A.I. Technologies Applied to Naval CAD/CAM/CAE

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Abstract

Artificial Intelligence is one of the most enabling technologies of digital transformation in the industry, but it is also one of the technologies that most rapidly spreads in our daily activity. Increasingly, elements and devices that integrate artificial intelligence features, appear in our everyday lives. These characteristics are different, depending on the devices that integrate them, or the aim they pursue. The methods and processes that are carried out in Marine Engineering cannot be left out of this technology, but the peculiarities of the profession and the people that take part in it must be taken into account. There are many aspects in which artificial intelligence can be applied in the field of our profession. The management and access to all the information necessary for the correct and efficient execution of a naval project is one of the aspects where this technology can have a very positive impact. Access all the rules, rules, design guides, good practices, lessons learned, etc., in a fast and intelligent way, understanding the natural language of the people, identifying the most appropriate to the process that is being carried out and above all. Learning as we go through the design, is one of the characteristics that will increase the application of this technology in the professional field. This article will describe the evolution of this technology and the current situation of it in the different areas of application. Some proposals for the future will also be highlighted to provide the integration of technology with the design systems and work methodologies. This integration will be based on the needs of the users of the shipyard, considering the constraints of the business and framing in the current reality, the digital transformation of the industry, the extension of new technologies in today´s society and the incorporation of the generations of Millennials into the labor market. This technical paper is ground-breaking for the Shipbuilding Industry and brings an innovative way to integrate new disruptive technologies to marine and ocean engineering projects. This is an integrated proposal from companies that encourages the collaboration between the different industrial stakeholders.

1. Introduction

There are many aspects in which Artificial Intelligence (A.I.) can be applied in ship design and ship production. The management and access to all the information necessary for the correct and efficient execution of a ship project is one of the aspects where A.I. can have a strong impact:

- Access all the rules, design guides, best practices, lessons learned, etc., in a fast and intelligent way,
- understanding the natural language of the people,
- identifying the most appropriate approach to a process carried out, and above all,
- learning as we go through the design.

These benefits will increase the application of this technology in our field. *Gartner's (2017)* report on the 10 most strategic technology trends concluded that those included in the field of Artificial Intelligence (A.I.) occupied the first three positions, https://www.gartner.com/smarterwithgartner/gartners-top-10-technology-trends-2017:

1. A.I. applied
2. Smart Apps
3. Smart things

A brief analysis indicates that their position in the supposed cycle of expected maturity suggested that they would reach maturity in an interval of between five to ten years so that they could be exploited effectively.

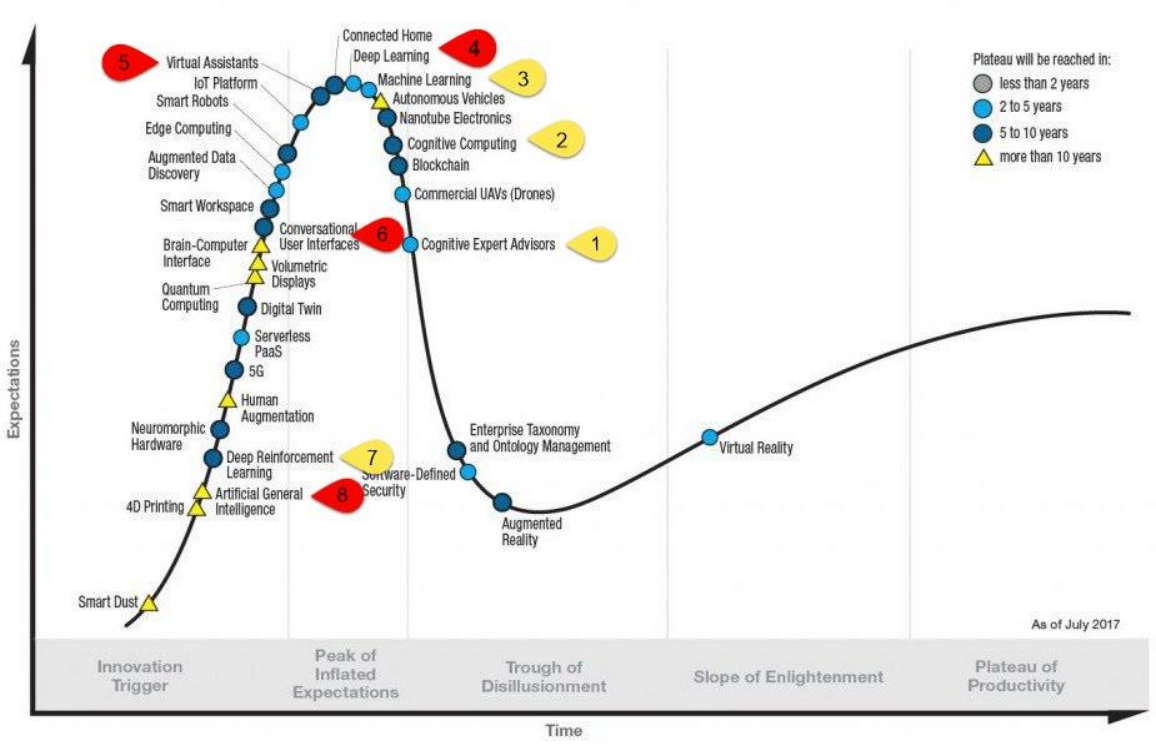

Fig.1: Gartner Hype Cycle, *Paneta (2017)*

In 2018, it seems to conclude that while technologies related to virtual assistants have matured faster than expected, other technologies related to A.I. would have disappeared from expectations, particularly those that explicitly mentioned cognitive knowledge. This does not mean that these elements have disappeared, but rather have found application within others that continue to evolve in maturity, thanks to this application.

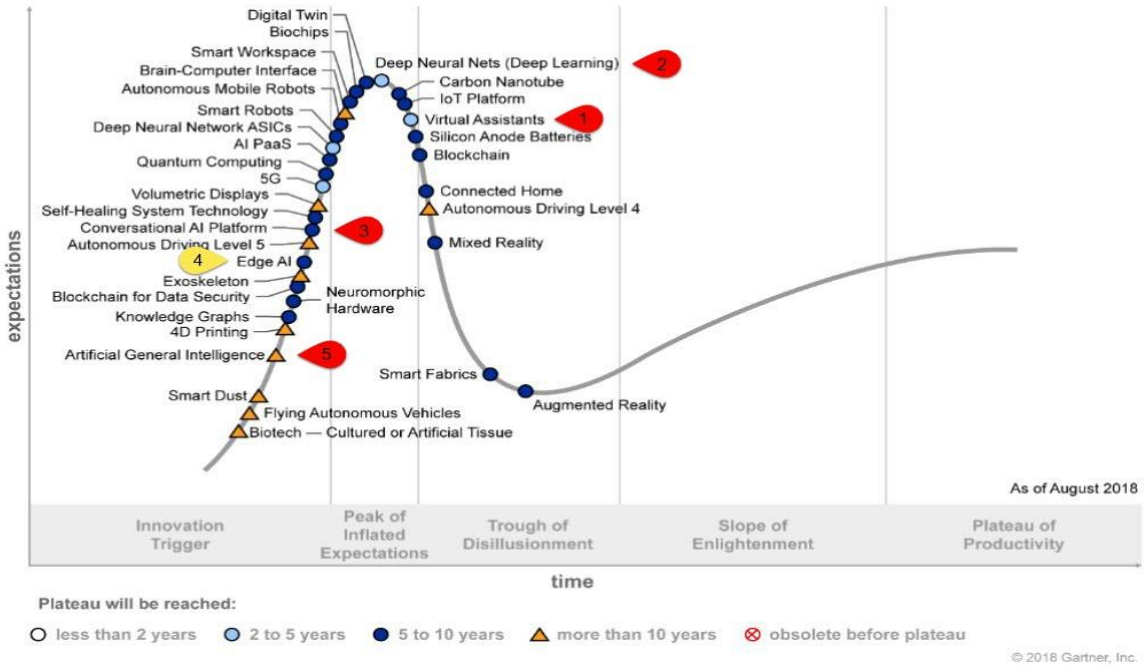

Fig.2: Gartner Hype Cycle 2018 *Paneta (2018)*

And this can be better understood by finding, once again, the technologies related to A.I. in the first positions of the strategic technological trends for the year 2018.

Leaving aside the criticisms that can be made to the loop of the technologies of Gartner (Gartner Hype Cycle) as explained in *Mullany (2016)* and the suspicions that after reading the referred article can be raised, it seems sensible to think that the technologies related to A.I. are going to have a strong impact on our lives and this is something that is already being seen.

There is no doubt that technological evolution is approaching towards a future that few years ago was only in the imagination and in the movies. The concept of A.I. opens a wide field of study which we could be writing for days and talking about it for hours. This paper aims to analyze what these technologies are, how they are influencing society, how they will influence it in the future and what we can do now to get a value from them seeking its application to the shipbuilding sector and more specifically to maritime design.

2. Background

It can be said that there is no single origin of the concept known as A.I. and therefore there is no consensus to define that concept, but to be able to understand any of the definitions that apply, it is convenient to know at least briefly the most relevant facts and some of the milestones in its history.

It can be considered that A.I. was born as a philosophical study on human intelligence based on the concern of man to imitate the behavior of other beings with capabilities beyond the reach of human beings (such as flying or diving), reaching the point of trying to imitate itself. In this sense, it can be said that A.I. is the search to imitate human intelligence. It is clear that it has not yet been completely achieved, but it is also increasingly true that we are closer.

2.1 A short history

- The first man who became aware of his own existence and was able to think, surely wondered how his thought would work and would conclude the idea superior creator, an intelligent being capable of creating another one. In this sense, the idea of a virtual design for intelligence is as old as human thought.
- In 1920, the Czech writer Karel Čapek, *Capek (2017)*, published a science fiction stage play called “Rossum’s Universal Robots”. The play is about a company that builds artificial organic humans in order to lighten the workload of other people. Although in the play these artificial men are called robots, they have more to do with the modern concept of android or clone. They are creatures that can be passed as humans and have the gift of being able to think.
- The English mathematician *Turing (1950)* publishes an article entitled “Computing Machinery and Intelligence” that opens the doors to A.I. The article itself began with the simple question: “Can machines think?” Later Turing proposed a method to evaluate if the machines can think, which got to know itself like the Turing test. The test, or “Imitation game”, as it was called in the document, was presented as a simple test to judge if machines could think.
- 1956 Dartmouth conference convened by McCarthy and where the term “Artificial intelligence” was coined. The conference was attended by researchers from Carnegie Mellon University and IBM, including: Minsky, Newell and Simon. In this conference extremely optimistic forecasts for the next ten years were made that were never fulfilled, which caused the almost total abandonment of the investigations during fifteen years, known today as A.I. winter, *Aggarwal (2018)*.
- Later, in the second half of the decade of the 1970s, A.I. resurfaced again with the appearance of the expert systems. Expert systems are programs that answer questions and solve problems in a specific domain. They emulate an expert in a specific branch and solve problems by rules. There are two types of engines in expert systems: First, there is the knowledge engine, which represents facts and rules about a specific topic. Second, the inference engine, which applies the rules and facts of the knowledge engine to new facts. To picture this: in 1981, an expert system called SID® (Synthesis of Integral Design) designed the 93% of the logic gates from the CPU VAX® 9000 . The SID® system was built around 1000 hand-coded rules. The final

design of the CPU cost around 3 hours of calculations and surpassed human experts in many ways. As an example, the SID® produced a 64-bit adder faster than the one designed manually. The error rate of the human experts was 1 error per 200 gates while that of the SID® was around 1 error per 20000. However, these expert systems required large computing capacity and the rise of personal desktop computers made these expert systems lose interest from investors, causing the fall of companies that were dedicated to build hardware and software for these systems, giving rise to what is known as the second A.I. winter.

- On May 11, 1997, the IBM computer Deep Blue defeated Gary Kasparov with three victories going to Deep Blue, two to Kasparov and a draw.
- In 2011, the Watson® IBM system beat two of the most successful human contestants on the American television game Jeopardy, a game which requires participants to ask a question in response to clues of general knowledge. In the event, Watson® marked a breakthrough in A.I. with its understanding of natural language and the ability to make sense of a large amount of written human knowledge.
- In June 2018 the Watson® IBM system participates in a debate to demonstrate the progress of the project Project Debater, developed by IBM since 2012. In one of these debates, the IBM computer discussed with Noa Ovadia, a former Israeli national debate champion. The debate was based on the following statement: Should we subsidize space exploration? If you are interested in finding out who won, check out some of the many references you can find on the internet, such as: "What it is like to see an IBM A.I. successfully discuss with humans."
- Since the beginning of the 21st century the advance of A.I. has been unstoppable, driven by the hardware improvements that make it possible to handle huge amounts of data in increasingly shorter times, as well as the efficient use of neural networks and the full connectivity of devices through high-speed internet. What previously required a lot of time, is now almost immediate.

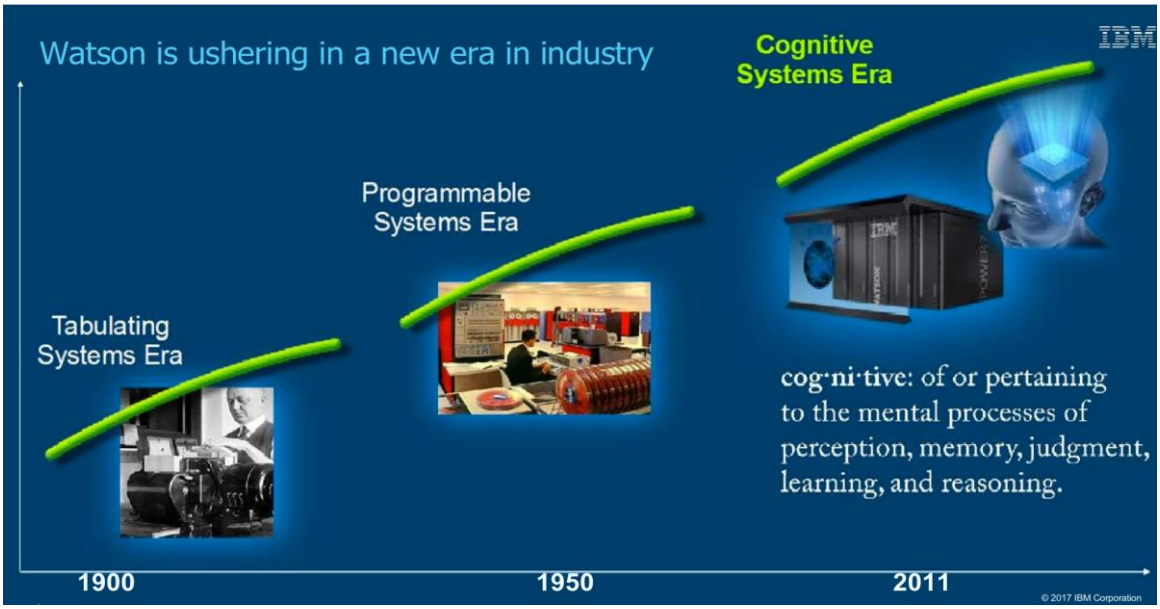

Fig.3: Stages of computing. Source: IBM

Fig.3 shows the history of computing from the perspective of IBM, which is undoubtedly the leading company in A.I. development, with its set of solutions called Watson®. According to Juan Ramón Gutiérrez, responsible for industrial solutions at IBM, the evolution of A.I. can be divided into three stages and we are now entering the cognitive era.

2.2 Present

In recent years the most important companies have begun to position themselves in the use of A.I. and they do so through acquiring companies, startups and technologies that have knowledge and technologies and develop them looking for applications that can add value to their investments.

It is interesting to collect the acquisitions of companies, many of them startups, which have been produced to position themselves in this reality. In the following table it is possible to see the purchases of companies by large companies that have opted for A.I. until 2017.

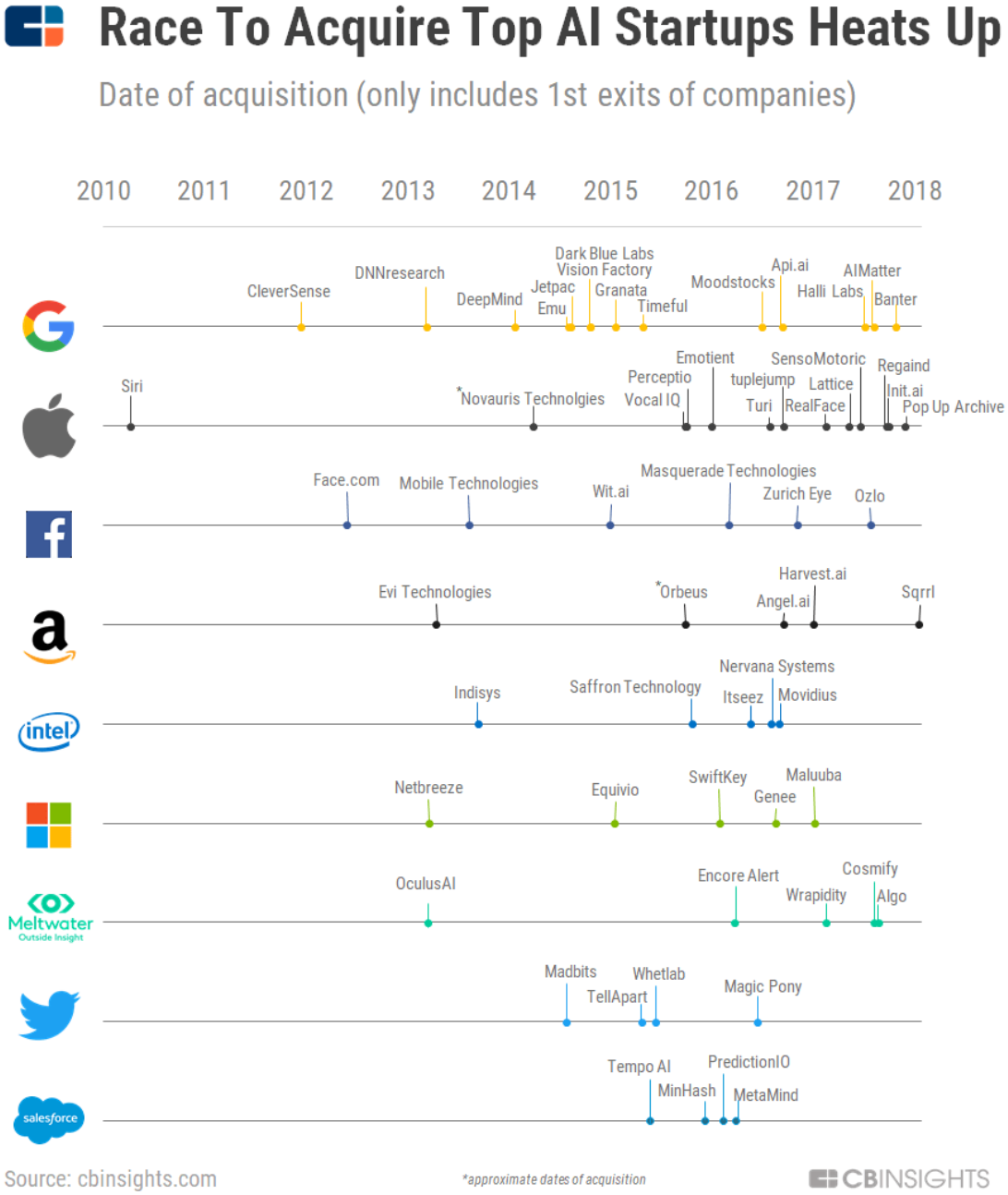

Fig.4: Acquisitions of A.I. startups. CBINSGHITS font

The development is so clear that we can speak of real race to appropriate the startups with the most potential within A.I. technologies. As stated in the CBinsight report "Large corporations in all industries, from retail to agriculture, are trying to integrate machine learning into their products. But at the same time, there is an acute shortage of A.I. talent*", CBINSIGHTS (2018).*

The positioning technology has made itself known through virtual assistants. Thus, large technology companies such as Google, Apple , IBM , Facebook, Amazon or Microsoft make marketing of their assistants as a banner to attract the attention of companies and thus also of the markets. Apple with Siri®, Google with Google Assistant® , Microsoft with Cortana®, Amazon with Alexa® or IBM with its Watson® project that goes far beyond what we would expect from virtual assistants.

Many well-known personalities are betting on the future of A.I., trying to ensure that there is some standardization of technologies and so Elon Musk promoted a project called 'Open A.I.', which seeks to unify all A.I. developments in a single project that being free and open can overcome the restrictions of commercial products. Under this project we can find interesting research projects, but where we have found a fertile field to grow is in the Multiplayer Online Battle Arena (MOBA), online games among multiple players who are changing the rules of leisure and even sports, as stated in *Martín (2018)*. However, it is still far from being able to make decisions in a minimum reaction time as many of these games require in certain circumstances. It is necessary to mention that Elon Musk decided to abandon this initiative to avoid "future conflicts of interest", http://fortune.com/2018/02/21/elon-musk-leaving-board-openai.

3. Basic Concepts

While A.I. and machine learning are by now widespread, people know very little about it. We hear about many concepts and tend to simplify and understand A.I. as an agglomeration of concepts and technologies that can mean different things to different people: virtual assistants, robots that pretend to do what people do, machine learning, automata that drive cars, etc..; and its applications are wherever we look. It is necessary to identify the basic elements that make up A.I.

3.1 What is A.I.?

What definition can be adopted for A.I.? As pointed out by Vicenç Torra in one of his articles, the first definition of artificial intelligence was given in the document prepared by J. McCarthy, M. Minsky, N. Rochester and CE Shannon for the preparation of the meeting held in Darthmouth (USA) during the summer of 1956 and in which the term *'Artificial Intelligence'* appears for the first time. According to the author of the article. It seems that this name was given at the behest of J. McCarthy. The proposal cited above of the meeting organized by J. McCarthy and his colleagues includes what can be considered as the first definition of artificial intelligence. The document defines the problem of artificial intelligence as that of building a machine that behaves in such a way that if the same behavior were carried out by a human being, it would be called intelligent, Torra (2011).

"There are, however, other definitions that are not based on human behavior. They are the following four:

1. Act like people. This is McCarthy's definition, where the model to follow for the evaluation of programs corresponds to human behavior. The so-called Turing Test (1950) also uses this point of view. Eliza system, a natural language bot (software program) is an example.
2. Reason like people. The important thing is how the reasoning is carried out and not the result of this reasoning. The proposal here is to develop systems that reason in the same way as people. Cognitive science uses this point of view.
3. Reason rationally. In this case, the definition also focuses on reasoning, but here we start from the premise that there is a rational way of reasoning. Logic allows the formalization of reasoning and is used for this purpose.
4. Act rationally. Again the objective is the results, but now evaluated objectively. For example, the goal of a program in a game like chess will be to win. To achieve this goal, the way to calculate the result is indifferent."

One might ask where the assistance systems available in our mobile phones fit or if one can think of the famous (although a bit obsolete) Turing test to determine if when talking to Siri® on the mobile phone and we get a reasonable response, we are in a position to affirm that we are facing an A.I. According to *Kirkpatrick (2018)*, A.I. is like an umbrella covering multiple technologies designed to supply computers with human-like capabilities in listening, vision, reasoning and learning. These techniques that include ML or machine learning, DL or deep learning, Computer Vision (CV) vision by computer, Natural Processing Language (NPL) or natural language comprehension, unmask hidden patterns in large data sets and later using complex algorithms can relate the findings between apparently unrelated variables. For all of this we could visualize A.I. in Fig.5.

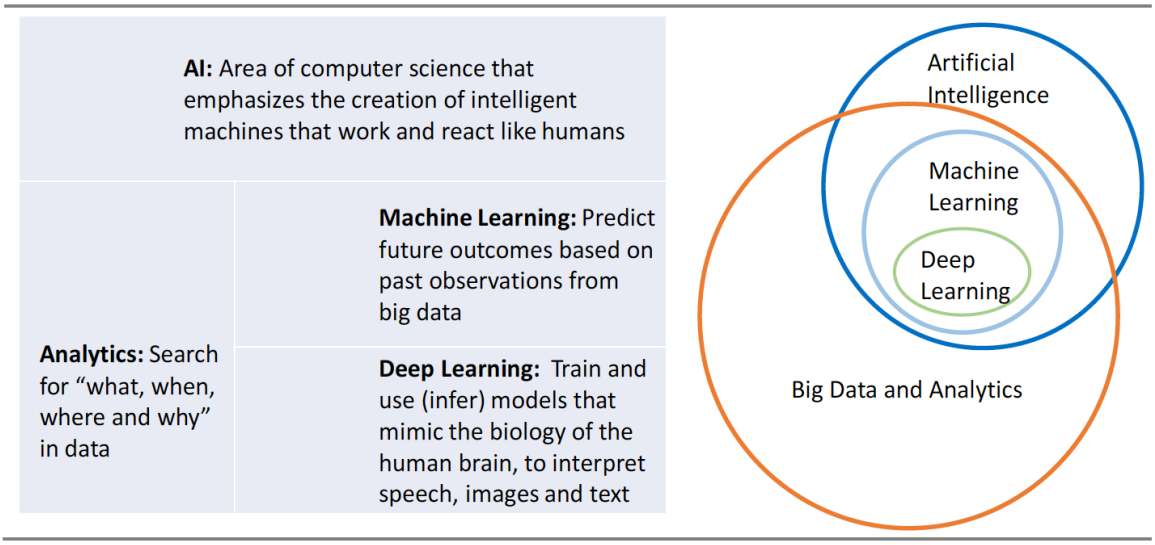

Fig.5: A.I. Techniques, *Kirkpatrick (2018)*

Leaving aside the 'Big Data' and analytical techniques and focusing exclusively on A.I., three fundamental elements can be detected:

- A.I. covers everything that allows computers to behave like humans. The techniques included are among others: automatic learning, natural language comprehension, NPL, language synthesis, computer image recognition, robotics, signaling and results analysis, optimization and simulation, etc.
- Machine Learning (M.L.) is the subset of A.I. which deals with the extraction of patterns from data sets. In this subset we will find: Deep learning, support vector machines, decision trees, learning Bayes, clustering k- means, learning of association rules, regression algorithms, etc.
- Deep Learning is a specific class of M.L. algorithms that use complex neural networks. In a sense, it is a group of related techniques comparable to a group of 'decision trees' or 'support vector machines'. They are the engine of the applications that use them and thanks to advances in parallel computing they have become accessible to common use. Its components include: artificial neural networks, convolution neural networks, recursive neural networks, long, short-term memory networks deepest beliefs and many more.

3.2 Why is A.I. important?

There are many reasons to underpin the importance of A.I., but focusing on the most relevant one, we want to share the view of *DataRobot (2018),* for which "A.I. systems are fundamental for companies that seek to extract value from data by automating and optimizing processes or producing actionable knowledge. A.I. systems Impulse damaged by machine learning enables companies to leverage their vast amounts of data available to discover ideas and patterns that would be impossible to fathom for one person, allowing them to deliver more targeted and personalized communications, predicting events critical care, identifying likely fraudulent transactions, and more."

Companies that do not adopt A.I. and machine learning technologies are doomed to be left behind:

- The world expenditure on A.I. will grow 50% annually and will reach 50 billion euros for the year 2021.
- Industries such as retail sales, marketing, health, finance, insurance and others will not only benefit from A.I. and machine learning, but those that do not adopt will disappear.
- As of 2020, the companies that bet on the management of data within A.I. will snatch 1.2 trillion dollars a year to those others that they do not do it because they do not have the same vision.

- 83 percent of first users are already gaining value from A.I. initiatives e automatic learning.
- The net gain in jobs resulting from the adoption of A.I. It will be above 5 million.

These are overwhelming figures. And as *McAffe and Brinjolfsson (2017)* point out "The effects of A.I. will be expanded in the next decade, since the manufacturing industry, retail, transportation, finance, health, advertising, insurance, entertainment, education and virtually any other industry will transform their core processes and business models to Take advantage of automatic learning."

4. Applications of Artificial Intelligence

After everything written in this article, anyone can understand how A.I. relies on three fundamental pillars: data, algorithms and computing power. This explains why the greatest development of applications is in those sectors where there is a lot of data, that can be analyzed and from them conclusions can be drawn that serve in time for a specific purpose. In short, that the application of A.I. to the analysis of the data provide a significant value to the sector, company or individual that uses its results.

There are countless sectors in which we can find the application of A.I. as it is currently built. Companies around the world are trying to take advantage of A.I. to optimize their processes and obtain higher revenues and profits. How are they doing it and in what sectors? It is known that some of the applications we use every day use A.I. for its operation, such as Netflix®, Spotify® and Siri®, among others. To illustrate the extension of the applications, some use case are collected below:

- Chat-bots: "A computer program designed to simulate conversations with human users, especially through the Internet." They are applications that interact with A.I. programs and provide a human like conversation answering frequently asked questions from users. The chat-bots they save time and effort by automating the first line of customer service. Gartner predicts that by 2020, more than 85% of the interaction is with customers will be handled without a human. However, the opportunities provided by the chat-bot systems go beyond providing answers to customer inquiries. 'WeChat' Chinese bots can schedule appointments, call a taxi, send money to friends, sign up for a flight and many others. They are also used for other business tasks, such as gathering information about users, helping to organize meetings, and reducing overhead costs. It is no wonder that the size of the chat-bot market is growing exponentially. The importance of the chat-bots are the interface between and human, i.e. it is a tool used by A.I. to materialize.
- Electronic commerce: Electronic commerce programs that include A.I. label, organize and search the content visually allowing buyers to discover the associated products, whether in size, color, shape or even brand. This technology allows companies of any size to reach an extraordinarily broad market.
- Human Resource Management: A.I. and machine learning is used in companies that have advanced in the management of human resources through specific software. The reasons why it has spread so much in this area have to be looked for in two aspects. First, by the amount of data handled in human resources, and secondly by the need to increase efficiency in an essential area of the company. The A.I. deals with the most laborious work of Human Resources (HR) (screening, paperwork, data entry, reports, etc.), in addition to offering powerful analysis tools to automatically generate high quality data for HR departments.
- Medicine: A.I. programs can take advantage of data collected from patients to provide support for clinical decisions during critical medical situations, as well as document those events electronically in real time. A.I. improves reliability, predictability and consistency of data and results of clinical trials. It also constitutes a tool for increasing decisions.
- Communication and collaboration: The A.I. can integrate communication and collaboration to improve employee interaction with data, providing real-time translation even improving management calendars or activating electronic meetings, etc.
- Energy: Interconnected power plants that obtain data on operation, consumption, climatic circumstances that influence energy needs or their generation.

- Automotive: Autonomous vehicles will make use of A.I. for its operation and is something that will be seen in the medium term. However, it is not necessary to wait to have some capabilities, such as the assistants integrated in the vehicle that anticipate the needs of the driver and passengers, or the monitoring of mechanics and driving to increase safety.

These are just some of the fields of application, but we don't want to miss the opportunity to mention others, in which A.I. application is generating good results or arouses enormous expectations: Intelligent cybersecurity, logistics and supplies, leisure, sports betting s, etc., these are just some of the areas where applied and A.I., but very soon we will see in applied to things in that never would have thought.

4.1 A.I. applications in the industry

Looking at the applications of A.I. to the industry, it is difficult to separate what is purely industrial from all other areas that help the development of the industrial business. The digitalization of industrial processes, robotization, improvements in the collection of data and its analysis that allow improving decisions and reducing risks, etc. All this, without a doubt, are indirect applications of A.I. in the development of the industry. But what A.I. can be found in the industry, and in particular in the naval industry?

In order to find a more direct application in the industry, the focus must be on the phases of the life cycle of the manufactured products and to look for opportunities to apply A.I. in them. If we consider that the phases of the life cycle of a product are the following: specification, design, operation, withdrawal. In all of them, applications of A.I. can be found to a greater or lesser extent.

During the definition or specification phase, A.I. tools linked to the Big Data and analytics allow us to better define what the client wants, help predict the behavior of the market and build a strong business case. For this phase, several of those applications explained above are of perfect application.

The design phase is the one that in our opinion is most lacking in A.I. applications that have a direct impact on generating value. It must be taken into account that the design phase is the one that most commits the necessary resources for the development and operation of the product. There are two points of view at the time of seeing the possibilities of application of A.I. in the design phase. A.I. applications that help to make a design and A.I. applications that help to make a good design.

If A.I. helps to make a design well, it will provide a time saving and probably reduce the number of errors. This means adding value to the product by decreasing its cost and being able to transfer this improvement to the consumer, obtaining a more competitive product. Given that currently designs are made with computer tools either Computer Aided Design (CAD) or office automation or management, such as Product Life Cycle Management (PLM), and Documentaries, (PDM), etc. It is necessary to look for in these tools the possible applications of A.I., and honestly, at present it is not easy to find them. As *Naoyuki et al. (2017)* assure "The technology of A.I. applied to the design of products in Monozukuri (form of Japanese manufacture) has as objective to provide computerized support for diverse tasks in the development of products that at the moment depend on the human experience." Given that this has its limitations propose a platform in the cloud that allows to collect data and manage learning models extracted from said data to take advantage of them in the design of new products. In this article, they propose cases and an implementation plan. As of today there are no results yet.

Companies of mechanical CAD or general design have tried to get its position by announcing tools of integrated A.I. into CAD and Solidworks® recently announced recognition capabilities characteristics and features, although its practical application is unknown in the CAD. More interesting is the proposal of EXALEAD OnePart that offers a product to recognize similarities in parts and informs the user to avoid duplicities. This product is integrated with 3DEXPERIENCE®, in addition, although the gain of reducing and simplifying a model is evident, it is a tool that works during later stages. The powerful Autodesk has a research project known as Dreamcatcher that seeks to facilitate the design of hundreds of alternatives that meet the specifications of the designer. In his own words "Dreamcatcher It is a

generative design system that allows designers to develop a definition of their design problem through objectives and limitations. This information is used to synthesize alternative design solutions that meet the objectives. Designers can explore the tradeoffs between many alternative approaches and select design solutions for manufacturing". This project is based on various ideas such as the DreamSketch interface that "combines the expressive qualities of the sketch and free forms with the computational power of the somewhat generative rhythms of design", *Rubaiat Habib (2017)*. At last, to mention the interesting approach proposed by the Artificial Intelligence Laboratory for Design (LAI4D) "LAI4D is an R&D project whose objective is to develop an A.I. capable of understanding the user's ideas regarding the spatial imagination". On its web page they have a web application that allows to experience the level they have reached.

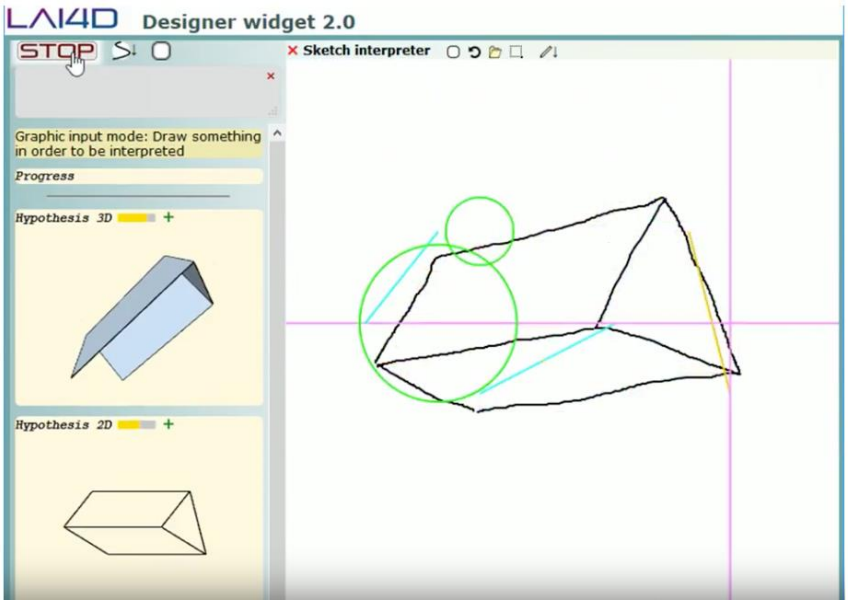

Fig.6: LAI4D sketch analyzer

A.I. also has the field of application to make a good design and this passes by being be able to parameterize the designs, collect usage and performance data and evaluate them. But this is the great difficulty facing the expansion of A.I. in this field since not enough information has been collected or parameterized from those designs that are to be made.

In terms of development and production, there are innumerable existing possible applications. It is precisely in this area where the implementation of work methodologies that use A.I. to obtain improvements in the productive process has advanced the most. Governments are paying for digital transformation of the industry through similar programs known as Industry 4.0 and it has made many initiatives materialize. However, not all initiatives are purely A.I., nor those that are, produce value to the product. There are repetitive tasks or requiring a certain programmable logic that can be automated through the use of A.I. applications. Industrial production can improve from the collection of performance data, analysis of results and the use of applications that use A.I. algorithms to detect inefficiencies in the production chain. For example, evaluating defective products can allow knowing which specific machines produce them or if the production design is wrong.

The great leap of A.I. in the industry has been given by the hand of what is known as *Internet of Things* (IoT) or internet of things and the momentum of *Industry 4.0* to improve the operation of products. All companies have launched a race to incorporate their products, sensors and connectivity with platforms that collect a multitude of data to draw conclusions about their function, improve and extend their operational life. Companies that provide products in this way sell what they call the industrial operating system. Thus, the giant Siemens offers MindSphere®, "the operating system of IoT open and based on the Siemens cloud that connects its products, plants, systems and machines, which allows it to take advantage of the large amount of data generated by IoT with advanced analysis", *Siemens (2018)*. Note

that ‘open’ does not necessarily mean that any other product can be connected to that cloud unconditionally and this is one of the aspects that significantly difficult the progress of the extension of A.I.: the absence of open standards, which anyone can use for our products and applications. Not only Siemens offers that approach, also PTC or IBM among others, have developed their connectivity and analytics platforms powered by A.I. applications.

We should not forget about the entire waste treatment or recycling industry, which like any other industry can make use of A.I. applications to optimize their processes.

5. A.I. applications in Marine Industry

The naval industry has always been very traditional and seems to be always in the tail of the implementation of the improvements that in other industries have matured previously. This fact has a reasonable explanation in the difficulty that the naval industry has to convert investments into profits. The naval industry is not friend of risks, especially when the simple fact of making boats is a huge risk in itself. On the other hand, the naval industry collects, to a greater or lesser extent, all the other industries and it may be thought that what is good for the others must also be good for it.

Focused on the shipbuilding industry, A.I. shall address important limitations among which are the lack of data or the confidentiality of the same. The marine industry has focused on immediate results, it is looking very quickly for a solution and does not store data and results in a systematic way that allows it to be used again in similar scenarios. The development of powerful algorithms requires that they can be applied in similar conditions with some recurrence. The data must be correctly structured and reasonably clean so that they can be used with advantage, *Muñoz et al. (2018)*. In the most successful cases there may be limited series of ships that have the same characteristics. It is difficult to find a systematic use of the data, but still there are interesting contributions that occur in the different phases of the life cycle of a naval project. However, it is possible to find a recurrent pattern in the characteristics of the steel parts of the ship. So A.I. systems can assess if they are correctly defined.

5.1 A.I. in marine design

The first stage of the lifecycle of ships and naval artifacts is designing. We can find interesting approaches to the use of A.I. in this phase. And it must be said that some of them are quite old and date back to the time of the first explosion of A.I. interest. In 1989, the Defense Advanced Research Projects Agency (DARPA) of the United States promoted a workshop held at Rutgers University, New Brunswick, NJ to support research initiatives of hydrodynamic designs of ships. One of the objectives was to clarify the relationships between the hydrodynamic design problems of ships and the areas of A.I. research related to the design and analysis of complex systems. Note that the results cannot be said to be very promising, since they concluded the need to acquire computational fluid mechanics analysis tools CFD and integrate them into the design processes and effective control of design processes, focusing on concurrent design and including approaches to explore feasible design space configurations and systematically recording and storing results, *Amarel and Steinberg (1990)*. However, the expectations remained open and unspecified. Later approaches have been made to apply A.I. to the resolution of complex design problems through expert systems and the appropriate selection of them for certain problems such as structure dynamics or vibrations, *Díez de Ulzurrun (1992)*.

Where it is possible to find a greater variety of proposals is in the task of optimizing the designs using A.I. algorithms that analyze the design space of certain vessels in which it has been made a systematic parameterization of the variables that allow to define different design alternatives. One of the examples can be found in the article, *Abramowsky (2013)*, for the application of A.I. to the design of cargo ships. However, it is not easy to find applications of A.I. to really systematic processes that are in real use, beyond purely academic or research attempts that have not finally materialized in the field of design. The reason can be found in the difficulty to develop these tools and the low return that companies and organizations derive from them.

5.2 A.I. in naval products and companies

It is possible to find some more tangible applications with a certain validity in the field of the operation of the ships, that is to say, the operation and the management of the transport. In this sense, the initiatives are much more numerous, although some are in phases of research or prototypes, others are in more advanced stages of implementation.

Thus, it is possible to find prototypes of unmanned vehicles that are used in very hostile environments and that require the support of A.I. This is well described by the MIT professor, Henrik Schmidt, in his course "Unmanned Marine Vehicle Autonomy, Sensing and Communications". These types of artefacts in difficult environments, such as ice water, where communication is an impossible limitation, the role of A.I. is crucial, *O´Leary (2017).*

Another interesting field of application of A.I. is described in an article about the use of A.I. techniques for the detection of small vessels, *Del-Rey et al. (2017).* The approach is interesting because it raises a situation in which the vessel is the subject of the observation, but can also be the owner of the application. Having on board systems with detection techniques of other vessels, based on A.I., opens the horizon of unmanned vessels and their possibilities of realization.

A.I. also is being integrated into the combat systems of modern ships as essential to identify threats. Thus, the software STARTLE® of the company Dstl was selected by the Royal Navy for the management of threats and is described as a software that continuously monitors the ship's environment in a cut and medium range, processes the data it receives and through techniques of A.I. helps crews to make decisions. "It is inspired by the way the human brain works, emulating the conditioned fear response mechanism of mammals. It quickly detects and evaluates potential threats, the software significantly increases the situational awareness of the human operator in complex environments," *Mathews (2016).* More recently the company Rolls-Royce has signed an association agreement with Google to use the latter´s machine learning engine to improve the company's intelligent awareness systems, *Kingsland (2018).*

It is also possible to locate A.I. applications in management systems for the exploitation of energy at sea or proposals of companies dedicated to energy in ships. Recently the company Eco Marine Power announced that it would start using the Neural Network Console provided by Sony Network Communications Inc., as part of a strategy to incorporate A.I. in various technological projects related to the ship, including the further development of the patented system of Aquarius MRE® propulsion (Marine Renewable Energy) and EnergySail®, *MI News Network (2017).*

One of the great references in the naval field is the marine area of Rolls Royce that is trying to promote the application of A.I. in ships in two lines: the intelligent management of assets that covers energy, health, data and fleet management and a second line of business of remote and autonomous operations. The latter includes intelligent detection or recognition, remote operations, autonomous navigation systems and connection with ships, *Rolls-Royce (2018).* As we can see on their website, not all lines of work are in operation, but some are in development.

5.3 The future of A.I. in marine business and industry

The exploitation of the marine business has an undeniable field of growth for A.I. There are many computer solutions that, based on the operating data of the different ship systems, can help manage assets in a more optimal way. The application of IoT to ships provides both data collection and the ability to act on assets to obtain their best performance, *Muñoz and Pérez (2017).* For this, it is necessary to have some essential elements. In the first place, we must have comprehensive solutions that cover all aspects of connectivity and integrate them in a coherent manner. It is necessary to have the signaling, connectivity and appropriate representation model based to provide interactivity with the end users. IBM with its program MAXIMO® and SENER with FORAN® are developing a proposal that integrates reality model made during the initial design stage, with the solution of IBM to merge asset management

with the power of data IoT obtained of sensors, devices and people to have visibility of them in real time. Have a model of the database in a single database, it allows obtaining virtual reality and augmented reality images on which the obtained data can be superimposed and compared with the technical performance measures expected for each element of the monitored vessel. In this way it will be possible to act in the way that each situation advises.

Another interesting field of work for the future of A.I. is image recognition. In this sense and placing the focus on the marine industry, two fields of application appear. The identification of images in autonomous vehicles that can help the mission and the operation of them. Although it does not only have application in ships and unmanned devices, it can also be used in surveillance systems and detection of possible threats or risks in manned ships. Part of this is what one of the projects that have been mentioned above covers, *Mathews (2016).*

The recognition of images through A.I. is also of interest in design stages. The need to have virtual models of the objects that are part of a project makes real models can be scanned and then try to be recognized to create the virtual model. This is of particular interest in ship revamping and retrofit. The need to have a virtual model from a real one in order to evaluate the possibilities of retrofitting, including the processes and maneuvers necessary to carry out such operations. While cloud applications are able to work with that amount of visual information, they have not yet passed the threshold of identifying the elements that appear in the scene and converting them into analytical geometric representations or not, on which can obtain measurements or manipulate as a whole. An extension of this, can be applied to the component models that are used in the design stages by the CAD applications. Currently, it is increasingly common for components to be modeled in CAD that are obtained through external files that for the most part have been obtained for marketing purposes. These format are superficial representations of many faces that do not have a geometric and parametric representation. This, which is useful simply to see a model makes it useless or even a problem to carry out projects, since it is necessary to have metadata that only exist when the models have a formal geometric representation. That is to say, it is not the same to handle the six faces of a cube, that the cube in its totality. This limitation opens a field of action to A.I. programs that are able to recognize that certain faces form a determined surface, and in turn that certain surfaces form a certain solid. By the moment the available programs help the user, but it is finally the user who validates the conversion. However, A.I. programs can go on igniting this type of recognition that makes a human being to be more decisive each time.

The realization of a naval project is something certainly complex, and not only by the transversality of it but also by the number of tools that must be handled and the limitations imposed by design rules or standards of various kinds: construction, security, etc. CAD systems provide more and more tools, but they are also increasingly complex to be used optimally. Along with this scenario, the marine engineering companies and the shipyards are faced with very demanding deadlines and staff or very young who, although they are familiar with new technologies, do not know the art of naval architecting and marine engineering or with very old people who are more reluctant to work with the CAD and with new capabilities. Therefore, it would be interesting to have a virtual assistant who can provide all the information necessary to do the job correctly. SENER and IBM are developing a project that integrates the cognitive abilities of Watson® with the functionalities of the CAD in the different stages of design.

The platform Watson® will have a corpus of information and data that will integrate everything needed to use correctly and optimally the FORAN® system Furthermore it also will include all regulations applicable to different types of vessels, regulation of IMO, fighting against the pollution, safety regulations, etc. It can even integrate the design and work rules of the shipyards themselves in such a way that CAD users can make designs according to all the regulations and applicable standards at the different levels: administration, construction and ship-owners. The system will be trained to learn in order to give the correct information to each type of intention and will be able to learn and trained in different and new things that may affect the design. The integration can be done at different levels, completely decoupled from the CAD or coupled to it to perform certain operations in the CAD. It launches events that are captured by the listener system and this in turn links with the virtual assistant to provide the information or data that are linked to those operations. The interaction with the system

may also be on demand or taking advantage of the natural language processing capabilities of the Watson ® system. This project allows the capabilities of the FORAN® system to be increased to provide the cognitive and analytical capabilities of the Watson® system and make them available to the marine industry to put it in the field of digitalisation 4.0.

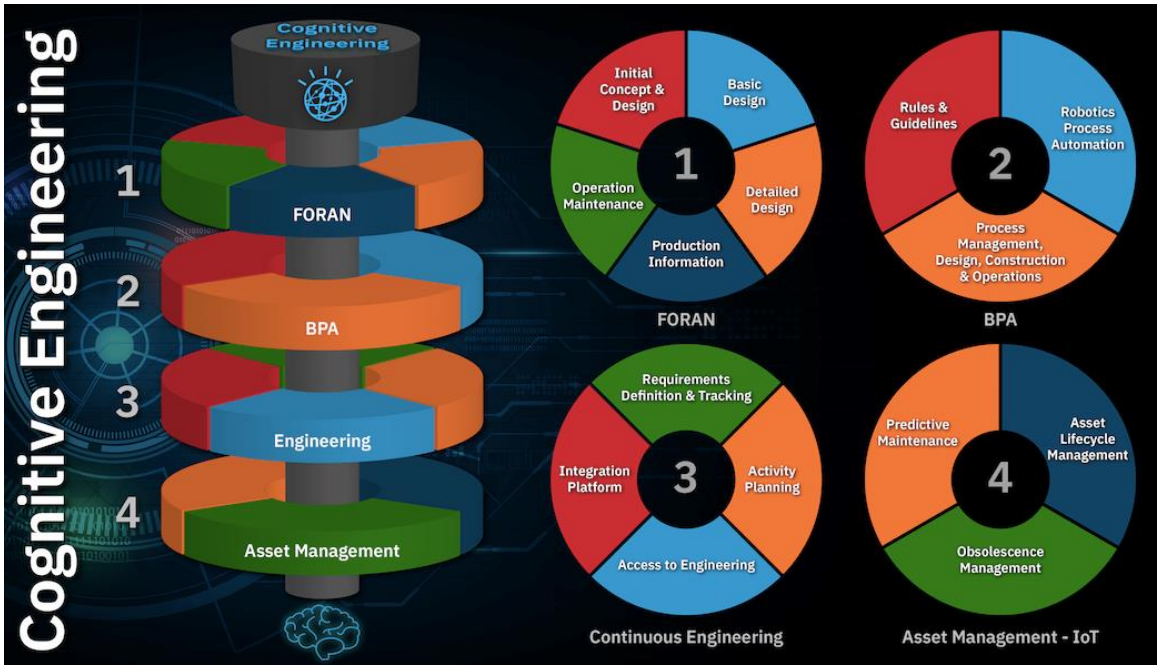

Fig.7: IBM Cognitive Engine in FORAN. Courtesy of IBM

As we have found possibilities of application of A.I. in the field of design, it will also be possible to see the realities of A.I. in manufacturing processes. Perhaps the first steps we will see in the ability of the machines to select the material of a manufacture. Machines that select clipping plates to take advantage of the material according to the remaining pieces or robots capable of organizing the movements of intermediate products in the workshop. The novelty of A.I., will be that these machines and robots will not have to be programmed, but they will receive the data or the objects with which they have to work and they will know how to act. "In the future, robots will no longer have to be expensively programmed in a time-consuming way with code pages that provide them with a fixed procedure for assembling parts, we just have to specify the task and the system will automatically translate these specifications into a program," *Wurm (2017).*

6. Conclusions

A.I. is one of the enabling technologies of digital transformation that has the greatest potential among those that make up the fourth industrial revolution. Knowing their characteristics and possibilities is essential to decide their application to certain processes and products, especially industrial ones and very particularly those related to the marine sector. It is important to identify the value that A.I. can contribute to the use cases where it can be applied.

A.I. automates the learning of repetitive tasks and the discovery of relationships through data. It is necessary to populate accurate and reliable data to A.I. systems as well as to provide sufficient information that is well structured and correctly tagged. The A.I. highlights the importance of the data.

It is necessary that those who use A.I. know how to make themselves understood and ask the right questions. The A.I. must be correctly fed, with questions and answers. An A.I. system is as intelligent as the individuals who prepare it.

A.I. adds intelligence to products, which means that it makes those technologies that incorporate them

better, but we must not forget that it is these technologies that provide the core of value to work processes and methodologies.

The use of A.I. in industrial environments such as the naval one is just beginning. There is still a long way to go, in the field of design, optimization of projects, maintenance of data and results. Fields such as the recognition of images, for their conversion into models, the automatic intervention in the validation of the requirements, the optimal exploitation of the processes inherent to naval engineering, are still practically unexplored.

With or without debate, the truth is that A.I. is present day by day in our environment, and its development will be growing. We will see A.I. in applications that we would not have imagined weeks ago. Musical compositions that are the most listened to can be created with A.I. or the most curious and tasty cooking recipes, intelligent cars without a driver or the best doctor capable of correcting diagnosis and treatment. But in spite of all these advances, we will continue to need intelligent people, people who are smarter than machines and who are ahead of them, because there are capacities of the human being who can never be embedded in an artificial intelligence.

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