Research on Automatic Target Tracking Based on Platform-lens Video System

Qigui Zhang*, Bo Li, Ni Zhang
Department of Information Engineering
Taiyuan University of Technology, Taiyuan, China
*corresponding author, e-mail: zhang_qg63@hotmail.com

Abstract

This paper studies an algorithm of automatic target tracking based on Platform-lens Video system. Select the tracking target and set up the target motion trajectory in the video screen. Along the motion trajectory, the system controls the Platform-lens rotation automatically to real-time track the target. At the same time, automatic zoom model can enlarge or reduce to make sure the target can display on the video screen center clearly at the suitable size. By testing on groups of video, verify the effectiveness of the automatic target tracking algorithm.

Keywords: automatic target tracking, Platform-lens, real-time track, automatic zoom model

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1. Introduction

With the development of computer software and hardware technology, video surveillance system based on multimedia technology has been widely used in various fields [1, 2]. Platform-lens monitoring system is now installed in many shopping malls, banks and high-end residential. But the current Platform-lens monitoring system needs to manually control the Platform-lens rotation and the lens zoom to track the target, so it exists human errors.

The intelligent Platform-lens monitoring system can automatically acquire and analyze external information. After selecting the tracking target, the system can automatically track the selected target and adjusts the zoom to enlarge or reduce to make sure the target can display on the video screen center clearly at the suitable size.

2. Select the Target and Set up the Motion Trajectory

2.1 Select the Target

Build the right-angle coordinates on video screen. Make the upper-left side of video screen as the origin of coordinates, the right side of horizontal axis as the positive direction of X-axis, and the down side of vertical axis as the positive direction of Y-axis. Set the mouse callback function to capture the events of click and release of the left button.

![Figure 1. The process of target selection](image-url)

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When the target enters the monitor area, move the mouse to target location. Click the left button on the upper-left of the target, and write down the clicked position coordinate \((x_1, y_1)\). Press the left button and slide to the bottom-right of target, then release the button and write down the released position coordinate \((x_2, y_2)\). Use \((x_1, y_1)\) and \((x_2, y_2)\) as two diagonal points to form a red rectangular box in the mouse callback function to lock the target. The results of the selected target as shown in Figure 1.

2.2 Set up the Motion Trajectory

This paper uses Kalman filter to estimate the target motion state [2-4], and Camshift algorithm to match the feature in estimated position to lock the moving target [6-8]. So by means of combining Camshift algorithm and Kalman filter, the target position is written down in each algorithm to match the feature in estimated position to lock the moving target [9, 10]. Link each position with red line segments to set up the target motion trajectory. The trajectory of motion target as shown in Figure 2.

![Figure 2. The trajectory of motion target](image1)

![Figure 3. The trajectory of motion target](image2)

3. Platform-lens Automatic Tracking Model

Using pixel to quantify the target moving speed, and angle to quantify the Platform-lens rotation speed. The video image sequences are processed as a group. A group includes N frames of the video sequences. When Platform-lens changes rotation speed, it needs the time transition. The transition time is called minimum torque of Platform-lens, that is \(T_0\).

3.1 Platform-lens Rotation Prediction

As shown in Figure 3 is the model of target prediction tracking. The curve is the target actual moving trajectory. As the Platform-lens can only rotate long straight line, so use the linear model to rotate during the tracking target. As the sample time and target moving speed are the almost same among each groups of video frames, suppose the target making uniform linear motion. So the target moving distance is the same between each group.

\[
P_0 = (x_0, y_0) \]

is the target actual position in the \((n-2)\)th group, \(P_1 = (x_1, y_1)\) is the target actual position in the \((n-1)\)th group. According to the supposed the state of uniform linear motion, you can predict the target position in the \(n\)th group. Link \(P_0\) and \(P_1\), and extend to \(P_2\)′. Make \(P_1\) as the central point of \(P_0\) and \(P_2\)′ as in (1).

\[
x_2' = 2x_1 - x_0 \\
y_2' = 2y_1 - y_0
\]  

(1)

3.2 Platform-lens Rotation Analysis

As shown in Figure 4 is the schematic diagram of camera imaging, A is the actual scene, and B is imaging scene. The resolution of video screen is \(D1\times D2\). The angle \(\phi\) is one half of vertical view angle of the camera, the angle \(\theta\) is one half of horizontal view angle of the
camera. The focal length of the camera is \( f \). The central point \( C \) is the \((n-1)\)th target position, \( P = (x, y) \) is the \(n\)th target prediction position.

According to the focal length of the camera and the resolution of video screen, the relationships can be got as in (2).

\[
\tan \theta' = \frac{D_1/2}{f} \quad \tan \phi' = \frac{D_2/2}{f}
\]  

(2)

According to the target prediction position, the target moving horizontal angle \( \alpha \) and horizontal angle \( \beta \) of the \(n\)th group can be got as in (3).

\[
\tan \alpha = \frac{x}{f} \quad \tan \beta = \frac{y}{f}
\]  

(3)

Because the focal length of the camera is the same, the relationships can be changed as in (4).

\[
\frac{\tan \alpha}{\tan \theta'} = \frac{x}{D_1/2} \quad \frac{\tan \beta}{\tan \phi'} = \frac{y}{D_2/2}
\]  

(4)

And then the target moving horizontal angle \( \alpha \) and horizontal angle \( \beta \) can be calculated as in (5) and (6).

\[
\alpha = \arctan\left(\frac{x}{D_1/2} \ast \tan \theta'\right)
\]  

(5)

\[
\beta = \arctan\left(\frac{y}{D_2/2} \ast \tan \phi'\right)
\]  

(6)

Converting rotation angle to image frames, then the Platform-lens horizontal rotation frames \( n_1 \) and horizontal rotation frames \( n_2 \) can calculate as in (7).

\[
n_1 = N \ast \frac{\alpha}{\alpha + \beta} \quad n_2 = N \ast \frac{\beta}{\alpha + \beta}
\]  

(7)

Figure 4. Schematic diagram of camera imaging

Figure 5. The ladder rotation rule
3.3 Platform-lens Tracking Model

The Platform-lens needs to track the target real-time. If Platform-lens directly finishes the horizontal rotation, then horizontal rotation, as dashed line shown in Figure 5, it may cause deviation during tracking for the large rotation angle. So this paper proposes a rotation rule, which called ladder rotation tracking.

(1) if \( (n_1 > n_2 \&\& n_2 > T_0) \), and \( n_1 \) is a multiple of \( n_2 \). Define \( bei \) as the multiple, and \( bu \) as the Platform-lens rotation step.

\[
bei = \frac{n_1 + n_2}{2} \quad bu = \frac{n_2 + T_0}{2} \quad (8)
\]

In this case, the Platform-lens firstly rotates a step in vertical direction, then rotates \( bei \) steps in the horizontal direction, finally rotates in order.

(2) if \( (n_2 > n_1 \&\& n_1 > T_0) \), and \( n_2 \) is a multiple of \( n_1 \). Define \( bei \) as the multiple, and \( bu \) as the Platform-lens rotation step.

\[
bei = \frac{n_2 + n_1}{2} \quad bu = \frac{n_1 + T_0}{2} \quad (9)
\]

In this case, the Platform-lens firstly rotates a step in horizontal direction, then rotates \( bei \) steps in the vertical direction, finally rotates in order.

(3) if \( (n_1 > T_0 \&\& n_2 < T_0) \), the Platform-lens only rotates in horizontal direction, and stops rotating in the vertical direction.

(4) if \( (n_2 > T_0 \&\& n_1 < T_0) \), the Platform-lens only rotates in vertical direction, and stops rotating in the horizontal direction.

(5) if \( (n_1 < T_0 \&\& n_2 < T_0) \), the Platform-lens stops rotating in vertical and horizontal direction.

4. Lens Automatic Zoom Model

4.1. Zoom Judgement Rule

Set a suitable size \( A_{set} \) of target shown in the video screen. Define \( A_{current} \) as target actual size in the video screen, and \( A_T \) as size threshold. When the system conforms to the conditions as below, it will automatically zoom.

(1) if \( \text{abs}(A_{current} - A_{set}) > A_T \&\& (A_{current} > A_{set}) \), pull far the lens. Make the target size zoom in to the suitable size \( A_{set} \).

(2) if \( \text{abs}(A_{current} - A_{set}) > A_T \&\& (A_{current} < A_{set}) \), pull into the lens. Make the target size zoom out to the suitable size \( A_{set} \).

(3) if \( \text{abs}(A_{current} - A_{set}) < A_T \), the lens does not zoom. If the lens current zoom is \( \text{zoom1} \), calculate the zoom ratio \( \text{mag} \), get the lens changed zoom \( \text{zoom2} \).

\[
\text{mag} = \frac{A_{set}}{A_{current}} \quad .
\]

\[
\text{zoom2} = \text{mag} \times \text{zoom1} \quad (10)
\]

4.2. Lens Zoom Model

As shown in Figure 6 is the nonlinear curve of camera zoom. Because the focal length of camera changed speed is non-uniform velocity, the lens zoom change is nonlinearity, but the neighboring zoom changing can be considered linear.
Vertical coordinates is lens zoom, horizontal coordinates is zoom time. According to lens parameters, get $\frac{f_{\text{max}}}{f_{\text{min}}}$ segments linear zoom function. Now know zoom1 and zoom2, then add the time period between zoom1 and zoom2 in the curve of camera zoom to calculate the zoom time. Send the instructions to the serial port.

5. Experiments

To verify the effectiveness of the method in this paper, you can use the software development tools VC++6.0 and OpenCV to analyze image sequences. The video is taken from a Platform-lens camera, and the format is 340×240. The system selects the pedestrian as the tracking target. As shown in Figure 7 and Figure 8 are the results of experiments.

Figure 7 shows the Platform-lens tracking without auto-zoom. As the target moves away the camera, its size becomes small in the video screen. And it is difficult to see the target and track it, so the tracking accuracy will decrease.

Figure 8 shows the Platform-lens tracking with auto-zoom. The platform will rotate as the target moving. When the target moves away the camera, the system can adjust the zoom and focus automatically so that the target can always display on the video screen center clearly at the same size.
6. Conclusion

The paper firstly selects the moving target in the supervisory area. Then use the Camshift algorithm and Kalman filter to set up the target motion trajectory. Finally use the paper proposed Platform-lens tracking model to track the target automatically to always lock the target in the video screen center, and use the lens automatic zoom model to ensure the target can always display on the video screen center at the suitable size. Use the algorithm to track the moving target in groups of video to verify the effectiveness. The experimental results denote that this method can track the moving target accurately, adjust the Platform-lens timely and accomplish automatic target tracking.

References


