Realizing Human-Friendly, Enriching Computers Through Research into Human Thought and Learning

Takeshi ITO Laboratory

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Measuring human mental states and developing friendly artificial intelligence

The Ito laboratory hopes to work with companies on joint research projects investigating human thought, learning, decisions, and other behaviors (see Figure 1). This research focuses on two main areas.

The first research area measures, using biometric equipment, physiological conditions and cognitive states closely related to human mental states. Some of the measurement tools used are eye cameras (devices that track eye movement), diaphoremeters (sweat sensors), sphygmometers, and optical topography equipment (devices that track blood flow variations in the brain).

The second area is joint research looking at intelligent systems (artificial intelligence systems). The vision is to develop friendly systems that act human and that are enjoyable and interesting.

The enabler of this kind of joint research is the Ito laboratory's work on research into advanced human cognitive activities. For example, the laboratory is attempting to clarify such questions as how do human solve difficult problems, what is human intuitive knowledge, and what thought processes do human follow in playing games (see Figure 2).

To answer these questions, the laboratory measures human cognitive processes and builds artificial intelligence systems. And in consideration of the interaction between humans and machines, another aim is to develop systems that enrich people's lives.

Different thought processes used in *shogi* and Go

Much of the research on human thought and learning examines the process of solving problems while following certain constraints. Games are good models of the actions taken to solve problems while following certain constraints — rules, in other words.

Shogi and Go are two popular board games that have been played throughout Japan for centuries. The Ito laboratory has researched *shogi* for many years and has determined the cognitive processes characteristic of *shogi* players. For example, the more experienced the player, the fewer the positions the player examines. Unlike a machine, these players intuitively select their move without randomly studying many moves.

The laboratory has recently started studying Go players as well using eye-tracking and other kinds of devices. The results show that expert players look at and consider a wider range of positions than beginners (see Figure 3). The finding that cognitive processes varied according to the game (problem) was of great interest.

The laboratory also studied, in partnership with RIKEN, the process by which beginners remember and become proficient at *minishogi*, a variant of *shogi* played on a 5 x 5 board with fewer pieces. The research found that when a certain part of the cerebrum (the caudate in the basal ganglia) is larger, learners gave a higher percentage of correct answers to intuitive problems at the outset of the learning process. The research also discovered that people who learn well initially thought for longer periods of time, had less eye movement, and recognized moves faster.

Making computers act human

The Ito laboratory has also researched artificial intelligence (AI) for many years using various thought games. The laboratory's research examines the thought processes of people who have mastered games and attempts to create AI to play the games on computers.

Shogi computers have gotten much more powerful in recent years, and the defeat of a professional *shogi* player by a computer at a public match made news. In the world of video games, smartphone games, and computer games, *shogi*, Go, Othello, mah-

jong, and many other game titles are very commonplace.

The problem here is the strength of game AI. If a software title runs game AI that is too strong, it is likely to be very boring for human players, since they can never defeat the computer.

For this reason, the Ito laboratory started researching AI that has natural, human-like weaknesses. There are two basic approaches to implementing weakness. One is to change the data that the computer learns from. For example, in *shogi*, have the computer learn from game records of weaker players with an amateur rank of under 5 kyu instead of learning from the game records of professional players.

The other approach is to have the computer deliberately make mistakes. If the computer makes a wrong move in a complex position that is difficult to work out, the conditions of the game will change significantly. The advantage may swing to the human player. With this approach, researchers are trying to bring out human nature in computers by incorporating models of human error in AI.

The laboratory is also working on developing AI that emulates a specific playing style for a game. For this, the research is trying to identify the elements that make up a human's playing style (personality). Taking *shogi* for example, researchers are attempting to enumerate the elements related to a certain *shogi* playing style and then identify in game records the elements making up distinctive characteristics and the distinctive characteristics themselves. For first-person shooter games, the laboratory is analyzing the play logs of advanced players.

Aiding sports tactics with AI

The Ito laboratory's next probable major research topic is the application of AI technology, accumulated through thought games, to sports. In curling, soccer, baseball, football, and other sports, constructing tactics to win (or not to lose) is important. The laboratory's researchers are thinking of systems to assist in forming tactics.

Research is currently underway on a tactical-support system for curling (see Figure 4). Plans are to expand the sports covered by the system over time.

[Interview and article by Akira Fukuda (PR Center)]

Images of joint research projects with the Ito laboratory

- Measuring human mental states with biometric equipment
  - → Tests of mental evaluations with new technology
  - → Development of learning assistance and interfaces
  - → Measurement of human factors

Non-contact eye-movement measuring system · Diaphorometers and sphygmometers · Wearable optical topography equipment

- Joint development of smart systems that act human and that are enjoyable and interesting
  - → Technology to identify and imitate human thoughts
  - → Applications of thought AI technology to real-time AI
  - → Creation of AI to make competition enjoyable
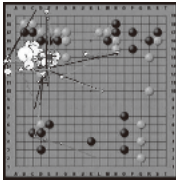 - → Research into human-like AI and man-machine interfaces

Figure 1: Image of the laboratory's joint research areas. The two main research topics are biometrics and artificial intelligence.
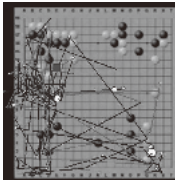

Research areas

- The laboratory researches advanced human cognitive activities (problem solving, learning, and emotional sensitivity)
  - — Advanced problem solving
    - ⇒ How do human solve complex problems?
    - ⇒ Clarification of human intuition
    - ⇒ Research into human thought processes when playing games
  - — Learning (learning assistance)
    - ⇒ Systems to boost the motivation to learn
    - ⇒ Metacognition to make learning more efficient
  - — Measurement and analysis of emotional sensitivities and feelings
    - ⇒ Research using devices that measure biological data
    - ⇒ Evaluations of interest and enjoyment

Figure 2: The laboratory researches advanced human cognitive activities. Advanced cognitive activities include problem solving, learning, and emotional sensitivity.
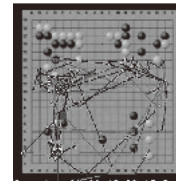

Research into the thought processes of expert *Go* players

Beginner · Intermediate · Expert

In *Go*, the better the player, the more positions considered
In *Shogi*, the better the player, the fewer the positions considered

Cognitive processes change depending on the problem

Figure 3: Differences in eye movements by level of experience with the board game *Go*. The left image is a beginner, the center image is an intermediate player, and the right image is an expert player.

Proposal of a tactical-support system for curling

System helps select best shot using a Monte Carlo simulation

What is the best shot given the stones' positions?

Enter the likelihood of success (transition probability) for potential shots

Monte Carlo simulation

What is the tactic with the highest chance of winning?

Tenth end, 15th shot
Red team (first rock): 7 points
Yellow team (last rock): 6 points

What is the best shot in this case?

Figure 4: Proposal of a tactical-support system for curling. The system selects the best probable shot based on the location of the stones.