Visualizing Mental Learning Processes
with Invisible Mazes for Continuous Learning

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Abstract. This paper presents the way to design the continuous learning process model based on general reinforcement learning framework for both a human and a learning agent. The objective of this research is to bring the learning ability of the learning agent close to that of a human. We focus on both the reinforcement learning framework for the learning agent and the continuous learning model of a human. However, there are two kinds of questions. First question is how to bridge an enormous gap between them. To fill in the missing piece of reinforcement learning whose learning process is mainly behavior change, we add two mental learning processes, awareness as pre-learning process and reflection as post-learning process. Second question is how to observe mental learning processes of a human. Previous methods of human learning researches mostly depend on observable behaviors or activities. On the other hand, a learning process of a human has a major difficulty in observing since it is a mental process. Then a human learning process is yet-to-be-defined. So it is necessary to add a new twist to observe the learning process of a human. To solve this, we propose a new method for visualizing mental learning processes with invisible mazes consisting of invisible walls which are perceived as a sign that is the number of walls in the neighborhood. Besides, we add meta-actions for expressing and summarizing something to be aware of learning from mistake or to be reflected on learning from experience. A learner can mark up his/her sign-action traces by meta-actions for future success. It turns out to visualize his/her mental learning processes. This paper reports our learning support system for a human learner to visualize his/her mental learning processes with invisible mazes for continuous learning.

Keywords: reinforcement learning, continuous learning, learning process, awareness, self-reflection, visualizing, invisible, sign, meta-action, learning goals.

1 Introduction

Researches on learning process are divided into two fields. One is a learning agent in Artificial Intelligence [12-13], the other is learning of a human in psychology [9].
For the learning agent, reinforcement learning is the major framework since it automatically learns after a learning goal is set in the learning environment. The main feature of reinforcement learning is that the learning goal is given by the human designer. On the other hand, researches on human learning ability have been performed in various research fields such as psychology, education, business, and so on. One of the main features of human learning ability is that it covers a vast territory of learning ability including discovery of learning goals, awareness, reflection, self-regulated learning [16], or continuous learning.

The objective of this research is to bring the learning ability of the learning agent close to that of a human. We focus on both reinforcement learning framework for the learning agent and continuous learning model of a human. However, there are two kinds of questions. First question is how to bridge an enormous gap between them. Second question is how to observe mental learning processes of a human. Previous methods of human learning researches mostly depend on observable behaviors or activities. On the other hand, a learning process of a human has a major difficulty in observing since it is a mental process. Then a human learning process is yet-to-be-defined. So it is necessary to add a new twist to observe the human learning process.

To solve these problems, we propose a new method for visualizing mental learning processes with invisible mazes. We focus on continuous learning [17-18], and aim for modeling the unified continuous learning process model based on reinforcement learning framework for both a human and the learning agent. Our new approaches are following;

1. To fill in the missing piece of reinforcement learning whose learning process is behavior change, we add two mental learning processes, awareness as pre-learning process and reflection as post-learning process.
2. The learning environment is the invisible maze consisting of invisible walls which are perceived as a sign that is the number of walls in the neighborhood.
3. We add meta-actions for expressing and summarizing something to be aware of learning from mistake or to be reflected on learning from experience. A learner can mark up his/her sign-action traces by meta-actions for future success. It turns out to visualize his/her mental learning processes.
4. For continuous learning, we design the sequence of invisible learning goals which allows the learner to discover them according to the learning ability.

This paper reports our learning support system for a human learner to visualize his/her mental learning processes with invisible mazes for continuous learning. The remainder of the paper is structured as follows: Section 2 gives a theoretical background on continuous learning and Section 3 presents the continuous learning process model with invisible mazes. Section 4 discusses several issues and Section 5 concludes the paper, addressing future work.

2 Background

This section describes a theoretical background of this research, continuous learning, awareness and reflection. The concepts awareness and reflection are viewed differently