

Chapter 7

Experimental Results and Discussions

7.1 Experimental Environment

All experiments of this study were conducted in our laboratory, Computer Vision Laboratory at the Department of Computer Science at National Chiao Tung University in Hsinchu, Taiwan, as show in Figure 7.1. There are many corners and narrow paths in the laboratory.

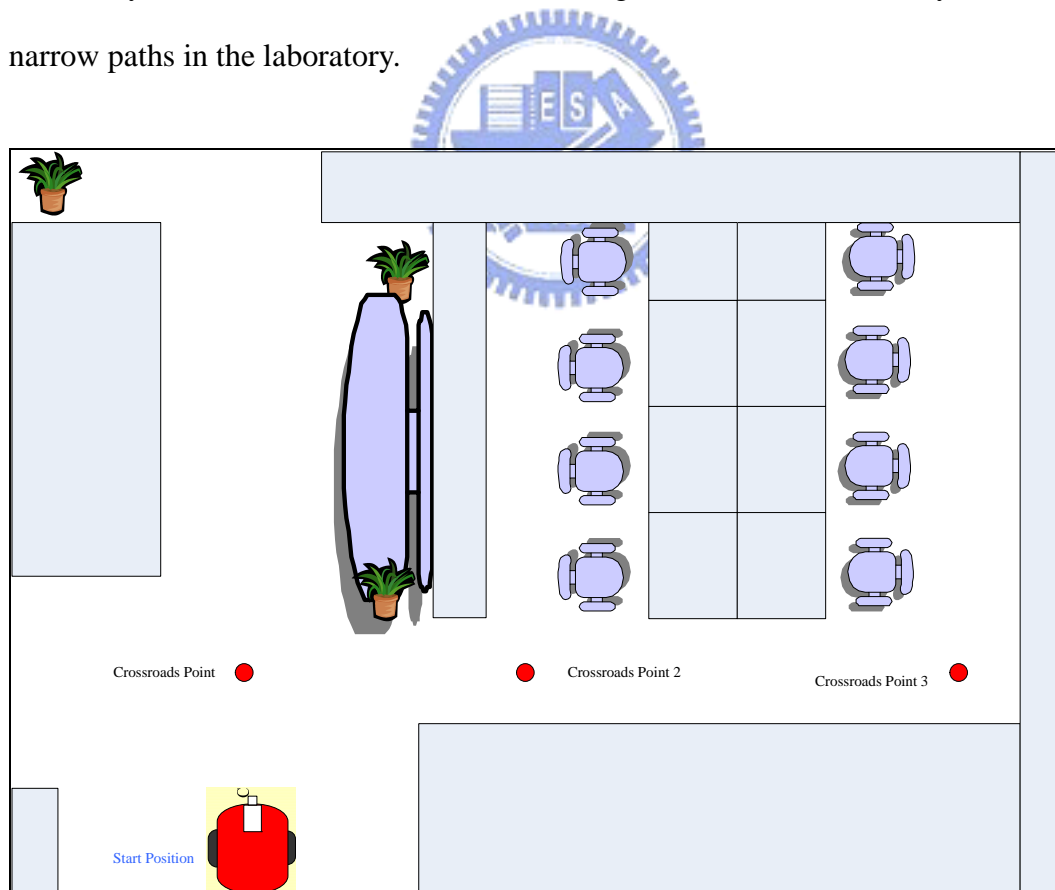


Figure 7.1 The illustration of the CV Lab in NCTU.

We simulate the situation of a bookstore by using the bookcases in the laboratory.

And we also define a fixed parking place for the vehicle to stand by and a position for the person who is ready to use the vehicle like shopping in a bookstore with a shopping cart, as shown in Figure 7.2.



Figure 7.2 The vehicle follows a person as a shopping cart.

7.2 Experimental Results

In this section, we show some experimental results of the proposed human detection and following system. The user interface of the system is shown in Figure 7.3. At first, a user controls the vehicle to learn the position of the crossroad points and the area information of the bookcases in the environment. Whenever the vehicle arrives at a position, a user controls the system to record the above information. The proposed system has four modes: a detection mode, a following mode, a turning mode and an interaction mode. The system will detect humans in acquired images in the

detection mode. In the following mode, the system will follow a target person by the use of the extracted clothes features.

After a user presses the start button, the system will start monitoring the environment in the detection mode. When a person enters the viewing distance of the vehicle, the system has to detect the face and adjust some parameters for any height difference from the reference person's height. Therefore, the system conducts face detection first in each cycle. If a face is detected, the system will learn the length of the person's face in the image and compute the real length of the person's clothes. Then the system will extract the clothes region and change the detection mode to the following mode, and then finish the current cycle, as shown in Figure 7.4.

Otherwise, when the vehicle is in the following mode, which means the system already has the image of the clothes of the target person, the vehicle will follow the target person using the color of the clothes.

When the vehicle follows the person, if the person turns fast at a corner, the system will change to the turning mode. Then the vehicle will go forward to a correct crossroad point and turn to the right direction to search the disappearing person, as shown in Figure 7.5.

Besides, if the person does some actions, such as turning to a direction to face a product and waving his/her hand to call the vehicle, the vehicle will enter the human interaction mode. If the person turns to the right or left for a while, the vehicle will make an introduction about the object which the person is interested in, as shown in Figure 7.6. When the person waves his/her hand, the vehicle will move close to the person and wait for a while for the person to put books which the person wants to buy in the basket, as shown in Figure 7.7.

Finally, we also defined a paying area. When the person finishes the shopping, the person can pay for the books there. When the person walks to this area, the vehicle

will also walk to the area and gives some suggestions to the person about the checkout procedure. An illustration of the experimental process is shown in Figure 7.8 and Figure 7.9.

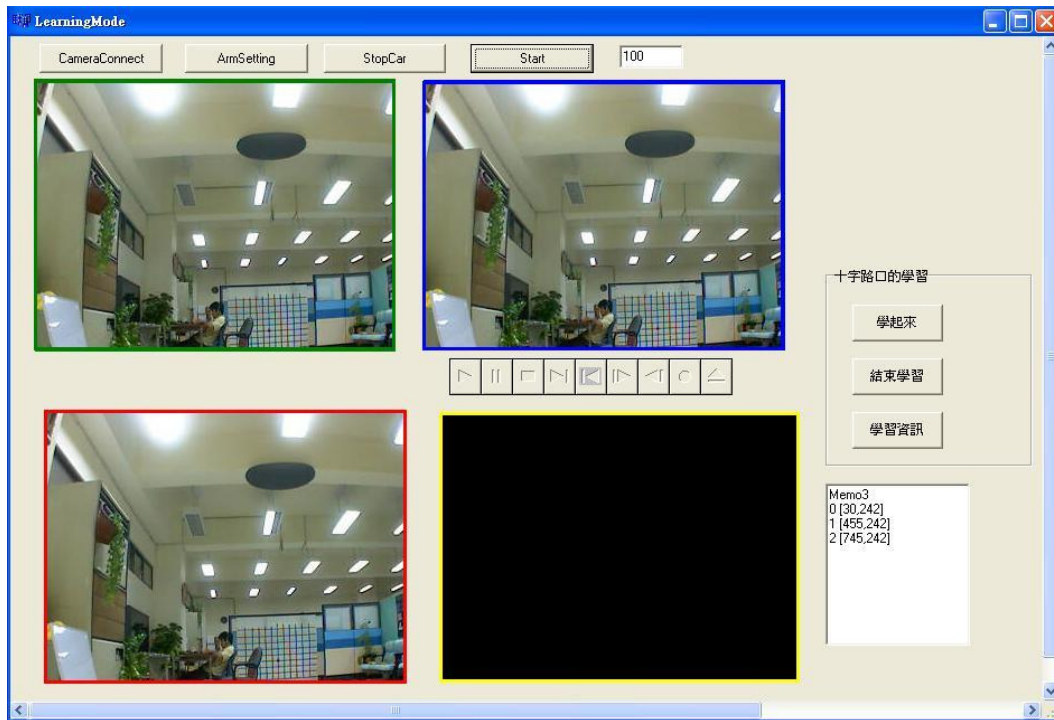
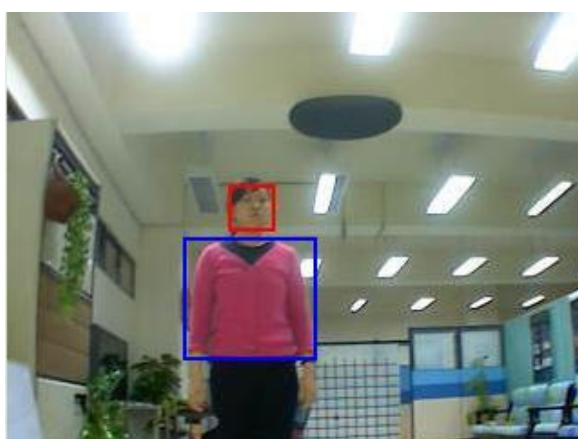


Figure 7.3 An interface of the experiment. The green box shows the image stream and the blue box shows the input image at this moment. The yellow box shows the difference image and the red box shows the output image.



(a)

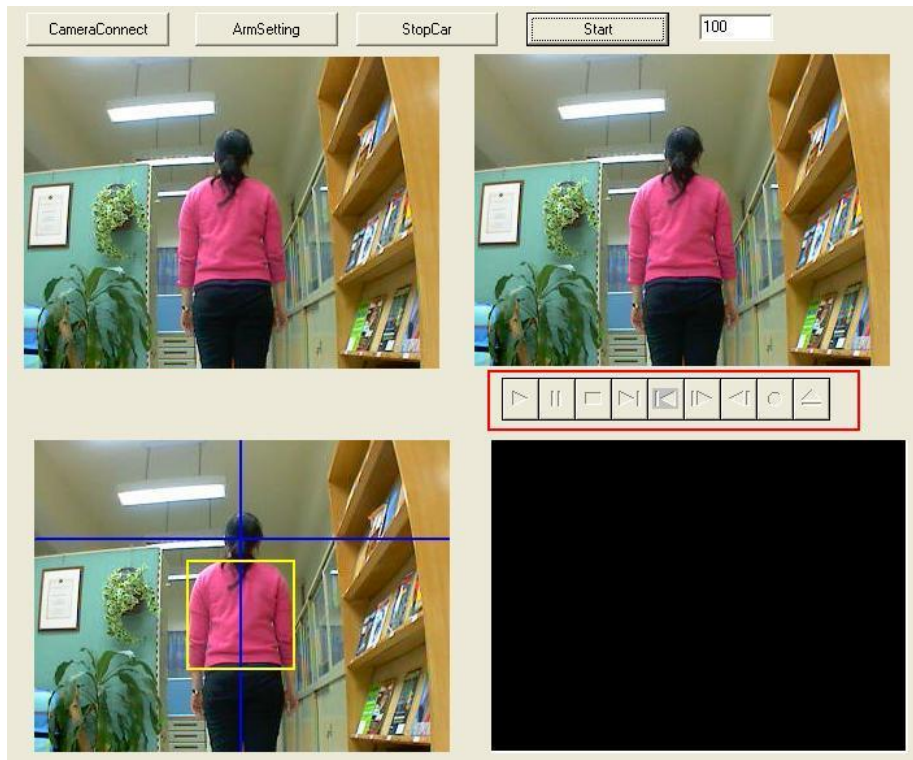


(b)

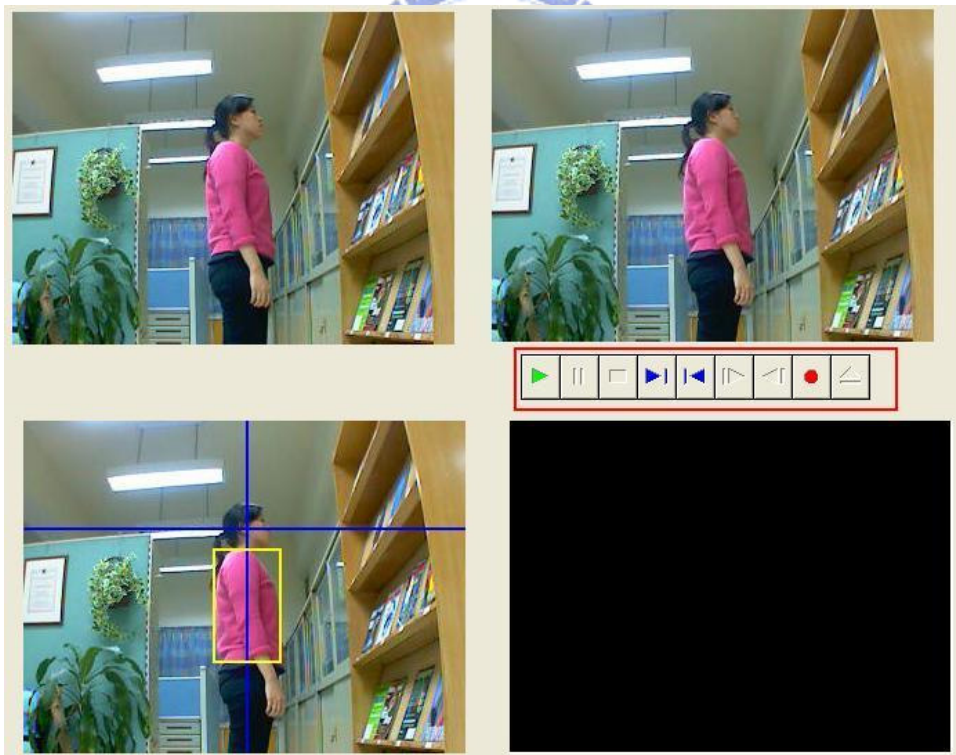
Figure 7.4 An experimental result of face detection and extraction of the clothes. (a) The output image with a detected face region and the extracted clothes region by region growing. (b) The image of the extracted clothes.



Figure 7.5 An experimental result of the person turning fast at a corner. (a) The input image. (b) The position of the vehicle.



(a)



(b)

Figure 7.6 The vehicle makes an introduction about these books. (a) The facing direction of the person is back and the media introduction is off. (b)The person is facing some books and the media introduction is on.

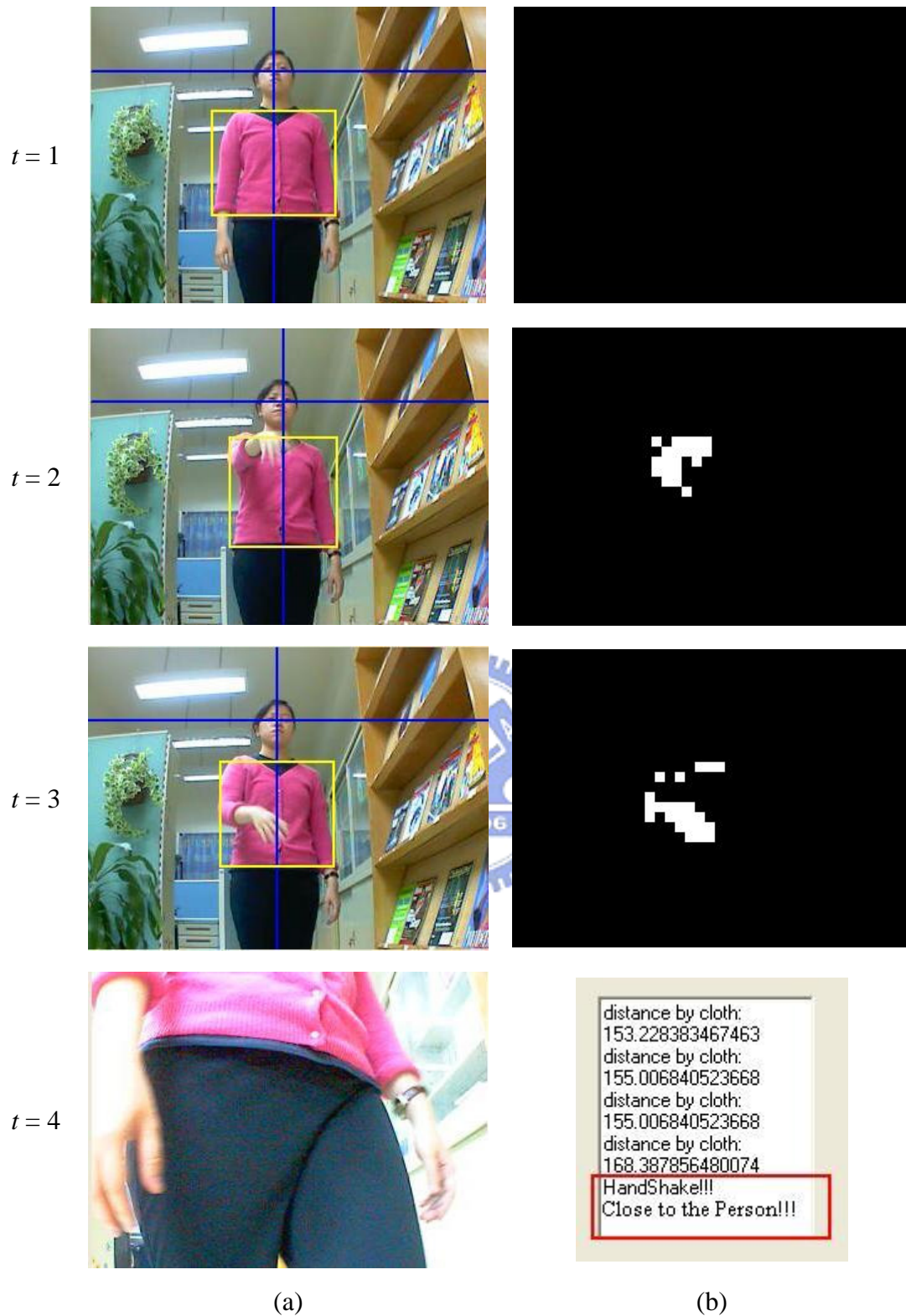


Figure 7.7 An experimental result of detecting the person waving her hand. (a) The input image. (b) The result of motion detection.

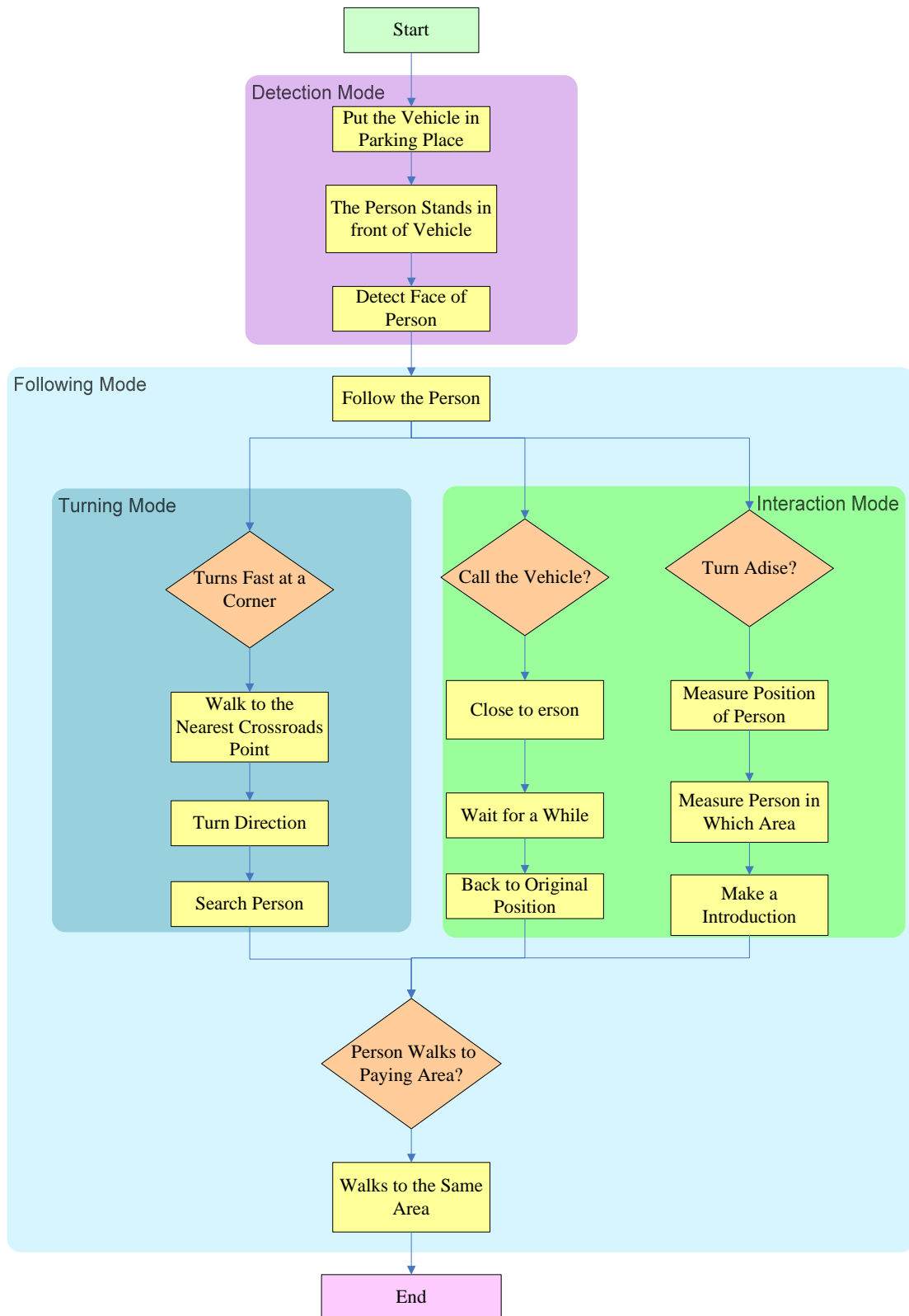


Figure 7.8 An illustration of the experimental process.

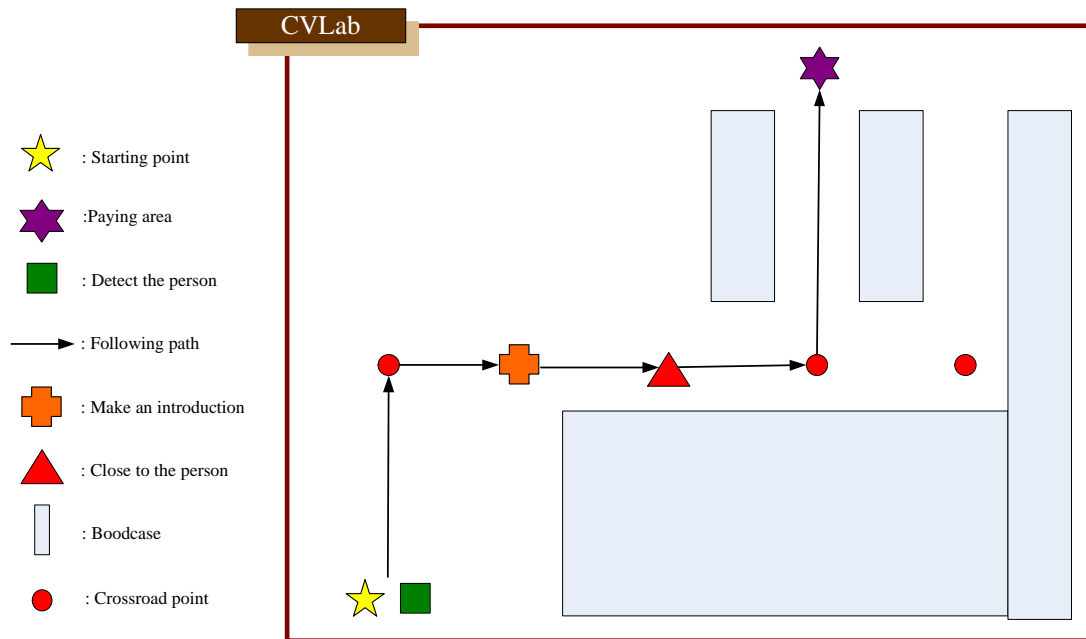


Figure 7.9 An illustration of the learned data and the actual path of following a person in an experiment.

7.3 Discussions



By analyzing the experimental results of guidance, some problems are identified as follows.

- (1) The human following process by the use of the clothes color might incur errors due to other people wearing clothes of the same color. When different people wear clothes of the same color, the system will be confused and cannot decide which person is the target on to follow.
- (2) The color-based face and hair detection may not be suitable for all people because the skin color model was built by the color of the yellow race. Therefore if the person is white or black, the result of face detection might yield errors. In the detection of the facing direction, we use the color of the hair, i.e., the black color, for judging the facing direction of the person. If the hair of the

person is dyed or the person has no hair, the system cannot work.

- (3) The result of detecting motion regions by frame differencing might become worse due to the condition of the floor in the environment. When the floor is not flat, it might cause the vehicle to have big quakes. Then the vehicle will consider the quakes as moving objects in the image and yield an erroneous result of hand movement.

