Intelligent Systems, Artificial and Human

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Abstract. The relationship of computer Chess to intelligence is discussed, and it is observed that, although current Chess programs are basically unintelligent, programs that learn to play Chess are a new frontier in the construction of intelligent systems. The definition of intelligent systems is then expanded to include systems in which individual humans are components, rather than organizers, of intelligence. From this perspective, internet communities and universities are observed to be intelligent systems that are undergoing rapid evolution — a process that Jaap and his students are actively advancing.

1 Introduction

I am happy to be invited to make a contribution to Jaap's Liber Amicorum. Our contact goes back a long way. To at least the 1970s, although I am not sure of the date. We met through our separate efforts to create Intelligent Systems of a specific kind. He worked with one called Pion, mine was unnamed, but was dubbed BCP by organizers of the first World Computer Chess Championship in 1974.

Computer Chess has engaged the attention of scientists, mathematicians and philosophers since computers were invented. The list of famous names is long, and includes such early pioneers as Turing, von Neumann, and Shannon, at or before the dawn of electronic computers, all of whom felt that creating programs to play Chess would illuminate the workings of human intelligence.

The efforts of hundreds of researchers and hundreds of scientific papers over 50 years led to a headline-making event in 1997. IBM's Deep Blue, a special-purpose hardware machine combined with equally special-purpose software defeated the human world champion, Gary Kasparov, in a tense match of 6 games.

Now, in 2007, a $1000 desktop computer with Chess programs for less than $100 can achieve similar levels of play. So, is silicon intelligence now a reality? Not yet. Even allowing for the tendency of humans to progressively redefine "intelligent behavior" as we become aware of what computer programs can achieve, it is clear that current Chess programs include very little that deserves the title "intelligent". Murray Campbell, the Chess expert on the Deep Blue team said "I never considered Deep Blue intelligent in any way. It's just an excellent problem solver on this very specific domain." However, Gary Kasparov did say that when playing Deep Blue it sometimes felt as if he was facing a deep intelligence.

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2 Intelligent Systems

Any definition of "intelligent system" risks debate because "intelligence" seems to be a slippery concept. We know humans are intelligent, and we grant that some other animals are intelligent in lesser ways, and we think we'd recognize intelligence if we saw intelligent behavior, but definitions will vary as science and technology progress. It's probably best to stick to examples, and not seek a definition.

Are computer Chess programs "intelligent systems"? Current programs certainly cannot claim general intelligence. However, I think we can talk about the relative intelligence of different Chess programs without trying to establish whether any of them qualify as intelligent against human standards.

Much of the history of constructing Chess programs has been dominated by a "knowledge versus brute force" debate. Early efforts, constrained by extremely tight limits on computational power, focussed on chess-specific knowledge in the hope that this could reduce the computation required. As computer speeds increased, searching the move tree with few pruning rules and simple position evaluations turned out better. The big-search, simple-evaluation, paradigm dominated most of the past twenty years, once it was understood how to get the most from two tiny but very powerful algorithm components: "alpha-beta", and "null move". (I should clarify, though, that the best programs do include as much Chess knowledge as the programmers could code in simple fashion, mechanisms to adjust the depth of search according to the positions found are important, and Deep Blue was somewhat different, although very much a "big-search" program.)

This "big-search" paradigm is hard to regard as intelligent, even though it requires extensive complexity in supporting detail to achieve high performance. The surprising conclusion from the past thirty years is that the best Chess programs are relatively unintelligent, compared to Chess programs that include knowledge, or learning, in an attempt to imitate human intelligence.

So why didn't thirty years of development of Chess programs produce intelligent systems? Quite simply, the ideas of thirty years ago about the mechanisms that might produce intelligence were wrong. They were tried and were not successful.

So, is the relevance of Chess to intelligent systems over? I don't think so, although it depends on the choices of future researchers. Chess still has the virtue of a precisely defined task, and a clear definition of success. The new frontier is machine learning. Researchers using computer Chess have always known that it would be both enormously useful and a scientific advance to have the machine learn for itself how to evaluate Chess positions, and choose the lines of play to explore.

3 Learning Systems

Machines that learn will do more for machine intelligence than specialized problem-solvers. The task of learning to play well, using learning mechanisms that are

not specific to Chess, will be a significant step forwards. The DEEP BLUE team tried to have their machine learn the best weight for each evaluation feature. But they found that hand adjustment of the weights was better. However, they may not have tried the best algorithms. Other researchers have reported encouraging results in simpler Chess programs using "Temporal Difference" learning.

Although not yet mastered, learning weights is only a subsidiary task for machine learning for Chess. It assumes that someone or something else has determined what features should be computed from a position. The discovery of useful features to compute is an unsolved problem, and a successful method for that would constitute a major advance. Researchers have tried artificial neural nets and artificial genetic evolution, but the results are not encouraging. Even simple nets are unacceptably slow compared to human-invented evaluation features, and nets that are elaborate enough to encompass the computation of some of the more elaborate human-invented features would be infeasibly large to compute and train. Conceptual breakthroughs may be necessary, either in constructing and training neural nets, or in new methods to create evaluations.

Success in this endeavor will be easy to demonstrate. Learning systems have the potential to surpass human-crafted programs. Eventually the best Chess programs in existence will be created by machine learning.

I notice Jaap's name on several papers related to neural nets and learning so here too, Jaap is active.

What other kinds of intelligent systems are there? Of course, people are intelligent systems.

But there is another level of intelligent system, the most intelligent of all. That further level is collections of people, i.e. people assembled into systems where each person is contributing only a portion of the intelligence of the whole.

This general concept covers a wide range of systems, all vital to modern society. Some human systems exhibit little more intelligence that the individuals that comprise the system, for example religions. Some however, exhibit a collective intelligence that far exceeds the intelligence of any individual. The most conspicuous examples are universities. They are specifically designed to accumulate knowledge and ensure the knowledge is operationally shared over numerous individuals. Moreover, the total knowledge accumulated today is greater than any one individual could possibly assimilate. A university, considered as a collection of individuals, is surely an intelligent system with more intelligence than any one person.

4 Humanity's Largest Intelligent Systems

There are other institutions that demonstrate intelligent systems: scientific institutes and research divisions of major corporations obviously qualify. In addition, many social systems: the law, the military, hospitals, commercial businesses, etc, can be argued to exhibit a collective intelligence that exceeds the intelligence of any individual. Human institutions vary in the degree of collective intelligence they exhibit. Worthwhile though they are, some human institutions

perform mainly routine functions, not requiring as much collective intelligence, even though they may rely heavily on intelligent staff within them in order to function. I will not try to assign degrees of intelligence to various human organizations — I really just want to draw attention to the notion of collective intelligence.

Recently, with the explosion of computer technology and the internet, a notable new intelligent system has attracted my attention. This is *Wikipedia*. This is rapidly becoming a world repository of knowledge, instantly accessible from anywhere, and comprises, not merely web pages, but also thousands of volunteers who contribute their intelligent thought to extend, correct and protect those pages — the *Wikipedians*. (I am a Wikipedian — hopefully you are too. People become one simply by adding to or correcting a page. If you have ever found Wikipedia useful, please consider helping!)

We can expect that there will appear many other intelligent systems within what has been dubbed Web 2.0 - the collective use of the internet to form new social, business and educational collaborations.

5 Conclusion

In the realm of collective human intelligence, Jaap has played major roles. His work at Leiden is at the interface of law and computer systems, and is a contribution to collective intelligence in the legal sphere.

However, the most important of all is Jaap's role in that collective human intelligence that is the world's universities. He has built intelligent systems, originally at Delft and then at Maastricht, that delivered as their outputs dozens of PhDs. These intelligent systems react to the humans who enter the postgraduate program, provide their research needs, inform and guide their research, and eventually accrete the graduate into humanity's collective brain.

The intelligence of these intelligent systems lies partly in the individual intelligences of the peoples embedded in them, but also in the emergent collective intelligence of the whole enterprise. (For example the identification of the hazard of global warming did not and could not have been discovered by any single individual, but it may enable the collective intelligence of humanity to correct the adverse effects of humanity's activities.)

As humanity progresses forward technologically to what Kurtzweil calls the "singularity" I anticipate dramatic further amplifications of intelligent systems, and I hope that Jaap and his students will continue to play a part in developments to come.