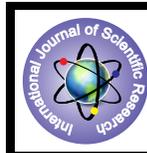


A Novel Algorithm for Object Detection in Low Contrast Image and Recognition by SVM



Engineering

KEYWORDS : Background subtraction, boundary detection, centroid, partition of image, segmentation, SVM classification, feature vector extraction.

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ABSTRACT

Detection of object by Low contrast images is a very crucial task in computer vision and machine learning. There are many existing methods are available but they take much time and results are not accurate. To address this problem here we proposed a novel algorithm. This algorithm mainly consist three phases. First, extraction of foreground region and generate a fine coarse region of interest of object. Second, calculate co-ordinates points of the boundary of object and plot 2-D histogram for extract shape feature vector. Third, feed this feature vector into SVM whether it is human being or non-human being. Experimental results of this algorithm demonstrate that it is robust enough to handle image of low contrast as well as normal light condition. This algorithm is used in surveillance system.

I. INTRODUCTION

Object detection and recognition is the key procedure of various surveillance applications. Method of object detection usually finds out the foreground region from low contrast image and classifies them as human and non-human based on their feature [1], color [2], [3] and shape [4], [5]. Background subtraction is a common technique to extract the foreground region of images. The gradient base feature are most decompose of background subtraction but it take much computation time so it not use. Image segmentation are also based on background subtraction technique such as Bayesian theory and Markov chain Monte Carlo.

Many methods are available but they take much time, also not give accurate and efficacy result and the boundary of object are not much clear because of not good background subtraction result. And this is invalid in case of illumination change. Moreover surveillance based camera are equipped with low quality yield low contrast video as much as images.

To resolve this issue here we present a novel algorithm based on background subtraction and use SVM learning technique. A new feature context i.e. shape feature vector [6] are introduced and it evaluated by polar 2D-histogram. For this shape feature vector we also introduce a new concept i.e. divide the foreground region of image into 4 parts based on the centroid of object and then perform XOR operation. Then, merge all the four parts and get a fine coarse mask of foreground region.

The rest of paper is organized as section II indicate related work, Section III indicate the proposed algorithm and its block diagram. Section IV demonstrates the SVM based training and detection method and mathematical expression of our proposed algorithm. Section V shows the result and comparison. Section VI concludes the paper.

II. RELATED WORK

A. Boundary Detection

There is much research work on this field and some are going on. Recent researches focus on detection with a variety of learning algorithm and feature of image. Viola et al [7] applied Haar like feature for both image and video but this method mainly focus on human at very small scale. Belongie and Malik [8] use shape matching technique for object detection with the help of shape of object image. Hamisc [9] discovered some set of points on the edges of object boundary then joined each point and find a complete set of contour points. However, in case of non-uniform object shape it failed because it requires more points on the edge of the image to find closed contour and it increases space-time complexity.

Qinkun Xiao Li et al [10] proposed hybrid online template method it is different from such as flatness texture or edge/corner. The template that comprises several number of multiple feature, including sketches/edge region that belong various links, ridges such as corner and junctions. But it is failed for moving objects, because its discriminating power of feature is change. Yunhua et al [11] proposed a new face detection method based on classifier. He builds a set of parameter based on the knowledge of interested object. Then he collects some positive or negative sample and then feed these data on the classifier and adjusts those parameters. But its delimit are illumination variation and it take more space complexity because it need a more object image feature for training the classifier.

B. Image Segmentation

It is a technique of finding ROI (region of interest) of images. It clusters the images into regions basis of their pixel values are other categories. There are several methods available for image segmentation like Region based segmentation, Data clustering segmentation and edge based segmentation. In region based are further divide into Seeded base segmentation and fast scanning algorithm. Some of them I explain here

i). Seeded region growing

R. Admas [12] proposed this, in which compare each neighbouring pixels to set of pixels, known as seed point and determine whether the pixel classified into a bunch of seed points or not. This algorithm starts with an initial seed that are clustered into n clusters. Then compare neighbouring pixel of seeds and if they are smaller than threshold cluster them in corresponding clusters. And set mean of each cluster as new source points and continue it until the whole picture is not clustered. The threshold usually given by a user based on intensity, gray level or colour value of image. The two main disadvantages are initial seed and computation time. Different number of initial seed yields different segmentation of the same image so reduce the stability of the image. Since it searches the entire pixel, it takes more time and reduces the time efficiency.

ii). Unseeded Region Growing

To increase the robustness of seeded region growing method algorithm Z. Lin, J.Zin, H Talbot [13] proposed this, instead of giving initial seed this algorithm automatically generate the seed points, and in this method algorithm start with an initializing cluster of region having same pixel value and running the state have set of clusters of identifying region. Define set for all unlocated pixels which must be a border of one of the clusters i.e. X is not an element of all clusters and there exists a neighbouring pixel such that the intersection of neighbouring pixels and any of the cluster is not an empty set. If the difference between

pixel value at x and the mean of that cluster is smaller than the threshold then point x belongs to that cluster else try to find other clusters to accommodate x and if can't find any clusters to accommodate define it as a new cluster. Repeat it for whole image. Computation time is more because sometime it creates bulky tree.

iii). *Boundary Search Algorithm*

This algorithm is implemented on binary images. Here assume that background with pixel '0' and region with pixel '1'. We start scanning from an uppermost leftmost point as first pixel with '1' and examine for 8- connectivity in clockwise direction. Simultaneously store the coordinates.

C. *SVM Classifier*

SVM is based on supervised learning method which associated with learning algorithm and used for classification of analysing data sets. SVM creates high-dimensional two hyper planes and there is a marginal separator between two hyperplanes, and noise on these hyperplanes are depend on the margin width, if margin width is greater than it take less noise and SVM classification is clear and if margin width is less than it take more noise and classification is not clear. These hyperplane consist some data points of image that are called feature vector. SVM model is classified into two different categories:

- Type 1 SVM classification (that also called C-SVM type)
 - Type2 SVM classification (that also called nu-SVM type)
- The SVM model used some number of Kernels function that are linear, polynomial, radial basis function (RBF), and sigmoid. This kernel function is the dot product of SVM input data points that mapped into high dimension feature space.

III. **PROPOSED ALGORITHM**

A. **Flow Chart of Proposed Algorithm**

There is not an automated system that can detect boundary of object image efficiently, so this work develops an automated system that can detect the boundary of object and then classify their class. The flow chart of proposed methodology is shown in fig.1. Our project work is object detection in low contrast images that are based on the surveillance system and it takes two image frames as input and then processes them. In which one is object image and other is background image of object image, then subtracting the object image and get the foreground region of image. After this, convert the image into RGB to gray scale and gray to binary image for further processing. Then binary image is shifted on x-axis and y-axis by n-units. Then perform XOR on shifted image and get the approximate edge of the region of interest. Then find coordinate points on boundary of object, for this divide the image into four quadrants based on centroid of object image. So, there will be four small images from one image, then for each image calculate the radius and angle to pixel of their corresponding centroid. Neglect the radii, which are less than thrice of standard deviation minus mean and greater then thrice of standard deviation plus mean. And select the maximum of radii within interval of edge and corresponding coordinates. These coordinate will provide information about shape of object. After getting the points on boundary, we map coordinate points on 2-D histogram with angle on x-axis and radius on y-axis. Then we extract these shape feature vector from histogram data to train SVM for classification. Here, we train SVM by shape feature vectors for identifying the class of object image. Here we use C type SVM that perform better classification of image.

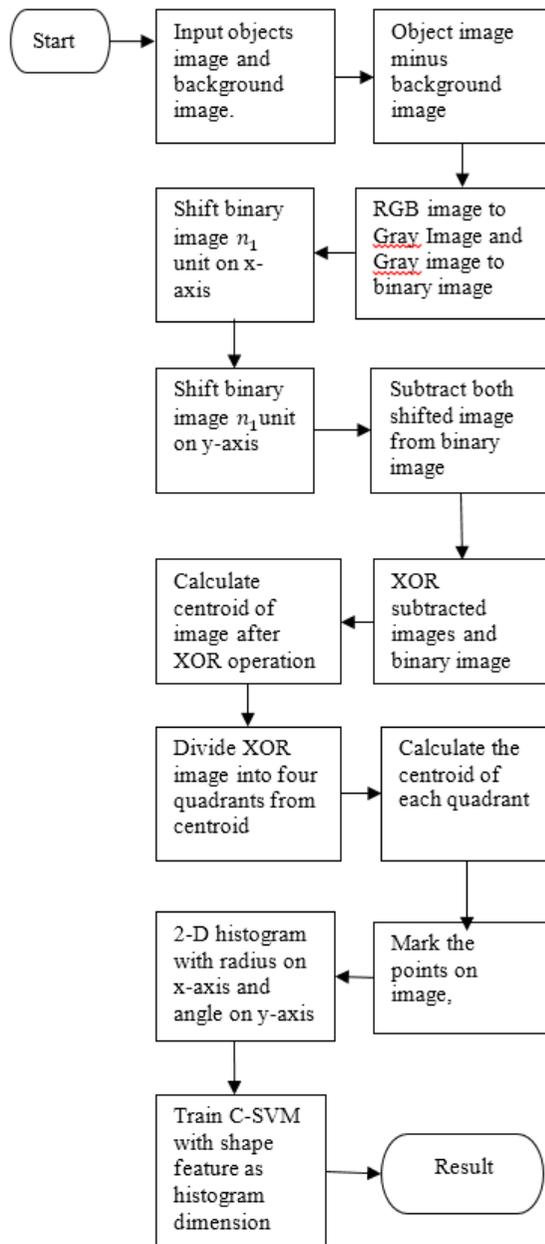


Fig. 1. Flow chart of Proposed Algorithm

B. **Implementation**

Since my focus on object detection, so we adapted background subtraction. It helps me to solve one issue when images in low contrast from and taken by still camera. For the background, I used simple subtraction of object image with a background image since my assumption that the camera is still.

IV. **OBJECT DETECTION AND TRAINING MODEL WITH SHAPE FEATURE VECTOR**

Here we provide a complete manifestation about shape feature to distinguish human and non-human, and training and detection procedure.

A. **Shape Feature Description**

A particular feature of object that can successfully differentiate between human and non-human class is his/her shape. Unlike edge are template feature that describe the shape. The shape of a person is assumed as star convex. In which every pixel are connected in from of English alphabet letter C. In which, exist n

points and a line segment between n to m in region C. Here, we assume a specific feature in case of human object i.e. shoulder is broader than head. This feature is commonly used for identifying the object image whether it is human or non-human class. For this we first try to find co-ordinate point on foreground region of object and these points are used as shape feature vector of object image. By region C we can conclude that all human shape features are same but it failed in case of non-human class, because different non-human objects contain different shapes or different object boundaries. For feature extraction first we need to calculate the coordinate points on object boundary. For this first we have to calculate the radius and angle of image from its origin with pixel and those radius which is greater than my threshold is neglected. Here my threshold is greater than thrice of standard deviation plus mean and less than thrice of standard deviation minus mean. My threshold is based on assumption that is 90 percent radius of object boundary is biased to mean. After processing each part of image we merge these separate parts of image and get a fine coarse mask of foreground region and this fine coarse mask called our region of interest. Then we plot a 2D polar histogram with angle between coordinates point to centroid on x-axis and radius between coordinate points to centroid on y-axis. This polar histogram is representing on 5X12 bins. These bins are filled with similar pixel of image. Where r_i and θ_i are the radius and angle between centroid to coordinate points respectively. The number of sample points defines the magnitude of these bins are satisfy the corresponding bins. These bins are from 60-dimension histogram space feature vector that is used as shape feature vector.

B. Training and Testing Of SVM

There are two phases of SVM first is training phase and the second is testing or classifying phase. In the training phase, first we have to collect some human and non-human object image and their background image, then manually obtain their region of interest and compute their shape feature vector from above method, then feed this feature vector into C-SVC (C-support vector classifier) for training the hyperplane of SVM. Here, we use C-SVM type classifier because its marginal width between two hyperplane is broader so the vector plane are not affected each other and we can easily classify the object image and it takes less computation time. Further, SVM are used kernel function that map the coordinate points to histogram, here we use GRBF (Gaussian basis radial function) type kernel function in case of non-linear by SVM. Shown by this equation

$$K(x_i, x_j) = \exp(-\gamma \|x_i - x_j\|^2)$$

In this expression x_i and x_j are the input feature vector and γ are the normalised constant.

Second phase is testing phase, in this phase the classifier contains those images that are obtained after performing background subtraction means foreground region of images. In addition, feed these images into classifier for classifying their class i.e. human being or non-human being.

C. Mathematical Modelling

We have two gray images I_1 & I_2 $I_1 = g_1(x, y)$ & $I_2 = g_2(x, y)$. Where I_1 the background image and I_2 be the image with the object. Then simple background subtraction, i.e.

$$I_3 = I_2 - I_1 \tag{1}$$

Converting the gray scale image I_3 to binary image using a variable threshold [1] eq. 10.3.

Let σ_{xy} and m_{xy} be the local variance and mean of set of neighbouring pixel at say, $g_3(x_a, y_b)$ where a and b varies from 1 to size of image.

$$R_{xy} = a\sigma_{xy} + bm_{xy} \tag{2}$$

a and b are the non-negative constant. The binary image is so formed as

$$g_4(x, y) = \begin{cases} 1 & \text{if } g_3(x, y) > R_{xy} \\ 0 & \text{if } g_3(x, y) \leq R_{xy} \end{cases} \tag{3}$$

After converting it into binary image we shift binary image in x-axis and y-axis with n_1 unit right and n_2 unit top respectively.

$$\begin{aligned} I_5 &= g_4(x - n_1, y) \\ I_6 &= g_4(x, y - n_2) \end{aligned} \tag{4}$$

After shifting its axis we do XOR binary operation since XOR operation is odd function operation as follows

$$I_6 = I_5(1 - I_6) + I_6(1 - I_5) \tag{5}$$

After XORing the image we divide image into four parts about the centroid say (c_x, c_y)

$$c_x = \frac{\sum_{i=1}^N x_i}{N}, c_y = \frac{\sum_{j=1}^M y_j}{M} \tag{6}$$

Where, i, j are the number of pixel with intensity one. N, M are total number of pixel with intensity one.

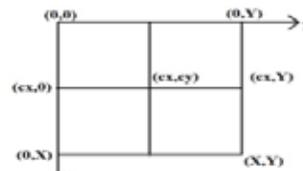


Fig. 2. Image co-ordinate

Converting all the pixel co-ordinate having value pixel value one for each divided part into corresponding radius and angle.

$$r_i = \sqrt{(c_x - x_i)^2 + (c_y - y_i)^2} \tag{8}$$

$$\theta_i = \tan^{-1} \left(\frac{c_y - y_i}{c_x - x_i} \right) \tag{9}$$

For each quadrant we define $[c_x, c_y]$ such that joining each part $[c_x, c_y]$ converges on same centroid point.

If the radius lies between thresholds we neglect that radius.

$$\begin{aligned} z_1 &= 3 \times (E[X^2] - (E[X])^2) + E[X] \\ z_2 &= 3 \times (E[X^2] - (E[X])^2) - E[X] \end{aligned} \tag{10}$$



Fig. 3 four partition of image co-ordinates

Then for each part, we make matrix of radius, angle, and corresponding x and y coordinate as shown below

$$c_1 = \begin{bmatrix} r_1 & \theta_1 & x_1 & y_1 \\ \vdots & \vdots & \vdots & \vdots \\ r_m & \theta_m & x_m & y_m \end{bmatrix} \quad (11)$$

$$c_2 = \begin{bmatrix} r_1 & \theta_1 & x_1 & y_1 \\ \vdots & \vdots & \vdots & \vdots \\ r_n & \theta_n & x_n & y_n \end{bmatrix} \quad (12)$$

$$c_3 = \begin{bmatrix} r_1 & \theta_1 & x_1 & y_1 \\ \vdots & \vdots & \vdots & \vdots \\ r_p & \theta_p & x_p & y_p \end{bmatrix} \quad (13)$$

$$c_4 = \begin{bmatrix} r_1 & \theta_1 x_1 & y_1 \\ \vdots & \vdots & \vdots \\ r_q & \theta_q x_q & y_q \end{bmatrix} \quad (14)$$

Then we merge these all matrix for finding a common region of interest

$$c_5 = [c_1 \quad c_2 \quad c_3 \quad c_4] \quad (15)$$

ThAfter filtering we mark x and y coordinates corresponds to maximum of radius within five degree intervals. Partition each coordinate again in four coordinates and perform the same.

V. RESULTS & COMPARISON

A. Results

Our proposed algorithm are tested with several different types of human and non-human low contrast images that are captured by static camera and it stored in our dataset and the size of images are kept small but there is not any specified size limitation. The experimental environment worked on a 2.00 GHz Intel(R) Pentium(R) Dual CPU T3200 with 1GB of RAM PC. By using computer simulation "MATLAB R2012a". We analyse the performance of algorithm using 2 MP still camera.

Here, we collect some input image (object image and background image) that are captured by still camera. Fig.4 shows the implementation of proposed algorithm with human and non-human images and the green points on images is coordinate points of image and we can see our SVM work successfully and identified class of images.

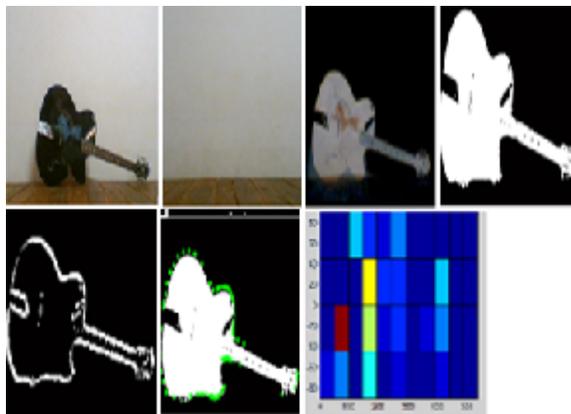
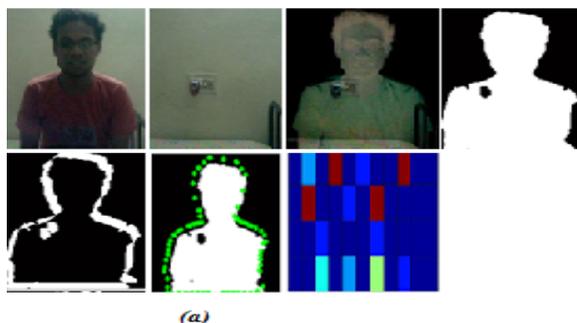


Fig. 4. Implementation of algorithm (a) human image (b) Non- human image (c) SVM outputs

B. Comparison

From result we observe that all image and there efficiently detecting small object and neglecting small points in 0.368062 sec (Time elapsed to execute program in MATLAB.) Fig.5 shows the result of implementation of proposed algorithm. And fig.6 show same types of images implemented by boundary search algorithm, here red lines are the boundary of object and green points are the hole of images, Boundary detected by boundary search algorithm is quiet good but the computational time require by MATLAB is 0.606900 seconds, which approx. twice than algorithm proposed



Fig. 5. Implementation of proposed algorithm on image

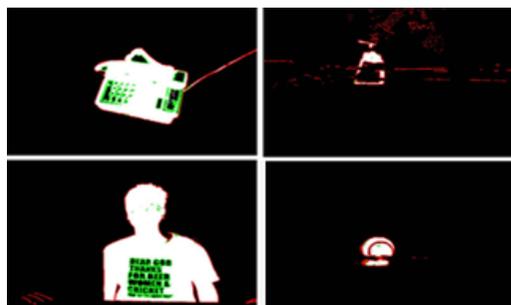


Fig. 6. Using boundary search

Table I: Time Computation

Algorithm	Time(ms)
Gradient	342.212
Shift	368.062
K-mean	866.850.
Boundary Search	606.900

VI. CONCLUSION

In this paper, we present a novel algorithm for detection and recognition of object image that are in low contrast based on surveillance system. It consist three main procedure: extracting foreground region of object image, and polar coordination based shape feature generation and train SVM with images and classify the object whether it belong human or non-human classes. For classification we assume a common feature vector i.e. shoulders is broader than chest. These three procedures mutually improve with each other and consummate a good performance. In addition, we get that our SVM work successfully.

In result phase we show the acceptable segmentation result with changing of light intensity environment, as well as high detection rate and real-time performance, the classification result is very accurate and take much less time for performing background detection. In Fig. 6 and 7 we can see comparison images that represent our algorithm give better result than other algorithm and we optimize that it take much less time as compare to previous proposed algorithm by given comparison table. This is a very big achievement in field of low contrast image.

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