Mutual learning of multi consciousness agent including the ego for autonomous vehicle

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Abstract: In this report, we propose a multi agent learning system for an intelligent robot control, based on the model of the human consciousnesses with including the ego. We pay attention to an intelligent learning process of human beings. We try to give high ability of learning to a robot by modeling roles of the human consciousnesses with including the ego. In almost ordinary methods, the instructions for learning are given only from outside of system. In the proposed method, the instructions are given not only from outside but also inside (from other agents in the system). Therefore, a robot can learn efficiently, since it uses more instructions than the ordinaries. The learning is more flexible, since agents learn while a learning agent and instructing agents exchange the roles by changing of environment. We verify experimentally that the proposed method is efficient by using an actual robot.

Keywords: Machine learning, Autonomous mobile robot, Multi-Agent system, Ego, Consciousness

I. Introduction

Autonomous robots are increasing such as cleaning robots and guard robots. It is requested that robots has more intelligence. Even if a human encounters a complex situation, he or she can adjust to the situation by learning. We pay attention to an intelligent learning process of human beings. Human beings has a feature that he/she can learn an environment while evaluating his/her decision by the ego. We try to give high ability of learning to robots by modeling the feature.

We think about the consciousness and the ego. But, none knows the mechanism of the consciousnesses and the ego yet. Moreover, the words are defined variously in various fields. For example, the words Consciousness and Unconsciousness are defined in each field as followings.

1. Psychology: Plural consciousness exists in a body. Unconsciousness is consciousness without the ego.
2. Philosophy: Consciousness is an ability to recognize. Unconsciousness is an ability to recognize oneself objectively.
3. Medicine: Consciousness is state that can feel stimulation to senses by activate working of a brain. Unconsciousness is state that cannot do them.
4. Upanishad philosophy: Consciousness are classified into 4 states. One is Unconsciousness.

In another field, they are defined as another. We take the idea of German psychologist Wundt. He analyzed human consciousness by internal perception, and thought that the ego is the subject of consciousness. We model them for engineering based on the above psychological definition.

There are ordinary researches for the model of the consciousness. Minsky describes that a human intelligent behavior has been achieved by the interaction of hierarchized mind agents. Maeno proposed consciousness model that controlled by the ego for episode memory.

However, there is no general model for the consciousness including the ego. There are a few researches about above-mentioned. In less cases, human consciousnesses were actually applied to robot control. We define the consciousness including the ego as multi-agent system, and try to apply to mechanical learning.

There are the following as a research of multi-agent reinforcement learning. Wiering[1], Osada[2] improved the learning efficiency by hierarchically arranging an agents and setting an sub-goal in each hierarchy. Ono[3], Fujita[4] learns efficiently by limiting the range of a state in Q-leaning used the partial state composed of an agent and another agent. In this report, we proposed a method that is modeled as multi-agent system based on the consciousness including the ego without the hierarchy, and verity that the proposed method is efficient for an actual robot by experiment.

II. Proposed Model

1. A definition of the consciousness and an ego

We define and model the human consciousness and the ego as follows. The model is regarded by the internal perception, and does not contradict the anatomy.

(1)Number of consciousness is more than two in a body.

(2)The human operation is caused by cooperating and competing of some consciousness.

(3)The ego is only one.

(4)The ego exists on the consciousness with the highest priority.

(5)When the consciousness with the ego competes against another in resources, it uses the resources by priority, the another is stopped.

(6)Only the consciousness with the ego can learn.

(7)The consciousness with the ego learns with using results of other consciousnesses recognition.

2. Modeling of a consciousness and an ego

We treat the above-mentioned consciousnesses rules as multi agent system (Fig.1).

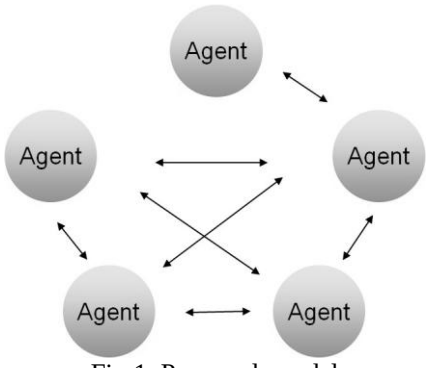

Fig.1 Proposed model

(1)Each consciousness is treated as agent.

(2) An agent is a data processer or a sensor with a priority and a condition for the running.

(3) If an environment satisfies a condition for the running, an agent executes processing.

(4) An agent has higher priority, if the agent is satisfied with the condition.

(5) An agent receives instructions and the priority from other agents.

(6) An agent uses only the instruction with the highest priority, when the instructions from other agents compete with each other.

(7) Only an agent with high priority can learn.

(8) When an agent learns, it uses recognition results of other agent.

III. Experiment

We verify experimentally that the proposed method is efficient. We select an image sensing and a body sensing for a mobile robot as agents that instruct and learn each other. Each agent estimates the current pose of the robot from each sensing data.

We use an actual mobile robot (MieC) for the experiment (Fig2).

Fig.2 Autonomous mobile robot MieC

The robot MieC has a camera as vision sensor, 4 touch switches as touch sensor and two crawlers as movable d evice.

The robot MieC is on a horizontal plane enclosed by vertical planes. Borders are between the horizontal plane and the vertical planes. Image sensing agent and body sensing agent find the distance from the robot to a border, respectively. Image sensing agent finds a border on an image by an appropriate threshold, and estimates 3-D pose of a border in the environment by transformation from image coordinate to robot coordinate. Body sensing agent finds the border under a vertical plane, if the robot MieC touches the plane. Otherwise, body sensing agent estimates the 3-D pose of a border by dead-reckoning with appropriate parameters.

In the future, each agent will be full built by the proposed framework, but currently, the Image sensing agent adjusts only the threshold, the body sensing agent adjusts only the dead-reckoning parameters.

The less accurately each agent recognizes the pose of a border, the higher priority it gets. For actual experiment, moving agent is added to the other agents image sensing and body sensing, but the agent doesn't learn nor instruct.

1. Learning in a case of clear recognition for image sensing agent

The image sensing agent could recognize a border in a situation (Fig.3 (b)). In other words, the image sensing

agent usually has lower priority than the body sensing agent. In the initial state, moving agent has higher priority than image sensing agent and body sensing agent. The body sensing agent doesn't know the pose of a border. The robot MieC might touch a vertical plane according to moving agent (Fig.3 (c)). And then the body sensing agent has higher priority than the others. The moving agent is stopped, and the body sensing agent is waked up and learns appropriate parameters from information of the image sensing agent (Fig.3 (d)). Concretely, the body sensing agent adjusts the dead-reckoning parameters while it is estimating the robot MieC self pose from the border pose found by the image sensing agent.

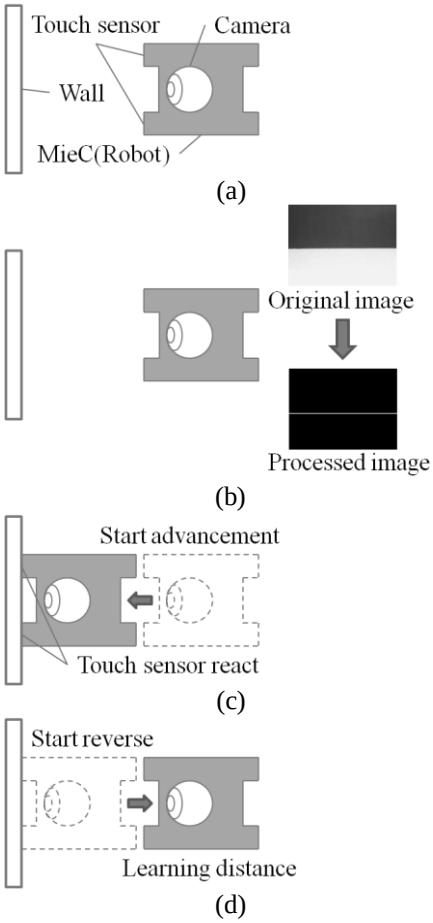

Fig.3 Learning of the body sensing agent

2. Learning in a case of hardly recognition for image sensing agent

The image sensing agent could not recognize a border in another situation (Fig.4 (e)). In other words, the image sensing agent usually has higher priority than the body sensing agent. The robot MieC might touch again a vertical plane according to moving agent (Fig.4 (f)). And then the image sensing agent has higher priority than the others. The moving agent is stopped, and the image sensing agent is waked up and learns appropriate threshold from information of the body sensing agent with already adjusted dead-reckoning parameters. Concretely, the image sensing agent adjusts the threshold so that it can find the border at the border pose estimated by the body sensing agent (Fig.4 (g) (h)).

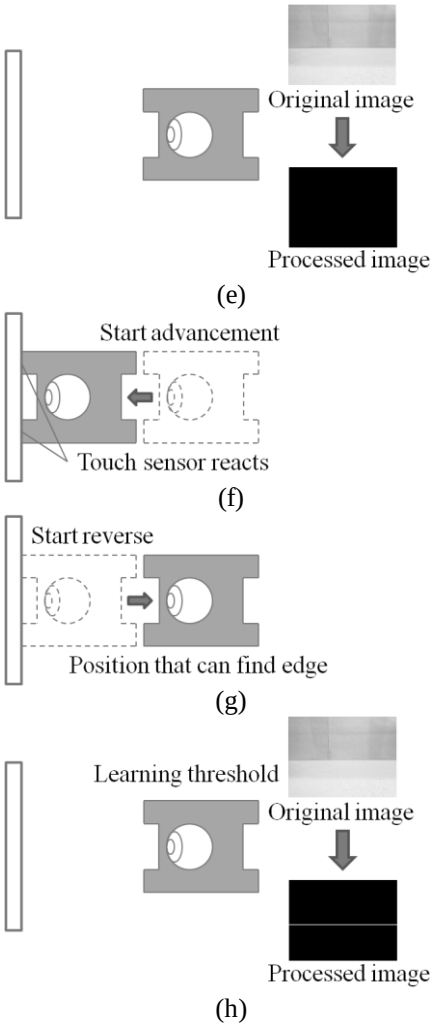

Fig.4 Learning of the image sensing agent

We experimented in the environment such as (Fig.5). In the left side (Fig.5), the image sensing agent can recognize the border easily, since the colors of the vertical and the horizontal planes are different clearly. In the upper side (Fig.5), it can hardly recognize the border, since the colors are similar. The robot MieC learned in the sequence of two above-mentioned environments.

By the above-mentions, we confirmed that two agents could learn cooperatively by the environment, and the proposed method was effective. (Fig.6) shows the pose of the robot MieC in 2-D coordinate system. (Fig.7)

shows learning and instructing state of the body sensing and the image sensing agents. We can confirm the following from (Fig.6) and (Fig.7). In the beginning, the body sensing agent was a learning agent, and learned from the image sensing agent as instructing agent. And then, the image sensing agent was a learning agent, and learned from the body sensing agent as instructing agent.

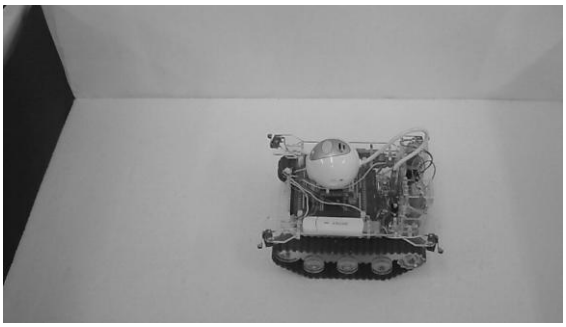

Fig.5 Environment of experiment

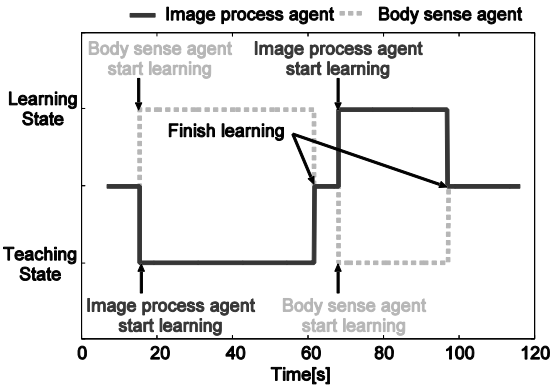

Fig.6 Result of agent's state

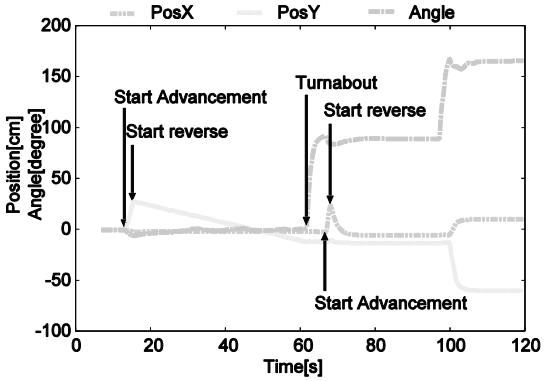

Fig.7 Result of robot's pose

IV. Conclusion

We proposed a learning model based on a mechanism of human learning that consists of consciousnesses including the ego defined by the psychology. We applied the proposed model to the actual robot MieC developed in our lab.. Concretely, in the experiment, we selected two agents, the image sensing agent and the body sensing agent, and confirmed that the agents exchanged the roles of learner and instructor each other to change the environment by MieC's movement.

We expect that the proposed method can learn by less trial frequency than ordinary reinforcement learning, since the proposed method uses instruction not only from the outside but also from the inside. But currently, the proposed method has been programmed for only a part of environment. In the future, the proposed method is applied to larger environment to increase agent types, and to select an agent by environment, automatically.

Concretely, we prepare some templates of an agent. When a robot cannot adjust an environment, an agent is generated by selecting a template automatically. In the initial state, the agent's parameter is given at random. The agent adjusts parameter by learning. If it's cannot learning, a new agent is made by selecting another template. An agent is automatically generated by environment like the above-mentioned, and robot may be able to adjust to a complex situation.

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