LIMITS OF ARTIFICIAL INTELLIGENCE

Edimar Veríssimo da Silva

INPE, ARTIFICIAL INTELLIGENCE - CAP-354
São José dos Campos, SP
yugi386@yahoo.com.br
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ABSTRACT

In this article we try to verify the evolution of artificial intelligence by analyzing the Deep Blue supercomputer created by IBM to play chess and the Watson computer that defeated human opponents in the TV show Jeopardy. We also present Godel's incompleteness theorem and its implications on the development of Artificial Intelligence.

Key words: Artificial intelligence, natural language processing, incompleteness theorem.

I. INTRODUCTION

This work presents Deep Blue (IBM computer designed to play chess) and Watson (computer that processes natural language). Following we discuss some implications of Godel's incompleteness theorem in Artificial Intelligence (abbreviated later by AI). In the conclusion we reaffirm our observations discussed in the immediately preceding topic.

II. DEEP BLUE

Artificial intelligence has always exerted a fascination on man, especially after the second half of the 20th century when computers were beginning their evolution.

Among the most difficult and strategic games is chess which allows a very large number of combinations. Thus in the mid 80's the roots of Deep Blue are found - a computer capable of playing chess on a high level. The doctoral student at the time, Feng Hsiung Hsu, from Carnegie Mellon University, started to design the computer to play chess called ChipTest [1]. Hsu and other collaborators were hired by IBM later and in 1993 they created the Deep Blue computer.

In 1996 the Deep Blue computer and the then world chess champion Kasparov played 6 matches and the champion won 4-2. However, in 1997, after several improvements, Deep Blue would win Kasparov by 3.5 to 2.5 [2]. There is a controversy over the machine's victory in this last round of games and Kasparov asked for a third round, but IBM refused the challenge [4].

Anyway IBM contributed to the understanding and exploration of the limits of parallel processing, paving the way for building computers to solve more complex problems [3]. As we know the number of chess combinations is very large and creating an algorithm to deal with this situation is not an easy task.

III. WATSON

In the Watson project (in honor of Thomas J. Watson, founder of IBM) IBM innovated once again by imposing itself the challenge of developing a system capable of processing natural language and competing with humans in the U.S. TV show Jeopardy [5]. It must be said that this challenge is much more difficult than the one faced when building the Deep Blue computer that had a specific purpose.

Among the challenges faced by IBM is natural language processing. For us humans language is indeed natural and usually understandable. However, for a computer to understand it, it is necessary to deal with many problems. Language is ambiguous, imprecise, full of idioms and idiosyncrasies. At the same time it can be very precise too [6].

The Watson computer uses IBM DeepQA technology that has more than a hundred different techniques to analyze the data, generate and classify hypotheses to present the response with a high degree of accuracy [5]. In fact, Watson beat human opponents in the question-and-answer TV show Jeopardy in 2011. According to Jim de Piante, who was project manager in Watson's development,

> *"The way Watson understands phrases is by analyzing a massive amount of information and establishing relationships between them. There is a machine learning process that leads him to understand what each question means. This is much more complex than simply recognizing spoken words". [7].*

No doubt the Watson project represents a giant leap from Deep Blue. From a specific goal (to play chess) IBM went to a software capable of answering questions in natural language which is really amazing.

> *"When you receive a question, Watson generates a hypothesis and brings both the answer and the level of trust to give it. And then Watson shows the steps he's taken to get this answer. In a way, Watson is reasoning. You don't program Watson, you work with Watson. And through your interactions he learns. As do we." [14]*

Watson is being used by banks like Bradesco to guide their managers in the search for financial products, is being used by Sky in broadband telecommunications operations, detecting and cataloging information on the most varied problems that can affect the communication network. Fleury Lab is using Watson to help analyze the mutations found in the genetic sequencing of tumors [15].

It is a fact that more and more AI is being used and this should continue to increase on an exponential scale because today's world contains more and more information and without the help of intelligent computers humans would not be able to research and synthesize data quickly to solve important issues for society.

> *"We are experiencing an explosion of data production. Ninety percent of all data in the world has been produced in the last two years. The expectation is that this trend will grow as we interconnect and instrument more of our world. And 80% of all information in the world is unstructured information, which includes texts such as literature, reports, articles, research reports, theses, emails, blogs, tweets, forums, chats and text messages. We need computers to be able to understand this great flow of information so that we can use it in the best way" [6].*

Of course, Watson is of great value in filling this great gap generated by the simple fact that we humans do not have time to deal with the immensity of current information and seek answers to our questions.

But is it possible to someday build a robot with human-like characteristics and capabilities, that learns alone, makes difficult decisions, knows how to differentiate opinions from facts, has criticism, self-criticism and other characteristics hitherto exclusively human? Perhaps Watson is a good start to this reflection.

IV. DISCUSSION

The turn of the 19th to the 20th century was a period of great changes in the mathematical world. The great David Hilbert (1862-1943) was a German mathematician who in the 1920s wanted to reform the mathematical foundations strictly from arithmetic. From a finite number of consistent axioms all mathematics could be reduced and in this way all propositions could be proved within this system [9].

In 1931 Kurt Godel published an article entitled "On the Undecidable Propositions of Principia Mathematica and Related Systems" and showed that Hilbert's goal was unattainable.

> *"Until recently it was tacit that a complete set of axioms can be assembled for any branch of mathematics. In particular, mathematicians believed that the proposed set of arithmetic in the past was really complete or, at worst, could be completed by simply adding a finite number of axioms to the original list. The discovery that this will not work is one of Godel's major achievements.*

Here are the two theorems of Godel's incompleteness:

> 1. "In any formal system consistent S, with a minimum of Arithmetic, it is possible to formalize a U sentence such that U can be interpreted intuitively as the statement that it itself is indemonstrable in S"[11].
>
> Or alternatively:
>
> 1. "For any coherent axiomatic system robust enough to describe the concepts of the arithmetic of natural numbers, there are true statements about natural numbers that cannot be proved from axioms"[12].
>
> 2. "The proof of consistency for formal systems (involving a little Arithmetic, under the conditions Hilbert wanted) cannot be formalized within the system itself"[11].
>
> Or even:
>
> 2. "For any formal theory effectively generated T, including truths of basic arithmetic and also certain truths of formal demonstrability, if T includes statements of its own consistency, then it is inconsistent."

What is Artificial Intelligence if not an ingenious and complex algorithm (or group of algorithms) that aims to solve a problem or even "represent" human behavior in many different ways?

> *"Science only understands what it can formalize, that is, put within logical parameters. All its methods, including dialectics, are 'logical'. Dialectics, unlike formal logic, tries to open spaces for less formalizable expressions, when using open questionnaires, life stories, statements, recorded conversations, etc., but, basically, when it intends to analyze information, it has to order it logically, formalizing it. (...) This feature recommends accepting that there are incomputable things, such as the problem of computer breakdown. Thus, computer processing cannot 'solve everything', because one thing is the way it has to process information, another thing is the real world, much more chaotic than binary". [16]*

This fact is seen in a practical way when, for example, we compare the first translator software that presented a very bad work. Today, programming techniques and new intelligent algorithms enable voice recognition and almost instantaneous translation. Translation into many very different languages and the level of accuracy has improved a lot but is still lagging behind the work of a human translator. It is possible that in a while software translators have come very close to the quality of human translation, but we could doubt if one day the machines would outperform us in this work, not in the question of speed and practicality, but in the quality of the final work.

The same happens with IBM's Watson artificial intelligence system: its algorithms also have limitations, but this is not demerit; on the contrary, it represents man's effort to create artifacts that can assist him in various tasks, and this is very positive. It is important to stress that the advantage of using intelligent systems like Watson becomes almost mandatory nowadays: we don't have time to do the work it does.

But unfortunately, as Godel himself says in his article there are problems that cannot be decided by a set of rules and axioms and this is what the AI proposes in a certain way.

> *"It is known that the development of mathematics, in the sense of greater accuracy, has led to the formalization of vast domains of this science so that demonstrations can be carried out according to some mechanical rules. The most exhaustive formal systems constructed so far are, on the one hand, Principia Mathematica (PM) and Zermelo-Fraenkel's system of axioms for set theory. Both systems are so general that all the demonstration methods currently used in mathematics can be formalized in them, i.e., they can be reduced to some axioms and inference rules. It is therefore reasonable to assume that these axioms and rules of inference are also sufficient to decide all the issues in mathematics that can be formally expressed in these systems. What follows will show that this is not so, but rather that in both systems cited there are relatively simple whole number problems that cannot be decided on the basis of the axioms. This situation does not depend on the special nature of the constructed systems but applies to a wide class of formal systems"[10].*

We see that the evolution of AI techniques will be constant and will certainly bring great benefits to society. But definitively replacing human intelligence in all sectors where it is employed seems to be something a little distant, at least for now.

Nagel [8] still explains clearly some important points about Godel's incompleteness theorems:

> *"Godel's proof should not be presented as an invitation to despair or as an excuse for the trafficking of mysteries. The discovery of the existence of formally indemonstrable mathematical truths does not mean that there are truths destined to remain forever unknown (...) this means that the resources of the human intellect have not been and cannot be fully formalized, and that new principles of demonstration await eternally invention and discovery".*

V. CONCLUSION

According to Nagel [8] the conclusions of Godel's theorem show that there are numerous problems that remain outside the scope of an axiomatic method:

> *"such devices are incapable of responding no matter how intricate and fast their operations may be. Given a defined problem, a machine of this type can be built to solve it; but it is not possible to make a machine of this type capable of solving each and every problem"[8].*

And it complements:

> *"the brain seems to embody a structure of rules of operation far more powerful than the structure of commonly designed artificial machines. There is no immediate prospect of replacing the human mind with robots"[8].*

On the other hand, we must pay attention to the fact that intelligence and certainty are different things. It is not because we cannot build a machine to solve all the problems that the AI is doomed to failure. On the contrary, many very interesting tools are being built with it.

> *"Intelligence is less the ability to deal with certainty than knowing how to survive in the uncertain world. To know how to think is not exactly to follow sequential instructions always the same, but to contest them, to innovate them, to discard them, especially to know how to face the new, that which was not in the script or had never been seen before. Decorating is, therefore, insanity, because it is assumed that we will always face the same problem, with the same solution. It is fundamental to know how to question, to research, to account for contexts and unknown references, to reinterpret what we already know, to learn from others without submitting. "[16]*

Are there really limits to Artificial Intelligence? According to Godel's incompleteness theorem the answer is yes. However, the benefits of good application of AI resources are undeniable, although we know that it will be unable to provide answers to all our questions and needs.

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