Computational Intelligence paradigm: an Evolutionary process in a solution space of Diversity by Olusola Teniola, a paper given to Computer & Information Science department, Covenant University on the 29th of September 2016.

"Whether you want to uncover the secrets of the universe, or you just want to pursue a career in the 21st century, basic computer programming is an essential skill to learn." **(Stephen Hawking, Theoretical Physicist & Author)**

What is (What do we mean) Computational Intelligence? (Source: https://en.wikipedia.org/wiki/Computational_intelligence)

The expression **computational intelligence** usually refers to the ability of a computer to learn a specific task from data or experimental observation. Even though it's commonly considered a synonym of soft computing, there is still no commonly accepted definition of computational intelligence.

But generally, computational intelligence is a set of nature-inspired computational methodologies and approaches to address complex real-world problems to which mathematical or traditional modelling can be useless for a few reasons: the processes might be too complex for mathematical reasoning, it might contain some uncertainties during the process, or the process might simply be stochastic in nature.[1] Indeed, many real-life problems cannot be translated into binary language (unique values of 0 and 1) for computers to process it. Computational Intelligence therefore provides solutions for such problems.

The methods used are close to the human's way of reasoning, i.e. it uses non exact and non-complete knowledge, and it is able to produce control actions in an adaptive way. CI therefore uses a combination of 5 main complementary techniques.[1] The fuzzy

logic which enables the computer to understand natural language,[2][3] artificial neural networks which permits the system to learn experiential data by operating like the biological one, evolutionary computing which is based on the process of natural selection, learning theory, and probabilistic methods which helps dealing with uncertainty imprecision.[1]

Except those main principles, currently popular approaches include biologically inspired algorithms such as swarm intelligence[4] and artificial immune systems, which can be seen as a part of evolutionary computation, image processing, data mining, natural language processing, and artificial intelligence, which tends to be confused with Computational Intelligence. But although both Computational Intelligence (CI) and Artificial Intelligence (AI) seek similar goals, there's a clear distinction between them.

Computational Intelligence is thus a way of performing like human beings. Indeed, the characteristic of "intelligence" is usually attributed to humans. More recently, many products and items also claim to be "intelligent", an attribute which is directly linked to the reasoning and decision making.

Difference between Computational and Artificial Intelligence

Although Artificial Intelligence and Computational Intelligence seek a similar long-term goal: reach general intelligence, which is the intelligence of a machine that could perform any intellectual task that a human being can; there's a clear difference between them. According to Bezdek (1994), Computational Intelligence is a subset of Artificial Intelligence.

There are 2 types of machine intelligence: the artificial one based on hard computing techniques and the computational one based one soft computing methods, which enable adaptation to many situations.

Hard computing techniques work following a binary logic, which only works with two values (the Booleans true or false, 0 or 1) on which modern computer is based. But one of the main problems of this logic is that our natural language cannot always be translated easily into absolute terms of 0 and 1.This is where the soft computing techniques step in,

based on a different logic, the fuzzy one[6]… Much closer to the way human brain works by aggregating data to partial truths (Crisp/fuzzy systems), this logic is one of the main exclusive aspects of CI.

Within the same principles of fuzzy and binary logics, follow the crispy and fuzzy systems.[7] The first one being a part of the artificial intelligence principles, consists in either including an element in the set, or not. Whereas fuzzy systems (CI) enable elements to be partially in it. Following this logic, each element can be given a degree of membership (from 0 to 1) and not exclusively one of these 2 values.[8]

The 5 main principles of CI and its applications

The main applications of Computational Intelligence include computer science, engineering, data analysis and bio-medicine.

Fuzzy Logic

As explained before, the fuzzy logic which is one of CI's main principles, consists in measurements and process modelling made for real life's complex processes.[3] It can face incompleteness, and most importantly ignorance of data in a process model, contrarily to Artificial Intelligence which requires exact knowledge.

This technique tends to apply to a wide range of domains such as control, image processing and decision making. But it is also well introduced in the field of household appliances with washing machines, microwave ovens... We can face it too when using a video camera, where it helps stabilizing the image while holding the camera unsteadily. Other areas such as medical diagnostics, foreign exchange trading and business strategy selection are apart from this principle's numbers of applications.[1]

So fuzzy logic is mainly made for approximate reasoning, but doesn't have learning abilities,[1] a qualification much needed that human beings have… It enables them to improve themselves by learning from their previous mistakes.

Neural Networks

This is why CI experts work on the development of artificial neural networks based on the biological ones which can be defined by 3 main components: the cell-body which processes the information, the axon which is a device enabling the signal conducting, and the synapse which controls signals. Therefore, artificial neural networks are doted of distributed information processing systems,[9] enabling the process and the learning from experiential data. Working as human beings, fault tolerance is also one of the main assets of this principle.[1]

Concerning its applications, neural networks can be classified into five groups which are data analysis and classification, associative memory, clustering generation of patterns and control.[1] Generally, this method aims to analyse and classify medical data, proceed to face and fraud detection, and most importantly deal with nonlinearities of a system in order to control it.[10] Furthermore, neural networks techniques share with the fuzzy logic ones the advantage of enabling data clustering.

Evolutionary Computation

Based on the process of natural selection firstly introduced by Charles Robert Darwin, the evolutionary computation consists in capitalizing on the strength of natural evolution to bring up new artificial evolutionary methodologies.[11] It also includes other areas such as evolution strategy, and evolutionary algorithms which are seen as problem solvers... This principle's main applications cover areas such as optimization and multi-objective optimization, to which traditional mathematical one techniques aren't enough anymore to apply to a wide range of problems such as DNA Analysis, scheduling problems...[1]

Learning Theory

Still looking for a way of "reasoning" close to the humans' one, learning theory is one of the main approaches of CI. In psychology, learning is the process of bringing together cognitive, emotional and environmental effects and experiences to acquire, enhance or change knowledge, skills, values and world views (Ormrod, 1995; Illeris,

2004).[1] Learning theories then helps understanding how these effects and experiences are processed, and then helps making predictions based on previous experience.[12]

Probabilistic Methods

Being one of the main elements of fuzzy logic, probabilistic methods firstly introduced by Paul Erdos and Joel Spencer [1](1974), aim to evaluate the outcomes of a Computation Intelligent system, mostly defined by randomness.[13] Therefore, probabilistic methods bring out the possible solutions to a reasoning problem, based on prior knowledge.

Further reading

- *Computational Intelligence: An Introduction* by Andries Engelbrecht. Wiley & Sons. ISBN 0-470-84870-7
- *Computational Intelligence: A Logical Approach* by David Poole, Alan Mackworth, Randy Goebel. Oxford University Press. ISBN 0-19-510270-3
- *Computational Intelligence: A Methodological Introduction* by Kruse, Borgelt, Klawonn, Moewes, Steinbrecher, Held, 2013, Springer, ISBN 9781447150121

Solutions: AI, Expert Systems, Analytics – Big Data (Refer to Public/Open Data below), -> Operational Intelligence Platforms (OIPs)

OIPs are a set of new technologies that IT leaders can use to reduce the time and cost required to implement monitoring, alerting and adaptive decision-making. OIPs are not real-time BI or BPM although there are similarities.

Where is the paradigm shift coming from?

In science and philosophy, a **paradigm** /ˈpærədaɪm/ is a distinct set of concepts or thought patterns, including theories, research methods, postulates, and standards for what constitutes legitimate contributions to a field.

So in the case of OIPs the paradigm shift is the assistance that these platforms render to companies in improving their situational awareness and ability to sense and respond

quickly to changing conditions. Operational Intelligence solutions run queries against streaming data feeds and event data to deliver real-time analytic results as operational instructions. Operational Intelligence provides organizations with the ability to make decisions and immediately act on these analytic insights, through manual or automated actions.

Student engagement to remain relevant to the digital world!

The areas that OIPs impact on the world are OSS/BSS systems; internal core and access network monitoring and operations; Data Center monitoring and Operations; Public/Open Data (data mining and data science applications). Public Data is usually appears in the form of general information such as the census, election results, GIS maps for towns and municipalities.

This data is often curated by a government agency responsible for collection, but is often maintained by other interested parties. These parties provide access to the data in more accessible formats for both human and machine consumption. There are also data sets that are restricted access. This can be weather data, market data, sports statistics etc.

Conclusion

The paradigm and evolution of Computer Intelligence as opposed to Artificial Intelligence has created data management as the new role in the 21st Century to be able to make proper sense of the large volumes (both in terms of the velocity, validity and veracity) of the data and complex algorithms that has made data scientists the sought after profession in the modern era of Computer Science.

Thank you for listening.

References

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