Getting Intelligence into the Minds of People

Robert W. Lawler

Abstract
In conversation, Seymour Papert asked me "What's the point of studying Artificial Intelligence if not to get intelligence into the minds of people?" His question inspires my juxtaposition of explorations of Natural Learning and Constructed Personal Knowledge. Since "you can't learn about learning without learning about learning something," [1] the analyses will proceed with two examples. The first, focused on strategy learning at tic-tac-toe, concludes that learning depends on specific relationships among the elements of the context in interaction with processes of incremental cognitive change. (Even if not news, the details may be interesting.) The second analysis, focused on mastering a solution for Rubik's Cube, argues 1.) the importance of reformulation of representations as a strategy for learning in more complex situations, and 2.) that the integration of multiple modalities of representation can be a key to "getting the intelligence into the minds of people."

Introduction

In **Sciences of the Artificial**, Herbert Simon introduced his discussion of "The Psychology of Thinking" with a novel perspective on agent - context interaction:

> "We watch an ant make his laborious way across a wind- and wave-moulded beach. He moves ahead, angles to the right to ease his climb up a steep dunelet, detours around a pebble.... Thus he makes his weaving, halting way back to his home.... Viewed as a geometric figure, the ant's path is irregular, complex, hard to describe. But it's complexity is really a complexity in the surface of the beach, not a complexity in the ant.... An ant, viewed as a behaving system, is quite simple. The apparent complexity of its behavior over time is largely a reflection of the complexity of the environment in which it finds itself...." [2]

Simon concludes that his aim was exploring a similar vision of behavior, but with "human being" substituted for "ant." Over many years he pursued that aim, especially with his collaborator Alan Newell. In a broad and detailed case study of my first daughter's learning, I captured a complete history of her play at tic-tac-toe. Although simpler than Chess and various puzzles that Newell and Simon explored,[3] tic-tac-toe touched upon some of the same issues that were grand themes in the early days of Artificial Intelligence research, such as representing knowledge, strategic play, and interactions of thinking and environment. With further inspiration from psychological observations and the epistemological focus of Piaget, and from the data-orientated ecological psychologists, Barker and Wright, I was able to exploit my case study material for the computational generation of paths of learning. Together, these enable a new idea of what makes discovery-learning possible and memorable (computer modeling turns this verbal "idea" into a worked example, with process detail).

---

[1] This is an echo, of course,of Papert's well known quip that "You can't think about thinking without thinking about thinking about something."
[2] Sciences of the Artificial, 1969, MIT Press.
[3] Human Problem Solving, Prentice-Hall, 1972. See especially section 4.

Conclusions

Returning to Herbert Simon's metaphor of the ant on the beach, our aim to understand learning as a side effect of thinking in specific contexts is what requires us to "look inside" mental processes and their possibilities of change. The issue of representation is thus central for formulating and expressing Artificial Intelligence notions of thinking and learning. The study of AI should lead to considering the role representation plays in peoples' problem solving. What we learn from our worked example of mastering Rubik's cube is that flexibility in applying representations may be key to being "smart enough" to solve Rubik's cube. Deployment of various representations and functions, mastery of a variety of such "ways of thinking," is more important to intelligence than "native ability" (as sampled by traditional tests such as the Stanford-Binet).[18]

Archilochus, a soldier-poet of ancient Greece, wrote a famous couplet:
The Fox knows many tricks.
The Hedgehog has just one, but it's a good one.[19]

If we can glimpse in mnemonics some tricks of the Fox and see in the formal methods of mathematics the one good trick of the Hedgehog, note that Artificial Intelligence found its home between the Fox and the Hedgehog, applying strong methods where possible and weak methods when necessary. Thus I find it a very "human," opportunistic approach to solving problems. But are tic-tac-toe and Rubik's Cube serious problems, worthwhile understanding and mastering, especially as they have involved us in such down and dirty, nitty-gritty problem solving? "YES!" is my resounding answer, since these examples approach "thought experiments" that permit us to ask:
What makes learning possible in a task domain?
How can mathematical and epistemological ideas advance peoples' understanding?

And if it helps any reader take a neglected or embarrassing Rubik's Cube out of the closet, then note these exercises meet Feynman's criterion of worthwhile problems:

> "No problem is too small or too trivial if we can really do something about it....
>
> The worthwhile problems are the ones you can really solve or help solve, the ones you can really contribute something to. A problem is grand in science if it lies before us unsolved and we see some way for us to make some headway into it. I would advise you to take even simpler, or as you say, humbler, problems until you find some you can really solve easily, no matter how trivial. You will get the pleasure of success, and of helping your fellow man, even if it is only to answer a question in the mind of a colleague..." [20]

If Feynman's view is adopted, we'll be "getting intelligence into the minds of people." [21] Seymour would be pleased.

---

[18] The second case study, LC2, at NLCSA, contains a public Binet Test Summary; it was summarized as an appendix in Computer Experience and Cognitive Development. An Analysis of Detail Data for the subject (at 6;1;17) exists under password protection at NLCSA.
[19] Greek Lyrics, Richmond Lattimore, U. Chicago. 1960.
[20] These comments, from a letter to a former student, show the wisdom of a man whose scientific brilliance is unquestioned. See http://genius.cat-v.org/richard-feynman/writtings/letters/problems
[21] One might also take seriously how rigorous was Feynman's notion of what it means to really SOLVE a problem; see his discussion of the experiments of "Mr. Young" in the legendary 1974 Caltech Commencement Address, "Cargo Cult Science."