Image Signal Processing Techniques for Hand-Eye-Foot Coordinated System

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Abstract: -In this paper, image signal processing technique is applied to a Hand-Eye-Foot Coordinated System. The considered system integrates IP Camera device, multi-joint robotic arm and wheeled mobile carrier is proposed to simulate the coordination of human hands, eyes and feet, and carry out the behaviour of taking objects in the air during the march. IP Camera performs image capture, cooperates with image processing software, and makes target recognition and target selection similar to the human eye. Multi-joint mechanical arm, simulate the human arm, the target object grab. Wheeled mobile mounts simulate the movement behaviour of human forwards, backs and turns. The rapid image processing and target identification technology related to the system are developed. 2D target tracking technology, including (1) Camera tracking target law and (2) platform tracking camera tracking law are proposed.

Key-Words: -image processing**,** hand-eye-foot coordination, intelligent robot, robot, target tracking
Received: March 17, 2021. Revised: April 12, 2022. Accepted: May 8, 2022. Published: June 8, 2022.

1 Introduction

In recent years, the development of robots is more and more vigorous, the field of robot research is also very broad, in which the research of autonomous robots has become a very important part, there are now many care robots, cleaning robots, display robots; etc. These service robots gradually into human life, the robot's appearance can easily be designed to be similar to the human appearance mechanism, but the action behaviour should be as important as human action behaviour is worth studying part. This paper studies the motivation, designing the robot to simulate the human action behaviour, can identify the desired object in the complex environment, and move to the object, grab the object, in the process to make the robot quickly and accurately find the target object, and in the process of moving the coordination of the action adjustment.

In this paper, a complex system that integrates IP Camera device, multi-joint robotic arm and wheeled mobile carrier is proposed to simulate the coordination of human hands and eyes and feet, and carry out the behaviour of taking objects in the air during the march. IP Camera performs image capture, cooperates with image processing software, and makes target recognition and target selection similar to the human eye. Multi-joint mechanical arm, simulate the human arm, the target object grab. Wheeled mobile mounts simulate the movement behaviour of human forwards, backs and turns. The proposed technology for the system will be verified by real test, can perfectly simulate the behaviour of human moving to take objects in the air.

2.Operational Concepts of Hand-Eye-Foot Coordinated System

2.1. The proposed System Hardware Design[

The proposed system design is shown in Fig.1[1-5]. It includes PZ7512 CCD Camera, Robot Wifi Module, Human Moving Detector, Wheel Increment Encoder, Ultrasonic Range Finder, IR Range Finder, 7-joint Robot Arm (Fig.2), Pressure Transducer for Fingers.

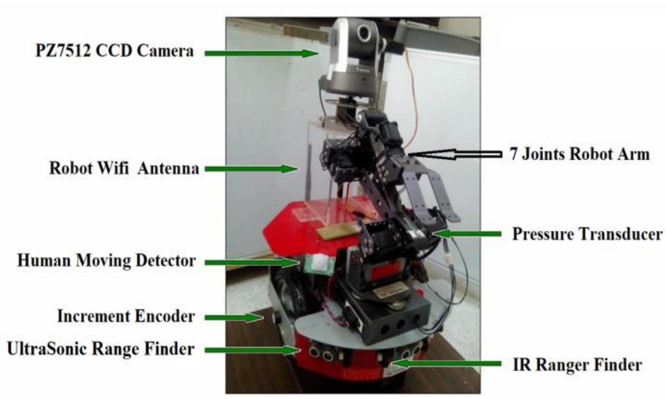

Fig.1. The Proposed System.

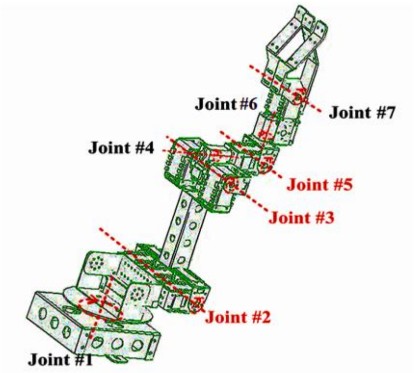

Fig.2. The 7-joints Robot Arm.

System hardware interface architecture, as shown in Fig. 3, with the PMS5005 motion card as the core of the system, there are 3 sets of ultrasonic distance sensors, 7 sets of infrared distance sensors, and the PMS5005 motion card connection, and connected to the set of incremental encoders respectively control the left wheel, the right wheel, In addition, the WFS802g wireless communication module is connected to the system core and CM-5 controller, the wireless network through the wireless base station and the PC communication, in addition to the CM-5 controller connected to the robot arm composed of 10 AX-12 servo motors, the camera built within the wireless communication module, Therefore, only by the wireless network through the wireless base station and PC communication, the entire development process in the PC to do program control, through the wireless network to do communication control, and must first set up the PMS5005 and camera IP. The camera part is (192.168.0.199:8081), while the PMS5005 part, through the X80SV WiRobot Gateway online software to do the connection as shown in Fig.3, in the Robot ID input PMS5005, select the second WiFi Connect, and enter IP: 192.168.0.205, Port:1001, press Connect to complete the connection communication. The power supply of the entire system is divided into a section, the X80SV and the camera are supplied by a 12V NH battery, and the arm and CM-5 controller are partly supplied by 12V DC.

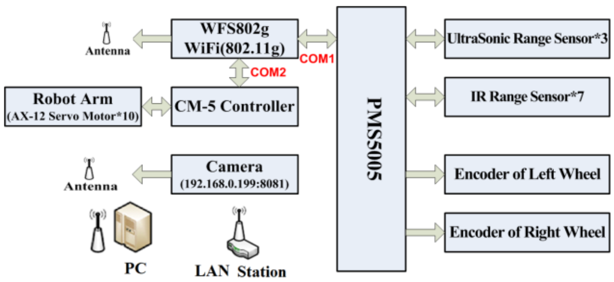

Fig.3. System Hardware Interface.

2.2. Tracking Control Configuration

The relationship on the horizontal plane between Target, Camera and the Moving Platform is shown in Fig.4, in which ψ_{SB} represents the angular deviation between central lines of platform and Camera; ψ_S represents the line of sight angle for target. The zero values of ψ_S represents the camera pointing to the target. The zero values of ψ_{SB} represents the body tracking the sight.

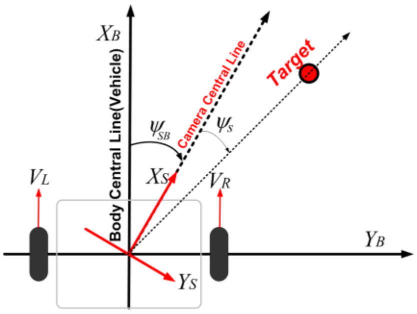

Fig.4. Relationships between Target, Camera and Platform (Vehicle).

The tracking and control configuration on the horizontal plane is shown in Fig.5. There are two tacking laws will be developed for camera tracking target and vehicle tracking camera. The ψ_S is the yawing angle of camera; The ψ_B is the yawing angle of the platform; (X_B, Y_B) and (X_T, Y_T) are platform and target positions, respectively; R_{BT} is the distance between the platform and target; λ is the line of sight; ψ_e is the tracking angular error of the target with respect to central of the camera screen; X_{err} is the tracking error in pixel. The relationships of them are

$$\lambda = \tan^{-1}\left[\frac{Y_T - Y_B}{X_T - X_B}\right] \qquad (1)$$

$$\psi_e = \lambda - \psi_s \qquad (2)$$

$$X_{err} = 160\tan^{-1}(\psi_e)/\tan^{-1}(H_{FOV}/2) \qquad (3)$$

and

$$R_{BT} = \sqrt{(X_T - X_B)^2 + (Y_T - Y_B)^2} \qquad (4)$$

where H_{FOV} is the horizontal field of view of the camera. Note that the tracking error ψ_e is replaced by X_{err} for it is difficult to find ψ_e for the size of the target is unknown. But X_{err} approaches to zero are equivalent to ψ_e approaches to zero. The definition of X_{err} is given in Fig.6. Fig.5 can be used to evaluate the tracking laws. The responses of the image seeker must faster than that of the vehicle yawing for the disturbance from platform can be suppressed. The vehicle yawing is accomplished by different speed two wheels[6-9].

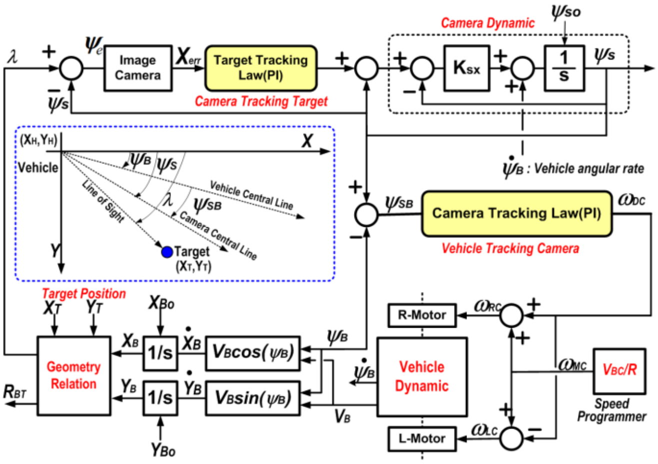

Fig.5. Tracking and Control Configuration of Horizontal Plane.

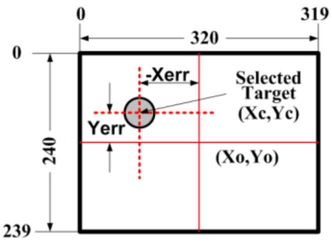

Fig.6. Tracking error definition of the Target.

2.4.The proposed System Operation Procedure Design

System signal process design, as shown in Fig. 7

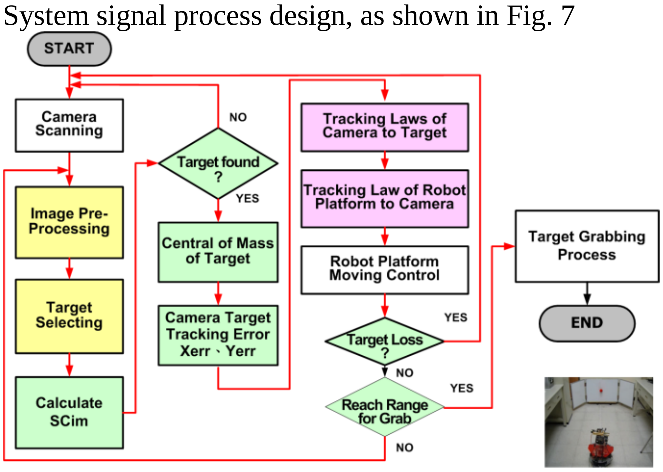

Fig.7. System Operation Flow Chart.

3. Image Processing for Finding Target Position Errors

The image processing process[10-13] for the target is shown in Fig.8. They are : (1)taking an image with a size of 320×240; (2)take out the RGB pixel array data of each layer; (3) do RGB colour model to HSI colour model processing，and set the colour of the target object you want to select; (4)filter out the colour you want; divide the part you want to select from the part you don't want to be black and white(shown in Fig.9); (5)calculate the central of the target(X_C, Y_C), the deviation from the central of the screen X_{err}, Y_{err}, and the target as a proportion of the screen is SCim. Formulas of the central of the target are listed as follows

$$X_C = \frac{\sum_i \sum_j i \times f(i,j)}{\sum_i \sum_j f(i,j)}; i = 0 \sim 319;\ j = 0 \sim 239 \quad (5)$$

$$Y_C = \frac{\sum_i \sum_j j \times f(i,j)}{\sum_i \sum_j f(i,j)}; i = 0 \sim 319;\ j = 0 \sim 239 \quad (6)$$

Where $f(i,j)$ represents pixel value of position (i,j). The value $f(i,j)$ equal to zero represents black, and that of 255 represents white. The deviation from the central of the screen X_{err}, Y_{err} are

$$X_{err} = X_C - X_O; \\ Y_{err} = Y_C - Y_O \quad (7)$$

Where $(X_O, Y_O) = (160,120)$. The target as a proportion of the screen is

$$SCim = \frac{\sum_i \sum_j f(i,j)/255}{320 \times 240}; i = 0 \sim 319;\ j = 0 \sim 239 \quad (8)$$

The SCim value is used as a determination of whether there is a target. Fig.9 shows that the final output for red/blue ball is selected.

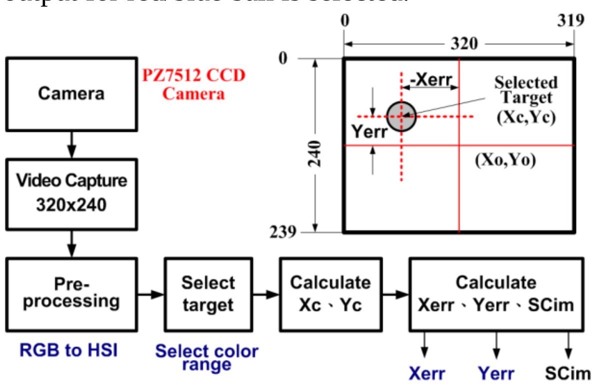

Fig.8. Data Processing Flow Chart & Parameter Definition.

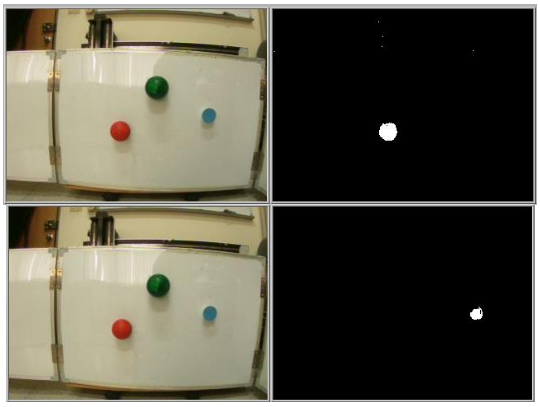

Fig.9. RGB to HIS Transformation for Selecting Red /Blue Ball.

4. System Verifications

The verification of the whole system designs are shown in Fig.10-12. Fig.10 shows approaching images form initial moving to final grabbing processes. Fig.11 shows internal evaluation datum of each system parameters. Fig.12 shows tracking errors X_{err}, ψ_{SB}.

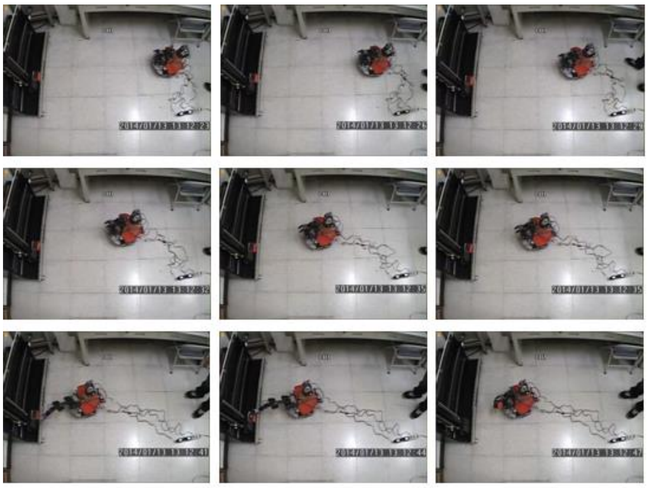

Fig.10. Moving and Scanning to find Target and Grab Target.

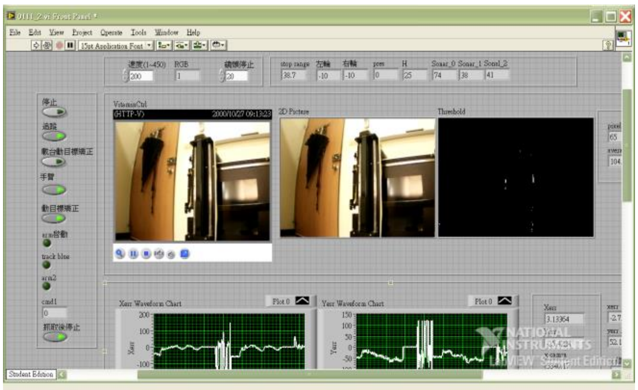

Fig.11. Screen Show of the Moving, Scanning and Grabbing Process.

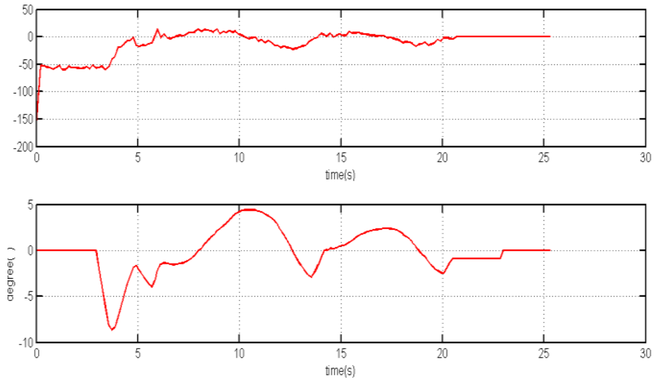

Fig.12. Tracking Errors of the Moving, Scanning and Grabbing Process.

5. Conclusions

In this literature, Hand-Eye-Foot Coordinated system is developed for the Intelligent Robot. The developed techniques including (1) the technology of rapid image processing and target identification. Selected for objects of special shapes and colours; (2) target tracking technology. Camera tracks the target law so that Camera is on target. The carrier tracks the Camera tracking law, making the carrier coincide with the camera's central axis. The proposed technology is verified by real test. It can be seen that the developed system can perfectly simulate the behaviour of human moving to take objects in the air.

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