Challenging the Intelligence of Systems: A Literature Review on How IT Deals with Reasoning and Action

Erwei Zhan
Candidate for M.Sc. In Analysis Design and Management of Information Systems
Information Systems and Innovation Group
Department of Management
London School of Economics

Whether a system can exhibit intelligence behavior like human beings has always been one of the hottest topics in the field of information system. The failure and unexpected difficulties of artificial intelligence (AI) have prompted more and more scholars to focus on the study of AI and intelligent systems. This paper will specifically focus on the debate of artificial reasoning and action, one of the most important parts of AI, and present a literature review on different perspectives and issues of how IT deals with reasoning and action. In this way, the paper can help us to have a clear understanding to the interesting phenomenon and important theories in this enduring topic related to IS construction. The paper also provides a discussion of AI's future development and what the debate can suggest for contemporary IS studies.

Keywords: artificial reasoning; plan and strategy; situated action; tacit knowledge; improvisation

1. INTRODUCTION

More than half century ago, Alan Turing, one of the computer pioneers, claimed that a high-speed digital computer, programmed with rules and facts, might exhibit intelligent behavior (Dreyfus, 1993). Thus was born the field later called artificial intelligence (AI). According to Marvin Minsky, artificial intelligence can be defined as: "the science of making machines do things that would require intelligence if done by men." Along with the fast development of information technology, many scientists and experts have tried time and again to enable systems or machines to have the same intelligence as human beings. However, the development of AI was not as easy as predicted. The field ran into unexpected difficulties.

In a holistic view of AI's history, it is interesting to find AI's development falls into a strange cycle of boom and bust, of "AI winters" and summers. The first boom of modern AI was accompanied by the birth of programmable digital computers. Actually, the field of AI was founded during this time at the Dartmouth Conference in the summer of 1956 (Copeland, 1993). During these golden years, many successful programs such as natural language were created. These resulted in the extremely optimistic attitude towards AI at the time. Minsky even announced in 1967 that within a generation the problem of creating "artificial intelligence" would be substantially solved (Dreyfus, 1993).

However, some serious problems later emerged. The most important critique was that most AI applications could not deal with commonsense knowledge and reasoning which require a truly vast amount of information. Thus followed the first "winter of AI". Many scholars had already pointed out that the failure was not only a superficial phenomenon but a fundamental issue. Dreyfus (1979) argued that human reasoning actually involved very little "symbol processing" but a great deal of embodied, instinctive, unconscious "know how". But the leaders of AI doggedly believed the problem was caused by the limited computer power at the time and refused to accept the critiques.

After the capability of computer had developed as fast as the famous "Moore's law" predicted, the field of AI entered another eight years' boom period in 1980 with the symbol of the rise of expert systems. Expert systems are described as a program, using logical rules that are derived from the knowledge of experts, to solve problems about a specific domain of knowledge. By restricting themselves to a small domain of specific knowledge, expert systems avoided the commonsense knowledge problem. Yet, the problem can not be avoided permanently. Even the AI researchers themselves later realized that the enthusiasm for expert systems had spiraled out of control. Their fears were warranted. In the late 80s, another "winter of AI" came.

To conclude the brief history of AI, there is no doubt that AI succeeded in many sub areas after more than half a century's attempt. However, there is still a long way to go before fulfilling the dream of human level intelligence. The two cycles of boom and decline reveal that the debate was on the fundamental aspect of AI: to use the methods based on the perspective of rules, plans and strategies; or to use the methods based on the perspective of commonsense knowledge, situated action and learning in order to solve the problem of artificial reasoning and action. The current methods do have serious limits. They can not realize many key factors which human beings have when dealing with reasoning and action (Harry and Martin, 1998). This actually prevents the development of the whole realm of AI from making substantial progress.

Thus, it is necessary to have a clear review and understanding of different perspectives on the topic of how IT deals with reasoning and action. In order to achieve this, the paper will contain an explanation of the current perspective based on rules, plans and strategies and of the opposite perspectives based on situated action and learning. Specifically, the opposite perspectives will be presented through three aspects: the aspect of tacit knowledge, the aspect of situated action and the aspect of improvisation. They are all related to some key theories of IS and convincingly challenge the intelligence of systems. Finally, in the third section, the paper will compare different perspectives and elaborate on future development and in what way the current study will be helpful to contemporary IS studies.

2. PERSPECTIVES OF THE DEBATE

Compared with most people's enthusiasm regarding the development of technology, there are always some sober voices pointing out the limit of modern technology. In the field of artificial reasoning and action, its development has always been accompanied by drastic debate since its birth.

In fact, many scholars in the field of IS are affected by the philosophical theory of Martin Heidegger, one of the most important philosophers in the twentieth century. In Heidegger's early article called "the question concerning technology", he had critically discussed the essence and limitations of modern technology. Enlightened by Heidegger's work, many IS scholars established their unique theories with a critical view of the current approaches of artificial reasoning based on plans and rules. As Hubert Dreyfus who was considered as a leading interpreter of the work of Martin Heidegger, he built his critique of AI which concerns what he considered to be the four primary assumptions of AI research. He also used some phenomenological theories to challenge traditional AI. Dreyfus' work further influenced many other scholars. These different voices resulted in the current debate.

2.1 Perspective of Plans and Strategies

Suchman (1987) defines the perspective of plans and rules as a prerequisite view to prescribe appropriate actions at every level of detail due to typical situations. This perspective has its origin in the structure of modern digital computers. As Weizenbaum (1984) advocates, though the modern computer has significant differences from the Turing machines that operate on an alphabet including only "0" and "1", it is necessary to recognize that a modern computer is fundamentally a symbol manipulator and a symbol system.

In this way, the perspective of plans and strategies greatly relies on the symbol system hypothesis. Copeland (1993) further shows the proposed recipe for making the symbol system adaptable in order to explain this basic hypothesis. The symbol system hypothesis would be justifiable and warranted if the recipe is correct.

Copeland (1993) concludes this recipe in five steps. First, use a suitable and recursive code to represent the objects, actions, relationships and everything important in the circumstances. Then, enrich the representation of the world; make it much more specific inside the symbol system. This "knowledge base" will include vast information in interconnected structures of symbols. Thirdly, since the system is always in interaction with the environment, it needs suitable input devices to represent the flux of outside stimuli in the right form. In the fourth step, the system's fundamental operations need to be designed according to its structures of input devices and "knowledge base". Finally, the output requires careful design in order to translate the symbols into appropriate behavioral responses.

Now, it is quite clear that the symbol system hypothesis not only shapes the way modern computers operate but also the way AI researchers deal with reasoning and action. Due to the described recipe, the knowledge, reaction and operations need to be previously codified. This kind of information is exactly what we call plans, rules or strategies. Since a digital computer is the most powerful tool human beings have to achieve ideal artificial intelligence, the current perspective and methods based on plans do to some extent make sense. Actually, the AI researchers have to compromise with the tools they developed, to accept the limit and weakness the computer has.

The intelligence based on these mechanics and perspective may be enough to deal with the Turing Test which Suchman (2007) describes as the test to judge whether a machine is intelligent enough to respond to questions in such a way that the person asking the questions could not distinguish between the machine and another human being. However, this kind of intelligence is certainly not qualified to face the much more complicated reasoning problems in the real world. This is why many different opposite voices arise.

2.2 Perspective of Tacit Knowledge

The commonsense-knowledge problem was firstly raised to question the validity of mechanics based on plans. The failure to solve this problem, as mentioned above, resulted in the first "AI winter". In order to explain the problem, Dreyfus (1993) suggests that a huge data structure comprised of facts and rules is required to represent the commonsense knowledge which is far more difficult to formulate than expected.

From another view, the commonsense-knowledge problem is "not really a problem about how to represent knowledge; rather, the everyday commonsense background understanding that allows us to experience what is currently relevant as we deal with things and people is a kind of know-how" (Dreyfus, 1993). The problem precisely was that the know-how, as a combination of all the interests, feelings, motivations and bodily capacities that go to make a human being could not be represented and conveyed to the computer by the data structures made up of facts and rules. The inarticulate symbolic way of input is almost impossible to finish this task.

Moreover, the commonsense-knowledge, appearing at a higher hierarchy than information and data, contains a number of skills for dealing with people or other things in the environment rather than facts about them (Dreyfus, 1993). Human beings need these skills to accomplish intelligent behaviors, so does the system. However, even if we accept the argument that the rules can play a role in the acquisition of these skills, it is not reasonable to say these rules still play a role in the skills' later application. That is to say it remains doubtful whether the skills can be fully applied through the methods based on plans and rules.

The discussion of commonsense-knowledge to some extent leads to the appearance of the new research realm of knowledge management. In the theory of knowledge management, a new concept called tacit knowledge appears in order to standardize the formal concept of commonsense-knowledge. Due to Nonaka (2000; 2001), tacit knowledge, compared with explicit knowledge, is rooted in a specific context. It remains unconscious but becomes explicit and comprehensible when aroused by certain factors. It contains skill, know-how, expertise and competence.

	KNOW	DON'T KNOW
KNOW	Knowledge that you know you have EXPLICIT KNOWLEDGE	Knowledge that you know you don't have KNOWN GAPS
DON'T KNOW	Knowledge that you don't know you have TACIT KNOWLEDGE	Knowledge that you don't know that you don't have UNKNOWN GAPS

Fig.1 : Knowledge Stock (Liam Fahey, Babson College)

Both the definition of tacit knowledge and the "Knowledge Stock" showed in Fig 1 reveal why the methods based on plans fail to deal with tacit knowledge. As Weizenbaum (1984) predicts, it is the fact that humans do know something they can not express by any kind of language. There is some knowledge that computers would never acquire. If tacit knowledge is something even human beings ourselves do not know we actually have, how can we expect the systems to know it? How can AI researchers find some rules and plans to define and describe it?

2.3 Perspective of Situated Action

The concept of "situatedness" can be described in a general way: the concept of situatedness, having many different terms such as "Situated Action", "Situated Learning" and "Situated Activity", means that the agent's behavior and cognitive processes first and foremost are the outcome of a close coupling between agent and environment. In this way, the perspective of situated action strongly emphasizes the importance of continuous interaction between agent and outside circumstances (Suchman, 2007).

Though the methods based on plans keep a keen eye on presenting different situations the systems will face by establishing many specific strategies, the environmental contexts are still ill-defined. Suchman (2007) emphasizes that no matter how detailed they are, the plans cannot represent the practices and circumstances in all of their concrete detail; especially human beings do not know ahead of time, or at least not with enough specificity, what the future situation will be. In Suchman's words: "even in the case of more deliberative, less highly skilled activities we generally do not anticipate alternative courses of action or their consequences until some course of action is already underway". This reflects the "wicked problem" in system design.

Suchman (1987) not only questions the feasibility of presenting situations through plans but also the practical objectivity of situations. Suchman says that if the environment of human's actions is made up of a succession of situations they move into, it is problematic to guarantee the objectivity of the previous descriptions of the situations. Moreover, how can we judge the practical objectivity of the descriptions of the situations ahead?

Though a little bit exaggerated, the profound metaphor given by Gladwin (1964) may be a good conclusion of the perspective of situated action: "This total process goes forward without reference to any explicit principles and without any planning, unless the intention to proceed to a particular island can be considered a plan".

2.4 Perspective of Improvisation

Improvisation is defined as an intriguing process: "Improvisation is a kind of situated performance where thinking and action emerge simultaneously and on the spur of the moment. It is purposeful human behavior which seems to be ruled at the same time by intuition, competence, design and chance" (Ciborra 1999). Though it is intentional, it happens extemporaneously and almost unexpectedly.

Improvisation plays an important role in human being's reasoning and action. It can be demonstrated through many interesting case studies. Weick (1993) tells the vivid story of the Mann Gulch fire disaster and how the unexplained improvisation, resulting from the panic and forces, saved the firefighter's life. It is also necessary to mention that the charm of jazz also has a strong relationship with the executants' improvisational performance (Ciborra 2002). It is such a joy to see the jazz musicians indulge themselves in the music they create extemporaneously according to their instantaneous feeling and inspiration.

Improvisation also takes an important part in the daily life of the main economic institutions (Ciborra 1996; Weick 1993). It is emphasized that some characters of improvisation such as immediacy, situatedness and local knowledge can be seen as the key elements of quickly adapting to the change of the market. It also helps the hierarchies to make decisions.

Ciborra (1996) further argues that improvisation is a much more grounded and useful process than plan-driven decision making which directly challenges the perspective based on plans. However, it is really difficult to copy the process of improvisation by the current mechanics of artificial reasoning. Ciborra (2002) argues the current mechanics can be reconstructed in order to meet the demanding of improvised decision making by adding symbolic representations of the ongoing problem. However, since improvisation is analyzed as quick design and simultaneous implementation of plans of action, its "magic" cannot be fully presented by the current methods. Ciborra (1996) jokes with AI researchers that their way of solving the problem of improvisation may be even worse than the departure point. In other words, the significant character of improvisation contradicts the rational and planned process of decision making and makes it almost impossible for systems modeling.

3. DISCUSSION-PERSPECTIVES & CONCLUSIONS

In summary, there are tight links between the three perspectives of tacit knowledge, situated action and improvisation, though they each have their own particular emphasis. These three critical perspectives, focus on situated action and learning, form the opposite view against the current perspective based on plans, rules and strategies.

There are some important hints and clues from the study of this debate. First, no matter how powerful IT would be, it is still the tool developed by human beings. In order to achieve ideal artificial intelligence, AI researchers must first have a clear understanding of the way how human beings ourselves present intelligent behaviors just as reasoning and action. Then, it is warranted to discuss the topic of how to fulfill AI. The fast development of IT sometimes puzzles us by making people too ambitious. Human beings would never use the technology to fight against the original mechanism we are born with.

Second, this topic actually reflects another deeper debate of whether computers are the best tool to realize AI or whether human beings think and do things in the same way computers do. In the future, a more advanced tool may be designed which reasons and acts in a way more similar to that of human being.

Last but not the least, the debate makes some important suggestions for contemporary IS studies. The problem researchers face in building intelligent systems reflects the "Wicked Problems" in IS construction. The uncompleted plans represent constraints based upon ill-defined environmental contexts. The problem of tacit knowledge shows how unreasonable it is to depend on human cognitive abilities to produce effective solutions since humans cannot even perceive the tacit knowledge they have. The way humans deal with reasoning and action is a sustaining unstructurable process sharing many key characters with "emergent knowledge processes". Moreover, the perspective of situated action also indicates the demand for accommodating complex, distributed and evolving knowledge-bases in order to support dynamically changing processes.

In my mind, the field of artificial reasoning and action is like a laboratory to test different IS development methods and methodologies in the most extreme conditions. Human beings ourselves are the most complicated systems in the world. Since the purpose of these methods is to imitate and realize human level intelligence, they will face and be verified by the most rigorous conditions. This kind of extreme test will magnify the limits current methods have. This is exactly where the value of this topic lies and why the discussion matters.

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