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An Auto-Driving System by Interactive Driving Knowledge Acquisition

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Abstract: An auto-driving system should be easy to treat for senior citizens who use a welfare cart. In this paper, we propose a system that acquires sets of landmark's information and action rules from a user as driving knowledge. The system drives a cart to a destination by using the knowledge. Results of experiment show the effectiveness of the system.

Keywords: Driving knowledge, Welfare electric cart, Intelligent controller, Predictive fuzzy control

1. Introduction

Driving operation is difficult and tiresome for senior citizens and physically handicapped persons who use a welfare electric cart. Therefore, an auto-driving system that can treat without difficulty is necessary to reduce the stress of their driving operations. On the other hand, the intelligent driving system [1] with the predictive fuzzy controller has been developed for a welfare cart. This system drives a cart flexibly to a strategy target that is set by a user. However, this system doesn't have driving knowledge that is necessary to reach a user's destinations. It means that users, who have the driving knowledge, must keep setting strategy targets till reaching there. If an auto-driving system that is easy to deal with for them is realized, it is necessary that the system acquires the driving knowledge from a user.

In this paper, we develop an auto-driving system that acquires the driving knowledge from a user by an interactive user interface and drives a cart by using the knowledge.

2. Driving Knowledge

Driving knowledge is necessary for drivers to arrive at a destination. Human drives to a destination by using information of a place and a car's course at there. In this paper, the driving knowledge is defined as sets of landmark's information (place's information) and action rules. It means that the driving knowledge is common knowledge of the system and users. Therefore, users can provide the driving knowledge for the system easily. A user can ride on a welfare cart without incongruity and uneasiness, because the system drives a cart by using the user's driving knowledge.

2.1 Landmark's Information

In this paper, a landmark is used as common information of a place that can be recognized both by users and by the system. Landmark's information consists of world coordinates and template images, which is used for pattern matching. Users can provide a template image as the landmark's information from the image obtained by the camera which is set in front of the cart.

2.2 Action Rule

An action rule is description of a car's movement at a place. In this paper, users can provide five action rules as follows about a landmark.

"Go straight"
"Approach"
"Pass"
"Turn to the left"
"Turn to the right"

The system sets strategy targets and drives a cart by using these action rules.

3. System Configuration

Fig.1 shows the hardware construction of the auto-driving system that acquires the driving knowledge by an interactive user interface. The system is constructed by two personal computers (the driving knowledge processor and the intelligent controller), a camera that is set in front of the cart, and a touch panel display for a user interface. The system's configuration is shown in Fig.2. The driving knowledge processor acquires the driving knowledge from a user by using a touch panel, and sets strategy targets that used the knowledge to reach the destination. The intelligent controller drives flexibly to a strategy target.

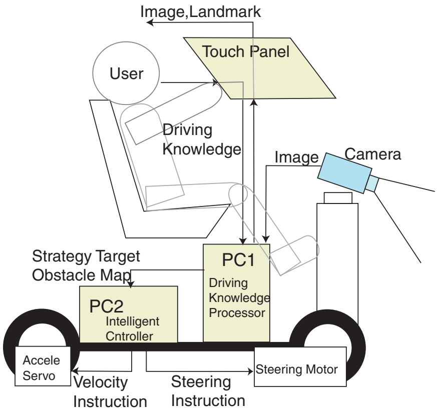

Fig. 1: Hardware construction of the auto-driving system

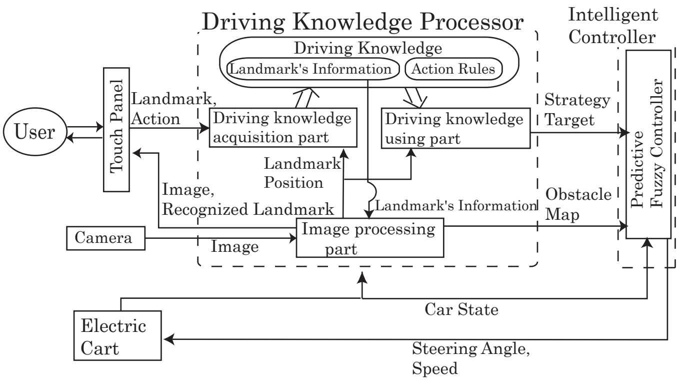

Fig. 2: System configuration

3.1 Driving Knowledge Processor

The driving knowledge processor is configured by "the driving knowledge acquisition part", "the image processing part", and "the driving knowledge using part".

Driving knowledge acquisition part The function of this part is acquisition of the driving knowledge from a user. The contents of touch panel display that is shown in Fig.3 is used as the interactive user interface for acquisition of the driving knowledge.

·Acquisition of landmark's information ··· Landmark's information is acquired by this part while a user drives the manual operation. A user specifies a range of a template's image by using the touch panel display from the image obtained by the camera, and gives a name to the template. The system calculates world coordinates of the landmark from the relative position of it, and acquires a template and coordinates as a landmark's information.

·Acquisition of action rule ··· The system recognizes a landmark by using acquired information, and shows it to a user. The user instructs about the action that is the cart's movement at the landmark to the system. The system acquires the action rule from the user's instruction.

Fig. 3: Example of touch panel display for the interactive user interface

Image processing part The functions of this part are recognition of landmarks for obtaining relative position, and recognition of obstacle objects for making obstacle maps.

The method of landmark's recognition is pattern matching [2], which use landmark's information that is in sight of the camera. Relative positions of landmarks are obtained by inverse perspective transform [3].

Recognition of obstacle objects uses black line that is on a passage's wall. This line is prepared in hospitals and welfare facilities too. Therefore, it is effective to recognize the line for auto-driving indoors. The method of black line recognition is a thresholding method. Connected regions obtained by the thresholding method are judged to whether it is black line or not by using areas, lengths and ratios of length to width.

Driving knowledge using part This part sets strategy targets for the intelligent controller by using the driving knowledge that is acquired from a user. Input of this part is action rules and landmark's coordinates. Output is strategy targets, which are set for the intelligent controller to reach at a destination. The example of strategy targets that are set by using landmark's relative position and action rules is shown in Fig.4. "Go straight" sets a strategy target on a place that is the distance of a traveling direction to a landmark. "Approach" sets it at near a landmark. "Pass" sets it to the distant traveling direction to a landmark. "Turn to the left (right)" sets it on the position in the direction that intersects with the traveling direction at a landmark. Basically, the cart moves in parallel to the wall, and stops.

3.2 Intelligent Controller

Fig.5 shows the structure of intelligent controller. The intelligent controller use predictive fuzzy control [4] that flexibly drives a cart to a provided strategy target in consideration of the characteristic of the four-wheeled vehicle [5]. This controller is constructed by three parts, which are based on expert driver's experiences.

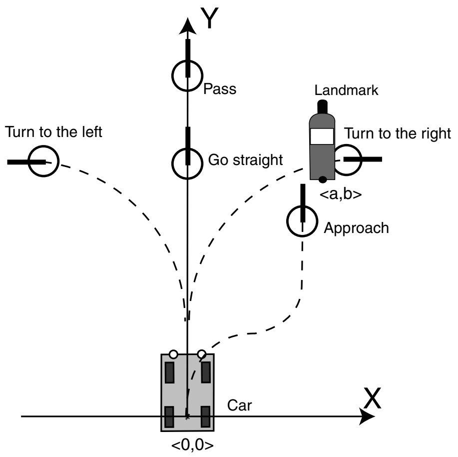

Fig. 4: Strategy target calculated from driving knowledge

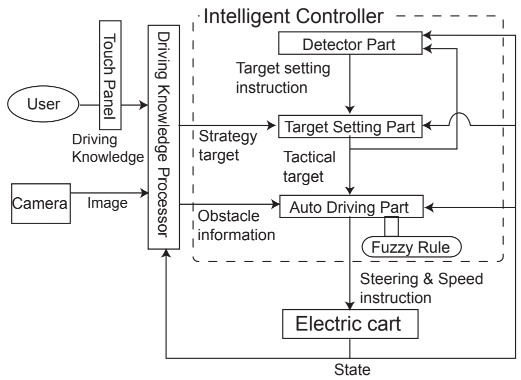

Fig. 5: Structure of the intelligent controller

4. Experiment

Experiment uses a welfare electric cart that equips the supposed system. Contents of experiment are acquisition of a driving knowledge, and auto-driving by using the driving knowledge.

4.1 Contents of Experiment

The experimental apparatus of this experiment is the welfare cart on the market that equips personal computers, a camera, and a touch panel. Fig.6 shows an appearance of the cart. The environment of experiment is shown in Fig.7. Contents of experiment are as follows.

Experiment I:

Driving from A$(0m, -5m, 90°)$ to B$(-4m, 0m, 180°)$

Experiment II:

Driving from B$(-4m, 0m, 0°)$ to C$(4m, 0.5m, 0°)$

4.2 Driving Knowledge Acquisition

Acquisition of landmark's information

First, the system acquired landmark's information as follows while a user was driving the manual operation.

· The extinguisher:$(2.5m, 1m)$ and Fig.8(a)
· The intersection:$(0m, 0m)$ and Fig.8(b)
· The door$(5m, 1m)$ and Fig.8(c)

Fig. 6: Electric cart with the developed auto-driving system

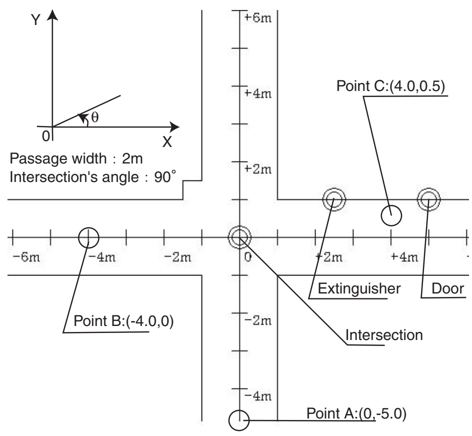

Fig. 7: Experiment environment

Coordinates of landmark are dealt with on the grid of 50cm×50cm.

Acquisition of action rules

Next, the system acquired action rules as follows.

Experiment I

· Turn to the left at the intersection$(0m, 0m)$

Experiment II

· Go straight to the extinguisher$(2.5m, 1m)$
· Approach the door$(5m, 1m)$

4.3 Driving the Cart by Using Driving Knowledge

Fig.10 shows results of the driving in experiment I and experiment II.

The result of experiment I is shown below. First, the image processing part recognized the landmark "Intersection$(0m, 0m)$" in the starting point$(0m, -5m)$. Next, the driving knowledge using part set the strategy target by using the action rule "Turn to the left at the intersection". Finally, the intelligent controller drove to the strategy target automatically, and the cart arrived to be near the destination$(-4m, 0m, 180°)$.

The result of experiment II is shown below. First, the image processing part recognized landmarks "The

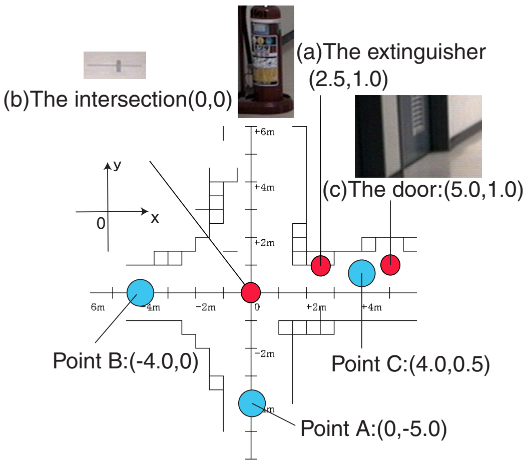

Fig. 8: Acquired driving knowledge and obstacle map

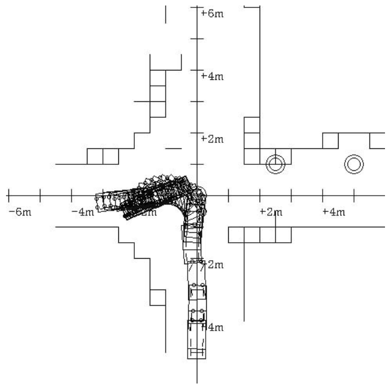

Fig. 9: Result of auto-driving I

extinguisher($2.5m, 1m$)" and "The door($5m, 1m$)". Next, the driving knowledge using part set strategy targets by using action rules that are "Go straight to the extinguisher " and "Approach the door". Finally, the intelligent controller drove to strategy targets automatically, and the cart arrived to be near the destination($4m, 0.5m, 0°$).

4.4 Consideration

Fig.11 shows strategy targets that are provided to the intelligent controller by the driving knowledge processor in experiment II. From results of experiment, it was proved that system can acquire the driving knowledge from a user by the interactive user interface, can set strategy targets by using the knowledge, and can drive the cart to the user's destination. In this experiment, the number of the landmark and action rules used was few. However, the system can drive the cart a longer distance, if there are more landmarks and action rules.

5. Conclusion

In this paper, the driving knowledge is defined as sets of landmark's information and action rules. That makes easy for system to acquire the driving knowledge as common knowledge of both the system and a user. Results of experiment proved that the proposed system

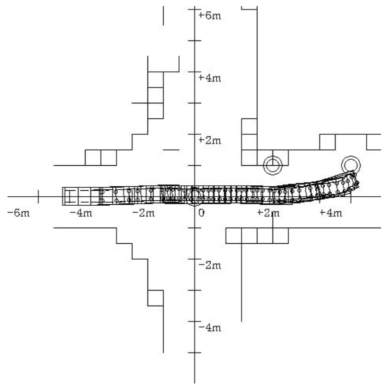

Fig. 10: Result of auto-driving II

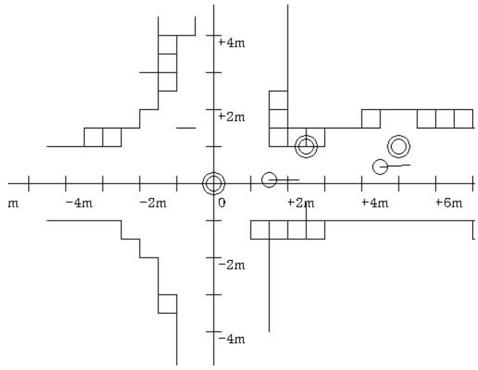

Fig. 11: Strategy targets of experiment II

can acquire the driving knowledge easily from a user by using the interactive user interface and can drive the cart flexibly by using the driving knowledge.

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