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A Positioning Method based on Image

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Abstract. Positioning system has been widely used in daily life, aerospace, industrial production. On the basis of analyzing the relationship between image coordinates and the actual coordinates, a positioning method based on global image is put forward. The basic principle and steps of this positioning method is described in this paper, and show a test case at last.

Introduction

Positioning system plays a more and more important role in daily life plays a more and more important role in industrial production. Car navigation, or aircraft take-off and landing control, and even step of software used in daily life need to use positioning system. Positioning system is also varied, Such as GPS, Beidou positioning system and inertial navigation and positioning system, etc. However these positioning system has certain defects, and there are some substantive issues remains to be further research, In this paper, we study and put forward a kind of locating method based on global image, and we hope to provide some ideas and ways.

Several Common Methods of Positioning

For now, common positioning system are following categories.

Positioning based on the Electromagnetic Wave. This kind of positioning system Represented by GPS (Global Positioning System) and UWB (Ultra Wideband), Through setting electromagnetic wave signal source in the environment, Locating objects get the distance between object and source by receiving electromagnetic wave signal and dealing with the signal, Further we calculate the object’s coordinates in 3 d space. The advance of this is that the positioning way is the high precision, and we can get the positions of the object in three-dimensional space, But we need to lay the signal source, and System is more complicated. And satellite position and attitude often can't be obtained or the precision can't meet the demand, consequently it is difficult to finish positioning[5].

Positioning of Image Recognition based on Independent Image Recognition. This way of positioning is mean that objects acquisition image about the environment around it independently, And then it will current collection of images and map matching in the database, get the current position. The image positioning of an automatic alignment stage typically contains two important steps: image processing to identify the current coordinates of used markers and servo motion control to minimize the tracking errors in position or image coordinate[4]. The advances of This way of positioning accuracy is high and it needn’t to receive the external signal, it will get the current position by independent way of gathering information. The disadvantage of this method is that need to enter the map in advance, and if the location position beyond the map ,it can't locate its coordinates. And image matching is easy to be wrong, especially when it be interference.

Inertial Navigation and Positioning. This way of positioning work with internal gyro accelerometer real-time monitoring of the current motion state of the object, and it calculate the coordinates of the current moment by integral operation. This method doesn't receive the external signal, positioning accuracy is high and it is without outside interference. But because the coordinates is obtained by using the integral method, Error will add up with the passage of time. This method is not suitable for long time positioning.

Mathematical Model

A camera model that accounts for major sources of camera distortion, namely, radial, decentering, and thin prism distortions is presented. The proposed calibration procedure consists of two steps: (1) the calibration parameters are estimated using a closed-form solution based on a distribution-free camera model; and (2) the parameters estimated in the first step are improved iteratively through a nonlinear optimization, taking into account camera distortions[7].
The mathematical model of small hole camera:

$$s\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix}\begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$\Rightarrow s \cdot \mathbf{m'} = \mathbf{A} \cdot [\mathbf{R} \mid \mathbf{t}] \cdot \mathbf{M'}$$

Where s refers to the multiplier factor, $\mathbf{m'}$ refers to the image coordinate system, $\mathbf{M'}$ refers to the world coordinate system, $[\mathbf{R} \mid \mathbf{t}]$ refers to linear transformation matrix, $\mathbf{A}$ refers to inside the camera parameter matrix.

In this paper, we use a monocular camera and there is no distance measuring module, so we can't get an image of the depth map, therefore $Z = 0$ .We can get the following formula.

$$s\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix}\begin{bmatrix} X \\ Y \\ 0 \\ 1 \end{bmatrix}$$

Let

$$\mathbf{H} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix}$$

And

$$\mathbf{H_{34}} = \begin{bmatrix} H_{11} & H_{12} & Don'tCare & H_{13} \\ H_{21} & H_{22} & Don'tCare & H_{23} \\ H_{31} & H_{32} & Don'tCare & 1 \end{bmatrix}$$

Because H_{33} is a part of s, we get a formula

$$\begin{bmatrix} \bar{x} \\ \bar{y} \\ \bar{s} \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \\ H_{31} & H_{32} & 1 \end{bmatrix}\begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

Let

$$\begin{cases} x = \dfrac{\bar{x}}{\bar{s}} \\ y = \dfrac{\bar{y}}{\bar{s}} \end{cases}$$

And

$$\begin{cases} x = \dfrac{XH_{11} + YH_{12} + H_{13}}{XH_{31} + YH_{32} + 1} \\ y = \dfrac{XH_{21} + YH_{22} + H_{23}}{XH_{31} + YH_{32} + 1} \end{cases}$$

$$xXH_{31} + xYH_{32} + x - XH_{11} - YH_{12} - H_{13} = 0$$
$$yXH_{31} + yYH_{32} + y - XH_{21} - YH_{22} - H_{23} = 0$$

So

$$\begin{bmatrix} X & Y & 1 & 0 & 0 & 0 & -xX & -xY \\ 0 & 0 & 0 & X & Y & 1 & -yX & -yY \end{bmatrix} \begin{bmatrix} H_{11} \\ H_{12} \\ H_{13} \\ H_{21} \\ H_{22} \\ H_{23} \\ H_{31} \\ H_{32} \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} \tag{1}$$

The formula (1) is the calculation formula that we managed to get.

The Positioning Method based on the Global Image

Traditional methods for positioning accuracy is not high and takes long time consuming problem[3].So we put forward a new technology to achieve the object of location. This positioning method is based on the Global Image, we only need get the object's image that we can calculate the t coordinate of the object. The technique only requires the camera to observe a planar pattern shown at a few (at least two) different orientations[1].

The positioning method based on the global image is according to the following properties of the image: for a specific point on the world coordinate system, which it has only the coordinates of the point and the matching in corresponding image coordinate system.

The steps of the image positioning method based on global are as follows:

Calibration. First we should calibrate the formula (1), In the practical application we should get four groups of related point in the world coordinate system and image coordinate system. we coordinate the generation into the formula (1),and we'll get the parameter $H_{11} \sim H_{32}$ to the linear transformation matrix $\mathbf{H}$.

Taking Pictures. First of all, we let the object emit beacon light ,Camera take pictures of objects. The object should emit beacon light that bright enough to be collected in camera, And the beacon of light used to locate should have significant characteristics to distinguish between locating objects and other objects. The camera should be able to take enough clear and accurate images, Under normal circumstances, The higher the resolution of the camera is, the more accurate image coordinates have, and the bigger the camera view is, the greater the location of the greater range is.

Processing the Image. After take the images of the locating object, Use the image recognition algorithm in the image to find the location of the object to be positioning, and calculate the coordinates that locate objects in the image coordinate system.

An important part of automatic target recognition systems is an algorithm based on which the images received by the camera are compared with a reference image. These algorithms are mainly classified into two general groups of image-based and feature-based methods. Image-based methods utilize direct operations on the available structures of the image[2].

Calculate the Coordinate. After get the object's image coordinates, we calculated by formula (1) that we can get the coordinates is positioned on the world coordinate system object. The algorithm can simultaneously calibrate different views from a camera with variable intrinsic parameters and it is easy to incorporate known values of intrinsic parameters[6].

Example

Fig.1 shows a camera collection of hanging in the roof to the object image, three of the figure

highlights the beacon of light to locate objects, To filter out natural light interference, Cameras installed the infrared filter, we choose infrared light as the beacon of light.

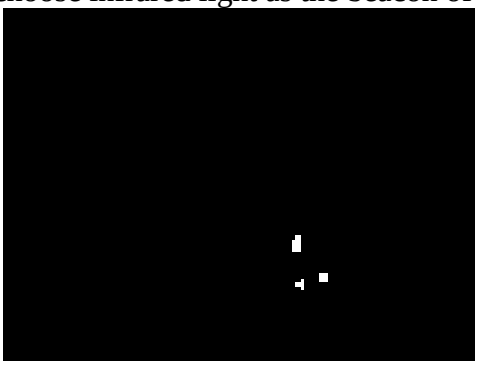

Fig.1 Image obtained by camera

We let the left upper corner of the image coordinates is (0, 0), the coordinates of this point in world corresponding are also (0, 0), and we let the lower right corner coordinates is (160, 90).

Coordinate calculation in the process of the data are shown in Table 1. We can find that from Table 1, Based on the global image positioning method has higher accuracy, So this new positioning method has certain application value.

Table 1 Positioning results

numbers	image coordinates	coordinates calculated by this method	real coordinates
1	(100,80)	(0.98,0.78)	(1.00,0.83)
2	(100,98)	(0.98,1.00)	(1.00,105)
3	(109,92)	(1.10,0.90)	(1.10,0.92)

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