An Intelligent Controller Based on Fuzzy Target Acquired by Reinforcment-learning

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Abstract: A co-operating system that operates it by human and computer becomes important. In this paper, an intelligent control system based on a fuzzy target is proposed. This fuzzy target is obtained by the reinforced learning. Human easily understands response to the change in the circumstance of this intelligent control system. The simulation results showed that this system was suitable in cooperation with human.

Keywords: Intelligent Control, Fuzzy Target, Reinforcment-learning, Vehicle Operation, Fuzzy control.

1. INTRODUCTION

”Reinforcement learning” [1] is a learning method to imitate the mechanism that the trial and error do learning of living creatures of the success. As a result, the action knowledge can be searched and be acquired doing neither the situation in which the object is put nor the characteristic of it in the programming. It was a little to use the huge knowledge that it was general that the knowledge that was the current learning used only one value of the maximum value etc. in the situation, and had obtained as a suboptimal solution.

In this paper, it proposes the method of using the knowledge of the target value of the learning by the reinforcement learning as it is as ”Fuzzy target”, and effectiveness is evaluated by the simulation.

2. FPSP-REINFORCEMENT LEARNING

The contingency fee after the action whether PSP-learning [3] is how many step floor goes back at each stage and it distributes it. This is often applied to a discrete state transition. Here, it applies to the movement control of the car that is the control of the state of a continuous value. The accomplishment of a goal degree of each step is fuzzy evaluated and fPSP-learning used to reflect the reward is used. Figure 1 shows this fPSP-learning Ki this concept. When the target is given to the intelligent control part of the subordinate position, the regulating system about which it thinks here outputs an appropriate operation instruction. Therefore, the action knowledge is described in ”IF $<$ condition:c_n $>$ THEN$<$ target:T_n $>$” by rule (S-table) that consists of the pair of the state of the becoming it form and the target. The control beginning from a certain initial value is called an episode. In each step n, The most appropriate target(or random target) T_n to point c_n(discrete value) of state p_n(continuous vale) is selected based on the action knowledge. It reflects it in the rule of N piece used by the episode while decreasing at the rate of □ when reaching the final target by the number of steps that requires reward R. On the way, the reward (punishment) is assumed to be negative when it is not possible to run and it becomes it.

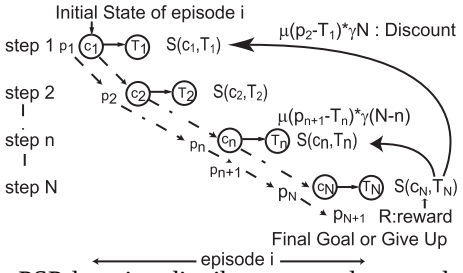

Fig. 1 PSP-learning distributes reward or penalty to the previous fired rules

3. INTELLIGENT CONTROLLER BASED ON FUZZY TARGET

3.1 Fuzzy target

A fuzzy target is a fuzzy set composed of alternatives of the target and the membership value. ”Membership value of alternatives” is a satisfaction rating of the control purpose when each alternatives is selected. The value grows as the control purpose is achieved. This member ship value is regularized from 0 to 1 and treated. The total set of the target is assumed the R. Fuzzy target $\widetilde{T_n}$ assumed to be a control target can be defined by the next expression in state c_n now.

$$\widetilde{T_n} = \int_R \square_{\widetilde{T_n}}(r_i)/r_i, \qquad r_i \in R. \tag{1}$$

Here, the membership value of alternatives r_i and n are the numbers of steps in alternatives of the control target that composes fuzzy target $\widetilde{T_n}$ and $\square_{\widetilde{T_n}}(r_i)$ in r_i. The concept of goal setting fuzzy knowledge that is the group of fuzzy target $\widetilde{T_n}$ in state c_n is shown in figure 2 now.

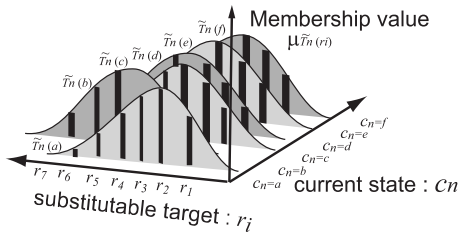

Fig. 2 Target setting fuzzy knowleadge.

3.2 Intelligent controller

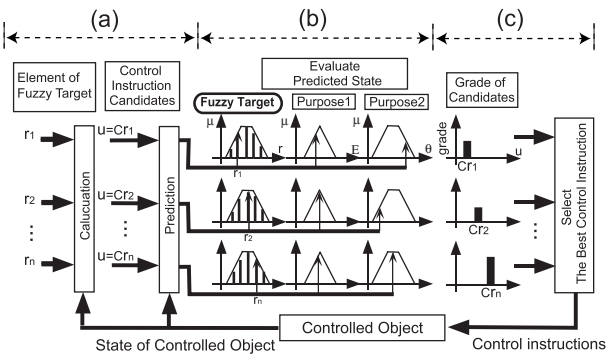

Fig. 3 An intelligent controller based on fuzzy target.

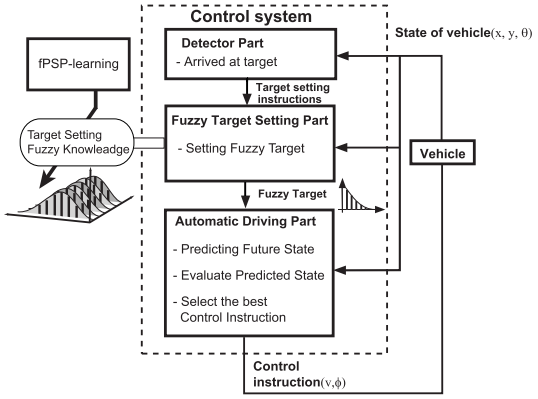

Fig. 4 Outline of the hierarchical intelligent controller.

Figure 3 shows the outline of the intelligent control system that uses a fuzzy target. This control system will consist of three parts of the decision of a prospect of the state and an evaluation of the state and the best control instruction of (c) of the (b) future with the calculation of the operation instruction candidate when (a) each alternatives is assumed aiming in the future.

(a)Then, fuzzy goal $\widetilde{T_n}$ in state c_n is set by using goal setting fuzzy knowledge in each state now. The state will be foreseen the calculation of operation instruction candidate $u = Cr_i$ when each alternatives r_i of the fuzzy target $\widetilde{T_n}$ is assumed aiming in the future. These are done to all alternatives in a fuzzy target in parallel.

(b)Then, the achievement level and the restriction fulfillment level of the membership value and alternatives of each alternatives will be fuzzy evaluated to the state overall in the foreseen future, and the evaluation to each operation instruction candidate is calculated.

(c)Then, the operation instruction whose evaluation is the highest in all the operation instruction candidates is selected, and it gives it to the object system. In this intelligent control, it has a characteristic model of controlled object and surrounding situation, and an appropriate control instruction to be getatable is output to the target in real time by giving the target (single, fuzzy amount).

4. APPLICATION AND SIMULATION TO CAR DRIVING

In this chapter, the intelligent control system that uses a fuzzy target is applied to the movement control of the four-wheeled vehicle, and the correspondence of the situation to the change by the arrangement of the obstacle is considered. Figure 4 shows the outline of the hierarchical, intelligent control system that does the movement control by using the fuzzy target taken out of goal setting fuzzy knowledge based on the state now. This system consists of three hierarchies (situation Monitoring Department, the fuzzy target setting part, and the automatic driving part) in addition to the goal setting fuzzy knowledge acquisition part.

In this paper, the effectiveness of the intelligent control machine that uses a fuzzy target is verified by the simulation that changes the situation. Goal setting fuzzy knowledge is acquired in the situation in which the obstacle is not arranged. The fuzzy goal in the state is set by using this knowledge now, and it uses it in the intelligent control system that constructs it. The situation of the external world is changed by arranging the obstacle and it simulates it.

5. CONCLUSION

This paper proposed the intelligent control system that had used the target knowledge in the state as "Fuzzy target" now at the time of having acquired it by reinforced learning. This "Fuzzy target" can be effectively used by not only the maximum value of the knowledge acquired by reinforced learning but also using knowledge with the satisfaction value less than it for the definition. It is acquired in consideration of the characteristic of the object system, and the shape can be changed corresponding to the situation change in the external world, it proposes an appropriate target, and this target can be executed. The simulation shows the following. Flexible correspondence is possible without searching for the target on the way at the situation change according to this intelligent control system. And, the knowledge acquired by reinforced learning has been effectively used.

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