INTELLIGENT AUTOCUEING OF TACTICAL TARGETS IN FLIR IMAGES

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ABSTRACT

Algorithms used to automatically detect, segment and classify tactical targets in FLIR (Forward Looking InfraRed) images are presented. The results are shown on a FLIR data base consisting of 480, 512x512, 8 bit air-to-ground images.

TECHNICAL APPROACH AND RESULTS

Fig. 1 shows the block diagram of the Intelligent Automatic Target Cueing (IATC) system. It allows to use structural information, to use feedback to obtain more refined boundaries and to adapt the cuer to the required mission. It runs in an automatic mode. Two new algorithms are used for localization and segmentation.

(a) Preprocessing followed by Relaxation : The technique make use of range, intensity and edge density information. Depending upon the angle of the field-of-view and the range maximum and minimum sizes of the targets are estimated. An edge image is obtained and a window twice the size of the maximum target estimates is passed over the thresholded edge image. If the number of edge points lying within the window is greater than a threshold (function of the window) then a mask image is created. Using the mask image the desired region from the original image can be selected. Note there are 4 possible overlaps. It is found that one or two overlaps flag the potential targets and reduce the image area to be subsequently processed by over 90% depending upon the details. As an example Fig. 2(a) shows a 512x512 FLIR image. Fig. 2(b) shows the thresholded Sobel magnitude image. Fig. 2(c) shows window overlaps and Fig. 2(d) shows the selected overlap superimposed on the original image. A two class gradient relaxation technique is used for the segmentation of each connected component (Fig. 2(e)).

(b) Modified Double Gate Filter & Difference Operators : A square mask configuration (Fig. 3) is partitioned into eight sectors. Each sector, in turn, is partitioned into a sequence of expanding triangular domains with each triangle accompanied by a corresponding perimeter bin. First the image is minified using range. At each pixel each of the filter's eight sectors is telescopically expanded from some minimum size to some predetermined upper size. For each sector's telescoping run the maximum difference of average intensity in the a and p domains is noted and the filter response at a pixel is set at its minimum. As the filter is scanned across the image, a preselected number of top filter response locations are noted. After the target is localized, the threshold used to segment the target is found by making use of Laplacian operator and a histogram analysis. Fig. 4 shows the target localization and segmentation results when we considered 10 top responses. Fig. 5 shows the number of detected targets vs. number of top responses for 76 targets. Most of the targets are found in the first 6 top responses.

Features & Classification: First a few target features are computed to check if it were a potential target. If so, a set of 36 features of the target is computed. Features used are mainly shape, gray scale and moment features. Shape features also include four Fourier features which are obtained using only 7 Fourier coefficient. Feature selection is done on the decorrelated features using the Bhattacharrya measure. The number of selected features are found to be 11. The classification algorithms include linear, quadratic training algorithms and clustering techniques. The technique that gives the least classification error on the selected feature set is selected. For the results reported here we have used K-means clustering technique for the training of the samples. An efficient K-nearest technique is used for classification. The classification results for the image of Fig. 2(a) are shown in Fig. 6. Clustering is checked for its fildelity and checks are made to make sure that it is not an artifact of the data or clustering method. Performance of the classifier is measured by the "leaving-one-out" method. When the range is small (100-550 meters) image can be minified with respect to some standard range so that the inside structure of the target is not visible in the image, or structural information can be used. Thus we have two sets of classification results. The final decision is made on a set of rules based on range and the confidence of the decisions from these two sources. The training data consisted of 420 images and testing data of 60 images. The classes in the training set were tank, truck, jeep, APC and clutter. Probability of detection was 85%. If the centroid of the detected and segmented target lies within a 10x10 window of the known target location, the target is said to have been detected. The probability of correct classification was 80% on the detected targets. Thus the overall cuer classification accuracy was 68%. False alarms were slightly more than 1 per frame. False alarms can be reduced using Algorithm (a). CPU time to process each 512x512 image was about 2 minutes on a VAX 11/780.

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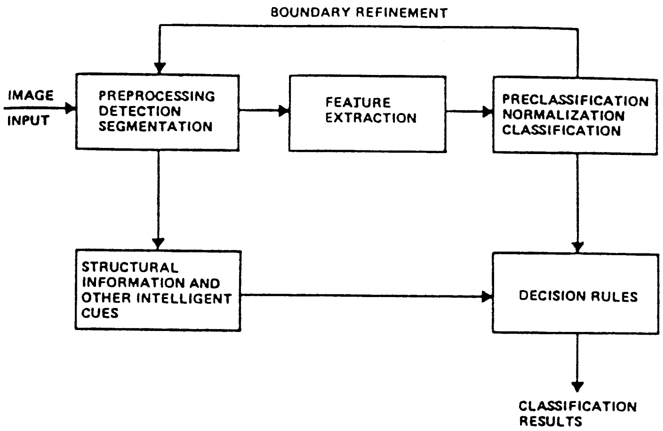
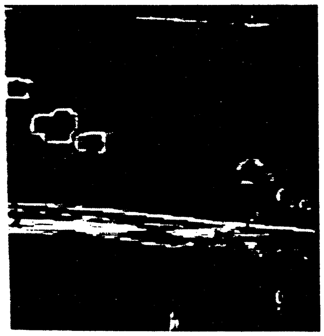
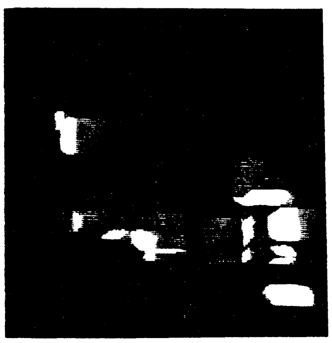


Fig. 1 Block Diagram of IATC System

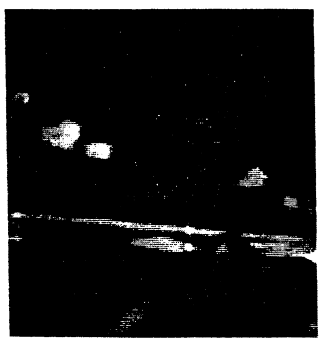
(a) Original Image



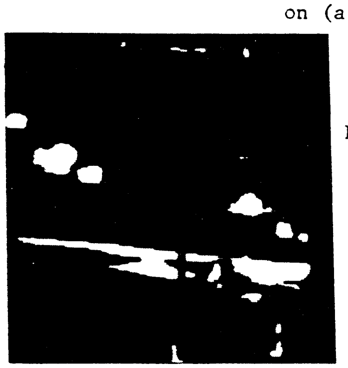
(b) Thresholded Sobel



(c) Window Overlaps



(d) Selected Window Superimposed on (a)



(e) Segmentation

Fig. 2 Preprocessing and Target Segmentation

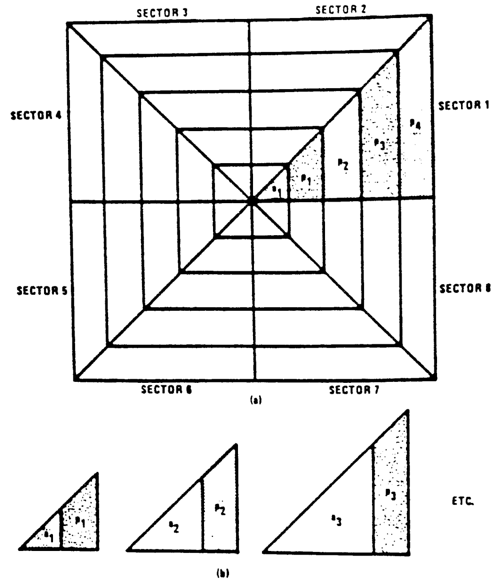


Fig. 3 Modified Double Gate Filter

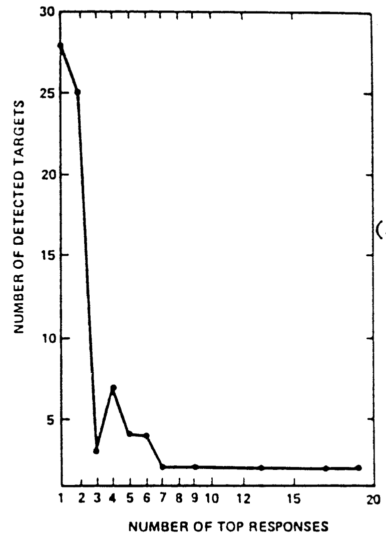
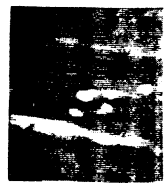
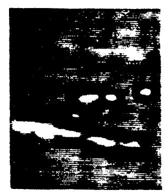


Fig. 5 Responses vs Detected Targets



(a) Original Image



(b) Detection

Fig. 4

Fig. 6 Classification Results