www.s2is.org
International Journal on Smart Sensing and Intelligent Systems
ISSN 1178-5608

# PERFORMANCE MEASUREMENT OF PHOTOELECTRIC DETECTION AND TARGET TRACKING ALGORITHM

Haidou Yang [1] and Wei Li [2]

1. Management science and engineering research, Air Force Engineering University, Xi'an 710051, China

2. Highway Communication Research, Traffic Occupation Technology Institute of Shaanxi, Xi'an 710000, China

Emails:haidouyang@163.com, leili_yhd2015@163.com

*Submitted: Apr. 3, 2015* *Accepted: July 22, 2015* *Published: Sep. 1, 2015*

***Abstract- To solve the unstable problem of target tracking detection system, this paper proposes an improved mean-shift algorithm for object tracking, establishes object tracking processing model;provides the processing algorithm of object tracking. According to the principal of object tracking, papersets up sky background brightness calculation model in photoelectric tracking optical detection area and detection capability calculation model of space object, analyzes the effect of background illumination on the signal to noise ratio(SNR) of photoelectric tracking system, gives the change curve of detection capability based on the exposure time of CCD camera, SNR threshold of photoelectric detection system and dark current of photoelectric detection system. Through calculation and test , paperprovidesthe comparison results of the improved mean-shift and traditional mean-shift, verifies the correctness of the proposed algorithm and calculation models for photoelectric detection capability in target tracking detection system, the results show the improved mean-shiftobject tracking algorithm and detection capability calculation model are correct.***

**Index terms: photoelectric detection; target track; detection capability; SNR.**

# I. INTRODUCTION

With the development of photoelectric technology, microelectronic technique, optical imaging technology and high speed processing equipment, the performance of a variety of offensive weapons increases continuously[1]. As the main firepower, high-tech weapons such as precision-guided munitions have been used widely, which has become a salient feature of modern warfare. Future war will be the integration of war with combined distance including air-to-ground and air-to-air, and so on. It does not only require attention on the front line, but also enable to achieve deep strike. It does not only attack tank but also destroy the air helicopter. More precision tracking system requires real time tracking system with higher accuracy which is to fulfill the advantages of high technology to achieve precision strike[2-3]. Due to environmental variety and goal of diversity, all kinds of moving targets tracking are not the only, which has unpredictable difficulties, especially on the dynamic parameter change characteristics of small targets with difficulty on target detection and access to information. There is target acceleration, deceleration, background environmental changes and the inconsistent of loading platform, which brings some difficulties to track small targets[4].Based on this background research, real-time tracking method for small target detection has high theoretical and practical significance, which provides data analysis basis for the remote target information acquisition, intelligent control and fault diagnosis.

In recent years, with the development of technology, target tracking and detection technology at home and abroad have made new breakthroughs. Development and application of infrared technology in particular have the broad application prospect, which promote weapon guidance, infrared warning and real-time surveillance and other aspects of reform[5]. Target tracking is a classical problem in computer vision, its basic task is to determine or estimate the position, velocity and effective features on interested targets of video sequences. In the civil context, the application of target tracking such as video coding, intelligent transportation and video surveillance, provide oversight and supervision role for travel safety to avoid the occurrence of accidents[6]. In military applications, target tracking is a key technology for reconnaissance target, intelligent control oriented, data analysis.

Radar measurement is one of the most commonly used target detection methods. Its main principle is speed will be measured using frequency variation phenomena which are generated by relative motion between the source and target. Infrared measurement is the second one. It uses the Doppler technique principle which can realize all-weather measurement with little effect by the background light. It is usually to detect infrared point target by using the target's radiation andenvironment temperature or emissivity difference that has higher precision than tracking radar[7]. Through the infrared measurement the azimuth angle and pitching angle of the target relative to the sensor can be gotten. Visible light measurement is the third one. It does this by measuring the visible light image at the target pixel position in image contrast and image sensors, combined with the geometrical model of the space, the use of image processing technology to identify the spatial location of the target is determined, it does not work at night. It does this by measuring the visible light image at the target pixel position in image contrast and image sensors, combined with the geometrical model of the space, the use of image processing techniques to identify the spatial location of the target is determined, it does not work at night.

In target tracking technology, the role of the key technologies is becoming increasingly importantto intelligent weapons and ammunition, robotics, virtual reality and other technologies. Target tracking requires a complete segmented target, reasonably extract features and accurately identifying the target, taking into account time algorithm. At present, the commonly used methods of tracking include wavelet multi-resolution analysis, fuzzy technology, genetic algorithms and neural networks, improved adaptive mean-shift and particle filter. In recent years, with the progress of mathematics theory and mathematical tools, processor performance increase rapidly[8-9]. Multi-spectral integrated into multi-sensor data fusion, tracking algorithm in-depth research and strengths, as well as the on-chip system or programmable system gradually, bring a rapid development of image target tracking technology, it will bring a profound impact on people's future life.

In order to effectively improve the stability of the target tracking system, it needs to establish a suitable environment object tracking algorithms from the optical platform target tracking, research and discuss the calculation model for the limited detection ability in photoelectric tracking system, analyze optical tracking system detection capability, and give the improved design method for the photoelectric target tracking system. Based on target tracking principle, this paper studies the improved target tracking algorithm and its photoelectric detection performance, and gives their calculation model.

## II.Target tracking theory

The measurement of dynamic target parameters is very important in ammunition. These parameters include the target's flight speed, rotation angle, acceleration, the flight angle. Especially with the development of high speed weapons, dynamic characteristics of high speed moving target restrict the development of weapons[10]. Projectile or car special sensor parameters calibration measurement, at present has become the validation of the various types of weapons, setting and production evaluation index. In the vehicle tracking system, dynamic changes of loading special sensors with the characteristic of heat radiation in the slide, the moment characteristics of each point position in the trace-back path, and the cooperation in running andefficiency operation of airborne systems, are the information needed to know for target tracking[11]. Due to the particularity of the target, the target can’t be monitored in the wireless transmission mode to avoid the effects of loading test platform. Therefore, the tracking method is put forward in the direction of lateral tracking pathsto monitor and verify the loading mechanism characteristics, which have drawn out the measures of lateral target tracking. However, due to environmental variability and the diversity of the goals, all kinds of moving target tracking are not the only. There are unpredictable difficulties, especially for the change of the remote dynamic characteristics. There is acceleration, deceleration, target motion background environment changes and loading platform inconsistent state, which also brings certain difficulty to remote dynamic target tracking. Therefore, Research based on real time tracking and detection method for dynamic target, can provide favorable acquisition for the remote target information and intelligent control, and fault diagnosis[12].

According to the composition of the targetstracking system, tracking turntable is the core of the optical imaging system. Through tracing the path of the start, stop and optical lens together, the synchronous trigger is used to start tracking turntable, and the whole path tracking model is established. Motion vector has accelerated uniform and reduction process[13]. In order to verify the tracking system, the theoretical speed and the rotating angle calculation speed of tracking rotating platform can be compared. If the target can be stably locked in the optical imaging field and velocity error is small in the whole process, the detection of design theory and target tracking turntable control is feasible.Figure 1 is thepath tracking test schematic diagram for tracking the platform, optical imaging system. It is assumed that point A is the starting point of the path tracking, point B is the end point of the path tracking and point O is the test points of tracking platform, OC is the vertical direction perpendicular. When the target fly from point A to point B, tracking turntable system captures the target CCD and do tracking control according to the target characteristic and the tracking algorithm, so as to achieve real time tracking of AB interval.

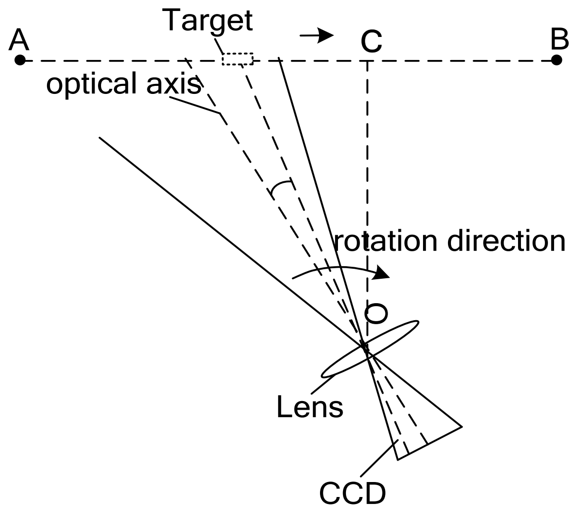



Figure 1 Schematic diagram of optical target tracking

## III.Target tracking algorithm

### A.The traditional Mean Shift algorithm

Mean shift is a procedure for locating the maxima of a density function given discrete data sampled from that function. It is useful for detecting the density modes.Let $X = \{x_1, \cdots, x_n\}$ beadatasetina n-dimensionalEuclideanspace $R^d$, mean shift vector can be defined as:

$$M_h(x) \equiv \frac{1}{k} \sum_{x_i \in S_h} (x_i - x) \tag{1}$$

In formula (1), it is the radius of the region, they meet:

$$S_h(x) \equiv \left\{ y : (y-x)^T (y-x) \le h^2 \right\} \tag{2}$$

$k$ determines the weight of nearby points for re-estimation of the mean. The difference $M_h(x)$ is called mean shift in Fukunaga and Hostetler[14]. The repeated movement of data points to the sample means is called the mean shift algorithm. This approach is known as kernel density estimation or the Parzen window technique. Once we have computed $f(\mathrm{x})$ from equation (1) and (2) and find its local maxima using gradient ascent or some other optimization technique. Starting at some guess for a local maximum $S_h$, which can be a random input data point, mean shift computes the gradient of the density estimate at $h$ and takes an uphill step in that direction.

According to the space vector of the form Mean Shift algorithm, the variety of forms, based on the research of scholars at home and abroad for many years, the Mean Shift algorithm is also proposed different representation model[15], the Mean Shift algorithm can be expressed by formula (3).

$$y_{t+1} = \frac{\sum_{i=1}^{n} w_i k(\beta \|x_i - y_t\|^2) x_i}{\sum_{i=1}^{n} w_i k(\beta \|x_i - y_t\|^2)} \tag{3}$$

In order to enhance the efficiency of treatment, the concept of window width is introduced, Main shift algorithm can express by using formula(4).

$$y_{t+1} = \frac{\sum_{i=1}^{n} w_i g(\left\|\frac{y_t - x_i}{h}\right\|^2)}{\sum_{i=1}^{n} g(\left\|\frac{y_t - x_i}{h}\right\|^2)} \tag{4}$$

In (4), $h$ is the window function.

Based on space vector form, the calculation method of weight parameters of expression is introduced. Main shift algorithm can be expressed by formula (5).

$$y_{t+1} = \frac{\sum_{i=1}^{n} w_i c_{k,j,h} g(\beta \left\|\frac{y_t - x_i}{h}\right\|^2) x_i}{\sum_{i=1}^{n} w_i c_{k,j,h} g(\left\|\frac{y_t - x_i}{h}\right\|^2)} \tag{5}$$

In (5), $c_{k,j,h} = \dfrac{1}{\int k((x - x_i)^T \sum_i^{-1} (x - x_i) / h^2) dx}$.

**B. Establishment and analysis of mean shift kernel function**

Let K:x→R be a kernel with K(x),it is put into the sample space of Mean Shift vector, then for broadband matrix $H$ of each pixel in the image set $X$ and kernel K(x)[16], multivariate kernel density estimation can be expressed by formula (6) and (7).

$$\hat{f}(x) = \frac{1}{n}\sum_{i=1}^{n} K_H(x - x_i) \tag{6}$$

$$K_H(x) = |H|^{-\frac{1}{2}} K(H^{-\frac{1}{2}}x) \tag{7}$$

$K_H(x)$ is a weighting function of non-parametric function estimation.

It is assumed that $X$ represents $d$ dimension vector space and $x$ is a point in space. Then $x$ vector norm is:

$$\|x\|^2 = x^T x \tag{8}$$

Let $R$ be a real number field, $X \to R$, $k:[0,\infty] \to R$, Then there is a profile function existing, which can be expressed as

$$K(x) = k\left(\|x\|^2\right) \tag{9}$$

If (9) meet the conditions: $k$ is non-negative and piece-wise continuous, and in the range of $k$ value, $\int_0^\infty k(r)dr < \infty$; in addition, if there are two numbers $a$ and $b$, the emergence of $a$ is less than $b$, then K( $a$ ) is greater than or equal to K( $b$ ), the function $K(x)$ is called Mean Shift kernel function[17].

**C. Improved mean shift algorithm**

From the above analysis, the traditional Mean Shift algorithm often relies on target area of gray distribution, optical imaging and target texture feature. It is to calculate space target center point displacement measures by means of similar goal function and describe goals through the concept of statistical distribution. Its advantages of the processing algorithm include less calculation parameters, fast processing speed, strong robustness and good real-time performance[18].However, due to different scenarios for dynamic target and large variations in brightness, it reduces the contrast of target in the background, appears even saturated state, can't detect the moving target feature, and reduces the real-time target tracking. Therefore, the traditional mean shift algorithm needs to be improved to meet the different requirements of the environment background. The improvement measure includes putting forward the gray space structure cascade, using this space as the feature space model, establishing target gray level of probability density distribution function. It overcomes unstable defects of target gray probability density distribution in the single gray space during establishing target gray, and improves the stability of detection and tracking.

Based on the principle of dynamic target tracking, to obtain real-time acquisition system for all stages of point target image, the gray space structure cascade is used as improved Mean Shift algorithm of feature space. In the target image, the object and background gray exist at the same time. Thus the target model is gray value and the probability density function of local standard deviation, the probability density function is used byEpanechnikov kernel processing method[19]. Then two Epanechikov kernel cascade form is as follows:

$$K_1(x)=\begin{cases}3(h^2-x^2)/(4h^3), x\langle h\\ 0, else\end{cases} \tag{10}$$

$$K_2(x)=\begin{cases}2(h^2-x^Tx)/(\pi h^3), x^Tx\langle h^2\\ 0, else\end{cases} \tag{11}$$

In (10) and (11), the first nuclear as feature histogram weighted factor; Second nuclear by Euclidean space between the characteristics of the target central position and distance, determine the spatial characteristics in accordance with the distance values.

Assuming that different regions of the width parameter contains the target choice for standard window, the probability density function of eigenvalue can be written as

$$\hat{q}=C\sum_{i=1}^{n}k(\|\frac{x_0-x_i}{h}\|^2)\delta[b(x_i)-u] \tag{12}$$

In (12), $k(\|x\|^2)$ is the kernel function, $x_0$ is the center pixel of search window, coordinate $x_i$is the its pixel; $b(x_i)$ and $\delta$ function is to judge the characteristic values of the pixel $x_i$ in the target region, $b(x_i)$ belongs to the characteristic value $u$ , $C$ is the normalized function[20].

In target tracking, because of in a certain sliding line, image optics are often continuous alternating image, the gray characteristics of its former image are the same as the next one. It can be analyzed by the subsequent image characteristics. The continuous interval acquisition time is longer, the common characteristics between the images of $t_1$ and $t_2$ is less. Moving object in each frame of the next frame and the later may contain the target candidate region.Assumethe target center coordinates is *y*.Then the probability density of characteristics value ( $u$ =1... *M*) of the candidate model in the region can be expressed as

$$\hat{p}_u(y) = C_h \sum_{i=1}^{n_h} k(\| \frac{y - x_i}{h} \|^2)\delta[b(x_i) - u] \qquad (13)$$

It is a similarity function to describe the degree of similarity between the target model and the target candidates by using the Bhattacharyya coefficient as a similarity function.

$$\hat{\rho}(y) \equiv \rho(\hat{p}(y), \hat{q}) = \sum_{u=1}^{m} \sqrt{\hat{p}_u(y) \cdot \hat{q}_u} \qquad (14)$$

From (14), the greater the value of $\hat{\rho}(y)$ is, the more similar the two models are. The candidatemodel can be calculated by different candidate region in the current frame, it makes the $\hat{\rho}(y)$ candidate region become the largest object in the frame position. In optical field of tracking, to stabilize the system target, it needs to do continuous frame diagram for continuous target image. Assuming the object appears in the $n$ frame firstly and $x_n$ as the center, gray-scale images can be calculated respectively and local standard template of difference image can be calculated for each gray level kernel density estimation, using kernel density estimation[21-22].

By minimizing the distance between templates, target and locating the target position $y$, it is to find the target location in the current frame. Distance is defined by formula (15).

$$d(y) = \sqrt{1 - \hat{\rho}(y)} \qquad (15)$$

In (15), $\rho(y)$ is the coefficient of the modified Bhattacharya.It combines the characteristics of intensity and local standard deviation chart. The coefficients of the modified Bhattacharya can be understood as the template and the candidate target distribution similarity[12].

The similarity function is defined by formula (16).

$$\rho(y) = \frac{1}{2} \sum_{u=1}^{M} (\sqrt{P_{L_u}(y) Q_{L_u}} + \sqrt{P_{q_u}(y) Q_{q_u}}) \qquad (16)$$

In (6), $M$ is intensity and local standard deviation of gray series distribution. The coefficient is Bigger, the distance value is smaller, and the candidate model is more similar. So, target tracking has become the new location of search target in the last target position of the field in the current frame, so that the distance function arrives at the minimum. The argument is $y_1$ , using Taylor expansion type (16) at a target position $y_0$ , its linear approximation to

$$\rho(y) \approx \rho(y_0) + \frac{1}{4c}\sum_{i=1}^{n}\psi_i \cdot K_2(y_1 - x_i) \quad (17)$$

In (17), $\psi_i = \sum_{u=1}^{M} K_1(L(X_i)-u)\sqrt{\frac{Q_{L_u}}{P_{L_u}(y_0)}} + \sum_{u=1}^{M} K_1(\sigma(X_i)-u)\sqrt{\frac{Q_{q_u}}{P_{q_u}(y_0)}}$ ,the first item has nothing to do with $y_1$, so as to make $d$ (y) is minimal, it should made the second item of formula (17) as the largest. This term represents using the $K_2$(x) calculation of the kernel density estimation in current position of the $y_1$ frame, $\psi_i$ is a weighted value. To make formula (17) as the largest, in the target center of the current frame. The position of $Y_0$ should be defined as the target center in the previous frame[20]. Starting from this point to find the optimal matching target, its center is set to $y_0$ .Firstly it is to do Taylor expansion in the calculation of the target candidate model $\hat{\rho}(y_0)$, and then it is to calculate the maximum value, so as to determine the location of the target.

Improved calculation processing flow chart is shown in Figure 2.

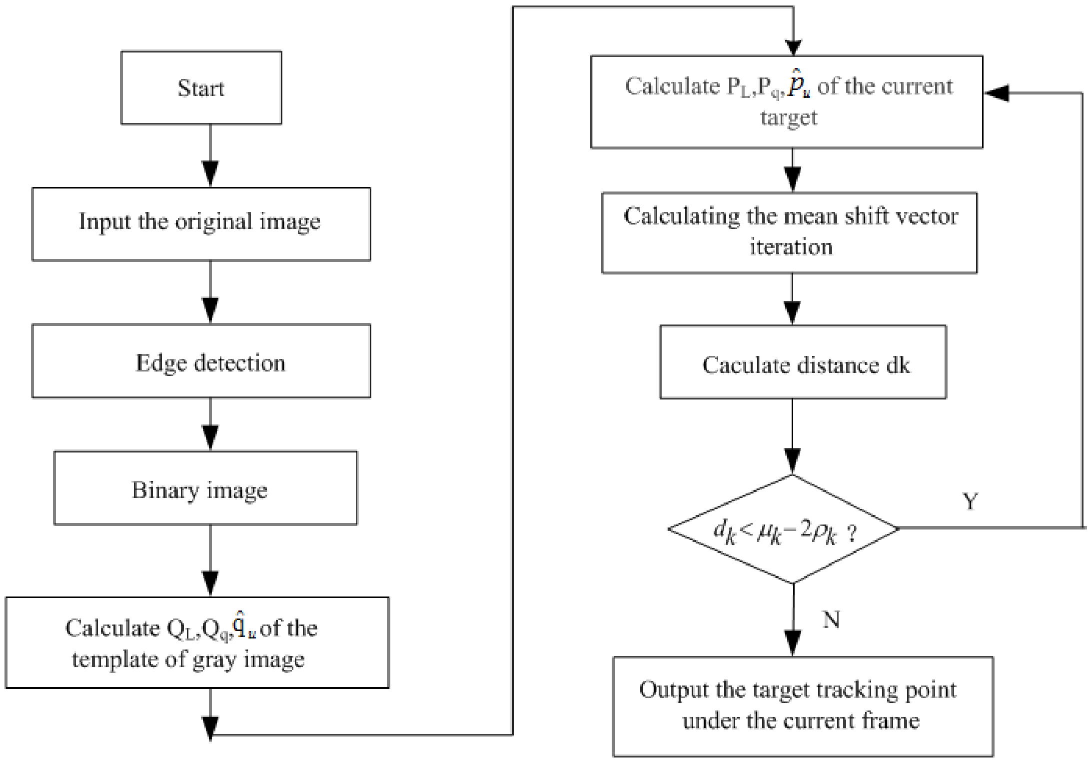



Figure 2 Target tracking processing calculation flow chart

Using the improved Mean Shift tracking algorithm to do infrared target tracking, the steps will be as following. Firstly, the kernel density estimation is used to calculate the template of gray image $Q_L$, with calculating standard deviation of the gray-scale image $Q_q$ for each kernel density and calculating the center of the target. Secondly, in the $K$ image, it needs to calculate the current target gray $P_L$ and the target standard deviation distribution of $P_q$ with calculating the candidate target and calculating the mean shift vector iteration. Thirdly, it is to calculate distance $dk$, and detect whether it can meet the requirements. If it can't meet the requirement, it should return to the second step. Or it is to judge distances $dk$. It is to determine $Q_L$ and $Q_q$ based on the requirement in updated template. Finally, it is to update $\mu_k$ and $\rho_k$ according to the calculation formula. It is repeating thesecond step until the output of the target tracking point under the current condition is detected

## Ⅳ. Photoelectric tracking system detection limit distance model

### A. Dynamic target light information characteristics in photoelectric tracking system

According to the optical detection principle of photoelectric tracking system, assuming that the background light spectral irradiance is $E_b$, the optical spectral radiometric detection system of background can be gain by formula (18).

$$E_1 = \int_{\lambda_1}^{\lambda_2} E_b(\lambda) d\lambda \tag{18}$$

In (18), $\lambda_1$ and $\lambda_2$ are the spectrum wavelength range of the optical system imaging CCD, according to the effective aperture of optical lens, CCD optical detector total luminous flux of photoelectric tracking system is $\phi$, it can be calculated by (19).

$$\phi = \int_{\lambda_1}^{\lambda_2} \frac{1}{4} \cdot \pi D^2 \cdot E_b(\lambda) d\lambda \tag{19}$$

$D$ is the aperture diameter of optical lens.If tracking platform optical lens light transmittance is $\tau_0$, then spectral flux obtained on the photosensitive surface of the CCD detection elementis

$$\phi = \tau_0 \cdot \int_{\lambda_1}^{\lambda_2} \frac{1}{4} \cdot \pi D^2 \cdot E_b(\lambda) d\lambda \tag{20}$$

Assuming that CCD exposure time is $t_0$, the total radiation on CCD detector element sensitive surface is

$$Q = \int_0^{t_0} \phi(\lambda, t) dt = t_0 \cdot \tau_0 \cdot \int_{\lambda_1}^{\lambda_2} \frac{1}{4} \cdot \pi D^2 \cdot E_b(\lambda) d\lambda \tag{21}$$

According to the detection principle of CCD, assuming that the CCD detector spectral quantum efficiency is $\eta(\lambda)$, then the photogenerated electron number of CCD photosensitive surface is:

$$N(\lambda) = t_0 \cdot \tau_0 \cdot \int_{\lambda_1}^{\lambda_2} \eta(\lambda) \cdot \frac{1}{4} \cdot \pi D^2 \cdot \frac{\lambda}{hc} E_b(\lambda) d\lambda \qquad (22)$$

In photoelectric tracking system, if the target imaging covering energy is divided equally by $M$ pixel of CCD, eachpixel photo generated electron number is:

$$N_S(\lambda) = \frac{1}{M} N(\lambda) \qquad (23)$$

Thenthe output voltage value of CCD photosensitive device is

$$V = \frac{e \cdot \eta_t \cdot t_0 \cdot \tau_0}{C \cdot G} \cdot \int_{\lambda_1}^{\lambda_2} \eta(\lambda) \cdot \frac{1}{4M} \cdot \pi D^2 \cdot \frac{\lambda}{hc} E_b(\lambda) d\lambda \qquad (24)$$

In (24), $\eta_t$ is the total charge transfer efficiency, $G$ is theamplifier gain, $C$ is the equivalent capacitance, $e$ is the electron charge.

In accordance with the relevant parameters and calculation principle of the photoelectric tracking system, photoelectric detection component output voltage of CCD photoelectric tracking system can be obtained under different illumination intensities. Through the relationship between the natural numbers and the target signal detection circuit noise signal output voltage, photoelectric detection ability of the tracking system can be gained.

B**. Background and noise characteristics of photoelectric detection system**

In order to improve the ability of photoelectric detection tracking system, it needs to establish a photoelectric detection system SNR model. In the photoelectric tracking and detection system, The total key noise includes target radiation photon noise $n_1$, background radiation photon noise $n_2$ and dark current noise in $n_3$. Target radiation photon noise is caused by the incident photondetection circuit and the stream generated by the random fluctuation when object entering the optical detection system, $n_1 = (N_s)^{1/2}$; The dark current noise is a kind of white noise and is a stochastic process signal which is a heat generated sign[15]. The equivalent number of electrons is equal to the number of electrons of dark current on the square root $n_3 = (N_d)^{1/2}$. Background radiation noise equivalent photon number $n_2 = (N_b)^{1/2}$, thenthe photoelectric tracking system of the total noise equivalent electron number can be expressed by formula (25).

$$n_{noise} = \sqrt{N_s + N_d + N_b} \qquad (25)$$

The equivalent noise output voltage of photoelectric detection system is

$$V_{noise} = n_{noise} \cdot e\eta_t G / C \qquad (26)$$

C.**The detection ability model of photoelectric electronic tracking**

The detection ability of photoelectric tracking and detection optical system can be used to measure the *SNR*, *SNR* is defined by:

$$SNR = V / V_{noise} \qquad (27)$$

In formula (27), if *SNR* is larger, the detection performance and the detection capability of optical detection system is stronger. But for photoelectric tracking and detection system, in order to stably access to the whole trajectory of each moment of the target image information, in addition to tracking turntable good stability, the detection ability of detection system is main dependent. According to (24) and (26), the calculation function of SNR can be obtained by formula (28).

$$SNR = \frac{t_0 \cdot \tau_0 \cdot \int_{\lambda_1}^{\lambda_2} \eta(\lambda) \cdot \frac{1}{4M} \cdot \pi D^2 \cdot \frac{\lambda}{hc} E_b(\lambda) d\lambda}{n_{noise} G^2} \qquad (28)$$

## V. Calculation and experiment analysis

### A. Calculation analysis

By the calculation model of photoelectric tracking system for detecting and tracking principle and magnitude, according to different light conditions, in the same photoelectric detection system, it can calculate the relationship between the ultimate magnitude and CCD camera exposure time, the relationship between the ratio threshold magnitude and the photoelectric detection system signal-to-noise limit detection, and the relationship between the ultimate magnitude and dark current of the photoelectric detection system. According to the track geometry relationship of photoelectric tracking system in Figure 1, assuming the average capable wavelength of CCD is 580nm, on the whole ballistic movement, the average pixel *M* that can be imaged in CCD detector is equal to 6, the transmittance of optical lens $\tau_0 = 0.65$, optical lens aperture $D = 50mm$, $N_d = 180e^-$, spectral quantum efficiency of measuring wavelength average by CCD in the average value of photoelectric tracking detection system $\eta = 0.68$. IfCCD camera exposure time $t_0 = 0.1s$, background illumination is equal to $4\times10^4\,cd/m^2$ , the changes occur on CCD camera exposure time, photoelectric detection system *SNR*threshold and dark current of photoelectric detection system, the corresponding change curve can be obtained. Figure 3 is the relationship between the limit of detectable magnitude and CCD camera exposure time,Figure 4 is the relationship between the limit of detectable magnitude and photoelectric detection system of dark current.

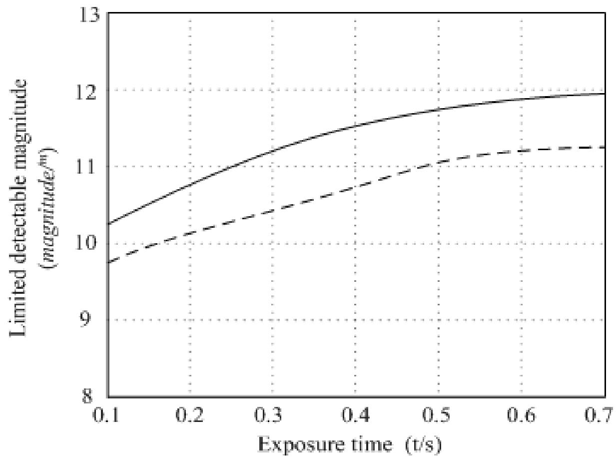



Figure 3.The relation of Limited detectable magnitude and exposure time

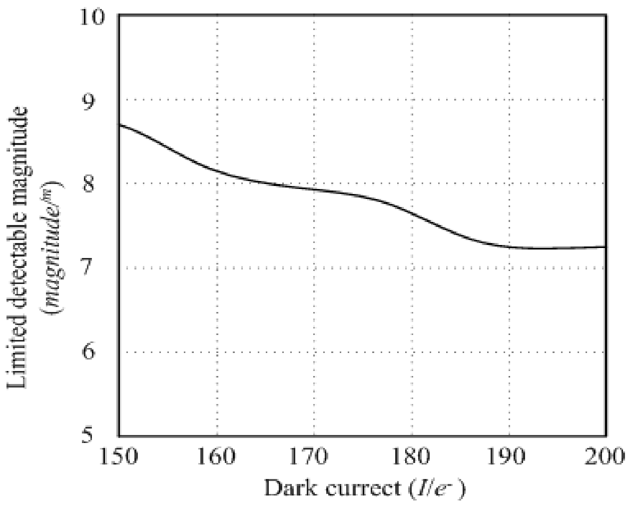



Figure 4.The relation of Limited detectable magnitude and dark current

Figure 3 shows the exposure time of CCD photosensitive device is longer, the higher the limit detect star equivalent is. It explained that in the stable rotation tracking platform, selecting a proper exposure time can also improve the detection capability of optical system.Figure 4 illustrate reducing the dark current of photoelectric detection system can increase the magnitude and improve the detection ability. The curve changes from Figure 4 shows that the ratio of dark current changes to the changes of limit detects magnitude decrease. When the dark current changes from $170e^{-}$ to $200e^{-}$, the limit of detection of the variation magnitude is only 5.5. Therefore, in order to improve the detectable magnitude limit of photoelectric tracking system, it will weakentheeffect of strong background light on magnitude, so as toimprove the tracking performance of photoelectric tracking system.

**B.Experiment and analysis**

In order to verify the dynamic target tracking algorithm, a certain type of test platform for the tracking is combined. Figure 5 is the schematic diagram of whole system. Track rotating platform includes angular-encoder and rotational structure, the rotational angle can be show in computer, synchronous triggerprovidea trigger signal to the image acquisition module, under synchronous trigger control, computer processing system can gather target image and dispose it by image processing techniques, at last, synchronous tracking target information can be gained.

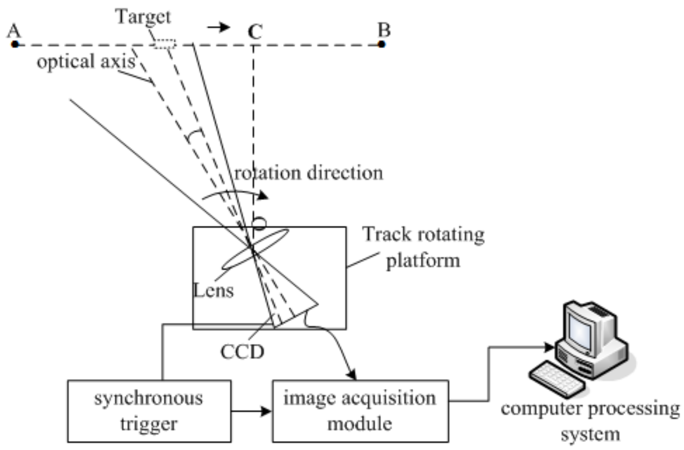
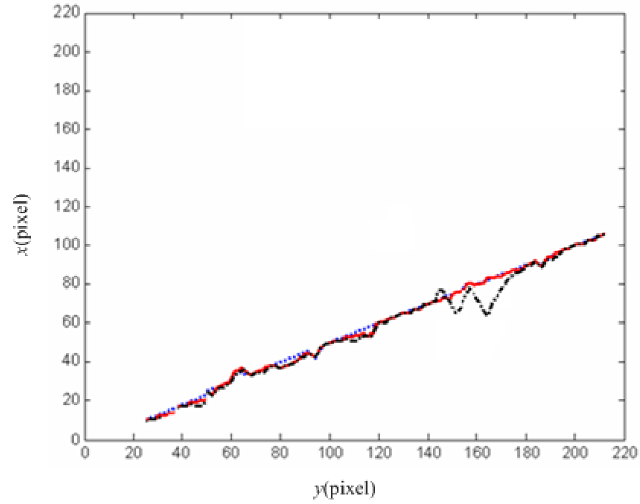
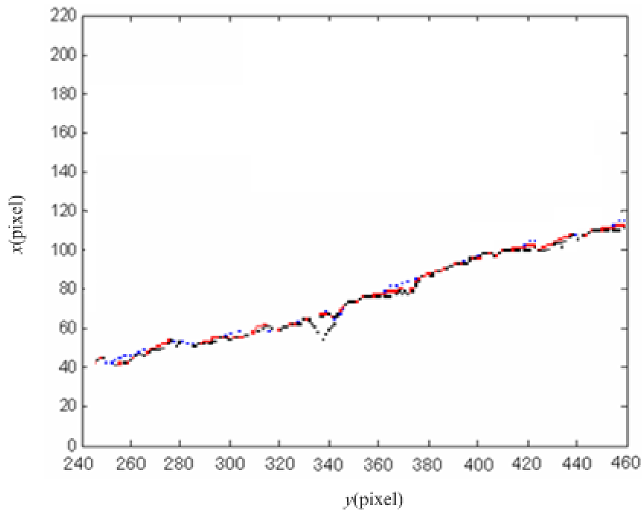



Figure 5 the schematic diagram of whole system

In the whole process of the field test, the target tracking system is always in the center region view image. The high precision angle encoder is used to gain the rotationalangle, this angle will be contrast to the result of theoretical arithmetic, and using the error to judge the effect of tracking. According to the improved Mean Shift algorithm applications for target tracking, the simulation process can be done by MATLAB. Figure 6and Figure 7 are the comparison results among the improved Mean Shift algorithm, the classical trajectory tracking algorithm and ideal target motion trajectory. The red line represents the improved algorithm results, blacklineindicate the processing result of no improved, blue lineindicate ideal target motion trajectory. The vertical axis represents the direction of X pixel position; the abscissa indicates direction of Ypixel location, their units are pixel.



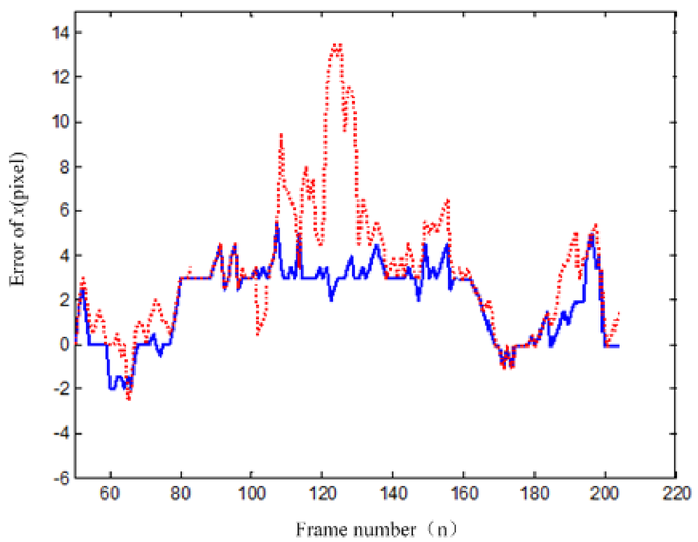

（a）



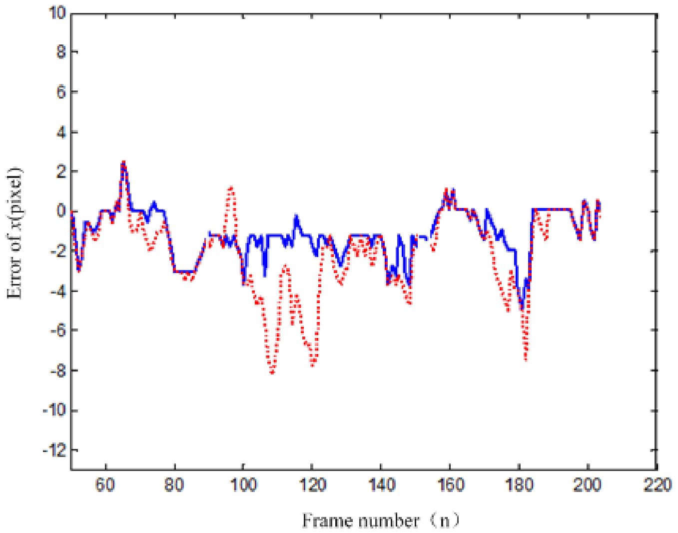

（b）

Figure 6 The comparison result between improved Mean Shift algorithm and the classical trajectory tracking algorithm

Figure 7illustrate whether it is from the tracking trajectory, or tracking error curve, the tracking error of proposed mean shift algorithm is significantly less than the classical algorithm, and the blue line represents the improved algorithm results by using improved Mean Shift, red lineindicate the processing result of no improved. Error unit is pixel in horizontal ordinate, frame number is gathering the *n* frame image in CCD. The calculation results show that, comparing with the classical mean-shift algorithm, improved mean shift greatly can promote the robustness and accuracy tracking.




（a）




（b）

Figure 7Partial image tracking error in X and Y direction

According to the collected image data, the maximum number of mean shift iterations is set to 10. Iteration termination threshold is a pixel. The tracking error of improved mean shift algorithmis significantly less than the one of classical MeanShift algorithm. Whether the movement in the path tracking speed loading the targetdevice and the displacement isconsistent with the optical imaging system can be determined by the geometric relationship between the control turntable angle of rotating platform in unit time andposition tracking path. Optical imaging system lays the foundation for the target center position. From the tracking error and the target treatment, those above can be analyzed by numerical readable angle sensor.

Table 1 and table 2 are the part of data obtained during the unit time $\Delta t$ in some tracking test,according to the geometric relations, tracking system, part of the data obtained.The value $\Delta t$ of rotating angle control of tracking platformis 0.1s. According to the difference between the theoretical speed and the actual speed of control angle calculation and the difference between the desired angle in theory and the measured angle, the real-time of tracking system can be calculated.

Table 1 Test data at initial stage

| Desiredangle in theory（°） | the measured angle（°） | $\Delta\theta$ |
|---|---|---|
| 24.108 | 24.982 | -0.874 |
| 24.892 | 25.345 | -0.453 |
| 27.453 | 26.911 | 0.542 |
| 28.912 | 29.315 | -0.403 |
| 33.209 | 34.386 | -1.177 |
| 34.924 | 35.894 | -0.973 |
| 36.845 | 35.452 | 1.393 |
| 39.718 | 39.003 | 0.715 |
| 44.783 | 45.274 | -0.491 |

Table 2 Test data at intermediate stage

| Desiredangle in theory（°） | the measured angle（°） | $\Delta\theta$ |
|---|---|---|
| 62.912 | 64.432 | -1.522 |
| 63.018 | 64.563 | -1.545 |
| 64.976 | 63.005 | 1.971 |
| 65.208 | 65.227 | -0.019 |
| 65.983 | 65.985 | -0.002 |
| 67.256 | 66.876 | 0.38 |
| 68.062 | 68.998 | -0.936 |
| 69.086 | 70.429 | -1.343 |
| 71.461 | 73.276 | -1.815 |

Through data analysis in table 1, it can be seen that the average value of tracking angle error at two stage interval is about -0.64 degree. According to the space geometry relationship, it can be seen the target offset in the tracking path is about 6.32m. The resolution of the tracking camera is $1028\times1028$, pixel size is $10um$, the focal length of optical lens is with 120mm lens. According to the imaging principle, the amount of deviation of imaging offset in the objective lens is $0.88mm$, this value is far less than the image plane of $10mm \times 10mm$. In the range of allowable error, the tracking target can be ensured in the effective field of view.

The test results show the target detection is to obtain information from the moving image, which is conducive to intelligent analysis and intelligent control system. Thealgorithm with detection before tracking are required for target extraction of single frame image, high pass filtering method and the minimum mean square error filtering method is the earliest processing algorithm, then median filtering method is found. It is suitable forfiltering ofdim small target in infrared image. Its advantage is that is a very good suppression of impulse noise with retaining the original characteristics of the target and simplifying the edge detection. With the development of digital image processing technology, the mathematical morphology method is found. This processing method makes the characteristics of target under complicated environment is more obvious. Wavelet transformation method is commonly used target detection processing technology in recent years. However the robustness of this approach is not strong which is hard to achieve the target of accurate detection under complex background. Anti-symmetrical bi-orthogonal wavelet method, and wavelet frame of image processing technology has overcome this disadvantage in the wavelet transformation method. Improved processing technology can improve the performance of target detection under complex background in a certain extent. The algorithm with tracking before detection does not need to judge the presence of the target in the single frame image. However it tracks of the target trajectory which does appear in the image more likely, using each phase target imaging information of the target image of tracking system in the tracking process. It is to obtain the real target trajectory and to complete the target detection with the help of the track and detection decisionby the characteristics of target in dynamic process. The earliest method is to bring the dynamic planning theory into the dim target detection. However the target energy accumulation forming in the process of gathering effect results that target detection and recognition effect is low in low *SNR* environment, which is not conducive to engineering application. Soon the method of projection target detection was put forward. It brings three-dimensional space for detection into two-dimensional plane. This method needs less calculationand is easy to achieve. But it will make some edge feature of the target lost, which has worse detection effect in low SNR conditions. Later, high order correlation method was found. It is a correlation analysis of target signal using of temporal and spatial to detect the target information from complex background. Combining with the actual characteristics of the target environment, the target detection algorithm for sequential hypothesis testing was proposed. This algorithm is to collect target information as many as possible in form of organization tree up. Through organized tree information, in accordance with the characteristics of temporal and spatial domain, the efficiency of detection for target information is improved effectively with appropriate delete and corrections by hypothesis test method each layer characteristic tree.

## VI.Conclusions

Based on the principle of target tracking system, this paper discussed the factors affecting of the tracking platform. According to the optical target tracking system, the improved mean-shift algorithm is studied for object tracking. And the processing model for target feature tracking is established, and the target tracking method and process is given. Based on the principle of the detection for optical target tracking system, according to the background illumination, the target size, and detector response, the environmental impact on the system can be analyzed so as to establish the sky background brightness calculation model of the photoelectric tracking optical field detection region, and calculation model of space target characteristics and detection capability. It is to give the benchmarks of the detection performance of target tracking from the definition of SNR. Based on theoretical analysis, the change curve can be given including tracking CCD camera exposure time in theoretical calculation model, *SNR* threshold of photoelectric detection system and detecting ability of dark current for photoelectric detection system. According to the experimental data, the comparison databetween the improved meanshift and traditional mean shift tracking algorithm can offered; it has verified the correctness of the proposed algorithm and the calculation model of photoelectric detection capability. The calculation model and theoretical analysis in this paper provides important basis of research for the design and application of the target tracking platform in various kinds of environment.

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