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A Systems Approach to the Artificial Intelligence Concept

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Abstract: To an entrant, Artificial Intelligence (AI) constitutes an amorphous phenomenon. Ways and means of containing this concept within a systems framework is the focus of this article.
The article resorts to qualitative analysis as a medium. It advances a systems theory framework as the boundary for an AI structure where all things would fall in place. The article suggests a framework where an artificial intelligence system has inputs, transformation processes and an output. A feedback loop as well. The inputs are built around data and artificial neurons. Transformation is done through analysis and learning. And the outcome is composed of insights, sub-systems and technologies. Feedback built on the outcomes completes the system loop.
The article provides a convenient vehicle for understanding of the components of artificial intelligence and their flow. It could be useful into understand AI applications and their situational relevance.

Keywords: The Artificial Intelligence, Neurons, Machine learning**.**

1 Introduction

To an entrant, Artificial Intelligence (AI) constitutes an amorphous phenomenon. A wide array of concepts, sub-concepts and hypothesis are presented. Technologies are touted and ultimate outcomes are mystified. It looks like an industry in the early stages of a life cycle with the life cycle itself shrouded into futuristic mystery. Ways and means of containing this concept within a systems framework is the focus of this article.

The article resorts to qualitative analysis as a medium. It advances a systems theory framework as the boundary for an AI structure where all things would fall in place. The article suggests a framework where an artificial intelligence system has inputs, transformation processes and an output. A feedback loop as well. AI Inputs, transformation and output elements are all present-day concepts referred to in current literature but not related to each other within a systems structure.

The article provides a convenient vehicle for understanding of the components of artificial intelligence and their flow. It could be useful into understand AI applications and their situational relevance.

2 The Framework

2.1 What is a system

"A System is a set of elements in interaction" according to the general systems theory (GST) (Bertalanffy 1968). . It is, also, any set of related parts for which there is sufficient coherence between the parts to make viewing them as a whole useful.

Systems are marked by a number of attributes. Systems have components, flows, boundaries (open or closed),

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synergies and a feedback mechanism. The sum total of system parts is less than that of the whole. A system flow represents the movement of inputs into the system from the environment, their transformation into outputs the supply of outputs to the environment and the provision of a feedback. A feedback mechanism measures the congruence of the output with established end goals. Systems can also be open or closed with open systems actively interacting with the environment.

2.2 What is Intelligence?

Intelligence is "the ability to acquire and apply knowledge and skills" (Legg and Hutter, 2007). Thurstone (Thurstone, 1943) equates intelligence to several different primary mental abilities that include verbal comprehension, word fluency, number facility, spatial visualization, inductive reasoning, memory and perceptual speed. Verbal comprehension, for example, involves the knowledge of vocabulary and reading while word fluency involves writing and producing words and number facility involves arithmetical reasoning. Some of those abilities relate, directly, to processes and technologies of artificial intelligence.

2.3 What is Artificial Intelligence?

Artificial Intelligence (AI) is "A branch of computer science dealing with the simulation of intelligent behavior ….. ". It is also "the capability of a machine to imitate intelligent human behavior." (Forbes, Feb 14, 2018,). The processes of simulation of human intelligence by machines, especially computer systems, include learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions) and self-correction. AI blends several sciences from computing and data sciences to psychology, philosophy and linguistics, among others.

AI concepts could be segmented according to the stage of concept development over time.

The present.

Present day intelligent systems are systems able to handle massive volumes of data but lack the analytical and independent self-awareness element. They are either reactive or limited memory.

- Reactive. These are equipment that analyzes possible moves, their own and their opponent's, and choose the most strategic move. They do not have the ability either to form memories or to use past experiences in order to guide current decisions. The computer's perception of the world is direct and it acts according to what it "sees ".
- Limited memory (corrective). This equipment use past experience in order to influence future decisions. Past information is, however, only transient and are not saved as part of a library or a learning experience. (The Conversation, November 14, 2016).

The future.

This AI segment does not only form an image of its own world, but also of other agents or entities in the world at large. It does not only understand consciousness, but has it.

- Theory of mind. This is a psychology term that refers to the ability to attribute mental states, beliefs, knowledge desires and intentions, to one self and to understand that others have beliefs, knowledge desires and intentions that are different from one's own. (Baron, Simon 1991). And they impact upon their decisions. This kind of AI does not exist yet...
- Self-awareness. In this category, AI systems have a sense of self and consciousness. Machines with self-awareness understand their current state and can use the information to infer what others are feeling. Conscious beings are aware of them, know about their internal states, and are able to predict feelings of others. This type of AI does not exist yet. (The Conversation, November 14, 2016).

3 The System Dimension of Artificial Intelligence.

AI fragments could acquire a coherent whole if put within a systems theory framework. AI is pictured, then, as a system with inputs, transformations, outputs and a feedback loop. Data, raw and other wise, as well as artificial neural sub-systems constitute the inputs. Learning (machine and otherwise) and analysis (diagnostic, predictive and otherwise) provide the transformation. Insights, technologies as well as derived sub-systems constitute the output. Feedback loop conveys outputs to the input and transformation segments and triggers essential adjustments.\ (Figure (1).

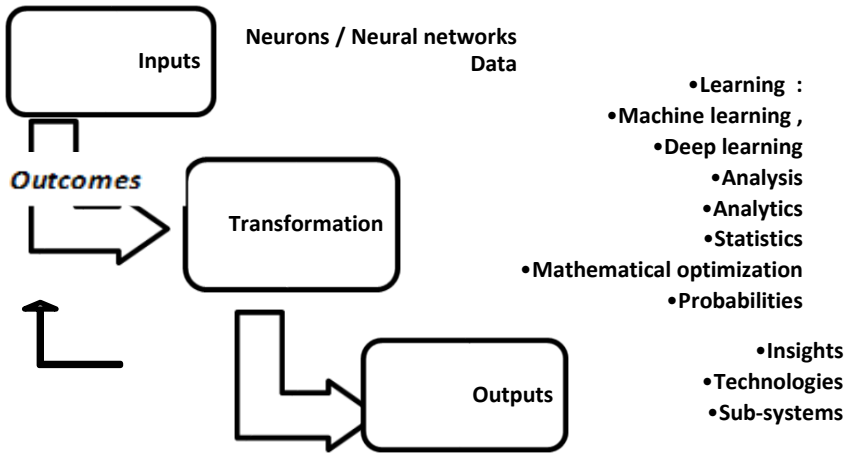

Fig. 1: AI system construct.

An Artificial Intelligence system is a system that recognizes two inputs: data and artificial neurons.

3.1 Inputs

- **Data**

Data constitute a prime input into AI systems.

Data is essentially " information in raw or unorganized form (such as alphabets, numbers, or symbols) that refer to, or represent, conditions, ideas, or objects….Data is limitless and present everywhere in the universe. To computers, data include symbols or signals that are input, stored, and processed by a computer, for output as usable information". (Business dictionary, 2017).

Most data can be categorized into 4 basic types from a machine learning perspective: numerical data, categorical data, time series data, and text data. Data could also be segmented according to different criteria: useless, nominal, binary, ordinal, and count. Time, interval, image, video, audio and text (Jeff Hale, 2018).

Data could be logged or collected. Data logging, according to Technopedia, is the process of collecting and storing data over a period of time in order to analyze specific trends or record the data-based events/actions of a system, network or IT environment. A data logger is an electronic device designed to measure and store data values, often independently of a PC.

Data collection largely consists of data acquisition, data labeling, and improvement of existing data or models

As AI technology advances it will develop an autonomous ability to seek, classify and validate data.

3.2 Neurons

Artificial neurons provide the second primary input into AI systems. Artificial neurons have biological roots.

- **Biological neurons**

Biological neurons are the basic information processing structures within the human CNS or "Central Nervous System" and PNS or "Periphery Neural System. Neurons are the cells that pass chemical and electrical signals along the pathways in the brain. There are motor neurons, for conveying of motor information, sensory neurons, for the conveying of sensory information and interneurons for conveying information between different types of neurons. (Stufflebeam , 2008). Neurons are connected to each other through synapses, sites where signals are transmitted in the form of chemical messengers. At the synapse, electrical impulses are converted into chemical signals.

Human nervous systems process information in three stages: sensory input, integration, and motor output. Sensors detect external stimuli and internal conditions and transmit information along sensory neurons to the central nervous system and motor neurons carry impulses from the CNS to effector organs

- **Artificial neurons**

An artificial neuron is a digital construct that seeks to simulate the behavior of biological neurons. Artificial neural networks are mathematical models for information processing based on how neurons and synapses work in the human brain. Using the human brain as a model, a neural network connects simple nodes to form a network of nodes - thus the term "neural network

Artificial neurons differ from biological neurons in several ways but the key difference relate to size, speed and learning. Human brain contains about 86 billion neurons and more than a 100 trillion synapses (connections). Biological neurons can fire around 200 times a second on average. Brain fibers grow and reach out to connect to other neurons, neuroplasticity allows new connections to be created or areas to move and change function. We do not understand how brain learns. (Nagyfi, 2018).

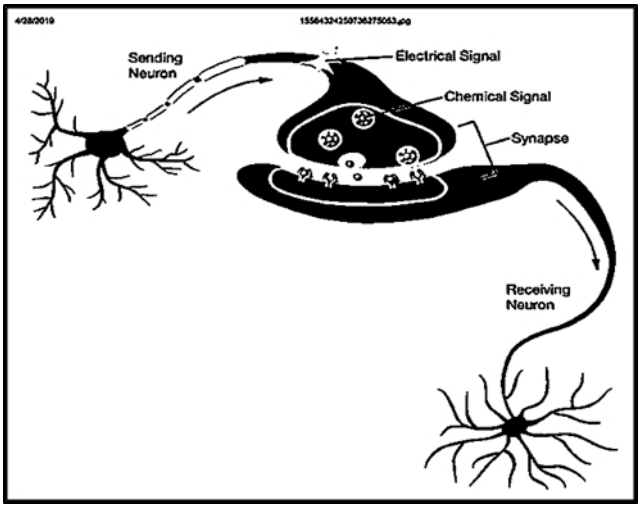

Fig.2: Communications within a biological neuron network.

Source: Genetic Science Learning Center. "Neurons Transmit Messages In The Brain." Learn.Genetics. June 30, 2015. Accessed July 9, 2019. https://learn.genetics.utah.edu/content/neuroscience/neurons/.

A solid artificial neural network is dependent on the connections between neurons. Good connections improve the efficiency of the network and the opposite is true. The process of making those connections is called training, and it is similar to what human brains do within a learning mode (Popular mechanics,

3.3 Transformation

The process of transformation is conducted through either learning or an analysis process or both.

- **Learning**
- **Machine learning**

Machine Learning refers to the ability of software to independently find solutions to problems by recognizing patterns in databases. Machine-learning algorithms detect patterns and learn how to make predictions and recommendations by processing data and experiences, rather than by receiving explicit programming instruction. The algorithms also adapt in response to new data and experiences to improve efficacy over time. Machine learning could be supervised learning, unsupervised learning and or reinforcement learning. Cloud providers such as Google, Microsoft, Amazon Web service and IBM have now created services for Machine Learning. (Klass L (ed), 2018)..

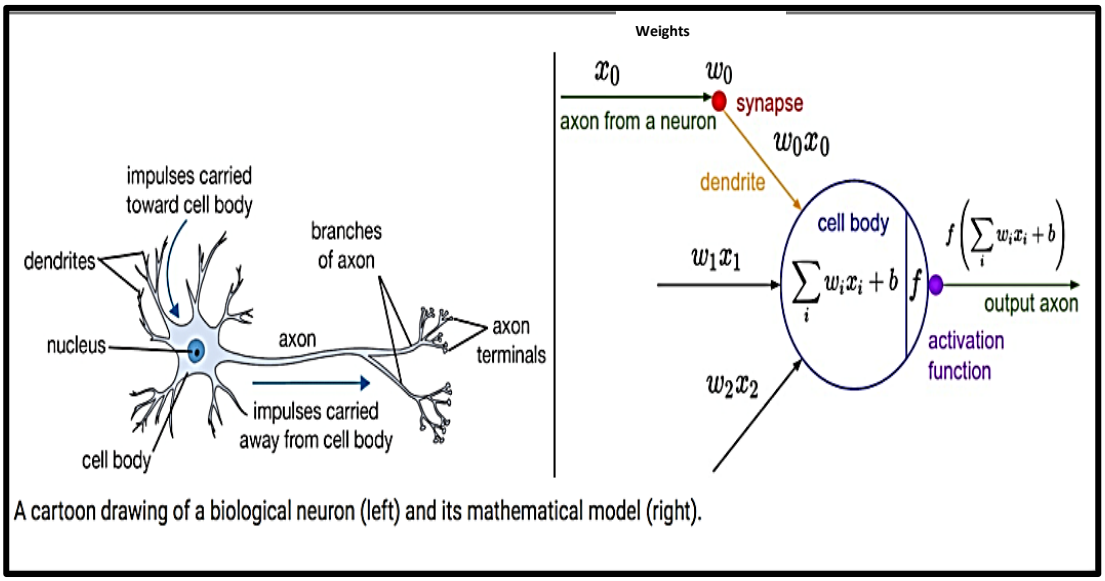

Fig.3: Artificial Neurons, a computational model.

Source: https://isaacchanghau.github.io/post/activation_functions/

- **Deep learning**

Deep learning is a type of machine learning that can process a wider range of data resources, requires less data preprocessing by humans, and can often produce more accurate results than traditional machine-learning approaches (although it requires a larger amount of data to do so). In deep learning, interconnected layers of software-based calculators or "neurons" form a neural network. The network can ingest vast amounts of input data and process them through multiple layers that learn increasingly complex features of the data at each layer. The network can then determine the data, learn if its determination is correct, and use what it has learned to make determinations about new data. Deep learning multilayered neural network have a special architecture designed to extract increasingly complex features of the data at each layer to determine the output.

Deep learning recognizes what is known as convolutional neural networks. Those are classes of deep neural networks that are most commonly applied to analyzing visual imagery.

- **Analysis : Analytics**

Data analytics are approaches to raw data analysis that could lead to parameters and conclusions underlying the raw data universe. Data analytics techniques can reveal trends and metrics that would otherwise be lost in the mass of raw information accessed in the first place. This information can then be used to formulate efficiency optimizing processes within the respective business or system.

Data analytics is usually broken down into four basic types starting with the descriptive and ending with the prescriptive. Descriptive analytics describe what has happened over a given period of time. Diagnostic analytics attempt at revealing the cause or trigger of the symptom. Predictive analytics moves towards projecting possible

change within the short term. And, finally, Prescriptive analytics suggests a course of action. Predictive analytics, a key element, focuses on interpreting existing data in order to make informed future predictions Tools include regression or the determination of the relationship between a dependent and an independent variable. Also classification or the establishment of shared characteristics of a dataset and the determination of the category of a new piece of data based on its characteristics. And, finally, clustering or the mapping of relationships between data that can then be applied to predict the status of future data. https://www.investopedia.com/terms/d/data-analytics.asp**)**

3.4 Outputs

AI connotes data driven decision making. Data-drivenness is about building tools, abilities, and, most crucially, a culture that acts on data. This is fulfilled through insights, sub-systems and technologies.

- **Insights and abilities**

Artificial intelligence processes could lead to insights or a capacity to gain an accurate and deep intuitive understanding of individuals and issues. The medium are abilities to solve problems, through logical deduction or reasoning, to set and achieve goals, to understand spoken and written language or communication and the to infer things about the world via sounds, images, and other sensory inputs. . Those abilities are expressed in many present day applications as medical diagnosis, autonomous vehicles and surveillance among others.https://www.hackerearth.com/blog/developers/applications-of-artificial-intelligence)

- **Sub-systems**

Artificial intelligence has the potential to penetrate industries where data prevalent. Subsystems congruent with the specific conditions of that industry would, then, emerge and blend with the operating flows of the industry.. Early symptoms of this penetration could be seen in a wide variety of industries from healthcare and banking to retailing, logistics and communication. Present day banking subsystems, for example, include fraud detection and credit analysis while government subsystems include facial recognition and smart cities. Health and life sciences subsystems include predictive diagnostics and biomedical images. Several other subsystems will soon emerge in manufacturing, logistics, marketing and probably above all, security and defense.

- **Technologies**

A wide array of AI technologies is emerging. They vary in penetration but some are already identifiable. Those include robotic process automation, biometrics, speech recognition; virtual agents' decision management, text analytics and NLP (Natural Language Processing) are gaining situational significance. https://www.forbes.com/sites/gilpress/2017/01/23/top-10-hot-artificial-intelligence-ai-technologies/#5edab2b81928.

3.5 The feedback loop

Feedback occurs when outputs of a system are fed back as inputs within the systems loop. It is an element of a control mechanism that allows for self-correction and that adjusts its operation according to differences between the actual and the desired or optimal output. Feedback is essential for AI systems. The transformation process could enhance inputs and may even alter some of the basic underlying variables. Feedback information flows take many forms including an ultimate information system that could feed into the input segment of the AI system. (Https://www.thefreedictionary.com/feedback+loop)

4 Conclusions

To an entrant, Artificial Intelligence (AI) constitutes an amorphous phenomenon. Ways and means of containing this concept within a systems framework is the focus of this article.

The article resorts to qualitative analysis as a medium. It advances a systems theory framework as the boundary for an AI structure where all things would fall in place. The article suggests a framework where an artificial intelligence system has inputs, transformation processes and an output. A feedback loop as well. The inputs are built around data and artificial neurons. Transformation is done through analysis and learning. And the outcome

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The article provides a convenient vehicle for understanding of the components of artificial intelligence and their flow. It could be useful into understand AI applications and their situational relevance.

Future research should ideally address AI system flows and how these compare to the human brain. This type of research would provide a realistic picture of the boundaries of AI system and, concurrently, what could be learned from the unusual processes involved in human brain functions and processes.

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