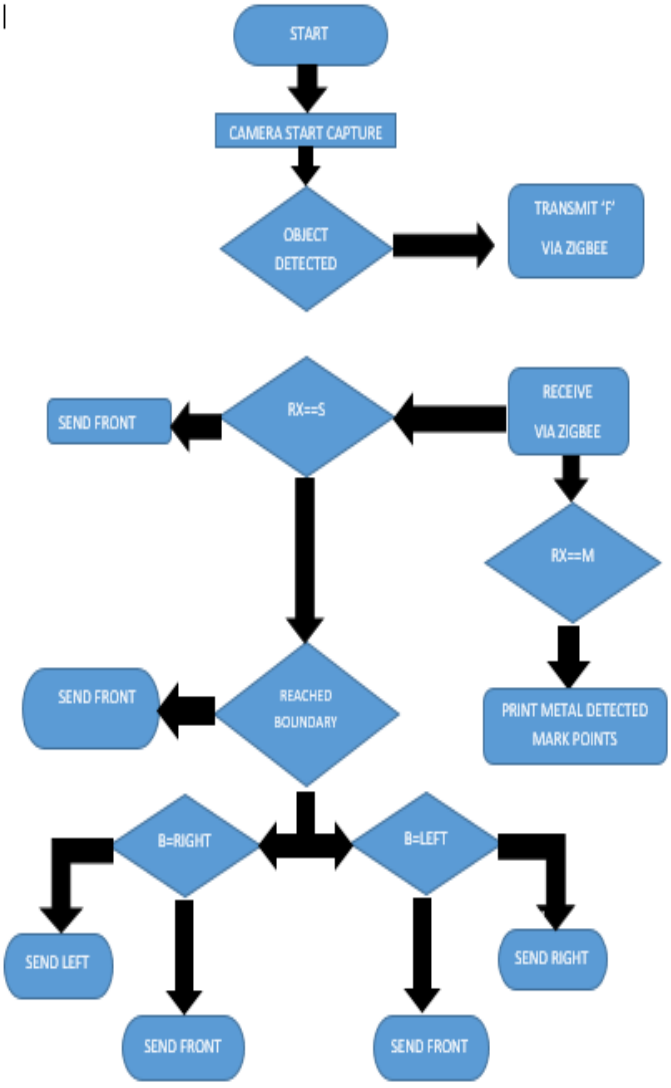
Capturing frames: For extracting complete details

We need to create an infinite loop of frame capturing which offers exactly the same as the video stream. Then we will convert each frame BGR color space to HSV. For color conversion,we use the func cv2.cvtColor(input_image,F) where determines the type of conversion. For BGR to HSV, we use the F as cv2.COLOR_BGR2HSV. We need to detect blue color so we specified the range of blue [8].

Masking technique: To detect some of the colors

We need to mask certain according to the rule of image processing. We need to detect blue color so we mask them. Now we do bitwise anding on masked image and threshold image to get only the blue color and its stored in res.Now we use imshow function to show these three images [8].

Display the frame: As imshow() is a function of HighGui it is required to call waitKey regularly, in order to process its event loop.The function waitKey() waits for key event for a "delay" (here, 5 milliseconds). If you don't call waitKey, HighGui cannot process windows events like redraw, resizing, input event etc. So just call it, even with a 1ms delay [8].



- *Cam-Bot Algorithm*

1. Start the camera
2. Fix the boundary.
3. It constantly check for the blue colour in the field.
4. Once it's found it sends START signal via ZIGBee.
5. S-bot receives start signal thus starts moving FRONT.
6. Now it constantly checks boundary, also moves FRONT.
7. If B==RIGHT sends turn LEFT
8. If B==LEFT sends turn RIGHT
9. Else continue with step 6

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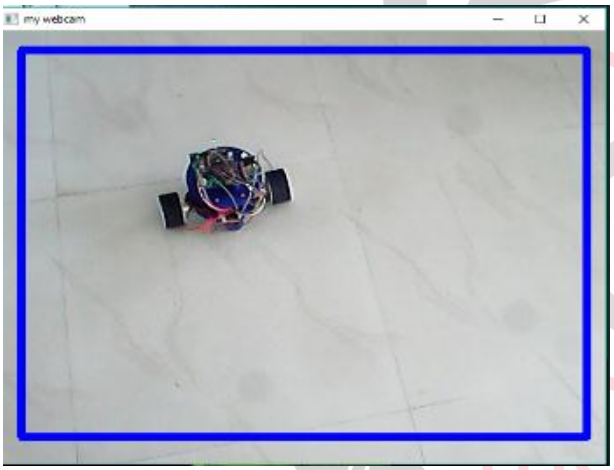
10. If rx== M print metal detected points are marked
11. If rx== L print scanning completed send STOP
12. Stop

- *S-Bot Algorithm*
  1. Start
  2. If it receives start move front
  3. If it receives left move left 90degree turn, stop move front then 90degree turn stop move front.
  4. If it receives right move right 90degree turn, stop move front then 90degree turn stop move front.
  5. . If metal detected it sends "M"
  6. Data from ultrasonic sensor if dis < 30 cm turn left.
  7. Stop

III. RESULTS

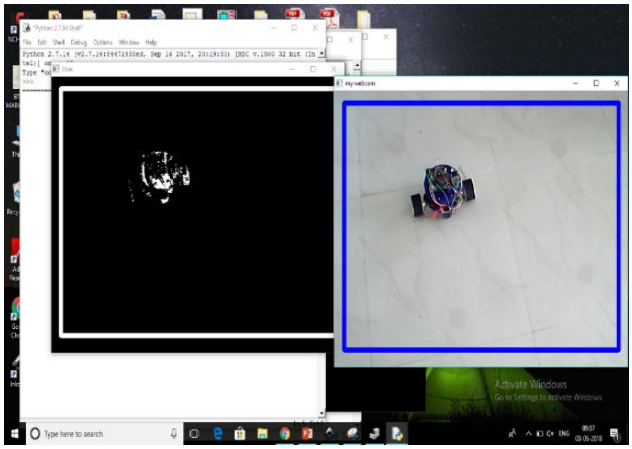
A. After the connections are made we fix the boundary of inspection



Here the blue rectangle box is the fixed boundary in which robot is allowed to move inside these fixed boundary. we have decided the pixel points of 60,60,540 and 360 in the camera as the boundary. Now the robot is free to move inside this boundary

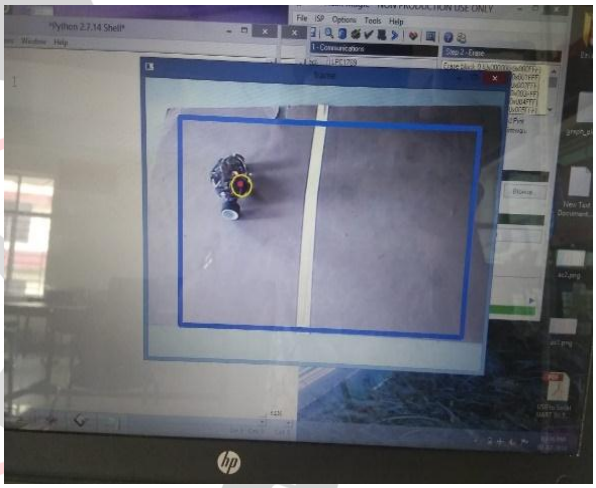
B. Now we start detecting blue colour:

Here the robot is identified with the blue colour by color detection and tracking using OpenCV functions.



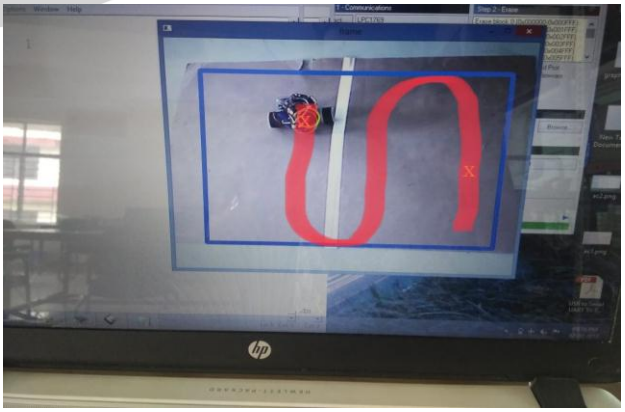
Here we masked by bitwise anding between masked image and threshold image . we can see that blue detected space white colour in the mask window

C. Next step is we track the blue color and we give the instruction according to the inspection:



Here that yellow cicle and red dot represents the tracking of the blue colour .yellow circle represents the are of blue colour detected in each frames. we constantly check whether pixel point of blue colour detected area have reached the boundary or not and we will send the controlling commands

D. Robot movement path.



Red track denotes the movement of the robot in the zigzag direction

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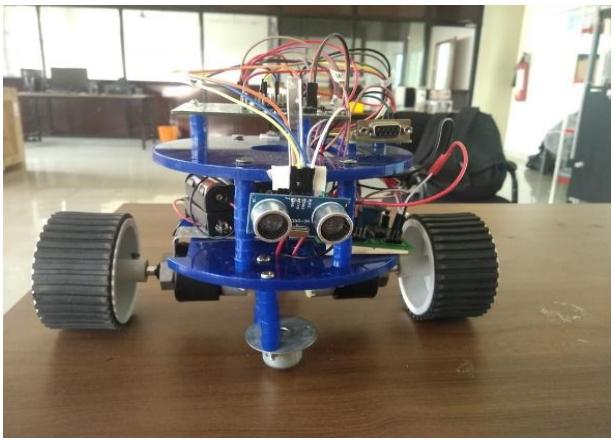
E. Prototype

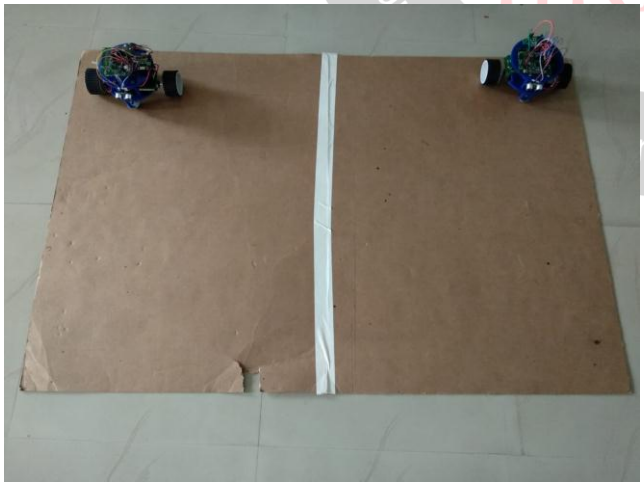


IV. CONCLUSION

We have successfully developed an autonomous robot that can detect mines. This robot can detect in any environment without the loss of information. But bad lightening can cause bad tracking of the object. The main advantage is that the boundary of detection can be varied. Thus the Cam-bot can be modified to a quad copter that gives best result. We also have developed the algorithm for the coordination of the two robots .We have tested the robot, also we were able to find the suitable path for the safe travelling of the army men. As this is a project based on the swarm robot, more robots can be included and also it creates an ad-hoc environment. This projet can further be modified by adding more robots we tried with two robots for the inspection.

A. Advantages:

1. The camera can be adjusted to any height This is adaptable any situation
2. With little changes in software any color can be detected



B. Disadvantages

1. We have used 45 RPM motor it makes detection process so slow .if we increase the RPM it will affect mine detection as its less sensitive sensor
2. Color detection is not so accurate so it totally affects the controlling of the S-bot.
3. Lighting always causes problem in image processing

C. Future Scope

1. This project can be further extended such that Cam-Bot can be modified to a quad copter that takes a wide range
2. More number of robots can be implemented.

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