Tracking Model of Moving Target Based on KNN - SVM

Changhong Wu, Cunbo Xue, Jianqiang Ren

Langfang Normal College, Langfang 065000, Hebei, China

Abstract

According to the defects of KNN(\(K\)-Nearest Neighbor) algorithm and SVM(Support Vector Machine) algorithm in tracking a moving target such the large consumption and the low accuracy of target tracking error, a tracking model of moving target is proposed based on the combination of KNN algorithm and SVM algorithm with minimum distance optimization. First categories divided according to the principle of minimum distance classifier, to optimize the classification accuracy of standard KNN algorithm. And then the SVM as the KNN classifier with each type of only one representative point, and the improved KNN classifier is used to improve the accuracy of classification of SVM classifier boundary surface, and the SVM classifier is used to reduce the operand of the improved KNN algorithm. The simulation experiments show that the proposed improved KNN algorithm has higher target tracking accuracy and less computation, and has good effect in the actual application of tracking a moving target.

Key words: Target Tracking, SVM Classification, KNN Classification, Minimum Distance, Computational Cost Optimization.

1. INTRODUCTION

The need of reality applications to push the relevant scientific research, the intelligent video surveillance has become a research focus in the academia. Video and film or daily life is different, people don’t pay attention to the scenery or picture or emotion in surveillance video, but focus on the moving targets and their behavior. So to find out and track the moving targets is the key and basic technology of intelligent video surveillance. On the one hand, it from the complex dynamic background to extract the target position, appearance, movement and other important information for users to view and retrieval; On the other hand it provides high-level video understanding with primitive information, is the basis of the higher level intelligence analysis such as the scene detection, behavior recognition, abnormal alarm (Wang and Yang, 2012). There is great significance to improve the degree of intelligent video surveillance system and to realize the networked mass linkage supervisory control and data sharing (Ng and Han, 2012).

Moving target tracking after many years of study, researchers at home and abroad has made some achievements, which are frequently used currently moving target tracking method mainly includes the following forms: based on tracking method is set image frames with the target area as the template firstly, on the experimental image for the template in different scanning the offset value of, again by similarity criterion is calculated for each offset value of the correlation coefficient, which can determine the position of the moving target practice (Hu and Han, 2012). The advantage of the algorithm whether obviously or not the characteristics of the target can use and simplier. Due to the effect of image grey value restricts the similarity judgment, when great changes have taken place moving target attitude or light intensity changes, the accuracy of this method will greatly reduce (Comaniciu and Meer, 2012). Also known as the Snake algorithm based on contour tracking method is using a closed curve contour to express the characteristics of the moving target, and the contour can be automatically updated in time, this tracking thought was put forward in the eighty s by Kass (Sebastian, 2011). In constructing the field of image features, the outline of moving target by closed parametric curve, again by dynamic iterative mininization curve function, and realizes the continuous updating of contour, gradually consistent with target edge (Li and Zhang, 2013).

Paragios and Deriche later adopted movable short line contour with Level Set theory method of combining the implementation of multiple target detection and tracking (Hu and Zhao and Chen, 2014). Tracking method based on the characteristics of the early to extract the characteristics of the moving object, the eigenvalues of the commonly used to include, geometric shape, texture, color, etc., according to the extracted feature matching method for moving targets, realize the tracking of moving targets (Ross, 2013). This method is simple summarized as: feature extraction, feature matching and target positioning (Comaniciu and Ramesh, 2013). The main matching method based on the objectives of invariant moment matching and matching based on Hausdorff distance (Wu and Cheng, 2012). Based on feature tracking has the characteristics of partial matches, so the algorithm has certain resistance to keep out (Collins and Liu, 2013). In order to improve the tracking precision,
often use multiple eigenvalues fusion method, and given different weights to each characteristic value. However, how to choose from several characteristic values as the most stability and distinct feature are the key and the difficulty of the tracking method.

According to the defects of KNN algorithm and SVM algorithm, a tracking model of moving target is proposed based on the combination of KNN algorithm and SVM algorithm with minimum distance optimization, and simulation experiment was performed to verify the validity of the improvement strategy.

2. DEFECT ANALYSIS OF THE TRACKING MODEL FOR MOVING TARGET

The popular movement target tracking models currently are the moving target tracking model based on SVM (Avidan, 2012) and the model of movement target tracking based on KNN (Yuan and Zhou, 2014):

(1) The moving target tracking model based on SVM

Support vector machine (SVM) is based on structural risk minimization principle, the structural risk minimization principle better solved played a learning problems in the traditional learning algorithm, the SVM algorithm in classification precision and efficiency are higher (12). Given a training set

\[ T = \{ (x_i, y_i), \ldots , (x_i, y_i) \} \in (\mathbb{R}^n \times \gamma)^l \]  \hspace{1cm} (1)

In the equation (1), \( x_i \in \mathbb{R}^n \), \( y_i \in \gamma = \{1, -1\}, i = 1, \ldots , l \). The root of the classification problem is to find a real function \( g(x) \) on the space \( \mathbb{R}^n \), through the decision function

\[ f(x) = \text{sgn}(g(x)) \]  \hspace{1cm} (2)

Concluded the output corresponds to any input \( x \).

Consider the classification problem of the classification problem of two-dimensional space \( \mathbb{R}^n \). If a straight line can divide the space \( \mathbb{R}^n \) into two parts, obviously there are many lines can distinguish the two types of points and we need to find the better line.

By calculating the distance between two straight lines, the distance of two straight lines is \( d = \frac{2}{\|w\|} \), the ideas of maximize “interval” is transform classification problem into solving the optimization problem of variables \( w \) and \( b \):

\[ \min_{w, b} \frac{1}{2} \|w\|^2 \]  \hspace{1cm} (3)

The dual problem: strives for the biggest interval problem cannot directly to solve the optimization problem (3), to solve the dual problem of the optimization problem, need to introduce Lagrange function.

\[ L(w, b, a) = \frac{1}{2} \|w\|^2 - \sum a_i (y_i ((w \cdot x_i) + b) - 1) \]  \hspace{1cm} (4)

\( a = (a_1, \ldots , a_l)^T \) is Lagrange multiplier vector.

Optimization problem

\[ \max_a - \frac{1}{2} \sum_{i=1}^l \sum_{j=1}^l a_i a_j (y_i x_i \cdot x_j) + \sum a_i \]  \hspace{1cm} (5)

Lagrange function is found not all classification problem can be obtained by linear classification, plus there may not be such a hyperplane, therefore the starting point is usually doesn’t work. Obviously we have to “soften” kind of hyperplane request, so we can continue to insist on a hyperplane partition. “Softening” is by introducing loose variables, while have training points at the same time allowing that not satisfy the constraint conditions \( y_i ((w \cdot x_i) + b) \geq 1 \) exist.

\[ \xi_i \geq 0, i = 1, 2, \ldots , l \]  \hspace{1cm} (6)

The constraint conditions of “soften” are:

\[ y_i ((w \cdot x_i) + b) \geq 1 - \xi_i \]  \hspace{1cm} (7)

Of course, when \( \xi_i \) are sufficiently large, training points \( (x_i, y_i) \) can always satisfy the above constraints. In order to constraint the value of \( \xi_i \) is too large, the solution is that \( \sum \xi_i \) to join in the optimization function, plays a role of punishment. The original problem instead of the original optimization problem:
\[
\min_{w, b, \xi} \frac{1}{2} \|w\|^2 + C \sum_{i=1}^{l} \xi_i
\]  
\(\xi = (\xi_1, ..., \xi_l)^T, \quad C > 0\) is the parameters for punishment.

Introducing the Lagrange function,

\[
L(w, b, \xi, \alpha, \beta) = \frac{1}{2} \|w\|^2 + C \sum_{i=1}^{l} \xi_i - \sum_{i=1}^{l} \alpha_i (y_i((w \cdot x_i) + b) - 1 + \xi_i) - \sum_{i=1}^{l} \beta_i \xi_i
\] (9)

\(\alpha = (\alpha_1, ..., \alpha_l)^T\) and \(\beta = (\beta_1, ..., \beta_l)^T\) are the multiplier vectors of Lagrange.

The optimization problem is the dual problem of the original problem.

\[
\max_{\alpha, \beta} - \frac{1}{2} \sum_{i=1}^{l} \sum_{j=1}^{l} y_i y_j \alpha_i \alpha_j (x_i \cdot x_j) + \sum_{i=1}^{l} \alpha_i
\] (10)

For classification problems unfavorable to adopt linear partition, and should adopt with nonlinear division. The key point is the introduction of an appropriate transformation \(\Phi\). Assume that the original training set as equation (11).

\[
T = \{(x_i, y_i), i = 1, ..., l\} \in (\mathbb{R}^n \times \{-1, 1\})
\] (11)

In the equation (11), \(x_i \in \mathbb{R}^n, \quad y_i \in \{1, -1\}\), and introduce the transformation \(x = \Phi(x)\) from space \(\mathbb{R}^n\) to the Hilbert space \(H\), then get equation (12).

\[
\Phi: \mathbb{R}^n \rightarrow H \quad x \rightarrow x = \Phi(x)
\] (12)

The SVM algorithm is applied to the moving target tracking, the following steps: first of all for a video image sequence, in the first frame manual calibration to track the target, the target and the surrounding region as positive and negative samples respectively, provide training support vector machine (SVM), thus forming the initial classifier. For a new video frame, by the method of feature extraction will be classified pixels as sample, into the support vector machine (SVM) classification, and the judge each pixel belongs to the foreground or background. For each image frames after the classification of the image, by defining a weighted optimization method, to locate the target area.

But the standard SVM algorithm in time and space are difficult to achieve a satisfactory degree. Lead to training algorithm is the main reason for the low efficiency of traditional SVM to adopt the standard quadratic optimization technology to solve the dual problem. First, since each iteration of SVM needs to save the whole kernel function matrix in computer memory, when the training sample in the sample is large, will cause the SVM training memory consumption increased dramatically. Second, the SVM training algorithm calculation process is an iterative process, this led to the SVM algorithm long training time consume memory.

(2) The movement target tracking model based on KNN

KNN classifier is also a kind of simple practical nonparametric classification algorithm, the results of classification and prediction value depends on the latest \(K\) samples with the current sample from sample space. Its core idea is to calculate the distance between the unknown sample and all sample, choose the closest \(K\) samples, and according to the voting principle, choose the most number of samples in the latest \(K\) samples as a category of unknown samples. Assumes that the samples have \(N\) class, in this \(K\) samples, belong to the \(i\) class number for the sample is \(K_i\), the discriminant function is as follows.

\[
g_i(x) = K_i, i = 1, 2, ..., N
\] (13)

Decision rules as equation (14).

\[
g_j(x) = \max_i K_i, i = 1, 2, ..., N
\] (14)

Then \(X \in j\).

Seen from the definition of the KNN classifier, when \(k = 1\), the degradation of the nearest neighbor classifier, the classifier is of unknown samples as the nearest that category.

KNN classifier determine its category by the category of nearest neighbor one or more samples, to a certain extent, reduce the interference of noise on identification, relatively minimum distance classification equipment has a higher recognition rate. Disadvantage is uneven KNN classifier is not suitable for sample size of sample set, and classifier needs and all samples distance operation, large amount of calculation and memory consumption is large, difficult to meet the performance requirements of high real-time system.
Using the above two methods for a certain period of human movement video real-time target tracking, obtain the tracking error and operation cost, the result is shown in figure 1 and figure 2.

![Figure 1. Relative motion tracking error of two algorithms](image1)

![Figure 2. Operation consumption comparison results of two algorithms](image2)

Seen from the results in figure 1 and figure 2, the two methods can effectively track the target, but with poor precision, and the computation of two algorithms are huge.

3. MOVEMENT TARGET TRACKING MODEL BASED ON KNN - SVM ALGORITHM

3.1. KNN Algorithm Based on Minimum Distance

Based on the minimum distance classifier and KNN algorithm, an improved algorithm with high recognition rate and efficient classification is proposed.

Assuming that $N$ kinds of samples, each sample has $N_i$, the unknown samples as $X$. $X_{i,j}$ means No. $j$ sample of No. $i$ class, $X_{i,j} \in R^3$. In addition, the algorithm for three kinds of assumptions used to categorize in scope, define the three assumptions as $H_1$, $H_2$ and $H_3$ respectively. Improved algorithm is described as follows:

1. Calculate each kind of category center, such as equation (15).

   $$C_i = \frac{1}{N_i} \sum_{j=1}^{N_i} X_{i,j} \tag{15}$$

2. According to the principle of minimum distance classifier, calculate the nearest center $m$ from $X$ and $N$ category, and according to the distance from small to large, the sort of sorted to $L_1, L_2, ..., L_m$ respectively, the results of the corresponding categories as $M_1, M_2, ..., M_n$ respectively, $L_i$ means the category center distance form $X$ to $M_i$ class, $M_i$ and $L_i$ is one-to-one mapping relationship, defined as equation (18).

   $$D(X_i, X_j) = \|X_i - X_j\| = \sqrt{(X_i - X_j)^T (X_i - X_j)} \tag{16}$$
\[ M[1-m] = \min_i(D(X, C_i),...,D(X, C_K)) \]  
(17)

\[ L_i = D(X, M_i) \]  
(18)

(3) First determine the category scope of \( X \). For \( L_1, L_2, ..., L_m \), if \( 2L_i < L_{i+1} \), can preliminary judge \( X \in [M_i - M_{i+1}] \). It can be interpreted as: if the distance \( L_{i+1} \) from \( X \) to the center of \( M_{i+1} \) category suddenly become bigger, far more than before \( M_i \), then is unlikely to be the current sample category, including the following from \( M_{i+1}, M_{i+2}, ..., M_m \), namely \( X \notin [M_i - M_{i+1}] \).

(4) Determine the specific categories of \( X \). Based on the preliminary judgment(3), \( X \in [M_i - M_{i+1}] \). If \( i = 1 \), \( X \) must belong to the class \( M_i \), this is because only this kind of sample, according to the analysis of (3), \( X \) into the center of the first kind of sample is far less than the distance to the center distance of the second category, can only be \( M_1 \), this assumption is defined as \( H_1 \); If \( 1 < i \leq m \), \( X \in [M_i - M_{i+1}] \), then hypothesis is defined as \( H_2 \). At this time only in the \([M_i - M_{i+1}] \) category to implement the KNN algorithm to determine the specific category attributes of \( X \).

(5) If \( X \notin [M_i - M_{i+1}] \), at this time it can identify errors. Define the situation for the hypothesis \( H_3 \).

3.2. Movement Target Tracking Model Based on KNN - SVM Algorithm

The SVM regard as KNN classifier with each type of only one representative point, because the SVM for each kind of support vector machine only select a representative point, so it is sometimes the representative points not well said this category, and combined with the improved KNN classifier is because each support vector as representative point in the improved KNN classification algorithm, which can greatly improve the classification accuracy. Thus, using the improved KNN classifier to make up for the shortcoming of the SVM classifier, enhance the accuracy of the boundary surface classification; Using the SVM classifier makes up the shortcomings of the KNN classifier, reduces the computation of KNN algorithm, save the time cost. The implementation steps of KNN and SVM algorithm are as follows:

(1) The traditional SVM algorithm is adopted to calculate the support vector and the constant \( b \). Assume that test set as \( T \), \( T_u \) for support vector set, \( K \) as the taken numbers of KNN, \( \varepsilon \) as the threshold value of the classification, usually set to 1, if \( \varepsilon \) as 0 then KNN classifier set as 0, system into the traditional SVM classifier;

(2) If \( T \neq \phi \), then \( x \in T \), if \( T \in \phi \), then stop;

(3) The value generation into the equation (19);

\[ f(x) = \sgn\left[ \sum_{i=1}^{K} y_i a_i^T K(x_i, x) + b^T \right] \]  
(19)

(4) If \( |f(x)| > \varepsilon \), then makes \( f(x) \) for the output directly, \(|f(x)| \leq \varepsilon \), and transmit \( T_u \), \( X \) and \( K \) to improve KNN algorithm classification, the return value for the output value;

(5) \( T \leftarrow T \{-x\} \), to step (1).

Among them, the improved KNN algorithm in step (4) \( T_u \) as all sample set.

we attempt to take advantage of the KNN - SVM classifier, and selected for natural images and the impact of different features for classification accuracy were analyzed, and automatically get appropriate weighting solution, using the weight to extract the characteristics of the weighted respectively, and set an adjustable precision value \( \varepsilon \), user can change according to the actual needs of their classification accuracy, finally with weighted KNN - SVM classifier realize tracking of moving targets.
4. ALGORITHM PERFORMANCE SIMULATION

To verify the effectiveness of the improved algorithm proposed in this paper, simulation experiments were conducted on it. First of all, the test environment as shown in Figure 3 for improved KNN algorithm was used for target tracking accuracy and the consumption of computation algorithm simulation. The results are shown in the figure below.

Figure 3. The relative error of improved motion tracking algorithm

Then, using the SVM algorithm and KNN algorithm and KNN - SVM algorithm for one frame of the human body movement tracking target in real time, the results are shown in the following figure.

Figure 4. Improved operational consumption simulation algorithm

Figure 5. Moving target tracking results of SVM algorithm
Figure 6. Moving target tracking results of KNN Algorithm

Figure 7. Moving target tracking results of KNN-SVM algorithm

Seen from the simulation experiments, the proposed improved KNN algorithm has less computation and higher accuracy for target tracking, and has good effect to tracking a moving target in the actual application.

5. CONCLUSIONS

How to automatically discover and track the interested target is the fundamental problem in intelligent video surveillance, and is one of the hot spot in the industry and academia. But, due to the complexity of the monitoring environment, so far has not been very good to solve these problems, and still has great research value. According to the defects of KNN algorithm and SVM algorithm, a tracking model of moving target is proposed based on the combination of KNN algorithm and SVM algorithm with minimum distance optimization. The experiment simulation results show that the proposed improved model can well real-time tracking moving targets to human body, and with high accuracy.

REFERENCES


