The Research of Machine Vision Motion Control System based on the Labview

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Abstract

We take the probe automatic location detection system as research target.According to the requirements of the measurement system for machine vision system, the vision system architecture is set up. Besides, a reasonable method for system calibration and visual localization algorithm of machine is Proposed. What's more, the automatic locate detecting system's feedback used probe is realized by using the visual system as motion control system's feedback, So the overall accuracy of the system is improved.

Keywords

Vision Positioning, Motion Control, Camera Calibration.

1. Introduction

Machine vision is the use of computer and camera to simulate the function of the human eyes. Image signals obtained by controlling the camera and transmitted to the image processing system. The color of the image, the pixel distribution and brightness is converted into digital signals.The visual system achieves a specific purpose by doing all kinds of operations for these signals. Machine vision system can improve the degree of production automation and can instead of manual operation in many dangerous environment or the workplace that the precision of human eyes can't meet the requirements. Machine vision system can improve the product quality and precision in production and detection. What's more, it can, to some extent, reduce the labor costs and improve work efficiency. In the production process of automation, machine vision system is widely applied in condition inspection, finished product inspection, quality detection, manufacturing process, security monitoring and control etc.[1].

Considering the work requirements of automatic positioning detection system using probe, the article based on related technology of machine vision system and the motion control system's feedback used machine visual is studied.Visual feedback is mainly divided into two parts.One is machine vision system, the other is motion control system. Machine vision system contains the build of visual system which is based on probe automatic positioning system, vision system calibration and precise positioning based on image system. Motion control system contains the build of motion control platform, performance analysis, position feedback control of visual system etc..

2. The construction of probe automatic positioning detection system

Based on machine vision system as the main body, probe automatic positioning detection system is the real-time image identification system. Its main function is realizing real-time monitoring for PCB position in the process of PCB testing, calculating PCB actual location and detecting probe position deviation. What's more, probe automatic positioning detection system combined with motion control system can straighten deviation to achieve exact orientation. It mainly includes the machine vision system and motion control system.

2.1 The composition of the visual system

The visual system is the core part of the automatic positioning system. Its structural design mainly includes the choice of camera and lens, the design of light source, the design of image processing program etc..

The design of light source: The light source of visual system has many different categories and shapes. The image of target obtained is PCB. In order to reduce the difficulty of image processing, highlight the demand for the characteristics of the target, reduce and restrain interference information and enhance image clarity, we design the annular LED light source as shown in figure 1.

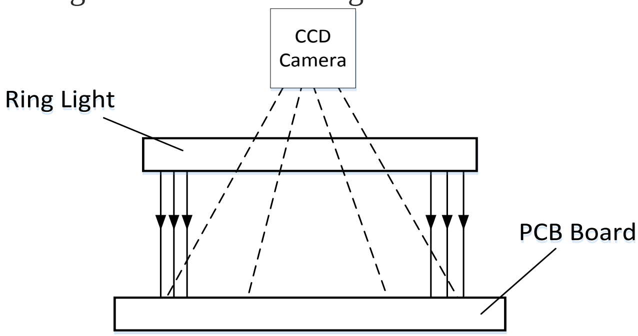

Figure 1. The design of light source

The choice of camera: camera in the machine vision system plays a very important role. It is the device that will show the image obtained from sensor. Although CMOS technology continually development in recent years, system requirements of noise, resolving power and sensitivity are considered.So we choice CCD camera. In the case of measuring accuracy satisfy,because the resolution is higher, the field of vision becomes greater and image becomes more clear, so high resolution camera preferentially is chosen. So pixel 3.0 Megapixels, 1/2 size color optical USB camera industry of MindVision company's is chosen.

The choice of the lens: The choice of the lens is critical. The wrong selection of lens may lead to the failure of entire visual system. According to the images of the PCB welding points is 6.5 x 6.5, so 6 to 60 mm 1:1.6 short focal lens is selected to match the camera.

3. Calibration of the visual system

In the machine vision system,in order to establish contact between the actual location of realistic goals and the coordinate position corresponding pixel of the resulting image, we must establish basic camera imaging model whose basic parameters is the camera vision system's parameters[2].

3.1 The basic model of the camera

Camera calibration is to determine the coordinate transformation relationship among the world coordinate system,the camera coordinate system, the image coordinate system, and the pixel coordinates,and calculate the camera's external parameters and internal[3]. We build a basic model of camera imaging according to the basic principle of optical imaging, see Fig. 3.

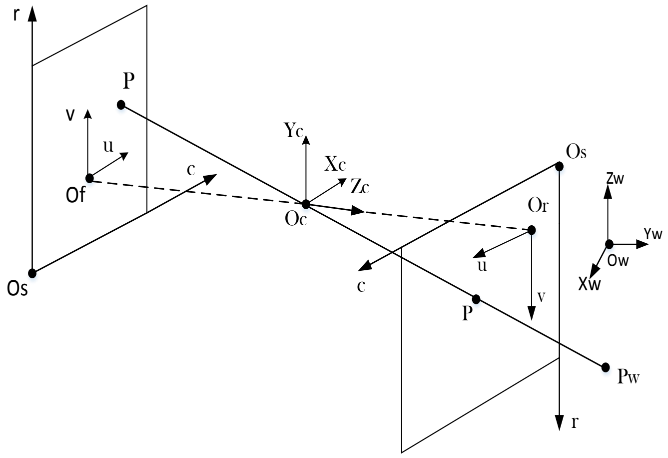

Fig. 3 The basic model of camera imaging

$O_S - rc$ is the image coordinate system, $O_f - uv$ is the imaging plane coordinate system, $O_c - X_cY_cZ_c$ is the camera coordinate system, $O_w - X_wY_wZ_w$ is the world coordinate system.

The imaging plane is generally at the rear end of the camera,but we adds one virtual imaging plane in the front end in the Fig. 3. The purpose is to reduce the computing amount for the camera model parameters.

3.2 Coordinate transformation

3.2.1 From the world coordinate system to the camera coordinate system

In the Fig.3 P_w is one point of the world coordinate system.first of all,we will transform it in to the camera coordinate system which include translation and rotation two operations.The translation between $P_w = (X_w, Y_w, Z_w)^T$ and $P_c = (X_c, Y_c, Z_c)^T$ is the following formula.

$$P_c = RP_w + T \tag{1}$$

3.2.2 Conversion from the camera coordinate system to image coordinates

Point $P_c = (X_c, Y_c, Z_c)^T$ of the camera coordinate system projected onto the point $P = (u, v)^T$ of the image coordinates is parallel projection. The projection relation is the following formula. The m is the magnification.

$$\begin{pmatrix} u \\ v \end{pmatrix} = m \begin{pmatrix} x_c \\ y_c \end{pmatrix} \tag{2}$$

Due to lens distortion factors, after imaging the point $P = (u, v)^T$ will change its position.For the vast majority of optical lenses, distortion can be understood as the radial distortion like formula(3). The k is the order of radial distortion.

$$\begin{pmatrix} \tilde{u} \\ \tilde{v} \end{pmatrix} = \frac{2}{1 + \sqrt{1 - 4k(u^2 + v^2)}} \begin{pmatrix} u \\ v \end{pmatrix} \tag{3}$$

3.2.3 Transformation from the imaging plane coordinate system to the image plane coordinate system

Point P in the image plane coordinate system can be expressed as $(r, c)^T$. In the formula(4), S_X and S_Y is the scaling factor, C_X and C_Y is the coordinate values of corresponding points of the origin of the imaging plane coordinate system in the image plane coordinate system.

$$\begin{pmatrix} r \\ c \end{pmatrix} = \begin{pmatrix} \dfrac{\tilde{v}}{S_Y} + C_Y \\ \dfrac{\tilde{u}}{S_X} + C_X \end{pmatrix} \tag{4}$$

3.3 Camera calibration

In the automatic probe positioning system, the optical axis of the test planes are perpendicular to each other,so in camera calibration process, we can set the rotation matrix R:

$$R=\begin{pmatrix}\cos\alpha & -\sin\alpha & 0\\ \sin\alpha & \cos\alpha & 0\\ 0 & 0 & 1\end{pmatrix} \tag{5}$$

By the formula (1) and (5) we can obtain:

$$\begin{cases}x_w = Ar+Bc+C\\ y_w = Dr+Ec+F\end{cases} \tag{6}$$

$$A=-ms_y\sin\alpha;\quad B=ms_x\cos\alpha;$$
$$C=-ms_xc_x\cos\alpha+ms_yc_y\sin\alpha+t_1;$$
$$D=ms_y\cos\alpha;\quad E=ms_x\sin\alpha;$$
$$F=-ms_xc_x\sin\alpha-ms_yc_y\cos\alpha+t_2;$$

Therefore, camera calibration process is transformed in the process of order to solve A,B,C,D,E and F the six parameters.Select n points from the world coordinate system $P_{wi}=(x_{wi},y_{wi},z_{wi})^T$, $i=1,2,3\cdots,n$. Then put them into the formula (6). We use the least squares method to solve target parameters .The following is the objective function.

$$f_1(A,B,C)=\sum(Ar_i+Bc_i+C-x_{wi})^2$$
$$f_1(D,E,F)=\sum(Dr_i+Ec_i+F-y_{wi})^2$$

After expanding the objective function, derivation and simplifying the various unknowns, we can obtain the following two equations.

$$\begin{cases}A\sum r_i+B\sum c_i+nC-\sum x_{wi}=0\\ A\sum r_i^2+B\sum r_ic_i+C\sum r_i-\sum r_ix_{wi}=0\\ A\sum r_ic_i+B\sum c_i^2+C\sum c_i-\sum c_ix_{wi}=0\end{cases}$$
$$\begin{cases}D\sum r_i+E\sum c_i+nF-\sum y_{wi}=0\\ D\sum r_i^2+E\sum r_ic_i+F\sum r_i-\sum r_iy_{wi}=0\\ D\sum r_ic_i+E\sum c_i^2+F\sum c_i-\sum c_iy_{wi}=0\end{cases}$$

Solving these two equations can solve A, B, C, D, E and F the six factors. And finally we achieve the camera calibration.

4. Research on positioning algorithm and the realization of positioning

4.1 Research on positioning algorithm

After the camera calibration, we can acquire an image and position it. Because the image of the PCB generally have many special tags, so we choose the mode matching method for targeting. The pattern recognition system consists of five major components: information acquisition, preprocessing, feature extraction and selection, classifier design classification and decision-making [4]. Simple block diagram of a pattern recognition system shown in Fig. 4.

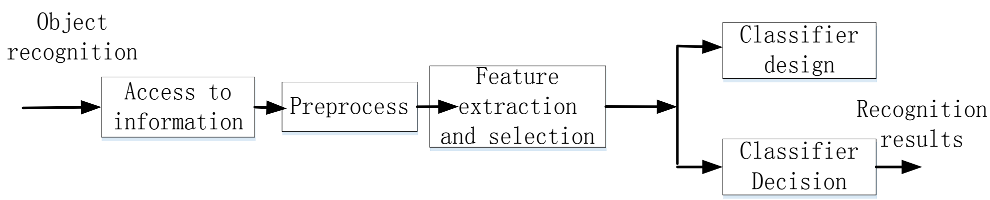

Fig. 4 Simple block diagram of a pattern recognition system

In the automatic positioning of the probe test system, identification purposes is to make the PCB solder its corresponding test probe accurate docking, to complete PCB board testing. Image matching algorithm can well meet the requirements to achieve accurate positioning of PCB. The following formula is a normalized cross-correlation function of a general definition.

$$NC(i,j)=\frac{\sum_{m=1}^{M}\sum_{n=1}^{N}T(m,n)F(m+i,n+j)}{\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}T^2(m,n)\sum_{m=1}^{M}\sum_{n=1}^{N}F^2(m+i,n+j)}}$$

Normalized cross-correlation algorithm has high accuracy and adaptability. It's not affected by the changes in linear gray value, ideal for matching the.

4.2 Positioning the realization

Distinctive two areas on the PCB is Selected as eyespots. Imaging system parameters obtained by vision system straighten the image and then the image after calibration is regarded as the image matching template. According to the location of the selected eyespots, system obtains the eyespot-image on the PCB. The eyespot-image which is corrected is regarded as the pattern recognition target image. Based on the algorithm of pattern recognition position, deviation value between the position of the eyespots and the corresponding points on the template image is calculated. Eyespots deviation is shown in figure 5.

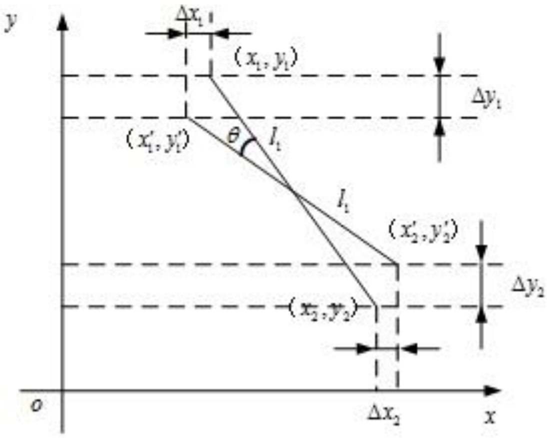

Fig. 5 Eyespot schematic

The two eyespots deviation is the average of the whole PCB's shifting deviation of X and Y:

$$\Delta x=\frac{\Delta x_1+\Delta x_2}{2}$$

$$\Delta y=\frac{\Delta y_1+\Delta y_2}{2}$$

If the two straight lines' slopes are k_1 and k_2 .Rotation angle error θ is the Angle between the two slashes.

$$\bar{k}=\tan\theta=\left(\frac{y_2'-y_1'}{x_2'-x_1'}-\frac{y_2-y_1}{x_2-x_1}\right)\Big/\left(1+\frac{y_2'-y_1'}{x_2'-x_1'}\bullet\frac{y_2-y_1}{x_2-x_1}\right)$$

$$\theta=\arctan\bar{k}$$

Finally, the received deviation value will be input to the motion control system to realize accurate positioning of PCB.

5. Conclusion

Through the research on the automatic positioning of the probe test system, this paper set up machine vision positioning system architecture, studied the system calibration method, the visual and visual localization algorithm.

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