Summary of robot visual servo system

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Abstract

In this paper, the survey of robot visual servoing system are introduced. The paper reviews the concept and history background of robot visual servoing system. This article also classify the robot visual servo system from different aspects. Finally, it introduce the research status quo, achievements and future trends in the field.

Keywords

Robot, visual servoing, summary.

1. Introduction

With the continuous progress of science and technology, robot technology has been playing a more and more important role in the field of aerospace, automatic production, automatic detection and so on. In order to enable the robot to complete the work in the complex working conditions, the robot needs not only more complete control system, but also need to be able to change the perception of the environment. And the impact of lack of one of the important reasons for the development of robot is like a person's ability to perceive in people for the robot to add various external sensors, robot vision to the information, complete information become the most important robot perception function [1]. The research of robot visual servo control technology is involved in many fields such as image processing, machine vision, control theory, kinematics, etc.. Robot visual servo control is an important research direction in the field of robotics, machine vision as one of the robot system is one of the most important sense, it was changed by robots, such as the operation object and environment must accurately modeling requirements [5].

With the development of imaging technology and computer technology, as well as the relevant theory of continuous improvement and practice of continuous inspection, through the visual servo control, the robot can achieve dynamic, uncertain situation operation. With the continuous expansion of the field of robotics applications, the importance is also increasing, and its related technical issues have become the current research hotpots [2]. So it is very difficult to realize the robot visual servo control, and it is a challenging task in the field of robot research.

2. robot visual servo system

2.1 definition of robot visual servo system

The concept of robot visual servo (servo visual) was proposed by hill and park in 1979. "Servo" - from the Greek word "slave". People want to put the "servo" as a handy tool to tame, obey the requirements of the control signal and action. Before the signal comes, the rotor is still not moving; when the signal comes, the rotor rotates immediately; when the signal disappears, the rotor can stop at once. Because of its "servo" performance, hence the name - servo system. Visual servo and the general sense of machine vision is different, machine vision is generally defined as: automatically get the analysis of the image to get a description of a scene or control some movement of the data. Visual servo is to realize the robot control for the purpose of image automatic acquisition and analysis, so it is using the principle of machine vision, from direct image feedback information, fast image processing, gives feedback information in the shortest possible time, involved in the generation of decision control, form the robot position closed loop control system [4].

2.2 the development history, direction and research background of robot visual servo system

In 60s of last century, with the rapid development of computer and robot technology, the robot with visual function began to appear. At first, robot motion control based on robot vision is open loop. Machine vision system to get the target position, and then calculate the position and orientation of the robot, in the whole process of the visual system to provide a one-time "provide" information, and then do not participate in the process of.

In 1973, the vision system was applied to the robot control system, in which the process is called visual feedback (feedback visual). Until 1979, hill and park proposed the concept of "visual servo" (servo visual). Visual feedback is only from visual information extraction feedback signal, and visual servoing is includes from the visual signal processing, to control the robot, so the visual servoing than visual feedback can more fully reflect the robot vision and control related research content.

Recent 20 years at home and abroad of the robot visual servo of extensive research, Hutchinson of three classic papers [1 - 3] for visual servo control research to guide. Application in recent years. Staniak [4] and azizian, [- 6] of visual servo system structure and medical robots respectively are reviewed. In the domestic research, Lin Jing [7], Qing Jie Zhao etc. [8], Xue Dingyu, [9], Lin Kun Wang, [10], Yongchun [11] respectively on visual servo control of the summary, summarizes the classical visual servoing control method.

3. main categories of robot servo system

3.1 different classification criteria

The robot control system can be classified from different angles, such as the type of feedback information, the control structure and the image processing time.

According to different criteria, the robot visual servo system can be divided into different types. According to the difference of the number of the camera, the system can be divided into a single visual servo system, a binocular visual servo system and a visual servo system. Monocular vision can not directly get the three-dimensional information of the target, and generally get the depth information by moving. Monocular vision is suitable for the working environment with simple task and low depth information. Visual servo can be observed in the target different parts can be obtained more abundant information, visual controller design but is more complex, and relative to the binocular visual servo more difficult to guarantee the system stability. Binocular vision can get depth information, the current visual servo system mainly uses the binocular vision.

According to the camera position is different, can be divided into hand eye system and fixed camera system. Accurate position of the eye in hand system can get the target, can achieve precise control, due to the eye in hand system can only be observed in the target and cannot be observed at the end of the robot. Therefore, it is necessary through known kinematic model of the robot to solve target and the end effector of the robot position, more sensitive to calibration errors and kinematic errors [6]. Fixed camera placement can observed in the target can also be observed at the end of the robot, and large working space scene can be obtained and can get the relative velocity of the end effector of a robot with respect to the target, but was unable to obtain the accurate information and robot motion may be caused by the occlusion of the target image. In order to overcome the shortcomings of two kinds of camera placement, one of the current solutions is to use [7] in two way

From the point of view of the control structure, the system can be divided into open loop control system and closed loop control system. Open loop control of visual information is used to determine the pose of the target before movement. Closed loop control of visual information is used as feedback, which can resist the camera calibration error [8].

In addition, it can be classified according to tasks, such as visual based positioning, tracking or grab and so on [9].

According to the different types of feedback information, the visual servo system can be divided into the visual servo based on the position and the visual servo based on the image. Based on the position

error signal defined in Cartesian space, and based on the image of the error signal defined in the 2D image space. We mainly discuss the classification of this method.

3.2 position based visual servo system

According to the obtained image, by geometric 3D model of the object and camera models to estimate the position of the target relative to the camera, at the end of the current robot pose and the estimation of pose error, adjusted by the visual controller is the position based visual servoing. The structure of the position based visual servo is shown in figure 1. The visual servo position required by 3D reconstruction based on image calculation error in three-dimensional Cartesian space. The advantage of this method is that both the error signal and the input signal of the joint controller are the spatial position, which is easy to implement. But due to the target image estimation of spatial position, the kinematics model of the robot error and camera calibration error have a direct impact on the control accuracy of the system and there is no direct control of the image, easy to make the target before leaving the field [10].

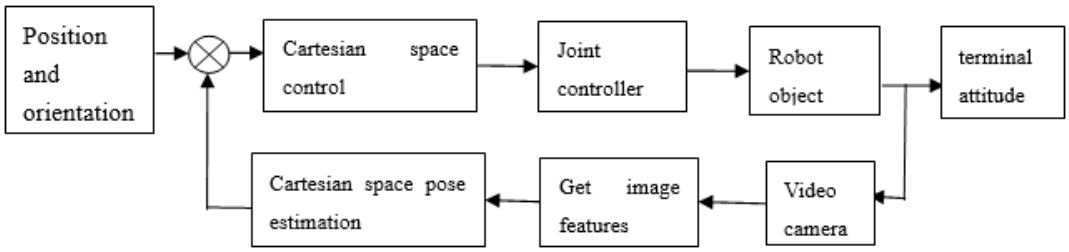

Fig. 1 the structure of the servo system based on the position control

3.3 image based visual servo system

Image based visual servo directly calculate the image error, generate the corresponding control signal, do not need 3D reconstruction, but need to calculate the image Jacobi matrix. Image based visual servo structure as shown in Figure 2 [11]. Based on the outstanding advantages of image-based visual servoing is the calibration error and spatial error model is not sensitive. The disadvantage is that the difficulty of controller design, servo control easy to enter the image Jacobian matrix singularity, generally need to estimate the target depth information, and only in the target location near the neighborhood convergence. And solving the image Jacobi matrix is a main task of image visual servo system [15].

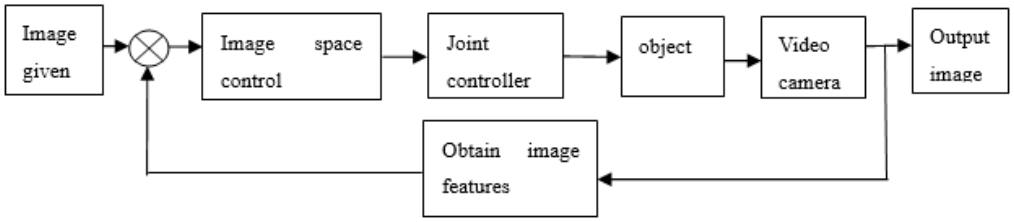

Fig. 2 the servo structure based on image control

3.4 hybrid visual servo system

Due to the location based and image based visual servoing approach has some insurmountable disadvantages, people put forward the hybrid visual servoing control method. The main idea of the hybrid visual servoing is based on image servo control some degrees of freedom, the remaining degrees of freedom using other technology control and does not require the computation of image Jacobian matrix. Proposed to Malis hybrid visual servoing 2.5D visual servoing method is the most representative. The method could be used to position based and image based on two kinds of structure of each other and system stability and convergence domain has improve [5].

4. main research difficulties and future research directions

4.1 difficulties in the research of visual servo robot

Robot technology in the field of industrial applications is bound to be more and more broad, will play an increasingly important role. Computer vision is the perception of the robots, an important tool of the surrounding environment, visual servoing can be complex special mission to provide important technical support for the robot execution. Likewise ascend visual servo robot performance and broaden the application scope of the robot, visual servo robot research also face many challenges.

(1) visual CCD camera is often used to achieve, in the imaging process will be affected by a variety of factors, making the visual information is inevitably mixed with noise, increase the difficulty of image processing;

(2) the sampling rate of the current video camera is not high, and it is necessary to take more time to transmit the visual information of a large number of data;

(3) the nonlinear problem of imaging process;

(4) previous research on visual servoing are mainly concentrated in the simple static environment for visual servoing tasks, which in the practical application of the robot is far from enough as to further improve the system sampling rate, it is necessary to in-depth study of the visual servo system of dynamic performance [14]. A comprehensive consideration of the dynamic characteristics of the robot and the dynamic characteristics of the visual process [13]

4.2 research on the future development of visual servo robot

Combined with the current research progress and the key difficulties, the future research of robot visual servo system can be carried out from the following aspects:

1) visual servo control of fast robot system

Sampling frequency and speed of processing constraints due to the visual system, the control frequency of the visual servo system is generally low, and most of the kinematics level control, mainly used to slow down the process. For actual need rapid response and to perform the task, you can use high-speed visual system and design of the robot dynamics controller and improve the robot dynamic response performance.

2) the application of multi camera vision system

Due to the single camera vision of the scope and limited resolution, not only limits the robot's workspace and precision of the operation, and in the process control need to sacrifice control performance to meet the constraints of field. Using multi camera vision systems can be extended range of vision and robot activity space, enhancing the fault tolerance of the system, improve the system's flexibility. The future can be to conduct the research to the visual redundancy system control and calibration of multi camera system and visual servo system fault tolerance based on.

3) visual servo in complex dynamic environment

Previous research mainly focuses on the visual servo task in the ideal static environment, and it is generally assumed that the environment is known, and the real environment is complex and changeable. On the one hand, in the process of practical control of large image noise, model error and time delay in control, affect the system dynamic performance and stability; on the other hand, environment in unknown or dynamic obstacles embodied as the systems with unknown dynamic constraint may cause occlusion or robot collision. In order to ensure the reliability of robot in complex environment, it is necessary to do further research in order to solve these problems.

4) the control of the generalized visual servo system

Previous research on visual servo controller is designed mainly for image feature points or based on homography matrix of the system, the system model relatively simple, but the application scene is limited. For using visual feedback system, the existing research is the main tendency in the design of the visual system, there is still room for further optimization of the performance of the control system, which can make a visual servo system has been more widely used.

5) multi sensor fusion control

Robot system commonly used sensors are mainly visual equipment, GPS, sonar, gyro, each sensor has its applications and scope of validity. The advantage of visual sensor is to more fully reflect the environmental information, suitable for task level control. And gyroscope, sonar and other sensors for the attitude of the robot control and obstacle avoidance control. Therefore, environment is complex task necessary other sensor information fusion.

6) man-machine collaboration system

At present, the development of artificial intelligence is far from mature, with the machine completely take the place of work is still too early. The robot in performing complex tasks will encounter some unforeseen circumstances. Therefore, it is necessary to add human control behavior and machine work to complete the task. Previous man-machine cooperation system of main tendency in the level of system design, in the level of robot control, especially in visual servo control research is less, based on visual servoing of human-machine cooperation system in practice has great application value.

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