

# Incremental Camera Motion Calibration

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## 1. The problem

An important problem in computer graphics is to estimate the position, orientation and focal length of a real camera, based on image information. In general, in a sequence of frames, the camera parameters change with time (see Figure 1).

Calibrating at different positions and interpolating does not provide a real time solution of the problem.

We propose an incremental calibration method to estimate the camera parameters.

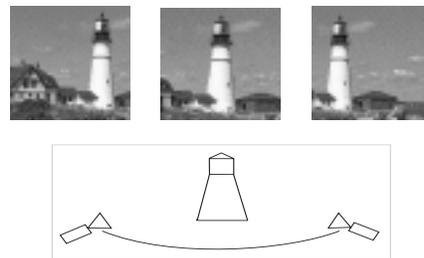


Figure 1

## 2. Techniques

*Calibration techniques* are static, and assume that the parameters remain constant for some period, after which a new calibration needs to be made. The computation of these parameters needs more than one image (see Figure 2).

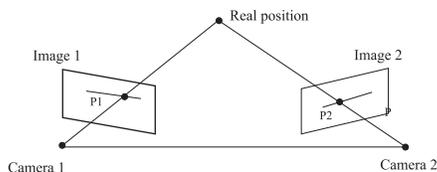


Figure 2

*Tracking techniques* update image information, along the time. Some methods get the calibration information and interpolate the intermediate positions to get movement (see Figure 3).

This fact makes it difficult to follow a continuous camera movement.

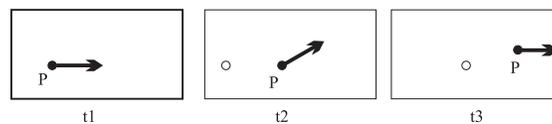


Figure 3

## 3. Proposed Solution

Our solution combines calibration and tracking in an incremental form. The virtual camera will follow the real image features, in real time. This technique is based on the differential approach<sup>a</sup>, using an optimization method.

The input data consists of the initial camera parameters  $\mathbf{c}$  and a set of image points  $\mathbf{p}$ .

The technique has the following steps:

1. expresses image points  $\mathbf{p}$  in terms of camera parameters  $\mathbf{c}$ ;
2. given the velocity of  $\mathbf{p}$ , determines the rates of  $\mathbf{c}$ ;
3. the function  $\mathbf{p}=\mathbf{f}(\mathbf{c})$  is derived with respect to  $\mathbf{c}$ , obtaining the Jacobian  $\mathbf{J}$ ;
4. finds the optimal solution for the equation:  $\dot{\mathbf{p}} = \mathbf{J}\dot{\mathbf{c}}$ ;
5. the computed value  $\dot{\mathbf{c}}$  is used to update the camera state, solving, numerically, a system of ordinary differential equations.

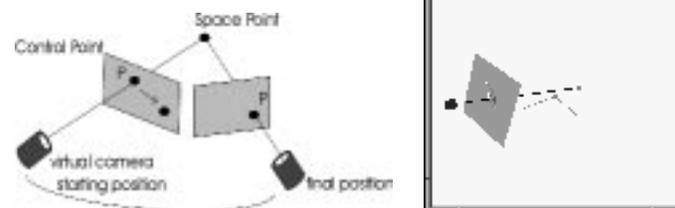


Figure 4

The incremental tracking can be applied to insert virtual elements in a real video sequence, in real time, and also to track a real element in a scene to be inserted in a virtual one.

<sup>a</sup>Gleicher and Witkin, Through-the-Lens Camera Control, SIGGRAPH 1992.