Modeling and Calibration Techniques for Pan-Tilt Camera Systems

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ABSTRACT

Pan-tilt camera and it application is growing day-by-day. In the era of automation, it is required have an efficient surveillance system. However, machine learning or Artificial intelligence based further enhance it capability. Besides, control of camera utmost important to deploy such system. Here in this study, a pan-tilt camera system modeling and it methodology to calibrate proposed. A proper and appropriate intelligence through surveillance could help combat enemies and terminate the threat. The proposed project aims at creating a pan-tilt camera surveillance system with features of object detection and weapon trigger controlled manually from the control room situated far away.

Keywords*: Pan-Tilt Camera Modeling and Calibration Methodology*

I. INTRODUCTION

The camera motion is motion is modeled as two idealized rotations around the origin, followed by a perspective camera transformation as shown in Figure1.4 This transformation can be written as a sequence of matrix operations.

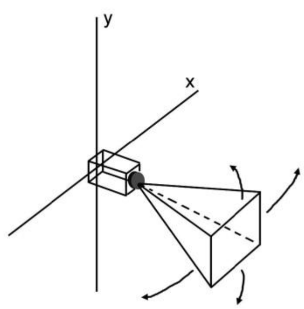

Figure 1 Simple pan-tilt camera motion model. Pan and tilt are modeled as axis aligned rotations around the camera's center of projections

$$\begin{bmatrix} I_x \\ I_y \\ I_w \end{bmatrix} = C R_y R_x \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad (1)$$

where$[x\ y\ z]^T$ is appoint in world coordinates. A rotation around the x axis R_x , and the y-axis, R_y,correspond to tilt and pan respectively. finally a perspective camera transform, C, results in the image plane coordinates at which the point is observed,$(I_x/I_w\ ,I_y/I_w)$.

For an ideal pan-tilt camera this model is sufficient. However, the assumption that that pan and tilt axes of rotation are orthogonal, aligned with image plane and through the camera's nodal point are frequently violated. The usual solution to this problem is careful engineering .so that the assumptions are as nearly true as possible [1 1]. Since our system uses commercially integrated pan- tilt cameras that significantly violate the assumptions and cannot be easily modified, a better model is needed.

II. Methodology

Improvedpan-tilt camera model

When a pan-tilt camera is assembled, it is difficult to ensure that the axes of rotation intersect the optical center of the camera imaging system.in addition, the axes are unlikely to be exactly aligned. In order to model the actual motion of the camera, new parameters can be introduced into camera model. As shown in Figure 1.5,rather than being coordinate frame aligned, the pan and tilt degrees of freedom can be modeled as a rigid element that rotates around each of these axes .This model more closely approximates the actual camera geometry, and can be written as

$$\begin{bmatrix} I_x \\ I_y \\ I_w \end{bmatrix} = CT_{pan} R_{pan} T_{pan}^{-1} T_{tilt} R_{tilt} T_{tilt}^{-1} \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad (2)$$

Where R_{tilt} is 3x3 rotation matrix which rotates tilt angles around a vector in the direction of tilt axis.$R_{pan}$is analogous. These axes do not necessarily pass through the origin, and T_{pan} and T_{tilt} represent translation vectors from the origin to each axis. Thus the projection of a point in space onto the image plane can be fond as a function of current camera pan and tiltparameters.

The above models assume that the angular that the angular rotation around each axis is known. Of course the motor control of each axis occurs in terms of some unknown units, and a calibrated mapping to angular units is required. In case of EVI-D30 cameras used in our system, rotations are specified to the camera in degrees, and empirical test suggest that angular rotation was in fact well calibrated.

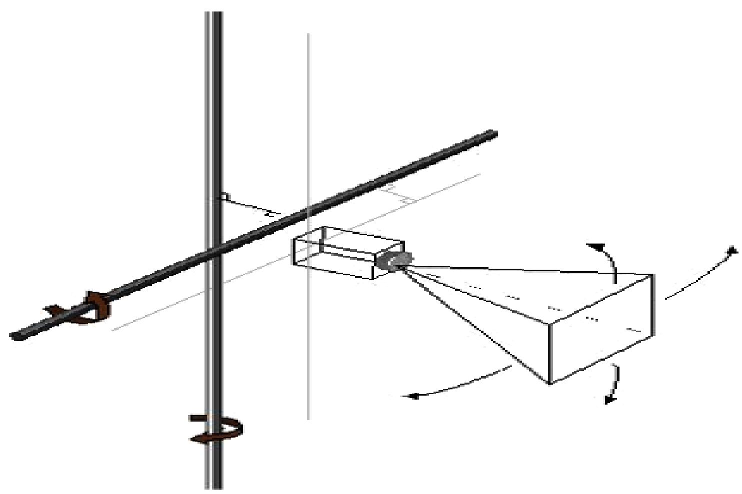

Figure 2 Improved model of camera motion. Pan and tilt motions are modeled as rotations axes around arbitrary in space

III. Calibrating The Model

The above model specifies the generic relations between geometric components. Each camera will vary within this general model, and determining the specific parameters of the model is typically referred to as calibration. In the case of this model, the parameters to be determinedare the two axes of rotation in addition to the standard set of camera intrinsic and extrinsic parameters. One reason that the simple camera model described above is often used despite its inadequacies is the ease of calibration. Since the axes of rotation are given relative tothe camera image plane, it suffices to calibrate the camera in a single configuration and then apply the model when a new set of pan-tilt rotations is required. In the more general case of arbitrary axes, a great deal of additional dataneeds to be collected in order to robustly determine allparameters.Traditional camera calibration proceeds by arranginga set of known 3D features in the camera's view frustum.The case of arbitrary axes, a great deal of additional dataneeds to be collected in order to robustly determine allparameters.Traditional camera calibration proceeds by arranginga set of known 3D features in the camera's view frustum.These are typically attached to some calibration target.The projection of each 3D feature is then observed on thecamera image plane. These observations are 2D datapoints. Camera parameters can be determined by solving

$$\textbf{arg min } \Phi \ \{C\ (\Phi,\ X_{3D}\ )\text{-}X_{2D}\} \qquad (3)$$

where C is the camera model that defines the projection of points onto the image plane, Φ is the set of camera parameters to be determined, **X3D** is the vector of 3D feature locations, and X2D is the vector of corresponding image plane observations. Since **Φ** often includes radial lensdistortion terms in addition to extrinsic geometric pose, minimizing this equation is usually framed as a non-linear search problem. In order to obtain a good estimate of the parameters,**Φ**, it is necessary that the spatial features**, X3D,** cover the working volume, and that the observations, **X2D,** cover the image plane. In the event that coverage is not comprehensive,parameters that fit the observed space will be obtained. If a target later moves outside of the observed calibration range, the model will extrapolate into the new area. Since data extrapolation is known to be unreliablerelative to interpolation, it is beneficial to obtain maximumcoverage In the case of the pan-tilt camera model considered here, two axes of rotation are added to the set of parameters, **Φ.** Since the current pan and tilt parameter settingsmust also be included, the equation now becomes

$$\textbf{arg min } \Phi \ \{C\ (\Phi\ ,\textit{pan tilt},X_{3D}\ )\text{-}X_{2D}\} \qquad (4)$$

where***pan*** and ***tilt*** are vectors specifying the setting corresponding to each feature-observation pair. As before, good calibration requires adequate coverage of the space. In this case, coverage of the range of pan and tilt parameters is implied, as well as coverage of space. Thus the procedure for calibrating this camera model is an iteration of the procedure used for a static camera. The pan-tilt parameters are set to some value, .e.g. (0º, 0º). A set of feature-observation pairs is obtained. Then the pan-tilt parameter values are changed to some newvalue,e.g. (100º, 50º) and an additional set of feature observation pairs is obtained. The procedure is repeated until the range of camera motion has been covered. Allvectors are concatenated and the equation is minimized.

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IV. Results

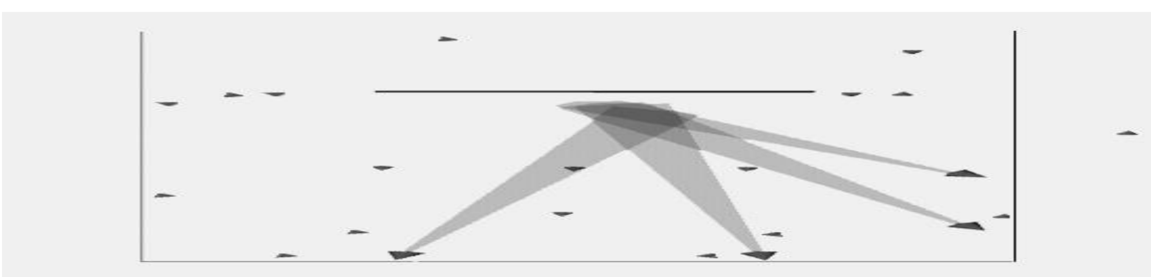

Figure 3 Top down view of pan-tilt camera placement. Cameras can be directed such that their view frustums intersect at the desired target feature location. Small triangles indicate the position of static cameras in the tracking network.

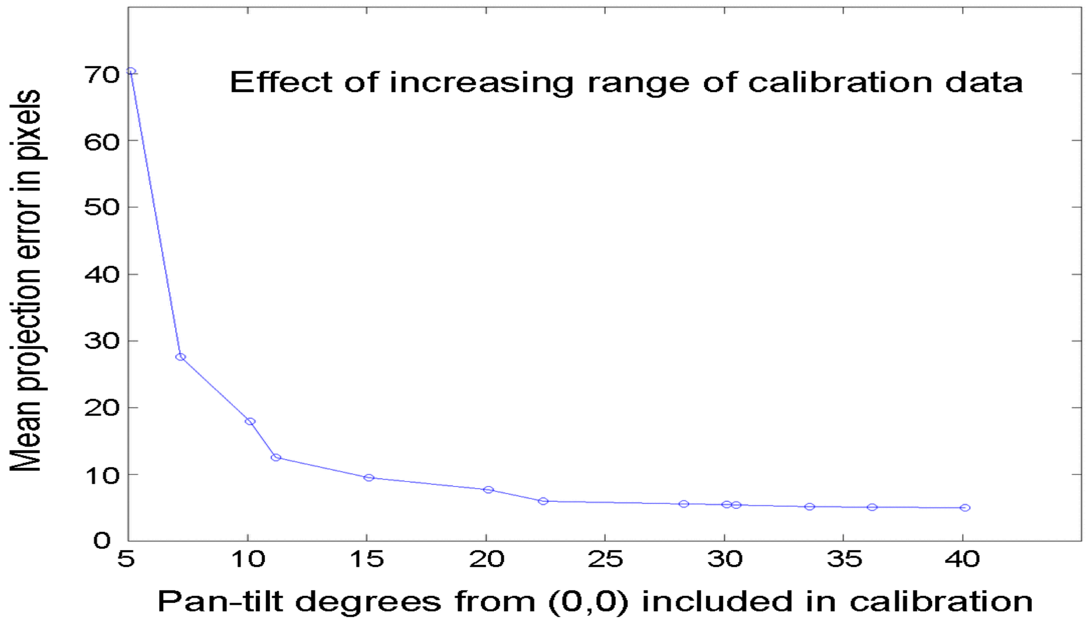

Figure 4 Plot of angular pan-tilt coverage vs. calibration quality. Including calibration data from a larger range of motion improves the quality of the calibration

V. Conclusion

The most aspect of the system lies in the fact that there exists an autonomous relation between the hardware control and the equipment control yet a cordial relation between the two exists. This can be realized by the fact that although the system can be remotely controlled but for a precise and specific function the equipment controller can also control the hardware for adjustments. The main applications of the project can involve from military applications to commercial uses. Some of the more phenomenal advantages are as follows.

VI. MILITARY AND DEFENCE

1. Environment acquisition including terrain mapping via image processing.
2. Target locking for objects in motion.
3. Remote control of a mounted weapon to engage in fire.
4. Identifying heat signatures in enemy areas.
5. Discriminating between friendly and enemy units.

VII. COMMERCIAL USES

1. Precise laser operations for cutting materia.
2. Image processing and recording.
3. Laser drilling a defined path.

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