

Comparative Analysis of Motion base Image Segmentation using Machine Learning Techniques

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Abstract

Objectives: In the computer vision task, motion based image segmentation is the foremost step which warrants for further research. Several progressive techniques are being created for motion base image segmentation. Machine learning methods are implemented and analyzed in this paper. **Methods:** Motion is one of the useful characteristics to segment object from the image as it provides a classification of pixel in motion or motionless type. Machine learning methods are giving promising result in classification type problems. Machine learning methods reduce the execution time. In this type of technique a training is required in beginning after that all processes are performed automatically. This paper presents two machine learning technique SVM and LS-SVM. The Segmentation of image can be done by selecting image feature. In proposed method intensity change basis of motion is used as texture feature. **Findings:** Both of techniques classify pixels of an image between two types, 1. Appropriate to a motion and 2. Not appropriate to motion. Results obtained using this approach shows that machine learning methods are very promising techniques for this type of area. **Application/Improvement:** LS-SVM method is very promising with enhancement in execution time and segmented object result quality as compared to SVM.

Keywords: Classification, Image Segmentation, LS-SVM, Machine Learning, SVM

1. Introduction

Motion base image segmentation subdivides an image into its constituent regions or objects in motion or immobile, for further analysis in video surveillance, traffic analysis etc. Motion base image segmentation can also define as the process of classification of pixel in foreground and background. In image objects like weaving tree, flag, intensity changes due to sunlight forms dynamic background, these pixels having similar brightness, color or texture but having very less movement. These properties are used to define different

regions of image. In segmentation process the image pixels are classified into two or more classes. Each class represents some region of image. Motion segmentation is the grouping of pixels associated with a smooth and

uniform motion profile. In the current years, many researchers are undertaking intensive works of moving object segmentation and proposed variety of very remarkable and pioneering methods.

In past years many image segmentation techniques are proposed and developed and these techniques are classified into following five major categories^{1,2}.

- Statistical - Region based
- Absolute difference - Edge based
- Threshold based
- Recursive - Feature based clustering
- Graph based

1.1 Statistical -Region based^{3,4}

The region-based segmentation method classifies the image in number of classes or regions. These regions

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might correspond to an object or a meaningful part of an image. There are various approaches of region based image segmentation: Local techniques, Global techniques and Splitting and merging techniques. The efficiency of region growing algorithms depends on the input image and type of application. This technique is used for only simple images.

1.2 Absolute Difference- Edge based^{1,2,4}

This is simple and widely used technique. Edge detection method classify image into continuity and sharp discontinuities in an image. In this technique boundary pixels are identified and the mark as edge of objects. This is discontinuous base segmentation. For developing edge around region pixels are compared with their neighbor pixels value. Edge detection can perform by: Canny, Sobel, Laplacian, Gradient or Robert edge detector. These algorithms are work with simple and noise free images.

1.3 Threshold based^{1,4}

This is easiest way of segmentation. In this technique the threshold value is obtain from histogram of edges of original image. Thresholding process converts multilevel image into binary image by assigning image pixels into background and foreground (using 0 and 1) based on any threshold value T (intensity or color value). Threshold value can be global or local for regions. Main drawback of this method is that it is not suitable for complex images or images which have target area smaller compare to background.

1.4 Recursive- Feature based Clustering^{1,4}

Clustering is a process to classify pixels in similarity and dissimilarity measure. Pixels may belong together because of the similarity in color, texture etc. There are two normal procedures for clustering: partitioning and grouping⁵. Clustering in colored image is done by unsupervised Fuzzy C. Another cluster technique K-Means is used for texture base image segmentation. Both are iterative techniques. Base on initial set of cluster the quality of solution can be define. Over segmentation is one of the major problems in this method.

1.5 Graph based Methods⁵

Graph is an ordered pair of vertices and edges. In

image processing vertices represents by pixel and edges links the nearby pixel. This method provides efficient computational mechanisms to segment pixels from its similarity. Normalized cut, Min Cut, Typical Cuts, isoperimetric partitioning and spanning tree base segmentation methods are used for image segmentation.

These algorithms tried to achieve success in several applications, none of these approaches can apply in general conditions, and all these techniques are using manual process which requires time constrain and ever time lots of work to be done. This drawback leads to requirement of automatic learning methods. In machine learning method, machines learn by it-self and provide output. Motion base object segmentation using the machine learning algorithms are presented here for research paradigm. Support vector machine is one of the approaches usually used for classification and the observed classification problem is the motion based object segmentation. Moving and motionless pixels are classified into two dissimilar classes and SVM gives prominent results in this approach. Least Squares Support Vector Machine (LS-SVM) is a novel based SVM contains a set of associated supervised learning methods that scrutinizes data and discriminate patterns and used for classification and regression analysis. This approach considerably decreases the complexity and the computation time. In this paper, SVM and LS-SVM methods are used to segment moving object. The section two presents basic theory of SVM and LS-SVM, section three presents proposed algorithm for motion base object segmentation, section four covers simulation results and section five concludes the paper⁵⁻⁷.

2. Support Vector Machine (SVM) and Least Squares Support Vector Machine (LS-SVM)

Machine learning algorithms categorize into subsequent types include supervised learning, unsupervised learning, semi supervised learning, reinforcement learning and transduction. SVM (Support Vector Machine) is good generalization classification methods, when the number of training samples is less and the dimension of feature space is very high^{8,9}. The principles of SVMs have been developed by Vapnik¹⁰.

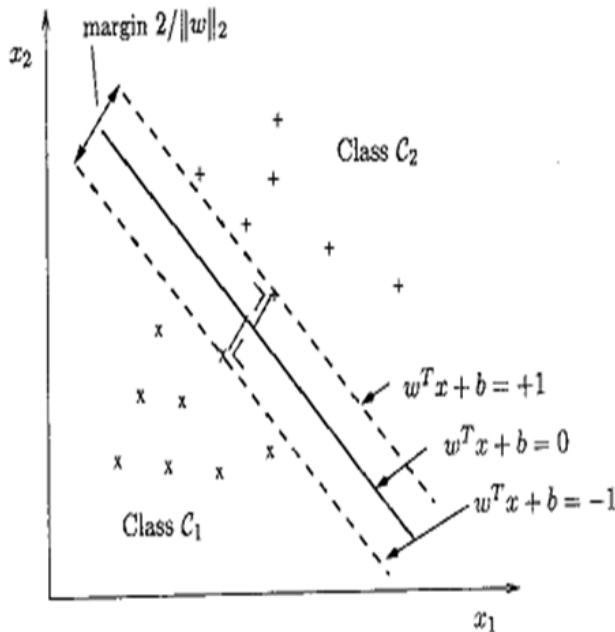


Figure 1. SVM algorithm.

Linear function is the simplest manifestation of separation. Linear function $f(x)$ for separation can be written as $f(x) = [w^T x + b]$, where, w is the weight vector and b as bias.

Vapnik and Chervonenkis described that the generalization capacity depends on distance between hyperplane and the training points. They presented the generalize depiction, a learning algorithm for distinct problems. They built a hyper plane which excellently separates the classes. The separating hyperplane described as w and b . SVM modelling is used to find out optimal hyper plane which separates clusters of vector in both side of plane in such a way that cases with one category of the target variable are on one side of the plane and cases with the other category are on the other side of the plane. The vectors which are near the hyper plane are the support vectors. As shown in Figure 1⁸.

If the margin of the hyper plane is wider, the more clear classification can be done and it classifies more easily the same data into required classes.

For linear separable two classes

$$y(x) = \text{sign} \left[\sum_{k=1}^N \alpha_k y_k x_k^T x + b \right] \quad (1)$$

For nonlinear separable

$$f(x) = \text{sgn} \left\{ \sum_{i=1}^m \alpha_i y_i K(x, x_i + b) \right\} \quad (2)$$

Where $K(x, x_i)$ is Kernel function. In case of linear function it is simple a dot product. Kernel function maps the input vector into a higher dimensional feature space⁸.

2.1 Types Kernel Functions

- Linear kernel

$$K(x, x_i) = x \cdot x_i \quad (3)$$

- Polynomial kernel

$$K(x, x_i) = (x \cdot x_i + 1)^Q \quad (4)$$

- Gaussian RBF kernels

$$K(x, x_i) = \exp \{ - |x - x_i|^2 / \sigma^2 \} \quad (5)$$

Generally RBF kernel is used. Linear kernel is special type of RBF kernel. In case of large number of features linear kernel used for better result. The values of y which appear in Equation (1) and (2) can be +1 for positive classification training vector, and -1 for negative classification training vector. Values of α denotes Lagrange multiplier obtain in minimization process⁸. Suykens and Vandewalle suggested a new kind of SVM called Least Squares-Support Vector Machine (LS-SVM) is a part of kernel-based learning method category. The computation speed of this algorithm is faster than the other SVM. The vapnik formulation is improved at two points 1. Use of the equality constraint. 2. Error variable e_k taken as a squared loss function. The Lagrangian for the problem is:

$$L(w, b, e; \alpha) = J_p(w, e) - \sum_{k=1}^N \alpha_k y_k [w^T (\varphi x_k) + b] - 1 = e_k \quad (6)$$

The classifier in the dual space takes the form

$$y(x) = \text{sign} \left[\sum_{k=1}^N \alpha_k y_k K(x, x_k) + b \right] \quad (7)$$

Where, α_k values are Lagrange multiplier, which can be positive or negative and $K(x; x_k)$ is the kernel trick. LS-SVM simplifies the SVM formulation by replacing inequality constraint to equality constraint. This helps in reducing the complexity and the computation time significantly⁸.

3. Proposed Methodology

Motion base image segmentation using machine learning techniques have following steps

- Pixel level feature extraction
- Training procedure
- Pixel classification

The process of motion base image segmentation using these methods can summarize in Figure 2 and 3.

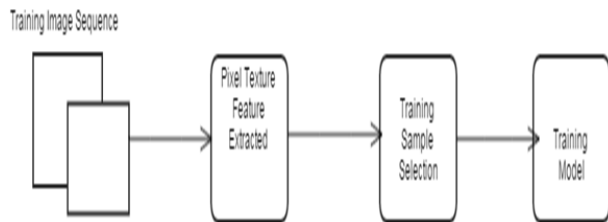


Figure 2. Training methodology.

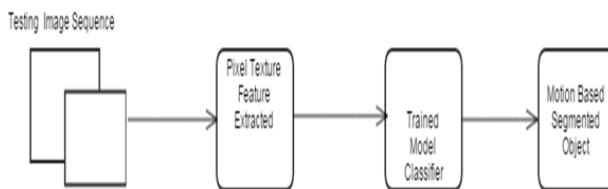


Figure 3. Testing methodology.

3.1 Pixel Level Feature Extraction

This is the first step of algorithm in which extraction of features on pixel levels perform. For segmentation features like color, texture or combination of both is used. Here image sequence is converted into gray level and texture features selected from the intensity change of pixel due to motion from successive frame.

3.2 Training

Once pixel level features are extracted, next step is to train the model. Select the texture feature of image by converting this image to 4×4 blocks, and calculate mean value of each block. Mean value of whole image was also calculated. Five image sequences are used to extract texture feature. From these all pixels randomly 4800 sample pixels are selected for training purpose. Both features were then given as input to SVM / LS-SVM training model. If the obtained mean value of image block greater than threshold T_{tr} then consider the block as positive support vector and assigned as + 1 otherwise - 1. The RBF kernel is used for this algorithm.

3.3 Pixel Classification

This is simple process in which the vector of original image is provided, the vector contains the feature information and based on function created in training procedure, test image pixels are classified into +1 or -1 classes. But it may happen some pixels are in between these two values then they are not taken in consideration. Value above +1 considered as the positive class or moving pixel and values below -1 considered as negative class or non-moving pixel. All values between +1 and -1 are considered as the error values. So, this indicates that function should be choosing such that it minimizes error pixels. For testing purpose adopt the first three steps used for training SVM /LS-SVM model. Output of the pixel level feature block given to classifier and finally it segment the moving objects for the given image sequence.

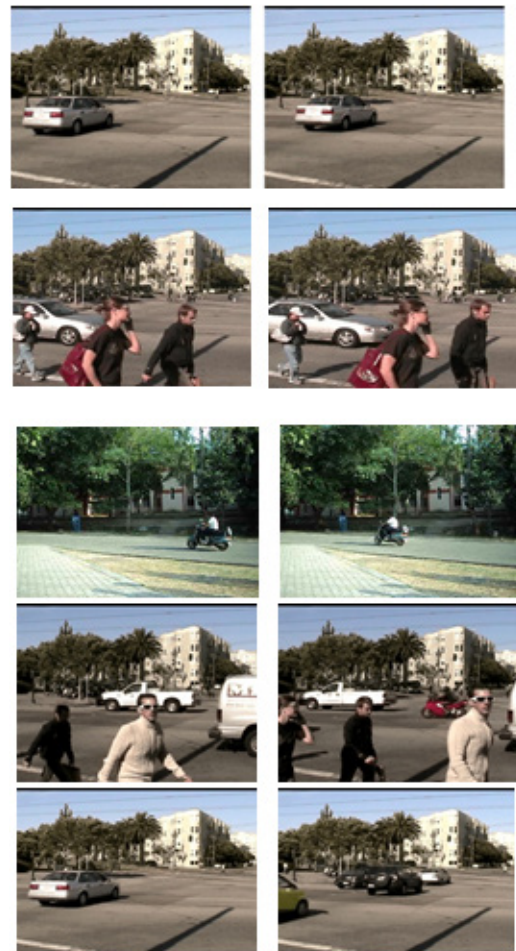


Figure 4. Training sequences.

4. Experimental Results

This section presents the results of experiments which were carried out for explained algorithm. The implementation of the algorithm has been carried out using MATLAB R2012a. The part related to SVM has been implemented using LIBSVM library that contains all the needed functions for training and classification process with SVM. This library is easy to use. For LS-SVM simulation, the KULeuven's LS-SVMlab MATLAB/C¹¹ toolbox employed to handle the training and testing techniques. As stated earlier in training phase intensity feature of image pixels are consider for classification.

Five real life images were taken as training and then other images are tested based on model created in training. The input image shows in

Four train sequences 1, 2, 4, 5 are taken from the video sequence stated in article by Seth Benton¹² and sequence 3 is captured by sony cyber shot camera at college campus.

The test image files were taken from caviar project and I2R dataset^{13,14}



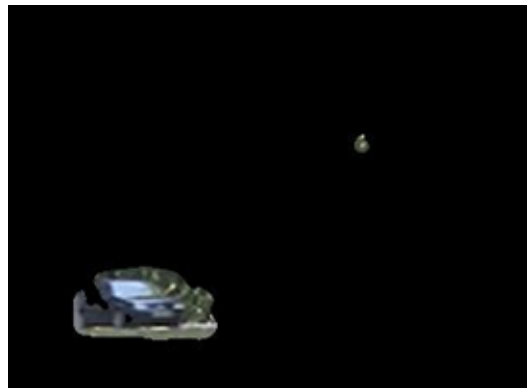
(a)



(b)



(c)



(d)

Figure 5. (a) Campus sequence (b) Original sequence (c) LS-SVM output (d) SVM output.

Campus sequence contains very dense vibrant background having many weaving tress and flag and movement of vehicle like car, bus and persons. Figure 5 shows one of the results. In that result car is detect in all three methods. Vibrant background is fully eliminated in LS-SVM. In SVM only little vibrant background is detected.



(a)



(b)

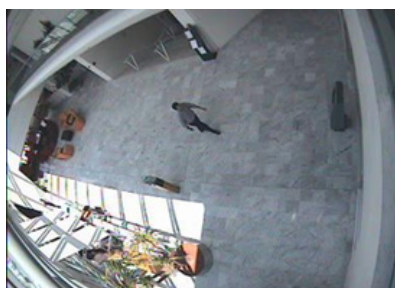


(c)

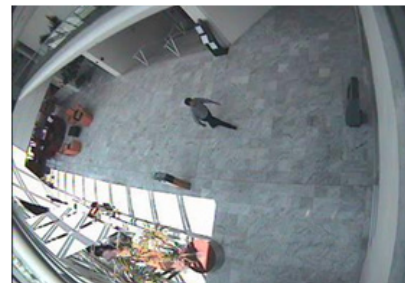


(d)

Figure 6. (a) Fountain sequence (b) Original sequence (c) LS-SVM output (d) SVM output.



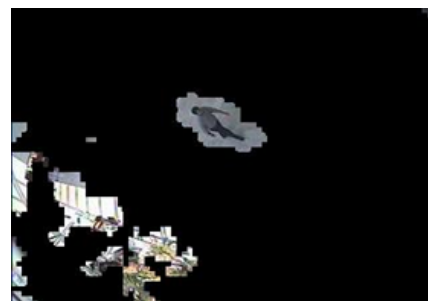
(a)



(b)



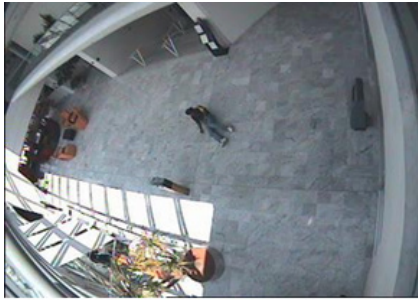
(c)



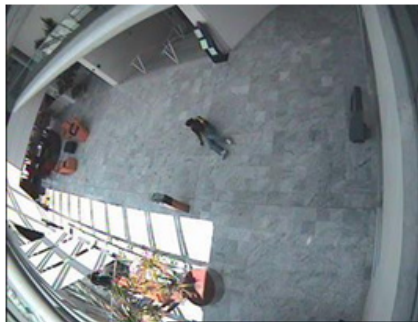
(d)

Figure 7. (a) Browse sequence (b) Original sequence (c) LS-SVM output (d) SVM output.

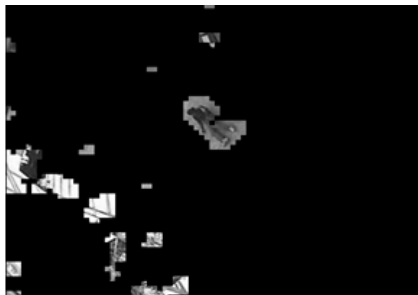
In this browse sequence person is moving towards kiosk for browsing. Sunlight is also coming from windows with varying intensity forms a dynamic background. Figure 7 shows one of the results. Moving person and very little part of window is detected as foreground by LS-SVM method. Moving person and sunlight from the windows is detected as foreground in SVM method.



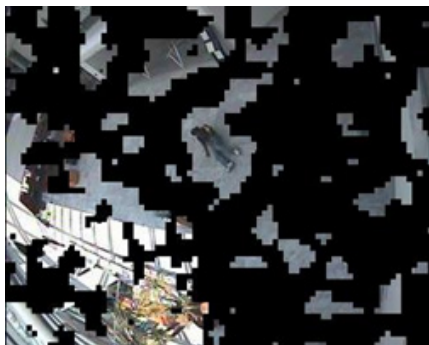
(a)



(b)



(c)



(d)

Figure 8. (a) Rest fall on floor sequence (b) Original sequence (c) LS-SVM output (d) SVM output.

In this Rest fall on floor sequence person is moving and then fall down on floor then get up and move again. Sunlight is also coming from windows with varying intensity forms a dynamic background. Figure 8 shows one of the results. Resting person and very less part of window is detected as foreground by LS-SVM method. Moving person and sunlight from the windows and large part of floor is detected as foreground in SVM method.



(a)



(b)



(c)

Hall sequence is indoor sequence of airport waiting lounge movement of many persons with luggage, one person is seating at reception and persons are moving

from one end to other end. In some sequences moving persons stops for some time and then again person will start moving. Figure 9 shows one of the results. In that two persons crossing is each other are detect in LS-SVM and SVM method.



(d)

Figure 9. (a) Hall Sequence (b) Original Sequence (c) LS-SVM output (d) SVM output.

4.1 Quantitative Evaluations and Computational Cost Analysis

We prepared the hand base segmented ground truth. Then, compared each segmented output with this ground truth. Evaluation result of all sequences using false positive ratio and true positive ratio is mentioned in Table 1.

Table 1. Comparison of Results

Sequence	LS-SVM		SVM	
	FPR	TPR	FPR	TPR
Campus	0.0195	0.9852	0.0064	0.8419
Fountain	0.0100	0.9125	0.0128	0.7272
Browse	0.0089	0.8978	0.0142	0.7497
Rest Fall on Floor	0.0242	0.9518	0.0387	0.6321
Hall	0.0249	0.7747	0.0042	0.7583

T.P.R values in most of sequence are above 0.75 for both SVM and LS-SVM method. It shows that the segmented outputs are matching with ground truth. Training time is near to 30 minutes and testing time is near to 3 seconds in LS-SVM. Training time is 35 minutes and testing time is 4 seconds in SVM. This result indicates that as testing time is very less in this type of algorithm such that it can work in real time.

5. Conclusion

Algorithm is tested on various indoor and outdoor sequences. Algorithm is implemented with two machine learning techniques SVM and LS-SVM. Result of LS-SVM is very promising. It removes mostly all dynamic background like reflection from sky, ground, weaving tree etc. It also detects far running vehicle in the sequence. In all sequence it is detecting specifically objects in motion. Results of SVM also show that it removes most of dynamic background like reflection from sky, ground and weaving tree. But in some sequences it detects floor and sunlight. Quantitative analysis shows that LS-SVM gives better result than SVM. Time computation shows that the LS-SVM is efficient than SVM.

6. References

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