Towards the Essentials of Cyberlogical Testing: Methodologies for Inculcating Knowledge Based Systems with Social Intelligence

William Jarrold
Counseling Psychology Area
Department of Educational Psychology
University of Texas at Austin
and
Cycorp
3721 Executive Center Drive
Austin Texas 78731
billj@cyc.com

Abstract

Knowledge rich symbolic reasoning systems can play an important role in the construction of socially intelligent agents. Drawing on my experiences with building Cyc, I will describe methodologies for constructing such entities. Where humans figure into the system construction "loop" as well as the system application "loop" will be described. Although such a non-embodied system will suffer from certain limitations I will describe ways in which they may usefully contribute to application and theory relevant to Socially Intelligent Agents.

Social Intelligence as "Cold" Empathic Inferencing

Social Intelligence (SI) is a broad competency having many components. I claim that one component of SI is the ability to model or reason about how other people might emote in a given situation and to act accordingly. (See also Mayer & Salovey, 1993; Salovey & Mayer, 1990). Although emotion is clearly not an entirely rational or logic driven process, it is clearly not completely irrational or illogical either. See, for example, The Rationality of Emotion (De Sousa 1987).

Although a wide variety of systems may be said to model other agent's emotions, I focus on "cold" models -- in particular, using a rule reasoning based system such as Cyc (www.cyc.com) to reason about the emotions of other agents. "Cold" models, unlike "hot" models, do not change processing behavior depending on emotional state. On the other hand, embodied or situated architectures typically instantiate hot models since they need to allocate limited resources in light of current goals and imperfect knowledge. Although one would be hard pressed to ascribe any such "hot" emotional state to Cyc I shall nonetheless show ways in which rule-based knowledge can take us a step closer to that component of SI I described above.

The term empathic inferencing shall be used to describe such "cold" reasoning processes involving axiomatized knowledge of emotions (see Ortony, Clore, and Collins 1988) for an example), common sense background knowledge, plus knowledge of a given person's beliefs, desires and intentions. Although I am by no means implying that a Cyc-like knowledge based system is a fully socially intelligent agent, I am claiming that some useful aspects of social intelligence can be engineered into an agents derived from such systems.

Take, for example, the following scenario:

On his way to the interview, Fred missed the bus. He paced. Looking at his watch he broke into a sweat. He breathed a deep sigh when a close friend drove up and offered a ride. They chatted amicably until the friend made a wrong turn and ended up mired in traffic. Fred became distant.

This scenario and inferences explicated below illuminate several points. First, shared common sense knowledge is a ubiquitous part of empathic inferencing. Just about any reasonably socially intelligent human speaker of english would agree with many inferences which follow from the above scenario such as:

(1) Lateness is a reasonable explanation for Fred's sweating.

(2) "distant" (above) refers to emotional not physical closeness.

To infer (1), emotion specific knowledge such as "distress is being displeased about an undesirable event" (Ortony, Clore, and Collins 1998) is not enough. Significant common sense background knowledge is also required. For example a system will need knowledge that transportation takes time, that being late for an interview makes a bad impression, that people desire to work, that most buses run infrequently, etc. This example illustrates how the claim (Pfeifer 1987) that even the most banal of
empathic inferences requires a bevy of common sense facts.

In sum, background common sense knowledge serves a dual role in empathic inferencing. It allows the system to reason about how particular "real world" aspects of a situation relate to the beliefs, desires and intentions of an agent. Secondly, common sense knowledge may facilitate emotions communicated by way of metaphor and metonymy. Empathic inferencing and its dependence on common sense reasoning suggests that knowledge based systems can play an important role in SIA's.

**Applications: Can Cyc Bring Tears to your Eyes?**

Although cold-reasoners like Cyc lack bodies, I outline several near-term SIA relevant applications that can be envisioned.

Lacking bodies, cold model SIA's may nonetheless leverage the sensory and visceral reality of their users. For example, although an eyeless Cyc-like system may never experience the depth of the Mona Lisa, it may be able to make good guesses about appropriate situations to retrieve such an image. The Cycorp "Image Demo" which parses short natural language captions and uses its knowledge base and inference engine to semantically match these parsed captions with a user's queries. Given propositional knowledge about sports teams and sports fans, Cyc is capable of reasoning that an image captioned "The New York Yankees winning the World Series" is likely to be significantly more pleasing to the eye of a Yankee fan than a Red Sox fan. Thus, if a user's search query was "Show me pleasing images" and the system knows the user as a devout Yankee Fan, the Cycorp Image Demo system is capable of making contextually relevant selections.

Music selection, like image selection, can also tap human emotion. Many of us can remember the powerful impact of hearing a lyrical piece of music which serendipitously match our current emotional or interpersonal reality. For example, perhaps you are familiar with the Beatles song "Little Black Bird in the Dead of Night" -- the rest of the relevant lyrics are "Take these broken wings and learn to fly". Such a song might be particularly energizing to someone in the throes of vegetative depression who wishes to regain the energy and courage to socialize in public places.

A disk jockey/diary companion SIA that knew about its user's crisis could infer a mapping between aspects of the user's situation and the scenario described in the lyrics. "Little black bird" could be mapped to the user. The bird's broken wings causal role in its inability to fly could be analogized to the user's phobia and its role in social disability. The bird's imperative, "Learn to fly" could be mapped to the users desire to have a social life.

Modest success using analogy engines in the context of knowledge based systems has already been achieved. With continued incremental advances, systems like the above should be realizable in a handful of years. An ultimate Turing-level test of such a system would be if it could bring tears to its user's eyes from time to time by playing the right song in just the right situation, by displaying just the right image in just the right context.

**Evaluation: Challenge, Regression, and Rumination**

Socially intelligent or not, continual evaluation is an important engineering practicality of building large knowledge bases. Unlike embodied systems, Cyc-like systems are not of necessity faced with the vagaries and complexities of constant interaction with the real world. Knowledge engineers are easily lulled into the complacency of "a bigger KB is a better KB." A partial workaround for this weakness is to subject Cyc-like systems to continual evaluative pressure. I describe three means of applying this pressure: Challenge Problems, Regression Tests, and Rumination based feedback.

As (Dautenhahn 1999) alludes if such systems are to be socially compelling to humans, clean GOFAI problems like chess, the traveling salesman, or the prisoner's dilemma will not pose challenges which approximate social reality. By the same token, if the challenge is too difficult, the only systems that will appear to do well are "smoke and mirror" AI systems such as Eliza which do not possess any form of real understanding. What is needed are challenge problems that are developmentally appropriate or closer to what Vygotsky would refer to as the zone of proximal development (as cited in Wertsch, 1991). There is not space in this paper to address what constitutes such developmentally appropriate challenges. However, it would be a good discussion topic for the symposium.

Although developmentally appropriate challenges are important for optimal learning, knowledge engineers must also be vigilant for cases in which new axioms fashioned to meet new challenges do not interfere with old axioms. Thus, it is important to test for regression against prior baselines after each new learning activity. In the
language of software engineering, regression tests should be performed after each system modification. At Cycorp we apply a battery of regression tests each night ensures that what worked yesterday continues to work today. With scores of knowledge engineers adding thousands of axioms per day, new violations are nipped in the bud nearly every day.

Thirdly, knowledge engineers must ensure that axioms do not combine in unforeseen ways. A set of processes that I call rumination-based quality control can be performed as a partial check. One of several types of this process involves formulating open-ended queries to the inference engine.

Although not yet a part of daily activities at Cycorp limited forays into this technique have already produced interesting results. In one such foray the Cyc system was asked the following question.

"Does anyone feel any emotion to any degree about any event or any object."

In cycl the query was:


There were hundreds of conclusions, the vast majority of them were correct. For example, Cyc inferred that Queen Elizabeth II feels loyalty towards England. But, what was most amusing not very plausible was that the system inferred that Hillary Clinton felt no contempt for her husband Bill Clinton. Translating these axioms into English the givens responsible for this deduction were as follows:

(Axiom A) Spouses love each other.
(Axiom B) Love and contempt are contrary emotions.
(Axiom C) Bill Clinton is Hillary Clinton's spouse.

Although each one of them may appear more or less correct standing by itself, when chained together they led to a conclusion which most people would rank as false. The are several possible repairs for such a deduction:

(1) Split apart the concept #$Love into at least two forms (a) an in the moment feeling inconsistent with contempt (b) a long-term affective disposition frequently felt by spouses.

(2) Add an exception condition to (Axiom A). Spouses love each other except in cases of adultery. Describe the Monica Lewinsky story to Cyc.

In this way, introspective or open-ended query type testing may be used to evaluate and suggest improvements to a knowledge-based system.

Conclusion

If the above described research is fully successfully about the best that can be hoped for is a system which mimics the social intelligence of a high functioning bed ridden autistic child who reads voraciously. In spite of such limitations work on such disembodied cold-reasoner systems is worthwhile. In particular focused applications or as a subcomponent of a larger system such an approach may make for a socially compelling intelligent agent. This paper argues that success in either endeavor can not be achieved without a judicious adherence to the essentials of continued evaluation and re-evaluation of system performance during knowledge base construction.

Acknowledgements

Thanks to Diane Schallert for many helpful suggestions.

References


