

Object Recognition, Tracking and Destruction for Military Application

R. D. Gade* and Prof. Anil Wanare¹

*Dhole Patil College of Engineering [ME-ENTC] Pune Maharashtra, India.

¹Dr. D. Y. Patil School of Engineering, University of Pune, Maharashtra, India.

For correspondence: rajashree25@gmail.com

Abstract- This paper is proposed for the purpose of detection, tracking and destruction of intruding object. The system will be mounted at suitable place from which complete and clear view of the area under surveillance can be captured with camera. Camera is fixed at one suitable position. It will detect intrusion and recognize the intruding object by comparing its features with features of the objects stored in database. If feature match is found, the intruding object will get tracked to and get bombarded with bullets and bombs until object gets destroyed completely. Thus image will be captured, proceed and desired action will be performed on it. This system works as automatic detection, recognition and destruction of intrusion which is very helpful for military application. The very tight security and safety can be assured without endangering precious life of human soldier. Our system ensures low execution time. Simplicity also ensures low implementation cost.

Keywords: Object tracking, Object recognition, autonomous cannon

I INTRODUCTION

This system is proposed for detection, tracking and destroying of intruding object. The system will be fixed at suitable location, from which complete and clear view of the surveillance area will cover and images of this surveillance area can be captured with camera. The system is consist with a high resolution camera, image processing hardware, microcontroller, two servo motors and

other supplementary hardware and mechanisms. The complete assembly set up is shown in Fig.1. Image Processing Hardware will acquire and stored images captured by camera. The images will be taken at some predefined interval of time. Then captured image will process for detecting intrusion. We have collected database for the objects those are to be destroyed. If captured image of intrusion is detected Image Processing Hardware will extract the features of that intruding object and compare them with features of objects stored in database. If match between intruding object and one of the objects from database is found object is said to be recognized. System will track that object to calculate its velocity of motion. This velocity information is needed to decide the angle and time instant at which projectile is to be launched at intruding object to destroy it. Position of the intruding object in the form of x-y co-ordinate is found and sent to microcontroller. Microcontroller will control the angle of rotation of two Servo Motors to position the cannon aiming at the intruding object. At last cannon will get fired.

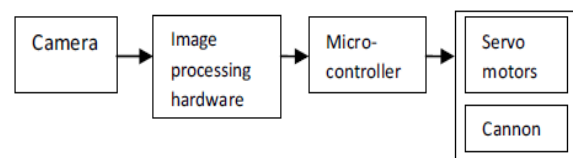


Figure1. Basic block diagram of complete system

II. DATABASE COLLECTED

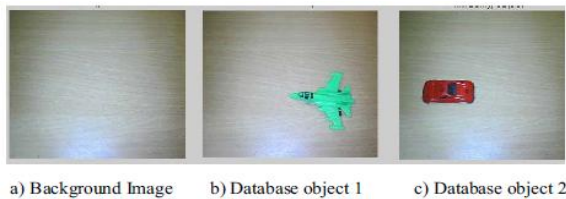


Fig 2. Shows example of collected database.

It shows captured images of background and two objects aero-plane and car. These are test objects taken for experimentation purpose.

III. METHODOLOGY



Fig1. Shows basic building blocks of the complete system. Here is block-by-block explanation.

A. CAMERA

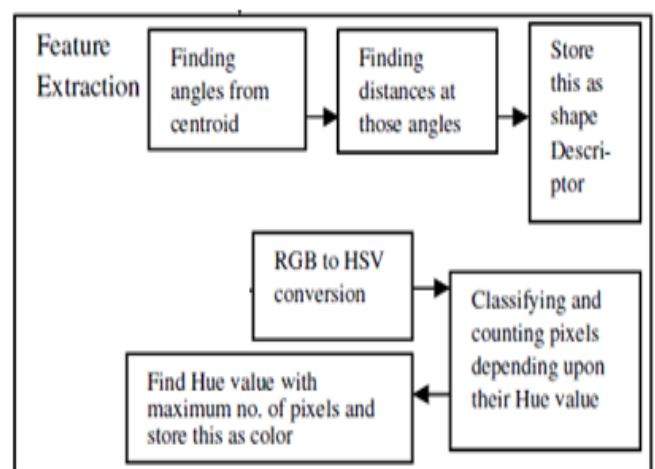
Camera used for experimentation purpose is “i-ballface2face, a USB webcam, with 640 by 480 resolution and 64M color depth. A Night-Vision Camera and camera with different resolution and color depth can be used depending upon requirement of application. Camera is fixed on the system and should not move from its place once background image is captured, otherwise it will adversely affect accuracy of the system as subtraction is used to detect intruding object.

B. IMAGE PROCESSING HARDWARE

A computer with Intel 1.6 GHz processor and 512MBRAM was used as Image Processing hardware. Camera is connected to this PC via USB port. The image acquired by camera is processed by this hardware and result of processing is sent to Microcontroller. Microcontroller will control the angle of rotation of servo motor to position cannon accordingly.

C. IMAGE PROCESSING SOFTWARE

When an object is observed from far distance, its overall shape and color are the prominent features which distinguishes it from background and other objects. So while extracting features of the object for identification, its peripheral shape and color are considered, instead of other features like texture and other minute details. The complete algorithm for this prototypic system is implemented in Matlab 7.2 software using Image Processing Toolbox.



D. STEPS INVOLVED IN IMAGE PROCESSING

1. Preprocessing

Background image has to be captured after installing camera at its place and care must be taken that camera shouldn't move once background is captured. Subtraction between background image and current image obtained from camera is used to detect intrusion. If there is no intrusion then previously captured background image and image taken from camera at any later time will have no difference and result of subtraction will be zero (a complete black image). But if some object has intruded in the scene then difference between those two images will be the object itself and is not zero, as in previous case. This subtraction process is shown in Fig.3. Result of subtraction is not suitable for feature extraction as outer edges of intruding object are not clearly

visible. This problem can be depicted from Fig.5. This is image obtained from inverting the result of subtraction which prominently indicates above mentioned problem. So this result of subtraction has to be preprocessed before feature extraction. Preprocessing involves following steps. As subtraction is obtained by subtracting color images, result of subtraction is also a color image. It is converted into binary image as shown in Fig.6.a. Our final aim of image preprocessing is to obtain image shown in Fig.6.f which is suitable for feature extraction. Canny edge detection is function is operated on Binary Image to detect the edges of the intruding object depending upon threshold chosen adaptively. Correct choice of threshold leads to proper edge detection, which will increase overall accuracy. Problem of unclear and broken boundary as depicted in the Fig.5 is present till this stage. To remove this problem image is dilated with some suitable mask to join these broken edges. The output of dilation is shown in Fig.6.c. Holes in binary images are black portion of image surrounded by white boundary. These holes are filled with filling operation to get number of different unconnected white areas. These white areas are related to different objects in image. At this stage, we get various unwanted white regions other than white region related to the intruding object. These unwanted white regions are result of illumination variations, minor changes in the background at the time of capturing images, camera imperfections etc. These unwanted regions shave inherent property that their area is lesser than intruding object. So only white region with maximum area is kept which corresponds to intruding object as shown in Fig.6.e. Edge of this image is detected using canny edge detection method. This edge corresponds to boundary of intruding object with some error introduced due to dilation operation. Error that is less than 13% is proved to be acceptable. So mask for dilation operation must be chosen adaptively depending upon size of objects. This edge detected image is suitable for shape detection.

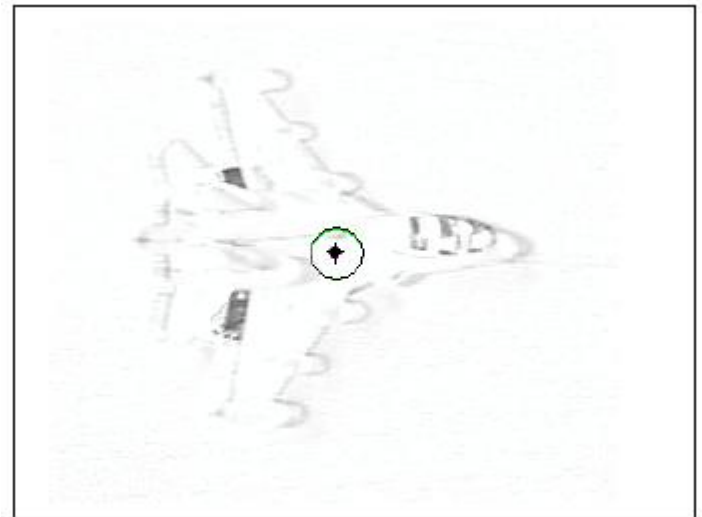
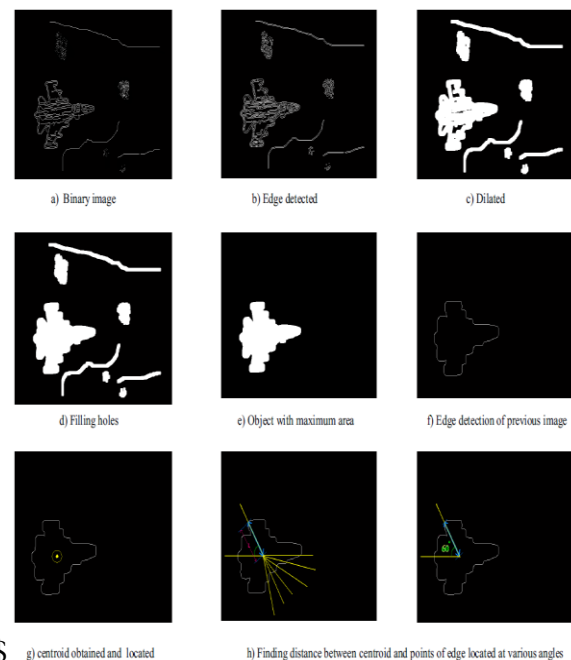


Figure. 5 complement of subtracted image



g) centroid obtained and located h) Finding distance between centroid and points of edge located at various angles

2. Feature extraction:

2.a The term shape is commonly used to refer to the geometric properties of an object or its external boundary (outline, external surface), as opposed to other properties such as color, texture, material composition. There are several ways to compare the shape of two objects: Shape description: Shape of an object is nothing but distances of all the points on its boundary from some reference point. This reference point can be centroid (center of mass) of an object Centroid of object does not change though object is rotated.

Center of circle is its centroid and distances of all points from centroid are equal. For square it will be different case. Similarly if we measure distances of some points on the boundary of an object as shown in Fig6.h then we can get shape descriptors. In our case we have considered those points on the boundary of the object which are separated by angle of 10 degrees. All the angles are measured from centroid of the object. Thus we have calculated 36 distances corresponding to 36 different angles separated by 10 degrees. This angle separation can be reduced in order to increase accuracy. But along with reduction in angle separation, number of readings will increase and it will increase computation time. So there is tread off between ability of system to work in real time and its accuracy. Normalization of the data obtained above is done in order to enable scale invariance. Object viewed from various distances will not differ in their shape. But they will differ their in sizes. Normalization will enable comparison between objects those are present at various distances from camera.

Normalization is done by dividing all above 36 distances readings by largest distance reading. This results in get all 36 shape descriptors readings to range from 0 to 1. Again shape descriptors obtained above can be made invariant to rotation of the object. To make it starting point or rotation invariant, circular shifting of readings (which issued in chain codes) can be implemented. This enables to compare objects having different rotational orientation. Thus we have made this system rotation invariant and scale invariant. Thus shape descriptor of the object is obtained.

2.b Color detection: If we observe some object from far distance, we consider its gross features instead of fine details. If that object is having different colors on its different parts then the color which is occupying maximum area of that object is considered, and it is said that object that object is of that color. e.g. Fig7.a shows object is having

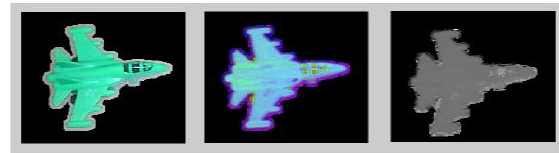


Figure 7. a) object b) HSV transformation c) only Hue plane

greencolor covering most of its parts, and blue and black colors covering only some of its portion. So color of that object is considered to be green only. To find color of the object, color image obtained from camera is logically ANDed with preprocessed image shown in Fig.6.e. Result of ANDing is shown in Fig.7.a. Now this resulting image is converted into HSV image as shown in Fig7.b. Hue plane of HSV image contains only color information. All the values of Hue plane lies between 0 to 1. Depending upon their values, color is detected. E.g. red, green and blue colors can be distinguished as in HSV plane as red pixels have values >0.8 and <0.15 , green pixels have values >0.15 but <0.48 , blue pixels have values >0.48 but <0.8 . Thus second gross feature of the objects that is its color is detected. Color and shape detection is also performed on database images. If match between any on the database object and intruding object is found then that object is said to be recognized. And it has to be destroyed. Fig.8 shows result of preprocessing and feature extraction on some sample database image

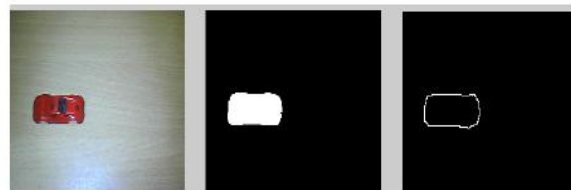


Figure 8. Preprocessing and feature extraction on database image

E. OBJECT TRACKING

Once object is found to be matching with one of the database objects, it is tracked to find its velocity, before bullet or cannon-bomb is fired at it. Both readings, size of object and its distance from camera is obtained and stored in database beforehand. Perpendicular distance of intruding object from camera can be obtained by comparing its size in image, with size of the same object stored in database using formula given below,

Velocity of intruding object can be found out by, finding relative distance covered by object in two consecutive frames captured by camera and time interval between two frames. This calculation of velocity and distance of object enables system to calculate angle of projectile (Bullet or Bomb) launch and time at which projectile has to be fired. This ensures accurate hitting of object by projectile and its destruction. The system will track and keep launching projectiles at intruding object until it gets destroyed and its motion stops.

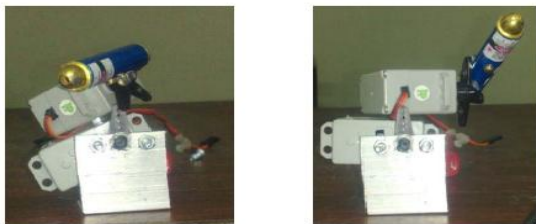


Figure 9. Servo motors mechanism for deciding angle of projectile launch.

F. SERVO MOTOR MECHANISM

Two servo motors, one responsible for motion of cannon in X-direction and other in Y-direction together decides angle of projection. Angle of rotation of servomotor can be changed by changing width of PWM signal fed to motor. 89v51RD2 microcontroller with inbuilt PWM module is used in prototype system. The results obtained after Image Processing are fed to microcontroller which in turn controls firing angle and time for projectile launch.

IV. RESULTS AND CONCLUSION
15 different objects were stored in database. Out of total 80 trials, system correctly recognized, tracked and destroyed intruding objects in more than 74 trials. This brings 93% accuracy. For shape description, total 36 distances corresponding to 36 angles were calculated. If total 32 distance readings of intruding object and database object are matched then object is said to be recognized. If number of readings used for shape description is increased, then it drastically improves accuracy. More readings are taken, more accurately shape of the object can be described. If number of readings taken is doubled it increases total execution time by 62%. A graph of number of readings verses

execution time in milliseconds is shown in Fig. 9. Above graph is plotted using number of readings for shape Figure 10. A graph of number of readings verses execution time in milliseconds 1488 2011

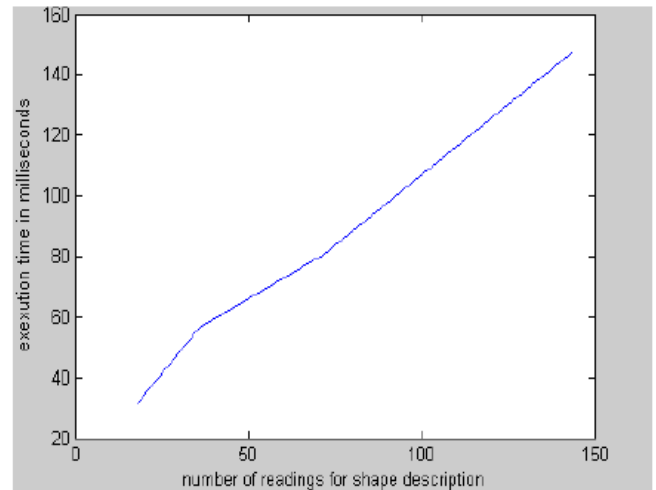


Figure 10. A graph of number of readings verses execution time in milliseconds

Above graph is plotted using number of readings for shape description as 18, 36, 72, 144 and their corresponding execution time in milliseconds as 60.83, 70.49, 81.12, 147.64. Advanced algorithm such as SIFT (Scale Invariant Feature Transform) is used for object recognition purpose, its execution time found to be 950ms on the same system. So the algorithm used in this paper is at least 7 times faster than SIFT without much affecting overall required accuracy. Also this system calculate the time required for detection and destruction. Though this system is tested under constrained environment, subtraction between background image and camera captured image ensures that similar accuracy of the algorithm can be guaranteed when images captured are real-life images. Thus by implementing this automatic system one can ensure complete intrusion free area under surveillance. This system has great application for military purpose. System eliminates need of human soldier to be appointed for this grave danger work, as this work is done by our system automatically.

V. FUTURE WORK

Instead of remaining dependent upon sun light as source of illumination, system can be made illumination invariant by using some active illumination source (e.g. infrared). Night Vision Camera can be is used for system to work at night also. Color information is not present in images captured by night vision camera. Thermal infrared camera can be used to get colored images depending upon temperatures of various objects of the scene. Database can be collected for the various times of the day, and can be used for recognition at that time of the day. Also along with shape and color, some more features of the object can be compared for recognition to get more accuracy and reliability.

Intrusion of multiple objects has to be considered. In such case, intruding objects with area greater than some predefined threshold can be kept and others can be eliminated. Again shape descriptor algorithm mentioned in this paper can be applied one by one, to all the object those are kept, and subsequent recognition can be done.

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