

## Research on Digit Recognition by Image Processing for Autonomous Mobile Robot

Fengzhi Dai, Daisuke Shimogaki, Yutaka Fujihara

*Department of Control Engineering, Matsue National College of Technology*  
(Tel : 81-852-365213; Fax : 81-852-365213)  
(daifz@matsue-ct.jp)

**Abstract:** In this paper, the autonomous mobile robot is proposed by improving the electric wheelchair for elderly people. The research aims at automatically moving the robot to the destination by image processing. In this paper, the digit of the room number or the limited speed is set as the traffic signal (such as 30, which means that the limited speed is 30km/h) and the robot will recognize it automatically and move to the expected room or run at the speed of it. The recognition of digit needs the technology of segmentation to the image.

**Keywords:** Autonomous mobile robot, Image processing, Image segmentation, Pattern recognition.

### I. INTRODUCTION

In recent years, as for the robot which had spread mainly for production uses of the industrial product, begins to face to various uses from manufacturing industry to non-manufacturer, to social enterprise support and life support. Also the interest of it rises rapidly from society and the company. For example, the recent practical use in Japan are for family life such as the field of meal support or home security such as the field of medical care welfare, and for danger work, for the guard and guidance such as the rehabilitation support, the power line repairing work, and so on.

It is expected that there is a big market if the robot helping system (independence support, care support, rehabilitation support, etc.) is developed and it may contribute to the world. For the reclamation of this promising market, it is hoped that Japan leads to the world in the domain of the robot technology. However there are some problems about the independent motion of the visually handicapped person:

The visually handicapped persons can come and go freely in the place where they usually visit, but they can't go to other place alone. Usually they need a helper to walk with or they walk independently with the white stick, or with the guide dog. However, there are the following problems for these independent walks [1].

(1) There is a big border for both the helper and the handicapped person. In particular the mental burden of the handicapped person is bigger.

(2) The handicapped person should be trained to be able to walk with the white stick safely. However, the

white stick is used to mainly acquire information close to the road surface and is insufficient to sense the space situation.

(3) The security of the walk with the guide dog is satisfied. But the dog can not understand the complex command of the people.

Therefore, in this paper, a welfare robot to assist to enter or go out of the house for a handicapped person is proposed. The image processing (as the eyes of the robot) and pattern recognition is studied.

The main study of the paper is to process the digit by image segmentation, and then recognize it by the template matching method.

For example, for the visually handicapped person, it is difficult to find the target room number in a building. If the mobile robot can recognize the room number automatically, it is very useful for the visually handicapped person.

### II. Specifications of the Mobile Robot

The system is treated as the wheelchair for physically handicapped people based on the Japanese Road Traffic Law. And the driver's license is unnecessary. Fig.1(a) is the electric wheelchair and Fig.1(b) is the mobile robot developed from Fig.1(a). The follows are specifications [2].

Dimensions:	1170×660×1060[mm]
Weight:	79kg
Forward speed:	2 ~ 6km/h
Reverse speed:	2km/h

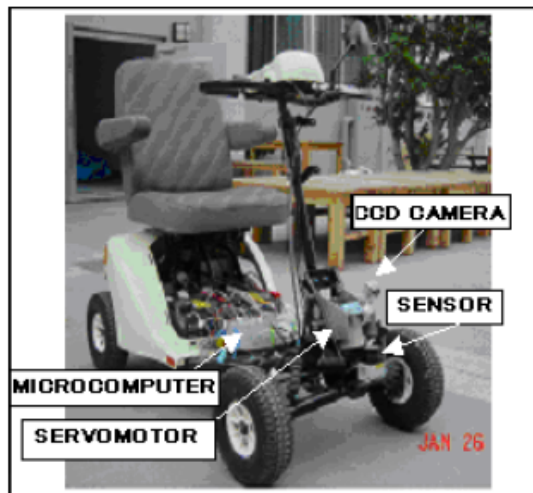
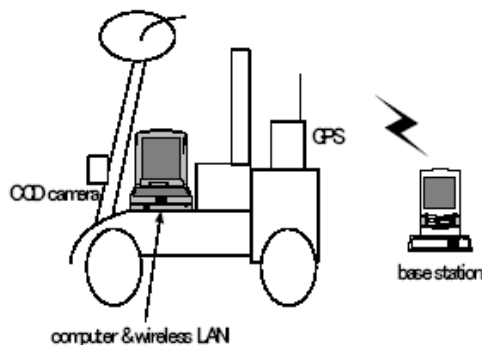
Drive system: Direct drive system with rear-wheel drive

Braking system: Electromagnetic brake that uses motor dynamic braking

Control system: Microcomputer variable speed electronic control unit for accelerator lever



(a) Electric Wheelchair



(b) Mobile Robot

Fig.1. Specifications of the mobile robot

### III. The Structure of the System

#### 1. The structure of the system

The structure of the system is expressed in Fig.2. GPS sensor and the camera send information to the computer that mounted on the robot and do image processing. It calculates the current and next state of the robot, and send it to the microcomputer (H8/3048). The microcomputer controls servomotors and operates the movement of the robot [3].

The base station uses a wireless LAN and it can terminate the movement of the robot when emergency. In addition, the base station knows the current position of the robot by getting the images sent from the robot.

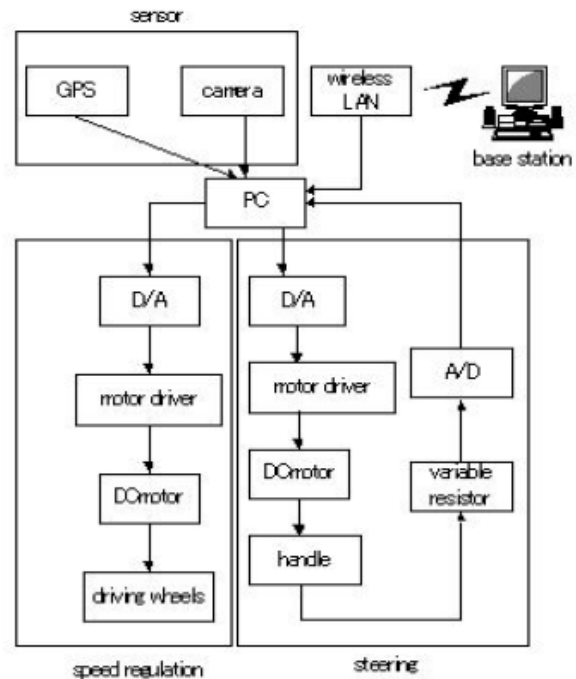


Fig.2. The structure of the system

#### 2. The flowchart of image processing

- (1) Robot takes the image from the camera
- (2) Binarizing the image
- (3) Do segmentation to the binary image and specify the number of the letters
- (4) Use template matching method to recognize the segmented digits (or letters) one by one
- (5) Understand the room number by combination of the recognized digits

#### IV. EXPERIMENT

There are four images in Fig.3, and Fig.3(a) is the original image sent from the camera directly.

Fig.3(b) regulates the threshold of binarization so that the digits look white. Fig.3(c) regulates the threshold of binarization to make the background black. Fig.3(d) is the result of the logic AND operation to the pixels between Fig.3(b) and Fig.3(c). The letters can be clearly extracted [4].

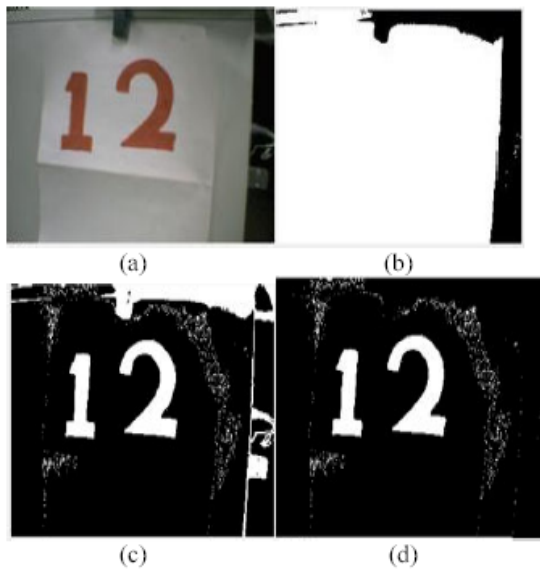


Fig.3. Image processing

##### 1. The flow chart of the program

Fig.4 gives the flowchart of the program and the meanings of functions are [5]:

ready\_image: whether the image data are prepared or not

file\_open: Open the template file

char\_cut: Segmentation (calculate the character's width, decide each letter's domain, and calculate the center of gravity of each letter)

do\_reco: Template matching (recognize the digit or letter one by one by template matching method)

##### 2. Segmentation

For recognizing the digits or letters, the image segmentation is important [6].

Fig.5 gives the example of the digit segmentation. It calculates the values of the pixels by searching the X-

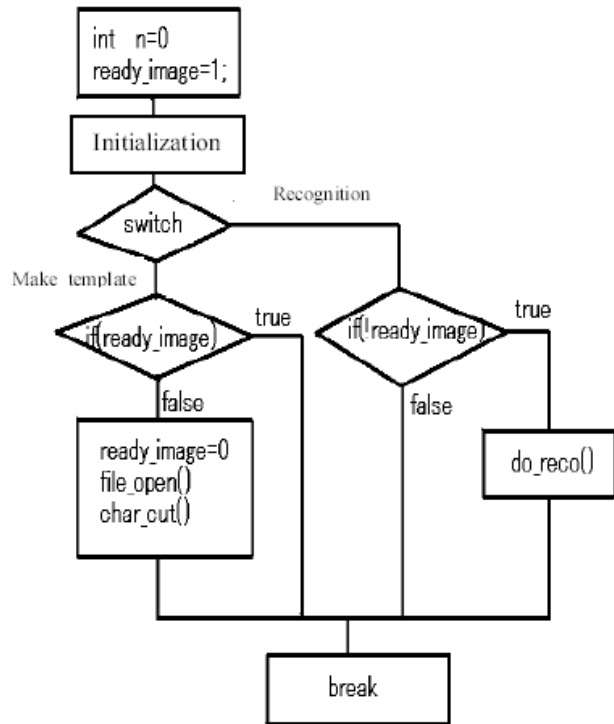


Fig.4. The flow chart

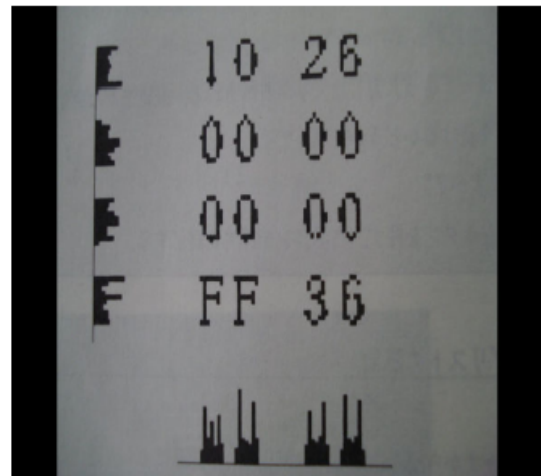


Fig.5. Image segmentation

axis and Y-axis to find the neighboring distribution of the digits (look for the break of the letter).

For each line (row and column) where there is a letter, it appears that the values of pixels is not 0. If there are blanks, it means that they are the space between one digit to another. Thus it gives the position of the break of the digits. In Fig.5, there are four rows and four columns of digits.

### 3. Experiment

One of the experiments is expressed in Fig.6, which is to segment the image and then recognize each letter one by one. Since the image has many letters within multi-lines, they should be firstly separated one by one.

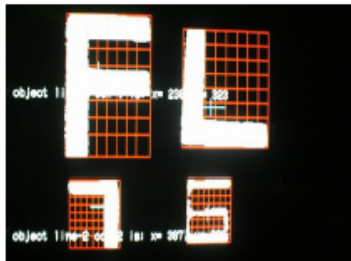


Fig.6. Multi-line characters

After segmentation, each digit or letter in the image can be located by their coordinate of center of gravity. Each letter's feature parameters are gotten by the start and end points in X-axis and Y-axis, the height and width of each letter.

The feature vector of each letter is extracted and then matches it to the templates. By template matching method [7], each digit or letter can be recognized one by one, and then the whole meaning of the image can be understood by combination of the meaning of each letter.

### V. CONCLUSION

In this paper, the autonomous mobile robot is developed from the electric wheelchair for elderly people. The research is to automatically control the robot to the destination by image processing.

In the experiment, the digit of the room number (e.g., the number 105 means the Room 105) or the traffic signal of the limited speed (such as 30, which means that the limited speed is 30km/h) is set. After taken by

the camera that mounted on the mobile robot, it will recognize the image automatically and move to the expected room or run at the speed of it.

In this paper, for image processing and pattern recognition, image segmentation is used. Image segmentation can decrease the number of templates. For example, generally each room number needs a template to match it. Thus if a building has 100 rooms, then the system needs 100 templates, each of which for one room number. But by image segmentation, the number of templates can be defined only to 10 (match the digit 0 to 9). Each digit can be recognized by matching the feature vector to these 10 templates.

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