The Study on Co-calibration Mechanism on Static-movable Camera Survilllance System

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Abstract: Currently, how to automatically realize acquisition, refining and fast retrieval of the target information in surveillance video has become an urgent demand in public security visual surveillance field. This paper proposes a new gun-dome camera cooperative system which solves the above problem partly. In the dual-camera cooperative video-monitoring system, the co-calibration between the master and slave camera is the key technique. We introduce one kind of automatic co-calibration method in this paper. The experimental results show the effectiveness and efficiency of this calibration mechanism.

1 INTRODUCTION

In this paper, we propose a new gun-dome camera cooperative system which adopts master-slave static panorama-variable view dual cameras cooperative video-monitoring system. Compared with the above solutions, it has the following advantages (Felzenszwalb, 2008):

1) Combining the advantages of the static-panorama camera and the camera with variable field of view (FOV), we can get the close shot of specific objects in the long shot. Meanwhile, we can also keep the attention to others objects in the distant scenery. By using this mechanism, we can expand the breadth and depth of video surveillance system. FOV of panorama camera is large, and distant scene can be observed via focusing the moving camera. Complementary advantages could be obtained by combining these two cameras. 2) Realize observation of multiple targets. If only the moving camera is used for observation of a target, the FOV of the camera becomes small. When other targets appear in the FOV, they could not be observed from the FOV. 3) Facilitate the detection of the target. Moving target detection method can be used to detect the target, since the wide angle camera is static. And if the target motion is not so rapid in the FOV of the panorama camera, it is easy to trace.

As the object detecion and tracing is concerned , the premise lies in the co-calibration mechnisim on the dual-camera survillance system. In the following paragraphs, we will discuss it in detail.

2 THE DUAL-CAMERA CONFIGURATION

Gun-dome camera cooperative system is one kind of dual-camera monitoring system. There are one wide angle camera and one Pan Tilt Zoom (PTZ) dome machine. The wide angle camera is responsible for the target detection in wide field of view, and PTZ dome machine (also known as active camera) for focusing and amplifying and tracking continuously for the target of attention. Dual-camera cooperative system function mainly is composed of three parts: moving object detection in the wide-angle camera, calibration of the moving camera and the wide-angle camera, coordinated control of these two cameras.

The proposed gun-dome camera cooperative system is shown in figure 1. It is key personnel target detection and recognition application platform architecture based on gun-dome camera. In figure 1, there is an overlapping region between the scene recorded by the gun camera and the scene recorded by the dome camera, which belonging to the joint calibration of overlapping scenarios. When

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calibrating, dome camera is in the wide-angle state, and under this situation, the gun-dome machine has an overlapping region. The calibration objects should be placed in the overlapping region in the joint calibration. The gun camera is responsible for panoramic monitoring with a wide-angle shot. Moving target detection is focused on and target position information is transmitted to the dome camera under the panoramic field. Meanwhile, in the scene of dome camera, according to the position mapping relationship obtained from the gun-dome camera cooperative calibration, we first transform the position of the moving target in the gun camera, and calculate the corresponding coordinate in initial scene of the dome camera, then we start real-time PTZ control and realize continuous tracing and facial image capture of the target of attention.

To realize dual-camera cooperative system need: Observe and detect targets in the scene with static wide-angle camera; obtain the position of target and transmit the position information to the moving camera; moving camera tracing the target according to its position and amplify it. The key techniques in this process is 1) target detection. Wide angle camera which is static relative to the scene, can realize pedestrian objective location by motion detection. Moreover, illumination, swing of branches and any other factors should be taken into consideration in actual scene. 2) Calibration of dual cameras (Cho, 2012). The calibration of gun-dome camera is to compute the angle which the moving camera rotates to aim at position of the target in the static camera. 3) Cooperative control of dual cameras. According to the state of the target in the static camera, appropriate cooperative strategy is set up and the clear image of the target is acquired.

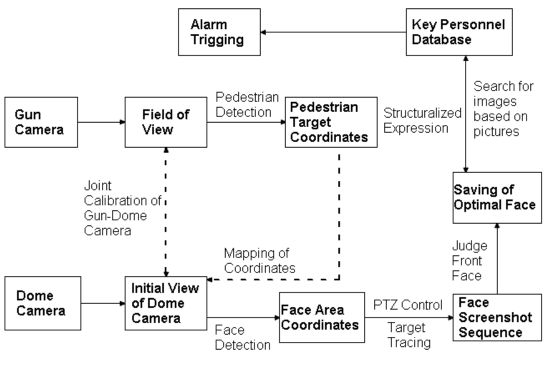

Figure 1: Block diagram of master-slave camera cooperative system.

As to the dual-camera co-calibration, we should satisfy the premise that the two camera have the common vision at the initial stage. After the execution of the co-calibration, the motion of slave camera is controlled by the master camera.

3 METHODOLOGY

The calibration of dual cameras is a process of computing parameters of geometric model of camera imaging. The calibration methods mainly include physical model method, look-up table method and etc (Beriault, 2008; Luo, 2011; Xu, 2015). The Physical model method calculates the rotation angle based upon the imaging physical model of the target in the dual cameras and motion model of cameras. However, it can only obtain a very accurate rotation angle theoretically and the practical operation is much complicated. Compared with physical model method, Look-up table method is much convenient, simpler and reliable. In practice, the original calibration data is still valid when the scene changes from the learning environment to another.

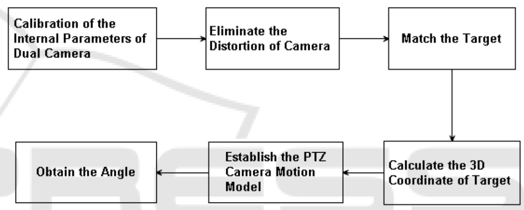

Figure 2: Process of dual camera calibration.

In the gun-dome cooperative linkage personnel detection and tracking system, the gun camera has to transmit the position of pedestrian detected by itself to the initial scene of dome camera, and then based on this the dome camera begins to do face detection and continuous tracking. The realization of the above functions requires of the mapping relationship between gun camera and dome camera (Li, 2006). Namely the imaging position of the object in the gun camera is mapped into the dome camera, and the dome camera adjusts the rotation angle in order to make the object in the centre of image of the dome camera. Establishing this mapping relation is implemented through dual camera calibration (Hao, 2010). The calibration of dual camera is referred to as : under the knowledge of the position of target in wide angle camera, to find the horizontal rotated angle α and the vertical rotated angle β , which make the PTZ camera rotate to aim at target, $L[M(u,v)] \to (\alpha, \beta)$.

The process can be elaborated with figure 2. First of all calibrate the internal parameters of cameras;

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Secondly eliminate the distortion of lens of cameras; Then match the image target in dual camera via the polar constraint conditions and image features; Calculate the 3D coordinates of the target under PTZ camera coordinate system; Finally compute the rotated angle (α , β) according to PTZ camera motion model.

The imaging model of dual cameras is as shown in Fig. 3. Through the analysis of the physical process of the dual cameras calibration, there exist a single mapping $[x,y,z]^T \leftrightarrow (\alpha,\beta)_T$ between the current position of the object $[x,y,z]^T$ and absolute position parameter (α,β) of camera when it is in the centre of the field of view of image. Thus, if the relationships between the three dimensional coordinate of the object $[x,y,z]^T$ and the position of the camera (α,β) is set up, the calibration of dual cameras will be realized.

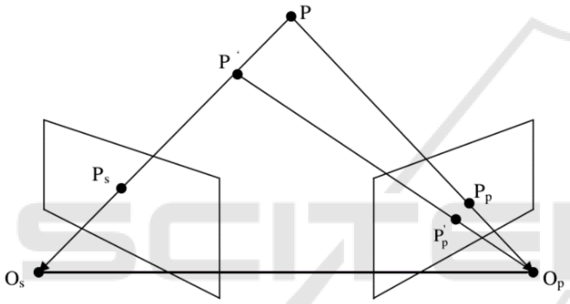

Figure 3: Dual cameras imaging.

The look-up table can be constructed by supervised learning, in order to acquire the angle which PTZ camera rotates to aim at the target, and realize the dual cameras calibration. Detailed steps are as follows.

1) Choose Region of Interest (ROI) which needs PTZ camera's key monitoring in visual surveillance area of the wide angle camera.

2) Divide ROI of wide angle image into grids according to appropriate spacing. Then acquire the pixel coordinates in the grid intersections.

$$M_{11}(x_1,y_1), M_{12}(x_1,y_2), M_{21}(x_2,y_1), M_{22}(x_2,y_2), \ldots,$$

3) Adjust the rotation of PTZ camera until the centre of PTZ camera image coincides with M11. Then read the current rotation angles in the horizontal direction and the vertical direction of PTZ camera $(\alpha,\beta)_{11}$, and record a group of data $L[M_{11}(x_1,y_1)] = (\alpha,\beta)_{11}$.

4) Repeat the *3)* operation for the rest intersections in ROI of wide angle image and take notes down all $L[M(x,y)] = (\alpha,\beta)$.

5) Look for the minimum rectangle $M_{11}M_{12}M_{21}M_{22}$ encircling non-grid-intersection S(x, y) in ROI, and calculate the rotation angle of PTZ camera by means of bilinear interpolation formula.

$$(\alpha,\beta)_s = \frac{1}{(x_2-x_1)(y_2-y_1)}[L(M_{11})(x_2-x)(y_2-y)+L(M_{12})(x_2-x)(y-y_1)+ L(M_{21})(x-x_1)(y_2-y)+L(M_{22})(x-x_1)(y-y_1)] \quad (1)$$

*6) C*ombining data obtained in *3), 4), 5)* gives the look-up table for the PTZ camera rotating and aiming at arbitrary position of ROI in dome camera view.

Figure 4: Dual cameras on the same vertical plane.

When calibrating dual cameras in the way of Look-up Table (Kim, 2009) it is easy to operate with depth information of the object with regard to the two cameras changing a little. Therefore, the installation positions of the two cameras are as shown in Fig.4 that the lens of each camera approximately stay on the same vertical plane.

4 EXPERIMENT

As a comparison, we first execute the calibration using the classic chess-board method, which depends on the reference object and is relevant to the spot circumstance, see Fig. 5.

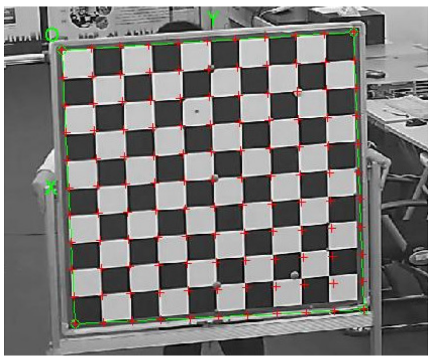

Figure 5(a): The chessboard for calibration.

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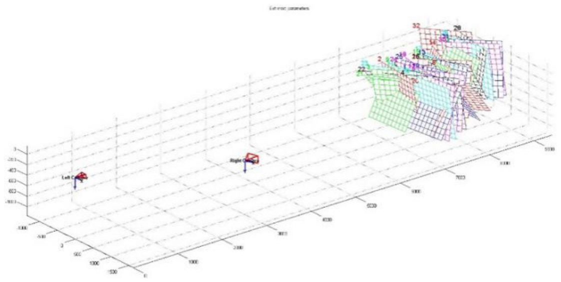

Figure 5(b): The correlation between camera coordinate and the chessboard coordinate.

As to the above-mentioned cooperative calibration, we adopted the calibration toolbox on Matlab platform (Xie, 2012). The classical chessboard is utilized to get the internal parameter matrixes of the two component cameras, see Fig. 5(a). The external matrixes and the rotation and translation relation between the two cameras is calculated using the 3D calibration methodology, see Fig. 5(b).

Now, we execute the proposed automatic co-calibration method, see the Fig. 6.

Figure 6: The interface of the automatic co-calibration procedure.

In Fig.6, the left image is the scene of master camera and the right is the slave camera. The green points painted in the left images is the pre-set calibration points. These nine points split the whole into four sections. Those points lie in the four sections are calibrated by the interpolated methods.

By this mechanism, the procedure can automatically deal the co-calibration job between the two cameras. The experiments shows its effectiveness and efficiency.

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