Brain and Artificial Intelligence

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Abstract

From ancient times, the history of human beings has developed through a succession of steps and sometimes jumps, until reaching at the relative sophistication of the modern brain and culture. Researchers are attempting to create systems that mimic human thinking, understand speech, or beat the best human chess player. Understanding the mechanisms of intelligence, and creating intelligent artefacts are the twin goals of Artificial Intelligence (AI). Great mathematical minds have played a key role in AI in recent years; to name only a few, Janos Neumann (also known as John von Neumann), Konrad Zuse, Norbert Wiener, Claude E. Shannon, Alan M. Turing, Grigore Moisil, Lofti A. Zadeh, Ronald R. Yager, Michio Sugeno, Solomon Marcus, or Lászlo A. Barabási. Introducing the study of AI is not merely useful because of its capability to solve difficult problems, but also because of its Mathematical nature. It prepares us to understand the current world, enabling us to act on the challenges of the future.

Keywords: Classical and Non-Classical Logics, Fuzzy Logic, Uncertainty, Brain, Networks, Artificial Intelligence, Neuroscience.

Motto: *Everything is vague to a degree which you do not realize until they have tried to specify.* (Bertrand Russell, 1923)

1. Introduction

The historical origin of Artificial Intelligence as a scientific field was established at the Darmouth Conference (1956). In that year, John McCarthy coined the term, defined as "the science and engineering of making intelligent machines". But this definition does not cover the actual breadth of the field. AI is multi-connected with many other fields, such as Neuroscience or Philosophy; and we can trace its origins further back, to arcane origins, perhaps to Plato, Raymond Lully (Raimundo Lulio, in Spanish), G. W. Leibniz, Blaise Pascal, Charles Babbage, Leonardo Torres Quevedo, etc., with their attempts to create thinking machines. A suggestive definition of the field would be to say that it is the area of Computer Science that focuses on creating machines that can engage on behaviors that humans consider intelligent.

The history of AI field is long and fruitful; just recall topics as diverse and important as the famous Turing test, the Strong Vs Weak AI discussion, the Chinese Room argument, and so on. And modern AI has spanned more than fifty years now.

We know the origin of ideas about thinking machines and the mechanisms through which the human brain works; the possibility of mimicking their behavior if we create some computational structure similar to the neuron, or perhaps the neural system, its synapses or connections between neurons, leads to the production of what is called a Neural Network.

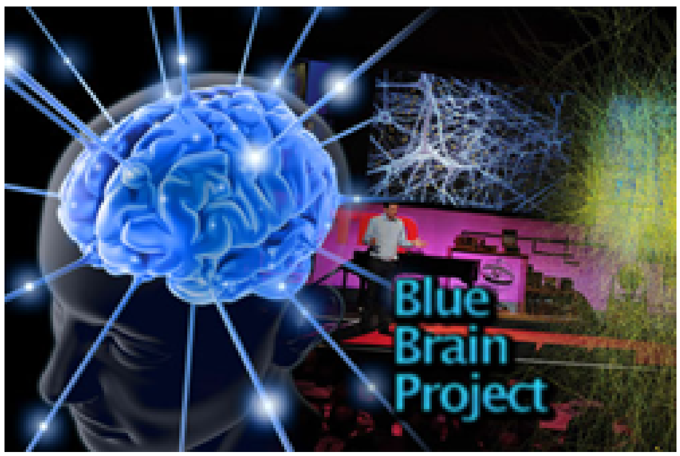
The central purpose of AI would be to create an admissible model for human knowledge. Its subject is, therefore, "pure form". We try to emulate the way of reasoning of a human brain. Research directed towards this goal can only happen in a succession of approximated steps, but the attempts proceed always in this sense.

Initially, AI worked over idealizations of the real world. Its natural fields were, therefore, "formal worlds". Search procedures operated in the Space of States, which contains the set of all states (or nodes, in the case of representation by graphs), that we can obtain when we apply all the available operators. Many early AI programs used the same basic algorithm. To achieve some goal (winning a game or proving a theorem), they proceeded step by step towards it (by making a move or a deduction each time) like searching through a maze, backtracking whenever they reached a dead end. This paradigm was called "reasoning as search".

2. Connection AI - Brain

Studying Artificial Intelligence is interesting not only because of its potential to tackle many open problems, both inside the field and in application to others scientific areas, and even in the study of the Humanities, but also because it is a new and very creative branch of Mathematics, and it prepares us to understand the current world, enabling us to act on the challenges of the future.

"An artificial human brain can be built within the next ten years", said Henry Markram, Israeli-born scientist, professor at the Polytechnic of Lausanne and director of the Blue Brain Project (BBP), also called Human Brain Project.



BBP: This is a project by the Swiss government, and also funded by private donations, with the aim of trying to build an artificial copy of the mammalian (and therefore human) brain. In 2013 many euros were assigned to this project (and another on graphene) for research over the next ten years. Turning to this Project, Prof. Markram's team is concentrated in the study of the `neocortex´, which is the layer of the brain responsible for higher functions directly, like, for example, the conscious thought. In recent years, this team has managed to decipher the structure of the `neocortical column´. By working with a software model that reproduces tens of thousands of neurons, all different from each other, they managed to create the artificial brain. All this opens up new and promising perspectives for science in its support for improving the lives of humans. We would need a laptop for each neuron. Therefore, ten thousand laptops are needed. So this team will use an IBM supercomputer with ten thousand processors.

Through simulations we can observe brain function and behavior in dysfunctional situations, as in the case of depression or Alzheimer. The tool will be able to understand what happens in the brain and may try different behaviors. It's like in aeronautics: a model simulates the flight and can test how it would be affected by wind, rain and other weather conditions, and how they respond to the aircraft. Now they are trying to do something similar with the brain. It is expected that in the future, neuroscientists know how the brain is formed, develops and ages, or the mechanisms by which we learn and improve our intellectual capacities.

We should also mention another program, somewhat parallel in purpose to the previous, which is the American BRAIN project. Their budget is for a similar amount, and aims to emulate the achievements of the Human Genome Project. It can be seen as a kind of `spatial´ new career, but now between Europe and the USA. The map of the brain will be built thanks to these new `cartographers´ of neuroscience, an initiative that will see its results in the coming years. Very big companies like Google, IBM, or Microsoft collaborated in these projects.

3. The future of neuroscience

Quantum computing is the `next generation´ of technology to transform our world. It is based on quantum mechanics properties that are completely different from the classic ones.

In the world of the smallest particles, we can assume that the laws of nature are frequently defied. Now, using particles like photons, it was possible to create a new element: the minimal unity of quantum information, named Qubit (Quantum bit), which allows us to process information so that if you dedicate centuries of classical computation, it would not be possible. And since the classical method is linear, in quantum case we can solve more than one operation at a time.

Lately, WATSON has concentrated on other tasks, such as developing new recipes from existing. Trying to create a mathematical model that allows us to understand cultural evolution is still a very difficult task, but nevertheless, is starting to be addressed by authors such as Donald Davidson, Daniel Dennett, as well as some theorist of artificial intelligence. It is a matter then of growing interest.

4. New applications of fuzzy logic

In Fuzzy Logic, statements are not absolutely true or absolutely false (Dubois, 1980). One thing can be 5% true (technically, its "degree of truth" is 0.05). Additionally, the variables (or categories) are no longer numbers and do not have borders linguistically accurate (high or low, rich or poor, fat or thin, healthy or sick, old or young, hot or cold, etc., depending on the occurrence degree of these properties), and the operators that modify them are "lot", "pretty", "too", "almost" or "not too much". These are called fuzzy modifiers ("hedges" or even "fuzzy modifiers"). This attributes a value to each of these features diffuse, and that value is accentuated or diluted accordingly, for example, the various powers or roots of the initial values or with polynomial expressions that depend on these functions. They are called modifiers "Intensification" or "Expansion" (Dilation), respectively, with gradual effects and variation. The feature of working with border regions is not fully defined itself in this area of mathematics (Garrido, 2011).

In 1973, with the basic theory of Zadeh fuzzy controllers, other researchers began to apply fuzzy logic to various mechanical and industrial processes, improving existing hitherto.

Several research groups have been established in Japan. Thus, Professors Terano and Shibata from Tokyo, with Professors Tanaka and Asai from Osaka, made major contributions both to the development of fuzzy logic theory and its applications (Jang, Sun, 1995, 1997).

In 1980 Professor Ebrahim Mandani in the United Kingdom (Mamdani, 1975, 1976, 1977), designed the first fuzzy controller for a steam engine, which would be applied to control a cement plant in Denmark, and did-of course-with great success.

In 1987 Hitachi used a fuzzy controller for the Sendai train control, which used an innovative system created by man. Since then, the controller has been doing its job very efficiently. It was also during 1987 when the company Omron developed the first commercial fuzzy controllers. So the year 1987 is considered the "fuzzy boom" due to the large number of traded products based on fuzzy logic. In 1993, Fuji Fuzzy Logic was used to control chemical injection water treatment for plants for the first time in Japan. The Fuzzy Technology grew in importance mainly in Japan and South Korea, having the support of the government, universities and industries. (Sugeno, 1977, 1985).

Parallel to the study of the applications of fuzzy logic, Professors Takagi and Sugeno developed the first approach to construct fuzzy rules (Fuzzy Rules), from training data or training (Fuzzy Learning). Since then, the applications of fuzzy logic in everyday life have grown rapidly. In fact, it is already a part of it. For example, some brands of washing machine using fuzzy logic are Electrolux, AEG and Miele, and they use these computational methods to moderate the program if the clothes washing "is not very dirty", which is a vague concept. The technique is also widespread in the ABS, braking cars, auto focus cameras, or control of the elevators, spam filters, also called "spam", and the now ubiquitous video games. Manufacturers do not want to give much publicity to the fuzziness involved in these developments for an obvious reason. To say that their cars brake is controlled by fuzzy logic does not contribute to their sales.

To build a fuzzy system, an engineer might begin with a set of fuzzy rules from an expert. An engineer might define the degrees of membership in various fuzzy input and output sets with a sets of curves.

The Fuzzy Rules, or the rules of a fuzzy system, define a set of overlapping patches that relate a full range of inputs to a full range of outputs. In that sense, the fuzzy system approximates some mathematical function or equation of cause and effect.

A very important result says that fuzzy systems can approximate any continuous math function. Bart Kosko (Kosko, 1993) proved this uniform convergence theorem by showing that enough small fuzzy patches can sufficiently cover the graph of any function or input/output relation. The theorem also shows that we can pick in advance the maximum error of the approximation and be sure that there are a finite number of fuzzy rules that achieve it.

Recent advances in Neural Networks, or Neural Nets (in terms of programs that learn from experience), and Genetic Algorithms (as programs evolve over time) are certainly a fitting complement to fuzzy logic. Another key reason for increased research in this field would be the interest in the resemblance between Neural Networks and Fuzzy Systems. The result from analyzing the relations between these two techniques are Neuro-Fuzzy Systems, which use learning methods based on neural networks in order to identify and optimize its parameters (Jang, Sun, 1997). Then appeared genetic algorithms, which together with neural networks and "Fuzzy Systems" are powerful and therefore are of great interest for future research, both current and mathematics for the most new, it is already here, quickly taking shape (Sugeno, 1985).

Neural networks are collections of "neurons" and "synapses" that change their values in response to inputs from surrounding neurons and synapses. The neural network acts like a computer, because it maps inputs to outputs. The neurons and synapses may be silicon components, or equations in software, that simulate their behavior.

Supervised learning, reached through supervised networks, tune the rules of a fuzzy system as if they were synapses. The user provides the first set of rules, which the neural net refines by running through hundreds of thousands of inputs, slightly varying the fuzzy sets each time to see how well the system performs. The network tends to keep the changes that improve performance and ignores the others.

Unsupervised learning, reached through unsupervised neural networks, blindly cluster data into groups (by a procedure so-called clustering), the members of which resemble one another. There may be no given right or wrong response or way to organize the data. It is in advance.

Fuzzy Modeling is many times used to transform the knowledge of an expert into a mathematical model. The emphasis is on constructing a fuzzy expert system that replaces the human expert, and also as a tool that can assist human observers in the difficult task of transforming their observations into a mathematical model. In many fields of science, human observers have provided linguistic descriptions and explanations of various systems. However, to study these phenomena, there is a need to construct a suitable mathematical model, a process that usually requires a very subtle mathematical understanding. Fuzzy modeling is a much more direct and natural approach for transforming the linguistic description into such a model.

5. Fuzzy modeling

A fuzzy model represents the real system in a form that corresponds closely to the way humans perceive it. Thus, the model is easily understandable, and each parameter has a readily perceivable meaning. The model can be easily altered to incorporate new phenomena, and if its behavior is different than expected, it is usually easy to find which rule should be modified, and how. Furthermore, the mathematical procedures used in fuzzy modeling have been tried and tested many times, and their techniques are relatively well documented.

The Fuzzy Logic research continues to advance in the leading countries (Zadeh, 1975, 1988, 1989) in terms of economic and technical progress, as well as in less advanced countries, such as Spain. But groups that have formed attempt to advance our science in this direction, as well as on deep (on mathematical foundations and philosophical) theoretical consequences, which influence the future challenges (Garrido, 2011, 2017).

It must be stated that there has been some important progress when it comes to the Aggregation Operators (T-Norms, T-conorms, and so on) in Fuzzy Modeling. Alongside all this development, new generalizations of the existing mathematical theories will come to create a new science, which will apply a lot more to our reality.

It is also important to note that fields apparently far enough outside of the treatment of fuzziness, such as the symmetry and the entropy, have entered into new avenues of research by Fuzzy Symmetry, the Fuzzy Entropy, the Fuzzy Graphs, and so on (Garrido, 2014, 2015, 2016, 2017).

There are more and more applications of all the new branches of Artificial Intelligence and Robotics. Among the most outstanding, we have the investigations carried out under the direction of Professor Doctor Manuella Kadar, with a view on the automation of the industrial processes of ceramic production, in the region of Transylvania. It has the support of European Union funds. In this team is integrated the author of this article.

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