Chapter 8
Conclusions and Suggestions for Future Works

8.1 Conclusions

Several techniques and strategies have been proposed in this study and integrated into an autonomous vehicle system for guidance in the indoor environments with human detection and following capabilities.

At first, a method of computing the distance between a person and the vehicle for different people heights is proposed. The process is divided into two parts: constructing the reference data and using them in the system. To begin with construction of the reference data, we define a *reference person* as a standard for measuring a set of parameters which are used to compute the distance between the vehicle and the person. Then, when a person is detected, we can check whether or not we have to adjust the reference parameters for measuring the distance between the vehicle and the person. Besides, when the vehicle is close to a person and cannot see the entire clothes of the person to compute the distance, we have proposed additionally an area tracking method to keep following the person. For this purpose, first we extract the color of the clothes of the person and take it as a tracking target. Then we use a shape circumscribing method for deciding the area center of the clothes for keeping following the target. Finally, we can adjust the camera orientation to keep seeing the followed target in the image.

Next, in the human detection process, we have proposed an improved skin color

model for adapting to luminance changes. First, we find out the values of C_b and C_r in every five scales with a light meter which is used to measure the light intensities. Then we use a curve fitting technique to build a smooth curve of the values of the skin color model in different light intensities. Finally, we adjust the center of the skin-colored ellipse in all intensities when the vehicle conducts the task of human detection. In addition, we use a progressive method for dealing with none-uniform luminance. In this method, we use blocks each of which consists of a square region of pixels in the image. The sizes of these blocks are all the same and vary from 320×240 to 40×30 until the system detects a human face.

Then, a method for detecting a disappearing person who turns fast at a corner and walks into a narrow path have been proposed for use in the human following process. After a person is detected, the system will remember his/her clothes and follow him/her. When the person makes a fast turn at a corner, the system will use the recorded information to command the vehicle to go to the correct crossroad point and turn to the right direction for searching the disappearing person in the acquired image. In addition, the vehicle adjusts its orientation for monitoring when it follows the person. Therefore, if the person walks in a narrow path, the vehicle will find the person again and will not hit the wall during turning and approaching the person.

In addition, human interaction techniques have also been proposed. We deal with two kinds of human actions for some applications. The first kind is the change of the facing direction of a person. By detecting the facing direction of a person, we can know the place where a person faces to and what the person is interested in. First, we use the ratio of the width and height of the person's clothes to know whether the person turns to the left or right. Then we use the distribution of the person's hair and skin to judge the exact direction of the person. The second kind is the movement of a person's hand. When the person waves his/her hand, the vehicle can know that the

person is calling it. First, we conduct motion detection by frame differencing. Then we combine the information of the person's facing direction to judge whether the person is calling the vehicle.

The experimental results shown in the previous chapters have revealed the feasibility of the proposed system.

8.2 Suggestions for Future Works

The proposed strategies and methods, as mentioned previously, have been implemented on a vehicle system with a robot arm. Several suggestions and related interesting issues are worth further investigation in the future. We state them as follows.

(1) Analyzing hand gestures to enable the vehicle to recognize other calling behaviors of different people.

(2) Improving the extraction of clothes colors.

(3) Conducting human following by different features, such as texture and shape, to eliminate errors caused by the case that the different people may wear clothes of the same color.

(4) Adding a face recognition capability to recognize specified persons and making the vehicle react differently.

(5) Following a group of persons by analyzing the features of this group. For example, when a family goes to a shopping mall, the vehicle can still follow any member of this family even when the first-followed person goes to another place, such as a washroom or an automated teller machine.

(6) Improving the detection of a person's facing direction by learning other hair and skin colors or using the position of the mouth to know the direction which a

person faces to.

(7) Adding a judgment of the position of a person's body. When a person slips and falls over, the person's body may fall down on the floor. If this situation continues for a long time, the vehicle can issue an emergence signal to call someone for help.