

Mobile Surveillance System for Object Detection and Extraction using Image Processing

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ABSTRACT

Security and safety of the people in public places is the major concern for the law enforcement departments of this country. Building surveillance system with video tracking and robotic platforms is the current challenge for the engineers to build indigenous Security Systems. The majority of existing systems are stationary with roof mounted video cameras for object tracking which do not provide full proof security.

In this paper, a prototype of semi-automated robotic system for surveillance, object tracking and retrieval in real time environment is discussed. Surveillance is accomplished by video camera, object detection and tracking is achieved by image processing techniques and a robotic system with an arm. The retrieved object is disposed in a pre designated location. The obstacle detection and avoidance is adopted in this robotic surveillance system [1].

General Terms

Image Processing, MATLAB PIC Microcontroller, Arduino Uno board, Robotic Arm, Chassis

Keywords

Surveillance, obstacle avoidance, objects detection, video tracking, centroid, bounding box, region of interest, object retrieval

1. INTRODUCTION

Most of current electronic gadgets for remote security system acquire videos of the scene of interest in real time environment but the analysis of acquired data is done in non real time. Real time acquisition, analysis of data and subsequent early decision making is the need of the day. Mobile systems for image acquisition to recognize the object of interest and its early retrieval and disposal ensures the safety of life in a densely populated area [1]. Figure 1 shows the images of an Airport Surveillance system to identify the unattended objects by video acquisition and analysis to ensure the safety of passengers. Installation of such systems is essential in public places as a precautionary measure to provide security for the general public.

2. METHOD AND MATERIALS

2.1 Block Diagram

In this work, the overall system is divided into six phases- 1. Image acquisition by a wireless IP camera. 2. Object detection and tracking using image processing techniques.

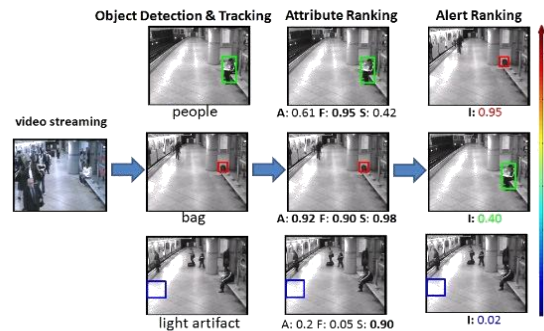


Fig 1 Airport Surveillance [2]

3. Robot control by generating control commands from MATLAB. 4. Obstacle detection and avoidance using range sensors. 5. Robot mobility by controlling the motors using PIC18F4550 microcontroller in accordance to the generated command signals. 6. Object retrieval by controlling the robotic arm and disposing the object in a predefined destination. Figure 2 shows the data flow diagram of these six phases.

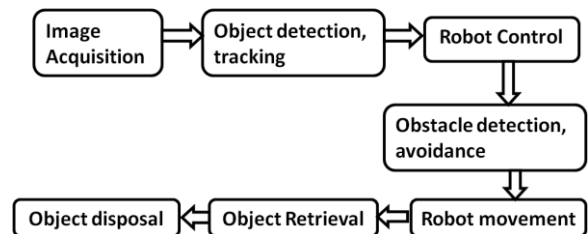


Fig 2 Data Flow diagram of mobile surveillance system [1]

The robotic base consists of IP camera, robotic arm, and robot chassis with wheels controlled by DC motor, motor driver, PIC18F4550 controller, RF receiver and two IR sensors. The arm gripper is provided with pressure sensors. The image processing unit consists of a computer system with MATLAB Version 8.1, an Arduino Uno development board and an RF transmitter [3]. The figure 3 shows the block diagram of the hardware implementation of the system.

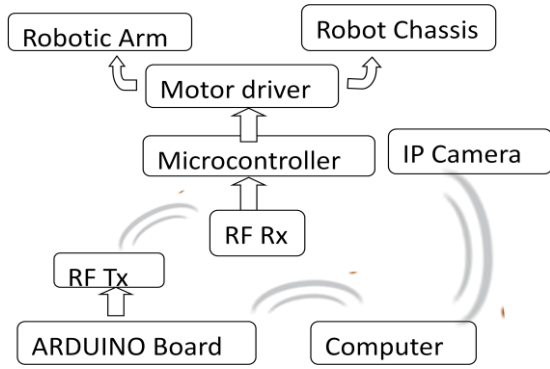


Fig 3. Block diagram of the hardware [3]

The video of the scene of interest is captured by light weighted, sensitive wireless IP camera and is transmitted to the image processing unit [4]. The image processing algorithms applied for preprocessing and object identification. Spatial filtering and red object subtraction algorithm is adopted to enhance the image.. Median filtering is adopted as it preserves the edges in the image after the noise filtering [5]. The exact location of the object is marked by the computation of the centroid with co-ordinates (Cx, Cy) and the rectangular bounding box is created for unattended object in red color as given by the equation 1.

$$C_x = \frac{\sum C_{ix}A_i}{\sum A_i} \quad C_y = \frac{\sum C_{iy}A_i}{\sum A_i} \quad i=1, \dots, N \quad (1)$$

where C_{ix}, C_{iy} are centroids of the subareas A_i for N subareas defining the object[6]. Based on this data of the scene, commands for movement of the robot are wirelessly transmitted to the controller using RF transmitter via Arduino Uno board. The robot is aligned suitably by left and right movements to visualize the object in the region of interest (ROI) in its path during its approach to the object [7].

The robot is provided with two IR sensors on the chassis of robot. The left and right mounted sensors visualize the obstacles on left and right part of ROI respectively to avoid obstacles. Once the robot reaches the object, the arm movements are initiated with semi automatically generated commands to pick up the object. The robot is redirected towards the destination to deposit the picked object using the same mechanism as the object detection. The right, left, forward, stop commands are generated by PIC microcontroller with MPLAB IDE v8.43.

2.2 Role of image processing

In this work the object of interest is limited to red colored with rectangular and cylindrical surface, lying at ground level and destination spot is identified in blue color. The IP camera is interfaced with MATLAB IDE and the images are captured at the rate of 30 frames/second [8]. The captured image is first converted to gray scale image then the red component is subtracted from this image. After filtering out noise, the image is subjected to blob analysis to compute the area and centroid of the red object [5, 9]. The entire image has been condensed to a single coordinate using which the robot can be programmed to move towards the red object by centering itself in front of the object until it is low enough in the frame for the robot to decide the object is in the region of interest and stop for the arm to pick it up. Once the red object is picked, the robot is guided towards the destination marked

by blue color by repeating the same algorithm [10]. The figure 4 shows the ROI and its neighborhood.

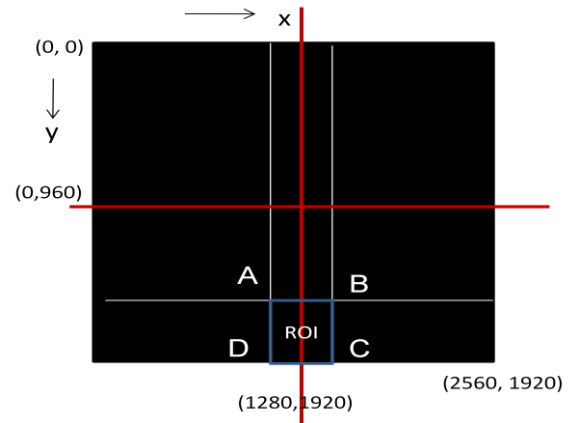


Fig 4. Region of interest of object

Table 1. Co-ordinates ROI of the in the scene

Co-ordinate point	x	y
A	1100	1600
B	1500	1600
C	1500	1920
D	1100	1920

2.3 Robot movement

The left, right, forward and stop movements of robot are controlled by the commands generated by the image processing unit with centroid position input. These commands are transmitted using RF transmitter in order to guide the robot towards the object and stop it in a distance reachable by its arm. These commands are received by RF receiver located on the chassis of the robot and is interfaced with PIC18F4550 controller. The controller moves the robot in accordance to the received command by rotating the DC motors of the robot chassis [11].

2.4 Obstacle Detection and Avoidance

IR sensors detect the presence of obstacle in the path of the robot and then suitable interrupts are generated by the PIC microcontroller to guide the robot to turn in opposite direction in presence of the obstacle. Figure 5 shows the flow chart of Obstacle detection and avoidance algorithm implementation governed by the IR range sensor inputs [11]. The various tasks involved in picking and placing process of the robot are shown in the figure 6.

2.5 Arm movement

The movement of the arm is controlled semi automatically soon after the robot moves near the object. The arm and gripper movement commands are generated by GUI created in the MATLAB. Figure 7 indicates the soft keys generated to control its movement. The five soft keys- bend, open, lift, close, and stop the arm and gripper movement. The grip of the object is indicated by a buzzer when the object is held tight enough to trigger the pressure sensors inside the gripper [12].

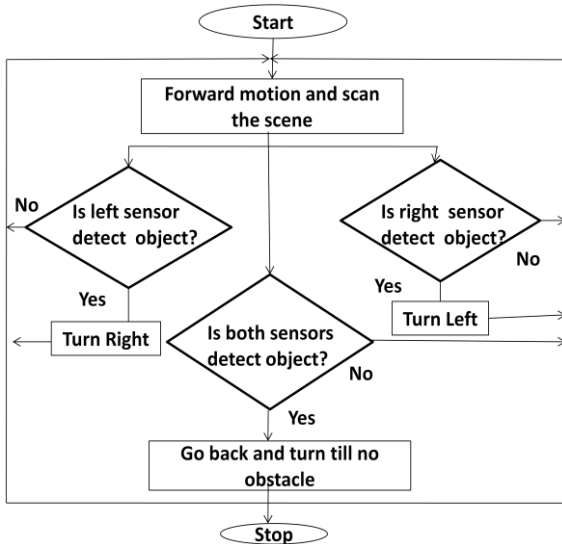


Fig 5 Block diagram of collision avoidance algorithm [9]

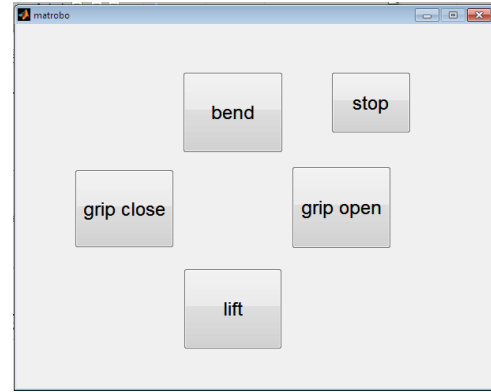


Fig 7. GUI Using MATLAB

3. RESULTS AND DISCUSSIONS

3.1 Hardware Implementation

The table 3 gives the various specifications of the robot chassis, robot arm and the arm gripper. It is capable of lifting the objects of rectangular and cylindrical in shape. The region of interest selection in the camera output is governed by the height of the robot and the arm length.

Table 3. Specifications of the robot

Weight	2000gm
Volume LxBxH	30X18X21 cm ³
Wheel Radius	5cm
Speed	Forward, reverse: 7.5cm/s Left and right Rotation: 15 ⁰ /sec
Arm span	Horizontal min 5cm – max 20cm Vertical min 5 cm – max 30cm
Arm length	14cms Fully extended
Arm Speed	2cm/second
Gripper span	Min 1cm – Max 6.5cm
Gripper Speed	1cm/sec
Size of object	Cubical , 15X8X30cm ³ Cylindrical – 4 cm radius
weight of object	Max 500 grams
Clear vision of camera	For red object- 5.7metres For blue color 4.5metres
Area for surveillance	Circular (360° coverage) with robot at centre

3.2 Software Implementation

The PIC microcontroller is programmed to navigate the robot towards the object in accordance with the commands generated by the MATLAB and transmitted by the RF transmitter. It is programmed using the MPLAB IDE v8.43 as per the flow chart indicated in fig 6. The microcontroller controls the movements of the wheels, arm and gripper of the robot.

The image processing algorithms were implemented successfully for a single red object in a light background under different ambient conditions. The algorithm is pretested to detect a single red object with a snapshot of size 2560×1920. The outputs are indicated in figures 8(a) to 8(d). The figure 8(e) indicates the bounding box for the red object with the centroid co-ordinates as given in the table 2

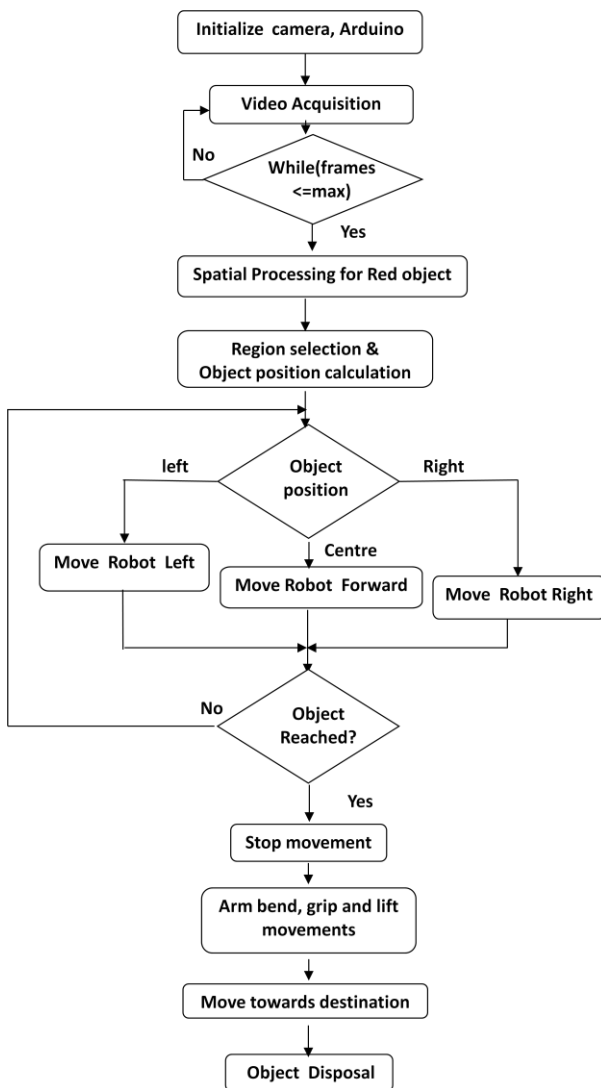


Fig 6. Block diagram of various tasks

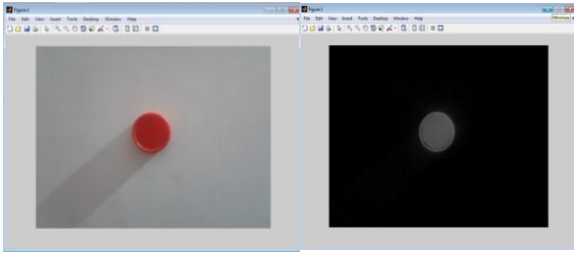


Fig 8a, 8b. Red image and component extraction

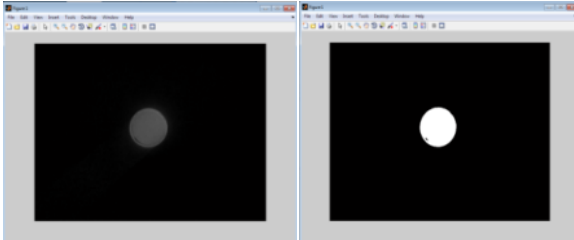


Fig8c, 8d. Filtered and binary output

Table 2. Centroid coordinates

x	1308
y	895

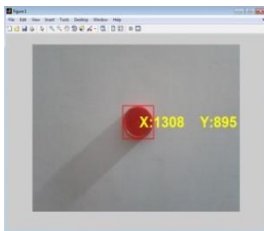


Fig 8e. bounding box for red object

The result of centroid computation for red object is shown in the figures 9, 10 and 11 for detecting the object in left, right, centre of the Region of interest (ROI). The wheels move in the clockwise and counterclockwise directions to turn the robot in the left, right and forward direction. The figure 12 shows the absence of the red unattended object in the scene. The robot continuously rotates counterclockwise direction in complete circular motion till it detects the red object. The corresponding alerts and message command generated by MATLAB is transmitted to the robot in wireless mode using Aurdino board. The figure 13 gives the corresponding commands to the robot generated in MATLAB.

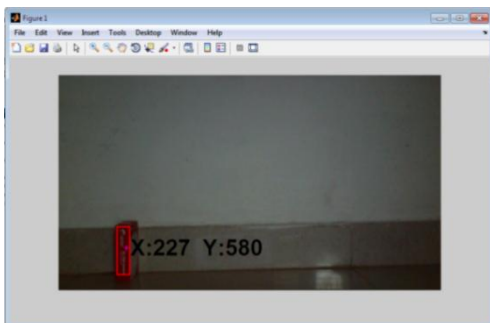


Fig 9. Object detected in left of ROI

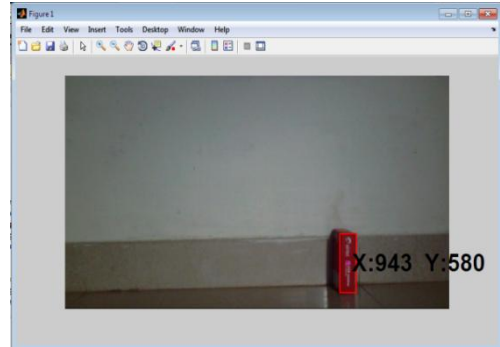


Fig 10 . Object detected in right of ROI

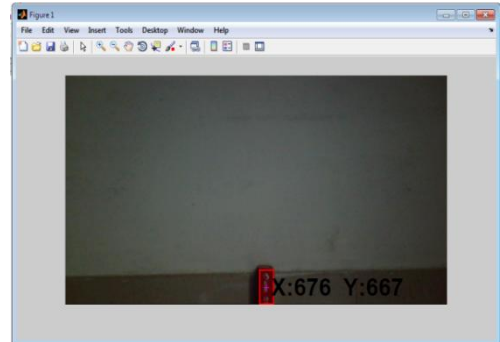


Fig 11. Object detected inside ROI

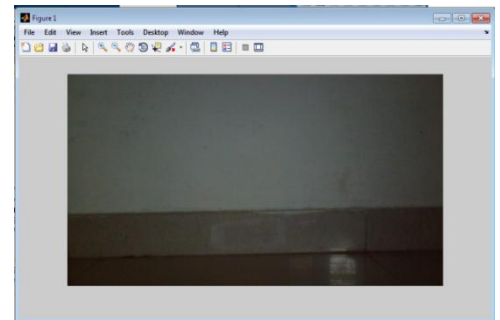


Fig 12. No Object detected in the scene

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Command Window
Editor - object_detection.m

>> object_detection
turn left
>> object_detection
turn right
>> object_detection
move forward
>> object_detection
object reached
>> object_detection
rotate anticlock
fx >> |
    
```

Fig 13. MATLAB Commands For Robot Movement

The plan of the designated boundary for the robot movement is shown in the fig 14 and for a typical real time implementation of this work the distance and time taken for the robot to reach different points to complete the object retrieval and disposal are given in the tables 4 and 5.

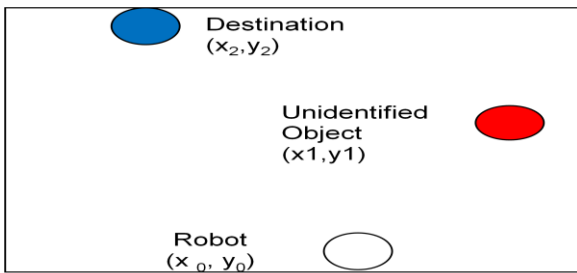


Fig 14. Plan of the scene for Robot movement

Table 4. Location of various spots

X	Y	Z
Robot location (x_0, y_0)	Unattended object (x_1, y_1)	Destination (x_2, y_2)

Table 5. Dynamics of the robot

Parameters	Between X and Y	Between Y and Z
Distance(Cms)	28	50
Time (secs)	17	23

The figures 15a, 15b show the snapshots of the object detection and retrieval and figures 16a, 16b process of object disposal to the destination. As the results are obtained in real time, the entire process is video graphed and archived.

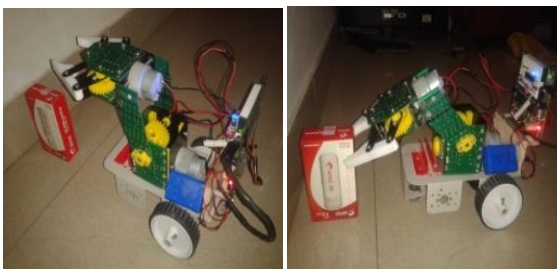


Fig 15a,15b object retrieval

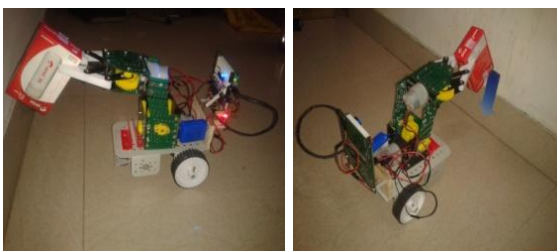


Fig 16a,16b object disposal

4. CONCLUSIONS

This paper discusses the implementation of the prototype of a wireless, semi automatic robot model for object detection and retrieval in real time. This work has the limitation of not

detecting the non red objects. This work can be improvised to detect objects irrespective of their colour, shape and sizes by adopting advanced image processing algorithms and sophisticated surveillance cameras. The degrees of freedom of the robot arm can be increased by proper modelling of the mechanical structure of the robot. The obstacle avoidance phase can be included in image processing to reduce hardware complexity and unnecessary delay. The entire robot can be developed as an indigenous system.

5. ACKNOWLEDGEMENTS

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