신경망 학습에 의한 영상처리 네비게이션

Visual Navigation by Neural Network Learning

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ABSTRACT

It has been integrated into several navigation systems. This paper shows that system recognizes difficult indoor roads and open area without any specific mark such as painted guide line or tape. In this method, Robot navigates with visual sensors, which uses visual information to navigate itself along the road. An Artificial Neural Network System was used to decide where to move. It is designed with USB web camera as visual sensor.

Keywords : Vision, Navigation, Neural Network, Mobile Robot, AMR

Ⅰ. Introduction

It has been developed that AMR (Autonomous Mobile Robot) navigates on the road with non-visual sensors as like ultrasonic sensor. It has been also researched in many methods that the algorithm avoids obstacles and constructs road map itself with distance data to the wall or obstacles using ultrasonic sensor. But, there are difficulties to recognize objects with only distance data and then it needs visual sensor to acquire visual data which human can recognize comfortable with. Human don't use distance data to avoid or recognize obstacles, but visual information. Therefore it is needed to research on navigation system using visual information.

However, it is necessary to control the direction and internal camera parameters of the video sensor actively in order to have them attend to the portion of the world that is to be studied. It also has the weakness of noise from circumstance. So it is required that pre-process to overcome these weaknesses and there are still remained a lot of problems now.

In this paper, I will present an vision-based process for AMR(Autonomous Mobile Robot) that is able to navigate on the indoor road with simple computation. We used a single USB-type web camera to construct smaller and cheaper navigation system instead of expensive CCD camera which was usually applied to navigation system.

In this research, we apply a preprocessing

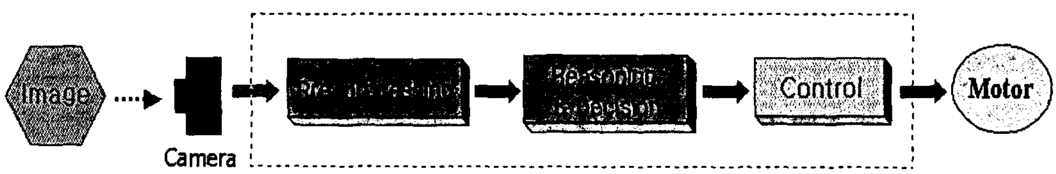


Figure 1. The block diagram of navigation system.

to reduce noise and computation which is the one of the most significant problem in the image processing field. To make real-time system, we have to diminish computations as much as possible. The block diagram of navigation system is shown in Figure 1.

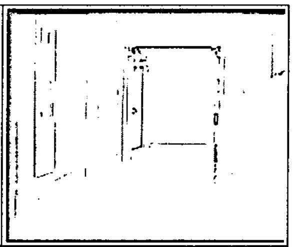
II. Preprocessing

Some pre-processors are used in our system as like noise reduction, edge extraction, extraction of straight line, minimizing computation time.

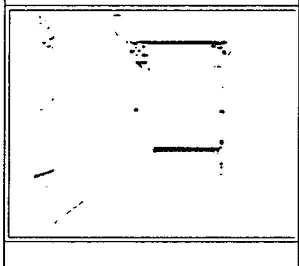
First of all, we need to extract road boundaries from input images. There are lots of methods to detect edges such as Laplacian, Prewitt, Sobel, directional detection, and etc. Figure 2 shows results of some methods.

All of these methods are tested, but we have empirically found that the best result is when edge detection is done with Sobel row-component detection. Row component and column component can be extracted separately in Sobel edge detection.

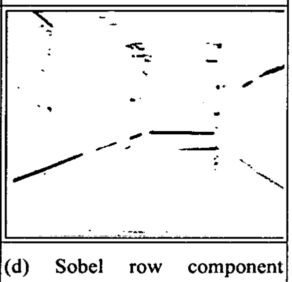
(a) Original Image of corridor



(b) Laplacian Edge detection.



(c) Hierarchical row mask detection. Difficult to find out road boundary.



(d) Sobel row component detection. This method is appropriate to detect road boundaries.

Figure 2. Results of Some extraction methods

We can take some advantages when we use Sobel edge extraction. Especially, it has significant effect of noise reduction. For example, one of the most serious problem was sunlight through window and reflection of fluorescent lights on the waxed floor. It makes a specific shape which could be recognized as a boundary of road or obstacles, so it makes difficult. Applying Sobel row-component edge detection, we can reduce these noises greatly and acquire suitable images to recognize road boundaries as you see in figure 2 (d).

III. Recognize Road Surface

3.1 Hough Transformation

Hough transformation was used to find out road boundaries and slope of them from image that was already pre-processed in this paper. Hough transformation is known as a method to extract the straight line in the image. Hough transformation can detect the slope of line with high accuracy. Furthermore, Hough transformation can detect the disconnected straight lines such as a dotted lines. Let us consider binary image on the x-y plane and u-v plane shown in Figure.3

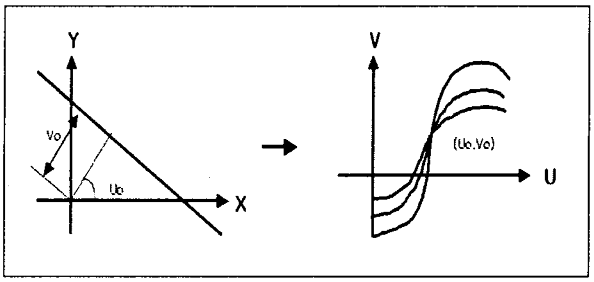


Figure 3. Hough Transformation. Transform from X-Y plane to U-V plane.

If a pixel exists on the x-y plane, draw a curve expressed in equation (1) on the u-v plane.

$$Vc = xcosuc + ysinuc \qquad (1)$$

where, x and y are coordinates of the pixel on the x-y plane. This process is repeated the number of pixels. When pixels more than one are exist on a line on the x-y plane, curves on the u-v plane correspond to those pixels cross each other on a point.

Therefore, the intercept of line and slope of a straight line can be detected by Hough transformation.

3.2 Visual Control System

The road image doesn't tend to change suddenly. We assume that the road boundary is linear in near section. Even though the road image has curvature lines, the near section of the road boundaries locate on the left and the right end sides of input image, can be regarded as linear line. So we found out vanishing point which was defined from extending both road boundary lines in the near section of the road.

We can figure out road boundary lines with Hough transformation. More than one line is found from each side. There are needed to find center of each vanishing points, since some vanishing points has detected. After getting centeroid of vanishing points, we also define a current heading point of robot as an objective line. The objective line always locates on the middle of horizon in the input image. The deviation of center vanishing point and the number of vertical vanishing points on each side present the relative position and orientation of the robot on the road. Then the robot is needed to try to move its center, objective line, to vanishing point for making robot parallel to the road. It is described in figure 4.

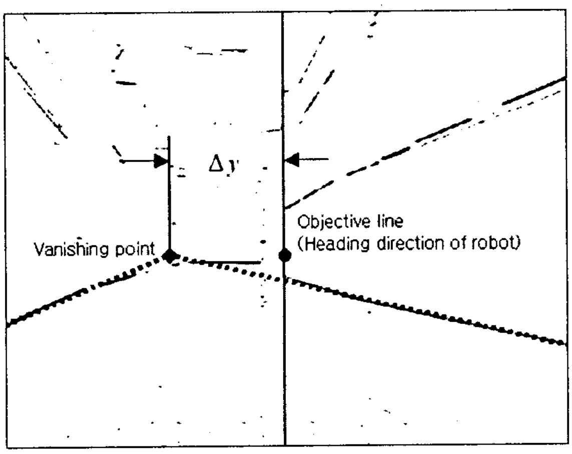


Figure 4. It shows the deviation between vanishing point and objective line

The deviation (Δy)of the vanishing point and the number of vertical vanishing points are used as input data of the neural network. As you see figure 5. The outputs of network will be steering value to the each DC-motor. These values decide where it should move and how fast it can move around.

Desired values, learning data, are made previously in table of standard navigation patterns and train the robot with that. The neural network is consist of 3 input nodes, 10 hidden nodes, and 2 output nodes. Back-propagation algorithm was used to learn data. The neural network learns the relationship between the steering angle and the deviation of vanishing point and the number of vanishing points. The neural network module is described in figure 5.

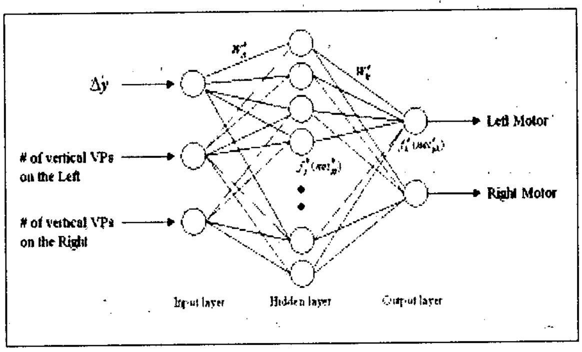


Figure 5. Back propagation network module.

IV. System Architecture

In this paper, we used sub-notebook computer with Pentium III-600Mhz as a processor. We used USB type PC-camera in order to construct cheaper and smaller mobile robot system in this research. Input image size was set to 320*240 in consider to computation time.

The AMR has 8 ultrasonic sensors in total, but those were used only to stop movement for urgent situation because visual information's limitation still exists. We set up the system to stop navigation when sudden obstacles were detected in range of 10 Cm. The navigation system is shown in figure 6.

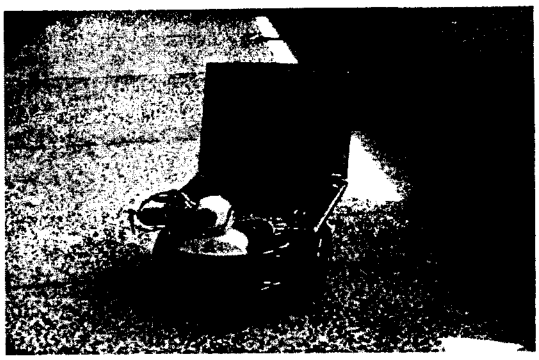
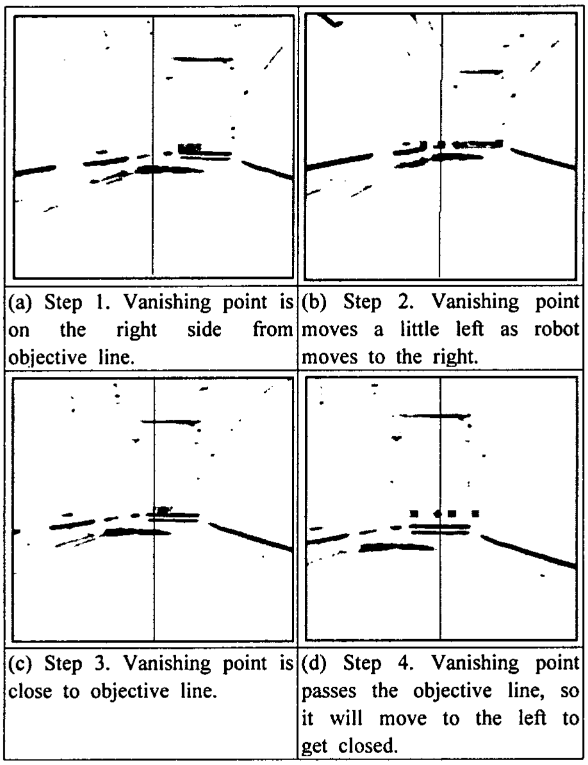


Figure 6. Autonomous Mobile Robot.

V. Result

The proposed method in this paper showed a good performance not only on the a little curved road but also on the straight road. Even though there are some noises as like sunlight and shades during the test, satisfied results are obtained. However, it didn't work well when there are strong reflections of sunlight as much as eyes are dazzled by the reflection.

This method was implemented well without complex geometrical mathematics. Results of processing on the slightly curved corridor are shown in Fig 7.



(a) Step 1. Vanishing point is on the right side from objective line.

(b) Step 2. Vanishing point moves a little left as robot moves to the right.

(c) Step 3. Vanishing point is close to objective line.

(d) Step 4. Vanishing point passes the objective line, so it will move to the left to get closed.

Figure 7. It shows the results in sequence as it moves on the road .

VI. Conclusion

The mobile robot navigates itself on the road with visual information that has non-linear relationship with motor control signal. This research shows that the neural network can be learned with combination of visual data and distance data. This approach is meaningful that it does not need complex computation and can be implemented easily.

However, it can not move fast since it still needs time to compute for image processing. It is needed to improve more image processing speed for fast movement.

Most of all, it didn't perform perfectly when it crossed intersection and wide open space was appeared. So we need to research more on these problems.

Acknowledgement

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VII. Reference

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