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Embedded Target Detection System Based on Visible Image Sensor

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Abstract: There is a real need to develop a sensory system that can monitor and track the behavioral status of a target from an image in real time. In addition, it is important to have the ability to detect stationary and moving objects in real time. This paper presents a new automatic target detection (ATD) algorithm to detect targets such as military targets, vehicle detection, oil storeroom detection. This algorithm uses concentric circles to extract features of object and the features are quasi invariant to target translations, rotations and scaling. From this it is effective to detect targets in the real – time applications.

Keywords: Automatic target detection, Feature extraction and Target recognition, ATD algorithm, CMOS Visible image sensor.

I. INTRODUCTION

Visual surveillance in a fixed and movable environment has drawn a great deal of attention nowadays. It spans a wide research spectrum, such as for access control, human or vehicle detection and identification, detection of anomalous behaviors, crowd statistics or congestion analysis, human machine interaction in an intelligent space, etc. Since the field of view of one sensor is limited, a sensor platform is usually equipped with degrees of freedom to extend its observing range. In order to construct a wide-area surveillance system economically, a sensor must be utilized to track target within its limited field of view. Here we use CMOS visible sensor to track the target from the image. And also we use an Automatic target detection algorithm that locates the potential targets in an image and identifies their types.

In general, many military and civilian applications entail the detection of an object or activity such as a military vehicle or vehicle tracks. Hence, the goal is to develop real – time algorithm for stationary and moving target detection, identification and tracking in cluttered environment. Most Automatic target detection algorithm consists of several stages. This paper uses new Automatic target detection algorithm which is mainly focus on three task:

(1) Template computation
(2) Target segmentation, and
(3) Feature Extraction using visible image sensor.

In the Template Computation task, Target templates are computed from images using off – line modeling step. Then, the gray-level images are converted into binary images using threshold algorithm. In the target segmentation, target gets partitioned by using the concentric contrasting circle method. Where target features are extracted from the image. At finally, this target features are compared with those of updated templates to recognize target.

II. SYSTEM OVERVIEW

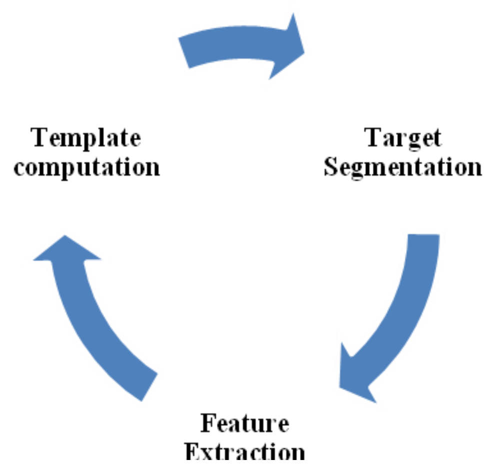

Fig. 1 Automated detection system overview

The ATD algorithm to be proposed aims to detect a target from images obtained by a visible image sensor. It can extract features of target which are almost invariant when image rotations or target translation and scaling, such that it can detect targets which rotate or swing and sway. Moreover, by the templates representing targets in different views, it also can detect the target in different view angles. Furthermore, it has low computational complexity such that

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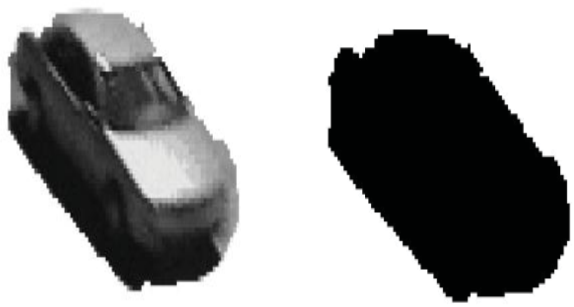
it is applicable to real-time applications of the robotics embedded system.

III. DESCRIPTION OF ATD ALGORITHM

The ATD algorithm involves three stages. First, some target templates are computed using images from image database by using off – line modeling and non – supervised learning is shown in Fig. 2 and 3. Second, a target segmentation method is used to extract the target from background using local adaptive threshold algorithm. Third, the features of the segmented images are extracted and compared to those of the templates to determine the types of targets. This can be done by using concentric circle method.



(a) (b)

Fig. 2 An example of a target image: (a) Original image, (b) Binary image

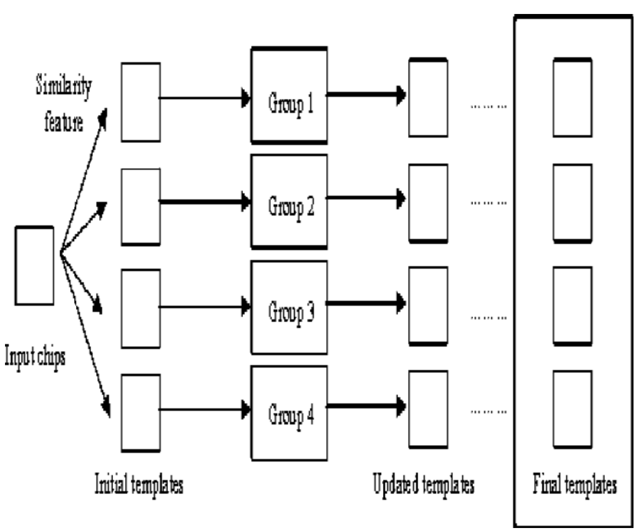


Fig. 3 Block diagram of non - supervised learning

A. Template Computation

We propose a binary template matching based on the properties of the CMOS images, which are susceptible to light conditions. In our application, we assume the real targets are darker than the background. We acquired monochrome CMOS images of target A total of 18 images for a target were taken for different views with an increment of 5 deg on a clear background. We converted the acquired gray-level images into binary chips. After obtaining the binary chips, we computed three binary templates using non - supervised learning, which could represent all binary chips in the template-matching process. We investigated the relation between the detection rate and the number of binary templates, as shown in Fig. 4, which shows the detection rate is adequate if the number of binary templates is three. Therefore, we selected this number of binary templates in the present study.

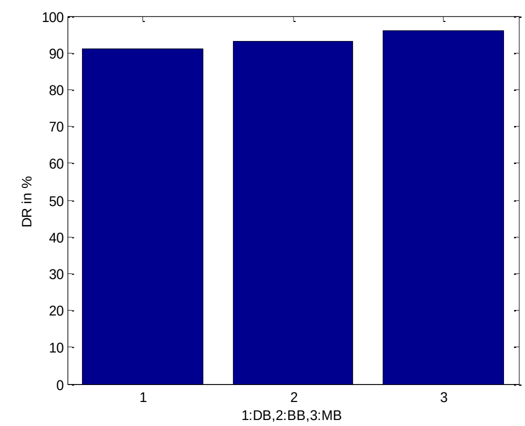


Fig. 4 Detection results under various light conditions

Before describing non - supervised learning, we introduce a similarity feature defined in terms of AND and XOR logic operations on binary images, which are used as a classification criterion. The similarity between binary images A and B is defined as follows:

$$\textbf{Similarity}=[\#(A \textbf{ AND } B)/\#(A \textbf{ XOR } B)+1],$$

Where, $\#(X)$ denotes the number of pixels having 1 in the binary image X.

We classify the binary chips into several groups according to similar characteristics defined in the above equation. Based on Fig 3, the non - supervised learning procedure is given as follows:

(a) Randomly select three initial templates from the binary chips.

(b) Cluster the binary chips into three groups using similarity features: Three similarity values according to the above equation are computed between an input chip and three initial templates, respectively. The initial template having the highest similarity among the three determines the group of the binary chip. The binary chip is then classified into one of three groups, each of which is represented by a template.

(c) After clustering, the binary templates are updated for the three groups. Let the number of binary chips in a group be Nc . If the number of binary chips having target pixels at (x,y) is larger than or equal to $1/2Nc$, the

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specific coordinate (x,y) is regarded as a valid pixel and updated as a target pixel in the updated template.

(d) Replace the initial templates with the updated templates in Fig. 5, and repeat the steps from (b) to(d) until there is no further change in the template update.

Fig. 5 Three binary templates obtained by offline template computing

B. Target Segmentation

When we perform the initial detection, we convert the input image into a binary image using adaptive thresholding. Global thresholding for image binarization may result in distortion in a real image whose intensities vary gradually due to illumination. Therefore, we divided the input image into many blocks. The size of the blocks is determined by the largest target size, and adaptive thresholding is applied to each block. Then, thresholding values for binarization are computed by mean (mean) and standard deviation (std) of each block as follows:

Thresholding value = mean – std

C. Feature Extraction and Target Recognition

Consider the binary image shown in Fig. 6. It contains a vehicle target and a small plant which acts as a disturbing factor. The vehicle target is segmented as an individual region which is within the circumscribed rectangle. A group of three concentric circles are drawn and each circle superimposes the vehicle target. The center of mass of each connected component is computed and considered as the center of a group of concentric circles with different radii. The maximal radius is defined by the minimal distance between the center of mass and the three vertexes (such as A, B, C or D) of the rectangle. For instance, suppose O is the center of mass of the vehicle, if the distance between O and D is the shortest one, OD is selected to be the largest radius in concentric circle. The maximal radius is divided into three equal parts and three concentric circles are drawn. The radius of the j -th circle is denoted by R_j , where the unit of R_j is pixel. Obviously, the minimal radius R_1 is equal to one threeth of the maximal radius R_4.

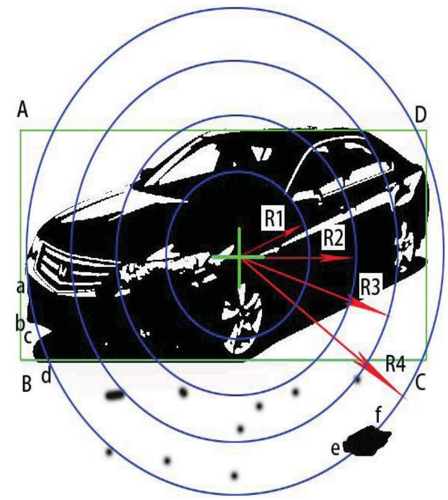

Fig. 6 Vehicle feature extraction

For the j -th concentric circle, the area of the vehicle region, denoted by X_j , is calculated by counting the black pixels in the j -th concentric circle. Define the area rate A_j by

$$A_j = Xj/\pi R^2_j \times 100\% \qquad (1 \leq j \leq 4)$$

which represents one type of target feature Another type of target feature is the rate of circle defined as

$$P_j = Nj/2\pi R_j \times 100\% \quad (1 \leq j \leq 4)$$

Where, Nj represents the number of black pixels overlapping between the j -th circle and the vehicle. For example, in Fig 6, the arcs such as ab, cd and ef are the parts superimposed by the circle 4 and the vehicle target. The arcs ab and cd are taken into consideration but the arc ef which is outside the circumscribed rectangle (ABCD) is not considered.

Note that in this study, we only used three concentric circles. To achieve higher recognition accuracy, more concentric circles should be used.

IV. EXPERIMENTATION AND RESULTS

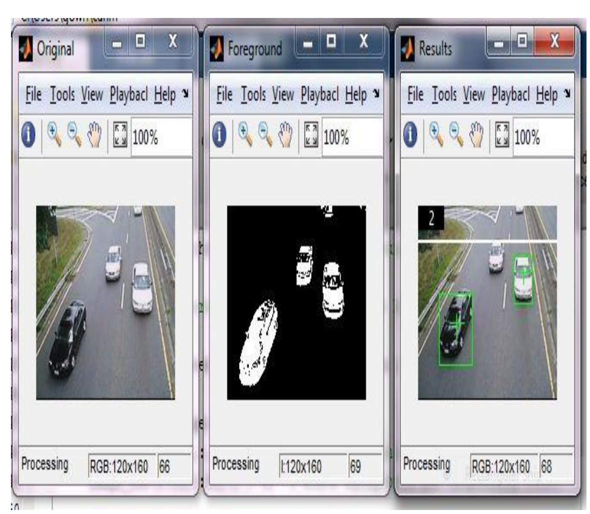

Fig. 7 Target Detection

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In practice, the vehicle target may be viewed from different angles or rotate itself. In such a case, its contour will make projective transformation and thus the feature of the target contour will change. Many templates explained above were used to represent the projective transformation of the target contour.

Here, we verify the validity of our method by detecting targets from different view angles in static images. As shown in Fig. 7, the vehicle targets in these images have different view angles and sizes. They are detected and labeled by the cross and the circumscribed rectangle. The non-target region is only labeled by the circumscribed rectangle. Obviously, our algorithm correctly identifies all targets.

V. CONCLUSION

The System is used to develop real-time algorithm for target detection in difficult situations. This will focus on three stages: (1) Template computation, (2) target segmentation, and (3) Feature Extraction using CMOS visible image sensor. The ATD algorithm first uses several templates to create the model of the target in different view angles. Then target segmentation method is used to extract the target from background. The features of the segmented images are extracted and compared to those of the templates to determine the types of targets. Where, ATD algorithm makes a good balance between recognition rate and image processing time. This system was applied to detect vehicles. However, its application can be extended to many other fields such as vehicle detection, oil storeroom detection.

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