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Neural networks and some practical applications in the field of artificial intelligence

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Abstract. Even since Antiquity, in ancient Greece 4th century BC, or in China, the 3rd century BC, but not only there, people have imagined and even created automatic mechanisms, mechanisms that somehow were trying to be shy replicas of real examples of intelligent life from nature, including replicas of Man's creation, such as the first bronze man, but nonetheless, non-intelligent replicas. Subsequently, in the modern age, attempts have been made to simulate a human neural network, as well as the first steps towards artificially simulating the functioning of the human brain. We will present in this article concepts of neural networks and some practical applications in the field of artificial intelligence and their capabilities to simulate autonomous thinking through advanced programming and complex assimilation of large data sets, using the three major learning paradigms, namely: supervised learning, unsupervised learning, and reinforcement learning. All these new concepts, over the past 75 years, and the advances in information technology have led to the emergence and development of practical applications of artificial intelligence. In this way, the human dream of creation tends to live and fulfil itself, why not, even in the coming years.

1. Introduction

Throughout human history, there have been various attempts to simulate intelligent life by building automatic mechanisms. Many of these attempts are mentioned in Greek mythology, such as, for example, Talos [1] - the first bronze man, or in ancient Chinese writings the automaton presented in Liezi's writings [2]. All these attempts imagined and created by the wise men of those times were, however, timid replicas of examples in nature, replicas lacking in intelligence and which only imitated the movements of animals or the movements of man. What was always missing was the technical possibility to theorize, define and effectively build an artificial neural network capable of making decisions based on certain previously accumulated knowledge.

The modern era, and especially the beginning of the 20th century, has led to an impressive development of technique and theories regarding the design of programs and mechanisms that simulate an artificial neural network.

The concept of neural network, by its first variant, called threshold logic, appeared in 1943 [3] and opened practically two paths, one focused on biological processes and another focused on the application of neural networks in the creation of new hardware and software applications with artificial intelligence [3].

The model focused on neural networks, in conjunction with the computational and data storage technical developments of the last 75 years with the constantly developing computing capabilities and the concepts of fuzzy logic defined as the superset of the conventional Boolean logic [4], have now led



to the development of neural networks with applications in artificial intelligence and the development of artificial entities capable of making decisions and simulating autonomous thinking. This has been made possible by advanced programming and complex assimilation of large datasets. The three major paradigms of learning and data assimilation were used for this purpose, namely: supervised learning, unsupervised learning and reinforcement learning.

2. Neuronal networks

Neural networks are computational systems that attempt to simulate the functioning of neural networks present throughout the animal world. Their main characteristic is the ability to learn and succeed in carrying out various tasks through examples and through the assimilation of large amounts of data [3].

Simulation of a neural network in the biological world is done by connecting several units or nodes that somehow reproduce the neurons connected to each other from a biological neural network.

Like neurons, each unit performs certain calculations, processes certain signals, their result transmits it to another unit or other units with which it is connected through links that practically simulate the synapses of neurons, each unit receiving information from another unit, it processes and transmits them to all other units with which it is connected. This results in an extraordinary multiplication of the computing capacity. The ability to make decisions based on previous examples is thus constantly improved and shared with all other connected units.

The first attempts to define an artificial neural network were made in the 1940s by Warren McCulloch and Walter Pitts by using mathematical algorithms and had as a first result the definition of so-called threshold logic [5], which led to the development of artificial neural network ideas and their subsequent application in artificial intelligence [3]. Below, in Figure 1 is presented a representation of interconnected group of nodes in an artificial neuronal network.

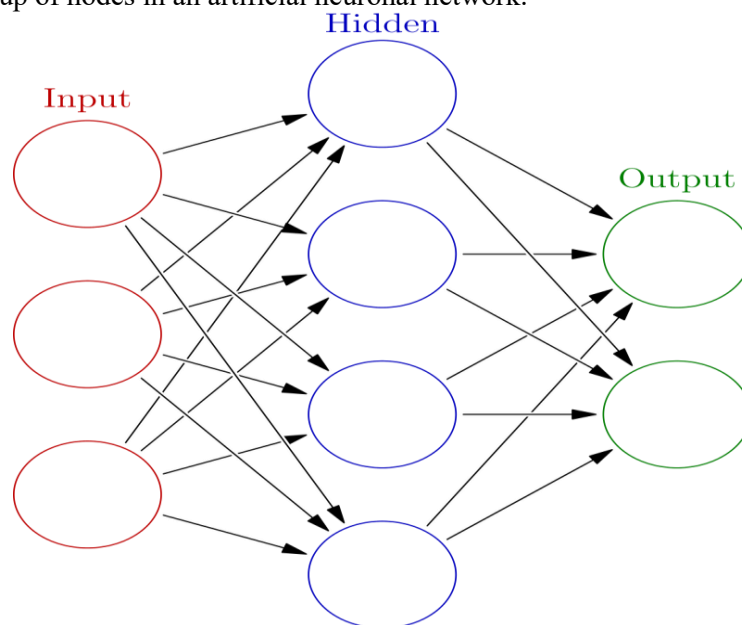


Figure 1. Representation of interconnected group of nodes in an artificial neuronal network, where each circle represents a neuron and each arrow a connection between an output of a neuron to an input of a neuron [3].

Understanding and simulating neural networks in artificial intelligence is currently halting at the simulation of electrical information exchanges between the synapses of a biological nervous system. To properly understand a neuron, below in Figure 2 is graphically represented a biological neuron.

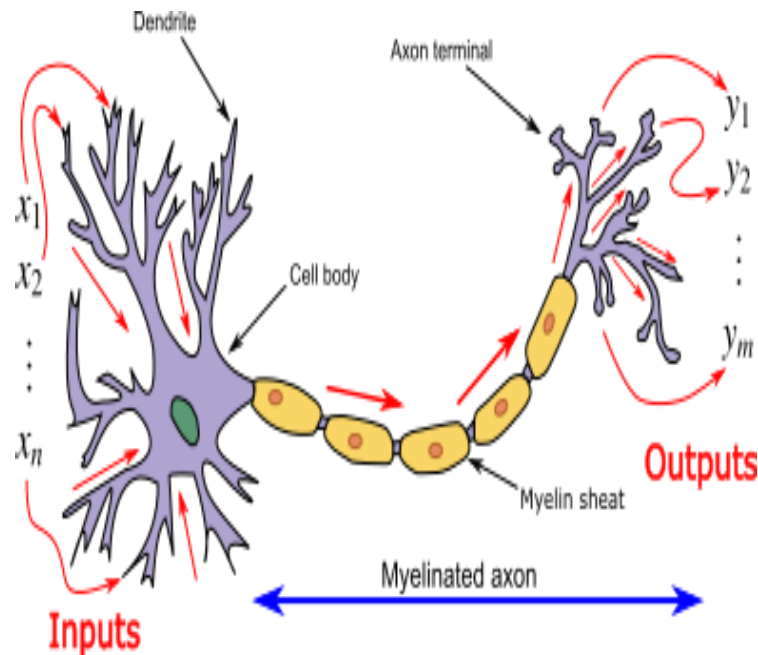


Figure 2. Representation of a biological neuron [3].

The part concerning the chemical neurotransmitters also used by biological neurons in transmitting information and which give the special versatility of biological nervous systems, remains to be studied and understood, however, at this moment there are some attempts to make practical applications of artificial neural networks that actually use biological neurons [6].

After the '40s, the next 30 years brought extraordinary developments in the theory of neural networks and laid the groundwork for advanced understanding in this area, some of them:

- Hebbian learning - the end of the 1940s with the definition of unsupervised learning;
- The application of these theories in new computational models with Turing type B machines - concept defined by Alan Turing in 1948 as an unorganized computing machine, similar to a new born brain [7];
- The first calculating machines named themselves: computers by Farley and Clark [8] in 1954;
- Definition of Perceptron by Rosenblatt [9] in 1958, as a neuron of the type Warren McCulloch - Walter Pitts, provided with a learning mechanism based on predefined examples. Further definition of the simple perceptron and the continuous perceptron.
- The back propagation algorithm created and defined by Paul John Werbos in 1975 by using multi-layer networks efficiently trained by back propagating errors through the layers of the neural network.

The limitations of the neural networks were given until the 1970s by the low computing power of the computers existing at that time. Increasing computing power since the 1980s, along with new concepts of neural networks (parallel distributed processing, feedforward networks, recurrent neural networks and deep feedforward neural networks, etc.), have brought this science of neural networks to the point where they make possible the existence of artificial entities that simulate autonomous thinking

3. Fuzzy logic

Since ancient times, Aristotle has postulated logic based on two values: true or false and has since expressed the logic of the excluded third [10]. In this way, any other variable was not possible.

This concept has shaped human thinking from then to our time and was enough to model real-life phenomena, but it was not enough to give a correct answer to some simple questions like:

- Are you smart or not?

Or:

- Is he a good man or a bad man?

And so on.

The concept of fuzzy logic comes and introduces new options to better represent reality, namely: uncertainty and inaccuracy as essential components of incompleteness. The uncertainty scale practically expresses the degree of confidence that can be given to certain information. The scale of inaccuracy deals with the informational content.

A simple fuzzy system, as is represented in Figure 3 from below, has 4 basic components:

- Fuzzifier;
- Rules;
- The inference engine;
- Defuzzifier;

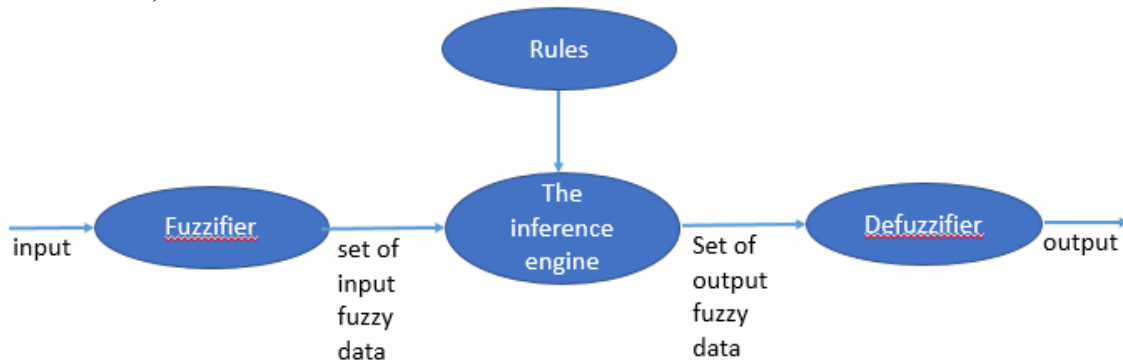


Figure 3. Simple Fuzzy logic system explained.

- The fuzzifier practically transforms numeric expressions and gives as outputs a set of fuzzy data that will be used in the rules activation process, rules that have fuzzy data sets associated with linguistic data as well;
- The inference engine performs the transformation from the set of rules defined in fuzzy data and has as main feature: the implementation of these rules defined previously;
- The defuzzifier transforms from fuzzy data sets into numerical values. The transformed data can be interpreted and used within the systems who implemented that fuzzy system.

Within such a system it is necessary to establish clear rules. By using these rules and using the system components defined above, that fundamental feature of a fuzzy system results, respectively, the input-output transformation that can be expressed through a predefined function within the system.

An important step in defining the modern notions of fuzzy logic is the type of fuzzy logic proposed by the Polish mathematician Jan Lukasiewicz in 1920, who proposed extending the truth value of a analysed sentence to all real numbers in the range (0,1), any number in this range (0,1) representing the possibility that the analysed sentence to be true or false.

All the researches in this field have led to the creation of the theory of possibilities regarding a system and a mathematical logic as they can modify an express rationality in general in inaccurate conditions, taking care of an extended theory of Lotfi Zadeh in 1965 in a system of mathematical logic, introducing the nuanced terms used in expressing a truth [11] [12], using natural language and thus defining fuzzy logic [11] through this representation and use of nuanced terms, thus differentiating traditional type logic that expresses very clearly belonging to a group compared to fuzzy logic that is always flexible when it comes to belonging to a group.

In recent decades, following the evolution of integrated IT systems and the evolution of computational technology in general, this feature of fuzzy uncertainty management systems has made possible various implementations in industry in many industrial processes, in communications technology, traffic management, in integrated energy systems etc.

4. Artificial intelligence

All the researches of the last 75 years in the field of artificial neural networks using the three major learning pathways, supervised learning, unsupervised learning and reinforcement learning, in

conjunction with fuzzy logic and information technology developments, have created in recent years the premises of the development of practical applications, namely the creation of hardware equipped with artificial intelligence.

In the process of defining and evolving neural networks, in the 1950s, Alan Turing defined the following Turing test in order to consistently express the ability of an artificial system to test and simulate the behavior and capabilities of human intelligence [13]. A representation of a Turing test diagram is presented in Figure 4 from below. The test has 3 participants, 2 people and a car, each positioned in a different room:

- 1 person judges;
- 1 person answers the questions asked;
- 1 machine answer the questions asked.

The received answers are evaluated, and an accuracy of at least 50% causes the test to be considered passed by the respective machine.

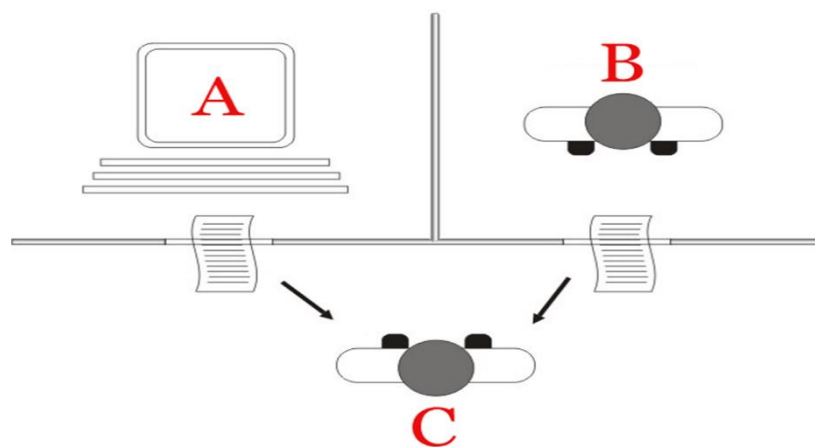


Figure 4. Representation of Turing test diagram [13].

Now, there are now various official implementations of such applications within major companies: Google, Apple, IBM, Adobe, etc., but also at the level of state structures in the world.

The major impact for people in general, is currently represented by the implementations made by companies in the field of information technology. Virtual assistants implemented in various communication devices (phones, tablets, laptops, IOT devices) have led to a major popularization of artificial intelligence programs

The main feature of all AI systems is that they are hardware and software systems capable of learning from experience and adapting according to the tasks that have been assigned and which they have already accomplished. They are not necessarily specialized in a particular field, they can offer eloquent solutions and interpretations in various new situations. They are systems capable of receiving and assimilating huge amounts of data. They are constantly supplied with new datasets from databases distributed through the various programming languages available.

As we said above, in this article, the main objective in creation of an AI system, is to make a system capable au autonomous thinking and detect patterns, a system capable to learn and detect patters based on data stored on servers. That kind of AI system can be integrated in an urban city administrating system [14].

The main characteristics of a smart urban city is the integrations of various management systems from within the city. This can be made using an AI system that will react much faster than a man when there is a need to make a fast decision. Certain approaches and solutions given by a AI system can and will affect the life of citizens, so there are questions regarding the ability of an AI to properly respond to all the crises situations encountered every day in a city [15].

According with [16], depending on how AI relate to external stimuli, AI can be classified into:

- Reactive machines: react to external stimuli;

- Machines with limited memory: they can take a look at the past and interpret the data received at a certain moment according to the past experiences;
- Machines that understand and apply "Theory of the mind": they can understand certain emotions, thoughts, states, human expectations and are able to interact socially (not yet fully realized);
- Machines that already have self-awareness: AI smart, self-aware (not yet realized).

5. Conclusions

In recent decades, following the evolution of integrated IT systems and the evolution of computational technology in general, neural networks, fuzzy logic applied to various integrated management systems and artificial intelligence applications have become a real and constant presence in everyday life, these it tries to simulate human interaction as accurately as possible and to function the way a human works.

We are currently somewhere between type III and type IV of AI and already the artificial intelligence systems change the way of approaching the various complex problems. Although very often a human can characterize a system with AI as a robot that will replace it in the future, the purpose of these equipment is only to improve human functionalities in general.

References

- [1] en.wikipedia.org 2019 *https://en.wikipedia.org/wiki/Automaton* [Online] Available: <https://en.wikipedia.org/wiki/Automaton>
- [2] en.wikipedia.org 2019 *Liezi* [Online]. Available: <https://en.wikipedia.org/wiki/Liezi>
- [3] en.wikipedia.org 2019 *Artificial neural network* [Online] Available: https://en.wikipedia.org/wiki/Artificial_neural_network
- [4] ro.wikipedia.org 2019 *Logică fuzzy* [Online] Available: https://ro.wikipedia.org/wiki/Logică_fuzzy
- [5] W S McCulloch and W Pitts 1990 *A logical calculus nervous activity** vol 52 no 1 pp 99–115
- [6] D Cameron 2002 *Rat-Brained Robot* MIT Technology review [Online] Available: <https://www.technologyreview.com/s/401756/rat-brained-robot>
- [7] en.wikipedia.org 2019 *Unorganized machine* 2019 [Online] Available: https://en.wikipedia.org/wiki/Unorganized_machine
- [8] B Farley and W Clark 1954 *Simulation of self-organizing systems by digital computer* Trans IRE Prof Gr Inf Theory vol 4 pp 76–84
- [9] F Rosenblatt 2005 *The Perceptron: A Probabilistic Model For Information Storage And Organization In The Brain* Psychol Rev vol 65 no 6 pp 1–23
- [10] en.wikipedia.org 2019 *Law of excluded middle* [Online] Available: https://en.wikipedia.org/wiki/Law_of_excluded_middle
- [11] L A Zadeh 1965 *Fuzzy Sets* Inf Control vol 8 pp 338–353
- [12] L A Zadeh 2015 *Fuzzy logic - A personal perspective* Fuzzy Sets Syst vol 281 pp 4–20
- [13] en.wikipedia.org 2019 *Turing test* [Online] Available: https://en.wikipedia.org/wiki/Turing_test
- [14] W G de Sousa E R P de Melo P H D S Bermejo R A S Farias and A O Gomes 2019 *How and where is artificial intelligence in the public sector going? A literature review and research agenda* Gov Inf Q no July p 101392
- [15] P Čerka J Grigienė and G Sirbikytė 2017 *Is it possible to grant legal personality to artificial intelligence software systems?* Comput Law Secur Rev vol 33 no 5 pp 685–699
- [16] C Kumar 2018 *Artificial Intelligence: Definition, Types, Examples, Technologies* [Online] Available: <https://medium.com/@chethankumargn/artificial-intelligence-definition-types-examples-technologies-962ea75c7b9b>