Robotics and Artificial Intelligence

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ABSTRACT

Artificial intelligence and robotics are very recent technologies and risks for our world. They are developing their capacity dramatically and shifting their origins of developing intention to other dimensions. When humans see the past histories of AI and robotics, human beings can examine and understand the objectives and intentions of them which to make life easy and assist human beings within different circumstances and situations. However, currently and in the near future, due to changing the attitude of robotic and AI inventors and experts as well as based on the AI nature that their capacity of environmental acquisition and adaptation, they may become predators and put creatures at risk. They may also inherit the full nature of creatures. Thus, finally they will create their new universe or the destiny of our universe will be in danger.

KEYWORDS

AI, Destiny of Universe, Intelligence, Robotics

1. INTRODUCTION

Artificial intelligence describes the work processes of machines that would require intelligence if performed by humans (Wisskirchen et al., 2017). The term ‘artificial intelligence’ thus means ‘investigating intelligent problem-solving behavior and creating intelligent computer systems.

There are two kinds of artificial intelligence:

- **Weak Artificial Intelligence:** the computer is merely an instrument for investigating cognitive processes – the computer simulates intelligence.
- **Strong Artificial Intelligence:** The processes in the computer are intellectual, self-learning processes. Computers can ‘understand’ by means of the right software/programming and are able to optimize their own behavior on the basis of their former behavior and their experience. 4 This includes automatic networking with other machines, which leads to a dramatic scaling effect.

According to the Robot Institute of America (1979) a robot is: “A reprogram able, multi-functional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks” (Bansal et al., 2017). A more inspiring definition can be found in Webster. According to Webster a Robot is: “An automatic device that performs functions normally ascribed to humans or a machine in the form of a human.” A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand.

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Robotics can be defined as the field of knowledge and techniques that can be used to create robots. Robotics is a branch of engineering that involves the conception, design, manufacture, and operation of robots. This field overlaps with electronics, computer science, artificial intelligence, nanotechnology, and bio-engineering. Robotics is the field of knowledge and techniques that permit the construction of robots. Designed to carry out various tasks in place of humans – for example, on a factory assembly line, or on a mission to Mars or other dangerous place – robots are more than simple computers: they must be able to sense and react to changes in their environment.

The robotics intelligence can be efficiently used in wide Industrial Applications that is achieved through Automation of Robotics tasks, and its key expertise in handling utmost requirements in various arenas that leads to cost effective and secured operational processes by

- Reliable advancements of equipment functioning and its control in order to trigger varying applications of automation and to strengthen the recycle of equipment and thereby increasing its competence on demand.
- Incline and controlled mechanized layouts to curtail transportation and to efficiently coalesce physical and computerized work-cells.
- IT enabled manufacturing apparatus for simultaneous artifact and fabrication in development and design, indoctrination and servicing of the tools.
- Robotic testing of electronic machinery (computer vision, electronic test equipment) for achieving 100% excellence.
- Advanced industrialized process like gluing, coating, joining, wiring etc; which are key tools for robot traversal and control the same time suitable for mass products and robot guidance and control. Here, laser based processes will play an increasing role in terms of joining, coating, cutting, and finishing.

The paper is organized in nine sections followed by recommendation, conclusion, acknowledgement and references. Section 2 describes about history of robotics and AI in detail. Section 3 gives a detailed explanation about robotics and AI. Section 4 and 5 talks about the seasons of robotics and AI, and AI technologies & disciplines respectively. Section 6 gives a detailed explanation of AI and robotics limitations. Section 7 and 8 talks about the weak and strong AI and robotics, and the impact of government on AI and Robotics respectively. Finally, Section 9, 10 and 11 deals about major technological firms AI and robotics, programming languages for AI and robotics, and risks and fears of AI and robotics respectively.

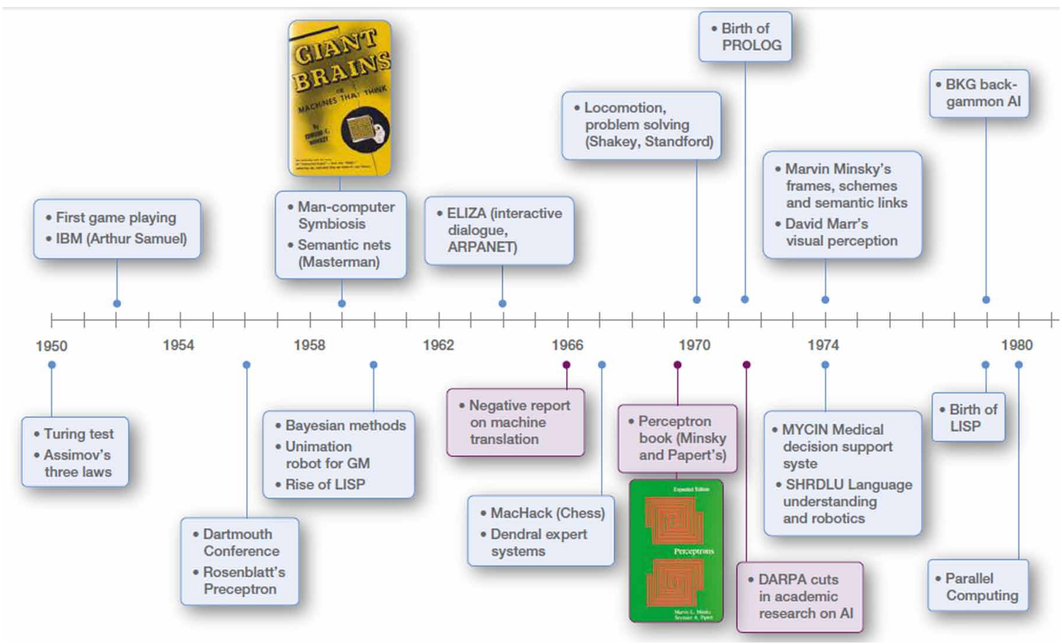
2. HISTROY OF ROBOTICS AND AI

The birth of the computer took place when the first calculator machines were developed, from the mechanical calculator of Babbage, to the elector-mechanical calculator of Torres-Quevedo (Perez et al., 2017). The dawn of automata theory can be traced back to World War II with what was known as the "codebreakers". The amount of operations required to decode the German trigrams of the Enigma machine, without knowing the rotor's position, proved to be too challenging to be solved manually. The inclusion of automata theory in computing conceived the first logical machines to account for operations such as generating, codifying, storing and using information. Indeed, these four tasks are the basic operations of information processing performed by humans. The pioneering work by Ramón y Cajal marked the birth of neuroscience, although many neurological structures and stimulus responses were already known and studied before him. For the first time in history the concept of "neuron" was proposed. McClulloch and Pitts further developed a connection between automata theory and neuroscience, proposing the first artificial neuron which, years later, gave rise to the first computational intelligence algorithm, namely "the perceptron". This idea generated great interest among prominent scientists of the time, such as Von Neumann, who was the pioneer of modern computers and set the foundation for the connectionism movement.

The Dartmouth Conference of 1956 was organized by Marvin Minsky, John McCarthy and two senior scientists, Claude Shannon and Nathan Rochester of IBM. At this conference, the expression "Artificial Intelligence" was first coined as the title of the field (Perez et al., 2017) . The Dartmouth conference triggered a new era of discovery and unrestrained conquests of new knowledge. The computer programmes developed at the time are considered by most as simply "extraordinary"; computers solve algebraic problems, demonstrate theorems in geometry and learnt to speak English. At that time, many didn't believe that such "intelligent" behavior was possible in machines. Researchers displayed a great deal of optimism both in private and in scientific publications. They predicted that a completely intelligent machine would be built in the next 20 years. Government agencies, such as the US Defence and Research Project Agency (DARPA), were investing heavily in this new area. It is worth mentioning, that some of the aforementioned scientists, as well as major laboratories of the time, such as Los Alamos (Nuevo Mexico, USA), had strong connections with the army and this link had a prominent influence, as the work at Bletchley Park (Milton Keynes, UK) had, over the course of WWII, as did political conflicts like the Cold War in AI innovation.

In 1971, DARPA funded a consortium of leading laboratories in the field of speech recognition. The project had the ambitious goal of creating a fully functional speech recognition system with a large vocabulary. In the middle of the 1970s, the field of AI endured fierce criticism and budgetary restrictions, as AI research development did not match the overwhelming expectations of researchers.. When promised results did not materialize, investment in AI eroded. Following disappointing results, DARPA withdrew funding in speech recognition and this, coupled with other events such as the failure of machine translation, the abandonment of connectionism and the Lighthill report, marked the first winter of AI (Lighthill, 1973). During this period, connectionism stagnated for the next 10 years following a devastating critique by Marvin Minksy on perceptrons (Minsky & Papert, 1969). From 1980 until 1987, AI programmes, called "expert systems", were adopted by companies and knowledge acquisition become the central focus of AI research. At the same time, the Japanese government launched a massive funding program on AI, with its fifth-generation computers initiative. Connectionism was also revived by the work of John Hopfield (1982) and David Rumelhart et al. (1985). AI researchers who had experienced the first backlash in 1974, were sceptical about the reignited enthusiasms of expert systems and sadly their fears were well founded. The first sign of a changing tide was with the collapse of the AI computer hardware market in 1987. Apple and IBM desktops had gradually improved their speed and power and in 1987 they were more powerful than the best LISP machines on the market. Overnight however, the industry collapsed and billions of dollars were lost. The difficulty of updating and reprogramming the expert systems, in addition to the high maintenance costs, led to the second AI winter. Investment in AI dropped and DARPA stopped its strategic computing initiative, claiming AI was no longer the "latest mode." Japan also stopped funding its fifth-generation computer program as the proposed goals were not achieved. In the 1990s, the new concept of "intelligent agent" emerged (Wooldrige & Jennings, 2009). An agent is a system that perceives its environment and undertakes actions that maximize its chances of being successful. The concept of agents conveys, for the first time, the idea of intelligent units working collaboratively with a common objective. This new paradigm was intended to mimic how humans work collectively in groups, organizations and/or societies. Intelligent agents proved to be a more polyvalent concept of intelligence. In the late 1990s, fields such as statistical learning from several perspectives including probabilistic, frequentist and possibilistic (fuzzy logic) approaches, were linked to AI to deal with the uncertainty of decisions. This brought a new wave of successful applications for AI, beyond what expert systems had achieved during the 1980s. These new ways of reasoning were more suited to cope with the uncertainty of intelligent agent states and perceptions and had its major impact in the field of control. During this time, high-speed trains controlled by fuzzy logic, were developed (Zadel, 2015) as were many other industrial applications (e.g. factory valves, gas and petrol tanks surveillance, automatic gear transmission systems and reactor control in power plants) as well as household appliances with advanced levels of intelligence (e.g. air-conditioners, heating systems, cookers and vacuum- cleaners). These were different to the expert systems in 1980s; the modelling of the inference system for the task, achieved through learning, gave rise to the field of Machine Learning. Nevertheless, although machine reasoning exhibited good performance, there was still an engineering requirement to digest the input space into a new source, so that intelligence could reason more effectively. Since 2000, a third renaissance of the connectionism paradigm arrived with the dawn of Big Data, propelled by the rapid adoption of the Internet and mobile communication. Neural networks were once more considered, particularly in the role they played in enhancing perceptual intelligence and eliminating the necessity of feature engineering. Great advances were also made in computer vision, improving visual perception, increasing the capabilities of intelligent agents and robots in performing more complex tasks, combined with visual pattern recognition. All these paved the way to new AI challenges such as, speech recognition, natural language processing, and self-driving cars. A timeline of key highlights in the history of AI is shown in Figure 1.

Figure 1. A timeline highlighting some of the most relevant events of AI since 1950. The blue boxes represent events that have had a positive impact on the development of AI. In contrast, those with a negative impact are shown in red and reflect the low points in the evolution of the field, i.e. the so-called "winters" of AI (Perez et al., 2017).



3. CURRENT STATE OF THE ART OF ROBOTICS AND AI

Building on the advances made in mechatronics, electrical engineering and computing, robotics is developing increasingly sophisticated sensorimotor functions that give machines the ability to adapt to their ever-changing environment. Until now, the system of industrial production was organized around the machine; it is calibrated according to its environment and tolerated minimal variations.

Today, it can be integrated more easily into an existing environment. The autonomy of a robot in an environment can be subdivided into perceiving, planning and execution (manipulating, navigating, collaborating). The main idea of converging AI and Robotics is to try to optimize its level of autonomy through learning. This level of intelligence can be measured as the capacity of predicting the future, either in planning a task, or in interacting (either by manipulating or navigating) with the world. Robots with intelligence have been attempted many times. Although creating a system exhibiting human-like intelligence remains elusive, robots that can perform specialized autonomous tasks, such as driving a vehicle (Rogers, 2015), flying in natural and man-made environments (Floreano & Wood, 2015), swimming (Chen et al., 2014), carrying boxes and material in different terrains (Ohmura & Kuniyoshi, 2007), pick up objects (Kappasson et al., 2015) and put them down Arisumi et al., 2010) do exist today.

Another important application of AI in robotics is for the task of perception. Robots can sense the environment by means of integrated sensors or computer vision. In the last decade, computer systems have improved the quality of both sensing and vision. Perception is not only important for planning but also for creating an artificial sense of self-awareness in the robot. This permits supporting interactions with the robot with other entities in the same environment. This discipline is known as social robotics. It covers two broad domains: human-robot interactions (HCI) and cognitive robotics. The vision of HCI it to improve the robotic perception of humans such as in understanding activities (Asada, 2015), emotions (Zhang et al., 2013), non-verbal communications (Mavridis, 2015) and in being able to navigate an environment along with humans (Kruse et al., 2013). The field of cognitive robotics focuses on providing robots with the autonomous capacity of learning and acquiring knowledge from sophisticated levels of perception based on imitation and experience. It aims at mimicking the human cognitive system, which regulates the process of acquiring knowledge and understanding, through experience and sensorisation (Mochizuki et al., 2013). In cognitive robotics, there are also models that incorporate motivation and curiosity to improve the quality and speed of knowledge acquisition through learning (Oudeyer, 2014; Chan et al., 2015).

AI has continued beating all records and overcoming many challenges that were unthinkable less than a decade ago. The combination of these advances will continue to reshape our understanding about robotic intelligence in many new domains. Figure 2 provides a timeline of the milestone in robotics and AI.

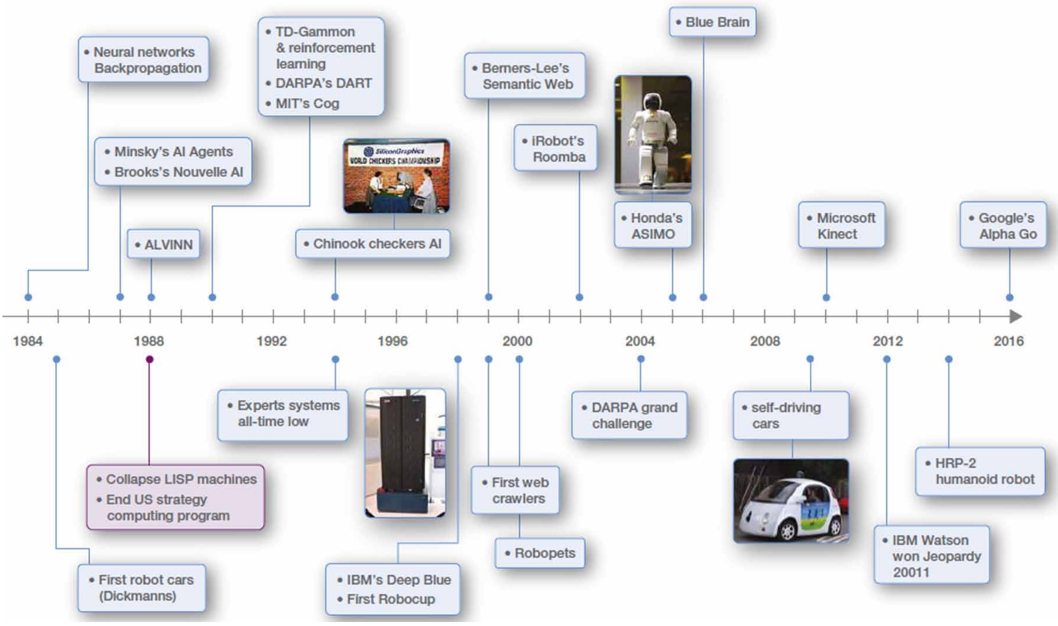
Moreover, the contemporary of AI and Robotics have dramatically developing their applicationS in differnet disciplines. For instance:

In March 2019 (Meet the World's First Female AI News Anchor, 2019), the Chinese Government-controlled Xinhua News Agency announced that they have lunched their latest AI news presenter, a female-gendered system names Xin Xiaomeng. They are working in collaboration with Chinese search engine company Soguo to produce Xin. As a remembered, in November 2018, the state news agency introduced Qiu Hao, a male-gendered AI presenter modelled on an actual Xinhua news anchor during China's World Internet Conference. Xinhua and Soguo have also announced that they have built an improved male-gendered AI system named Xin Xiaohao, who is able to gesture, stand, and move more naturally than Xin Xiaomeng or Qiu Hao.

Space expeditions and discoveries (AI Applications, 2019) always require analyzing vast amounts of data. Artificial Intelligence and Machine learning is the best way to handle and process data on this scale. After rigorous research, astronomers used Artificial Intelligence to sift through years of data obtained by the Kepler telescope in order to identify a distant eight-planet solar system. Artificial Intelligence is also being used for NASA's next rover mission to Mars, the Mars 2020 Rover. The AEGIS, which is an AI-based Mars rover is already on the red planet. The rover is responsible for autonomous targeting of cameras in order to perform investigations on Mars.

For the longest time, self-driving cars (AI Applications, 2019) have been a buzzword in the AI industry. The development of autonomous vehicles will definitely revolutionaries the transport system. Companies like Waymo conducted several test drives in Phoenix before deploying their first AI-based public ride-hailing service. The AI system collects data from the vehicles radar, cameras, GPS, and cloud services to produce control signals that operate the vehicle. Advanced Deep Learning algorithms

Figure 2. A timeline of robotics and AI (Perez et al., 2017)



can accurately predict what objects in the vehicle's vicinity are likely to do. This makes Waymo cars more effective and safer. Another famous example of an autonomous vehicle is Tesla's self-driving car. Artificial Intelligence implements computer vision, image detection and deep learning to build cars that can automatically detect objects and drive around without human intervention.

These days Virtual assistants (AI Applications, 2019) have become a very common technology. Almost every household has a virtual assistant that controls the appliances at home. A few examples include Siri, Cortana, which are gaining popularity because of the user experience they provide. Amazon's Echo is an example of how Artificial Intelligence can be used to translate human language into desirable actions. This device uses speech recognition and NLP to perform a wide range of tasks on your command. It can do more than just play your favorite songs. It can be used to control the devices at your house, book cabs, make phone calls, order your favorite food, check the weather conditions and so on.

Another example is the newly released Google's virtual assistant called Google Duplex, that has astonished millions of people. Not only can it respond to calls and book appointments for you, but it also adds a human touch. The device uses Natural language processing and Machine learning algorithms to process human language and perform tasks such as manage your schedule, control your smart home, make a reservation and so on.

Ever since social media has become our identity, we've been generating an immeasurable amount of data through chats, tweets, posts and so on. And wherever there is an abundance of data, AI and Machine Learning are always involved. In social media platforms like Facebook, AI is used for face verification wherein machine learning and deep learning concepts are used to detect facial features and tag your friends. Deep Learning is used to extract every minute detail from an image by using a bunch of deep neural networks. On the other hand, Machine learning algorithms are used to design your feed based on your interests. Another such example is Twitter's AI, which is being used to identify hate speech and terroristic language in tweets. It makes use of Machine Learning, Deep Learning, and Natural language processing to filter out offensive content. The company discovered and banned 300,000 terrorist-linked accounts, 95% of which were found by non-human, artificially intelligent machines.

4. THE SEASONS OF ROBOTICS AND AI

The evolution of AI to date, has endured several cycles of optimism (springs) and pessimism or negativism (winters):

- **Birth of AI (1952-1956):** Before the term AI was coined, there were already advances in cybernetics and neural networks, which started to attract the attention of both the scientific communities and the public. The Dartmouth Conference (1956) was the result of this increasing interest and gave rise to the following golden years of AI with high levels of optimism in the field.
- **First Spring (1956-1974):** Computers of the time could solve algebra and geometric problems, as well as speak English. Advances were qualified as "impressive" and there was a general atmosphere of optimism in the field. Researchers in the area estimated that a fully intelligent machine would be built in the following 20 years.
- **First Winter (1974-1980):** The winter started when the public and media questioned the promises of AI. Researchers were caught in a spiral of exaggerated claims and forecasts but the limitations the technology posed at the time were inviolable. An abrupt ending of funding by major agencies such as DARPA, the National Research Council and the British Government, led to the first winter of AI.
- **Second Spring (1980-1987):** Expert systems were developed to solve problems of a specific domain by using logical rules derived from experts. There was also a revival of connectionism and neural networks for character or speech recognition. This period is known as the second spring of AI.
- **Second Winter (1987-1993):** Specialized machines for running expert systems were displaced by new desktop computers. Consequently some companies, that produced expert systems, went into bankruptcy. This led to a new wave of pessimism ending the funding programs initiated during the previous spring.
- **In the background (1997-2000):** From 1997 to 2000, the field of AI was progressing behind the scenes, as no further multi-million programs were announced. Despite the lack of major funding the area continued to progress, as increased computer power and resources were developed. New applications in specific areas were developed and the concept of "machine learning" started to become the cornerstone of AI.
- **Third Spring (2000-Present):** Since 2000, with the success of the Internet and web, the Big Data revolution started to take off along with newly emerged areas such as Deep Learning. This new period is known as the third spring of AI and for time being, it looks like it is here to stay. Some have even started to predict the imminent arrival of singularity - an intelligence explosion resulting in a powerful super-intelligence that will eventually surpass human intelligence. Is this possible?

5. AI TECHNOLOGIES AND DISCIPLINES

AI is a diverse field of research and the following sub-fields are essential to its development. These include neural networks, fuzzy logic, evolutionary computation, and probabilistic methods.

Neural networks build on the area of connectionism with the main purpose of mimicking the way the nervous system processes information. Artificial neural networks (ANN) and variants have allowed significant progress of AI to perform tasks relative to "perception". When combined with the current multicore parallel computing hardware platforms, many neural layers can be stacked to provide a higher level of perceptual abstraction in learning its own set of features, thus removing the need for handcrafted features; a process known as deep learning (LeCun et al., 2015). Limitations of using deep layered ANNs include 1) low interpretability of the resultant learned model, 2) large volumes of training data and considerable computational power are often required for the effective application of these neural models.

Deep learning is part of machine learning and is usually linked to deep neural networks that consist of a multi-level learning of detail or representations of data. Through these different layers, information passes from low-level parameters to higher-level parameters. These different levels correspond to different levels of data abstraction, leading to learning and recognition. A number of deep learning architectures, such as deep neural networks, deep convolutional neural networks and deep belief networks, have been applied to fields such as computer vision, automatic speech recognition, and audio and music signal recognition and these have been shown to produce cutting-edge results in various tasks.

Fuzzy logic focuses on the manipulation of information that is often imprecise. Most computational intelligence principles account for the fact that, whilst observations are always exact, our knowledge of the context, can often be incomplete or inaccurate as it is in many real-world situations. Fuzzy logic provides a framework in which to operate with data assuming a level of imprecision over a set of observations, as well as structural elements to enhance the interpretability of a learned model (Zadeh, 1996). It does provide a framework for formalizing AI methods, as well as an accessible translation of AI models into electronic circuits. Nevertheless, fuzzy logic does not provide learning abilities per se, so it is often combined with other aspects such a neural networks, evolutionary computing or statistical learning.

Evolutionary computing relies on the principle of natural selection, or natural patterns of collective behavior (Fogel, 2006). The two most relevant subfields include genetic algorithms and swarm intelligence. Its main impact on AI is on multi-objective optimization, in which it can produce very robust results. The limitations of these models are like neural networks about interpretability and computing power.

Statistical Learning is aimed at AI employing a more classically statistical perspective, e.g., Bayesian modeling, adding the notion of prior knowledge to AI. These methods benefit from a wide set of well-proven techniques and operations inherited from the field of classical statistics, as well as a framework to create formal methods for AI. The main drawback is that, probabilistic approaches express their inference as a correspondence to a population (Breiman, 2001) and the probability concept may not be always applicable, for instance, when vagueness or subjectivity need to be measured and addressed (Senn, 2007).

Ensemble learning and meta-algorithms is an area of AI that aims to create models that combine several weak base learners in order to increase accuracy, while reducing its bias and variance. For instance, ensembles can show a higher flexibility with respect to single model approaches on which some complex patterns can be modeled. Some well-known meta-algorithms for building ensembles are bagging and boosting. Ensembles can take advantage of significant computational resources to train many base classifiers therefore enhancing the ability to augment resolution of the pattern search - although this does not always assure the attainment of a higher accuracy.

Logic-based artificial intelligence is an area of AI commonly used for task knowledge representation and inference. It can represent predicate descriptions, facts and semantics of a domain by means of formal logic, in structures known as logic programs. By means of inductive logic programming hypotheses can be derived over the known background.

6. LIMITATION OF AI AND ROBOTICS

Current AI and robotics technologies are limited to very specific applications (Perez et al., 2017). One limitation of AI, for example, is the lack of "Common Sense"; the ability to judge information beyond its acquired knowledge. A recent example is that of the AI robot Toy developed by Microsoft and designed for making conversations on social networks. It had to be disconnected shortly after its launch because it was not able to distinguish between positive and negative human interaction.

AI is also limited in terms of emotional intelligence. AI can only detect basic human emotional states such as anger, joy, sadness, fear, pain, stress and neutrality. Emotional intelligence is one of the next frontiers of higher levels of personalisation. True and complete AI does not yet exist. At this level, AI will mimic human cognition to a point that it will enable the ability to dream, think, feel emotions and have own goals. Although there is no evidence yet this kind of true AI could exist before 2050, nevertheless the computer science principles driving AI forward, are rapidly advancing and it is important to assess its impact, not only from a technological standpoint, but also from a social, ethical, and legal perspective.

7. WEAK AND STRONG AI & ROBOTICS

When defining the capacity of AI, this is frequently categorized in terms of weak or strong AI (Perez et al., 2017). Weak AI (narrow AI) is one intended to reproduce an observed behavior as accurately as possible. It can carry out a task for which they have been precision-trained. Such AI systems can become extremely efficient in their own field but lack generalization ability. Most existing intelligent systems that use machine learning, pattern recognition, data mining or natural language processing are examples of weak AI. Intelligent systems, powered with weak AI include recommender systems, spam filters, self-driving cars, and industrial robots.

Strong AI is usually described as an intelligent system endowed with real consciousness and is able to think and reason in the same way as a human being. A strong AI can, not only assimilate information like a weak AI, but also modify its own functioning, i.e. is able to autonomously reprogram the AI to perform general intelligent tasks. These processes are regulated by human-like cognitive abilities including consciousness, sentience, sapience and self-awareness. Efforts intending to generate a strong AI have focused on whole brain simulations, however this approach has received criticism, as intelligence cannot be simply explained as a biological process emanating from a single organ but is a complex coalescence of effects and interactions between the intelligent being and its environment, encompassing a series of diverse ways via interlinked biological process.

8. THE IMPACT OF GOVERNMENT ON AI & ROBOTICS

Government organizations and the public sector are investing millions to boost artificial intelligence research. For example, the National Research Foundation of Singapore is investing $150 million into a new national programme in AI. In the UK alone, £270 million is being invested from 2017 to 2018 to boost science, research and innovation, via the Government's new industrial strategy and a further funding of £4.7 billion is planned by 2021 (Yang, 2017). This timely investment will put UK in the technological lead among the best in the world and ensure that UK technological innovations can compete. Recent AI developments have triggered major investment across all sectors including financial services, banking, marketing and advertising, in hospitals and government administration.

In fact software and information technology services have more than a 30% share in all AI investments worldwide as of 2016, whereas Internet and telecommunication companies follow with 9% and 4%, respectively (Inc, 2016).

It is also important to note that the funding in AI safety, ethics and strategy/policy has almost doubled in the last three years (Farquhar, 2017). Apart from non-profit organizations, such as the Future of Life Institute (FLI) and the Machine Intelligence Research Institute (MIRI), other centers, such as the Centre for Human-Compatible AI and Centre for the Future of Intelligence, have emerged and they, along with key technological firms, invested a total of $6.6 million in 2016.

9. MAJOR TECHNOLOGICAL FIRMS AI & ROBOTICS

Major technological firms are investing into applications for speech recognition, natural language processing and computer vision. A significant leap in the performance of machine learning algorithms resulting from deep learning, exploited the improved hardware and sensor technology to train artificial networks with large amounts of information derived from 'big data' (Andreu-Perez et al., 2015; Ravi et al., 2017). Current state-of-the-art AI allows for the automation of various processes and new applications are emerging with the potential to change the entire workings of the business world (Figures 3,4, & 5). As a result, there is huge potential for economic growth, which is demonstrated in the fact that between 2014 and 2015 alone, Google, Microsoft, Apple, Amazon, IBM, Yahoo, Facebook, and Twitter, made at least 26 acquisitions of start-ups and companies developing AI technology, totaling over $5 billion in cost.

In 2014, Google acquired DeepMind, a London-based start-up company specializing in deep learning, for more than $500M and set a record of company investment of AI research to academic standard. In fact, DeepMind has produced over 140 journal and conference papers and has had four articles published in Nature since 2012. One of the achievements of DeepMind was in developing AI technology able to create general-purpose software agents that adjust their actions based only on a cumulative reward. This reinforcement learning approach exceeds human level performance in many aspects and has been demonstrated with the defeat of the world Go game champion; marking a historical landmark in AI progress. IBM has developed a supercomputer platform, Watson, which has the capability to perform text mining and extract complex analytics from large volumes of unstructured data. To demonstrate its abilities, IBM Watson, in 2011, beat two top players on 'Jeopardy!', a popular quiz show, that requires participants to guess questions from specific answers. Although, information retrieval is trivial for computer systems, comprehension of natural language is still a challenge. This achievement has had a significant impact on the performance of web searches and the overall ability of AI systems to interact with humans. In 2015, IBM bought AlchemyAPI to incorporate its text and image analysis capabilities in the cognitive computing platform of the IBM Watson. The system has already been used to process legal documents and provide support to legal duties. Experts believe

Figure 3. A conservative estimate of venture capital investment in AI technology worldwide according to data presented in (Chen et al., 2016)

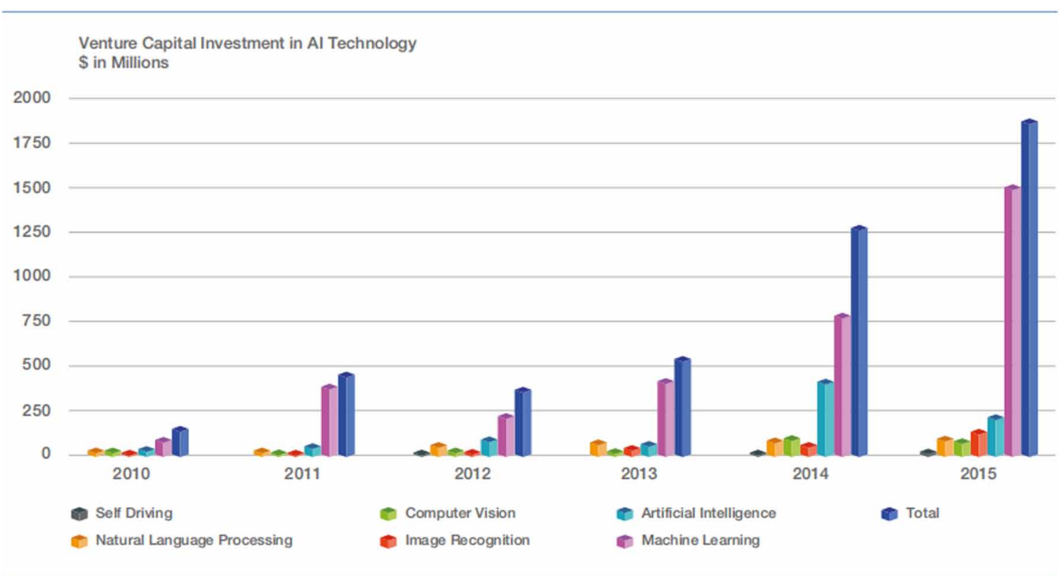


Figure 4. Total estimated equity investments in ai start-ups, by start-up location 2011-17 and First Semester 2018 (OECD, 2018)

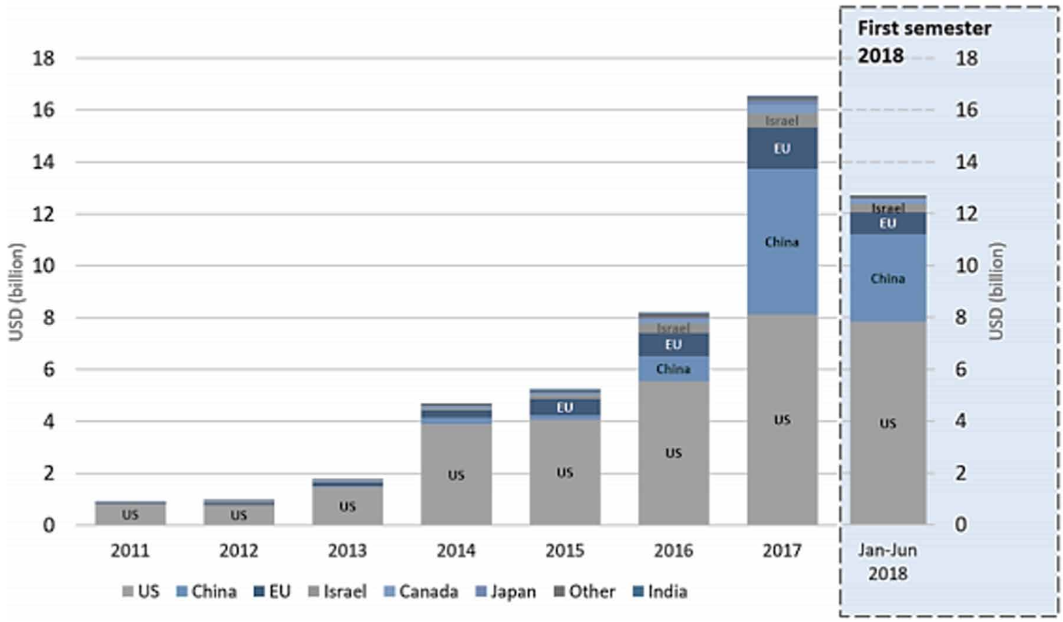
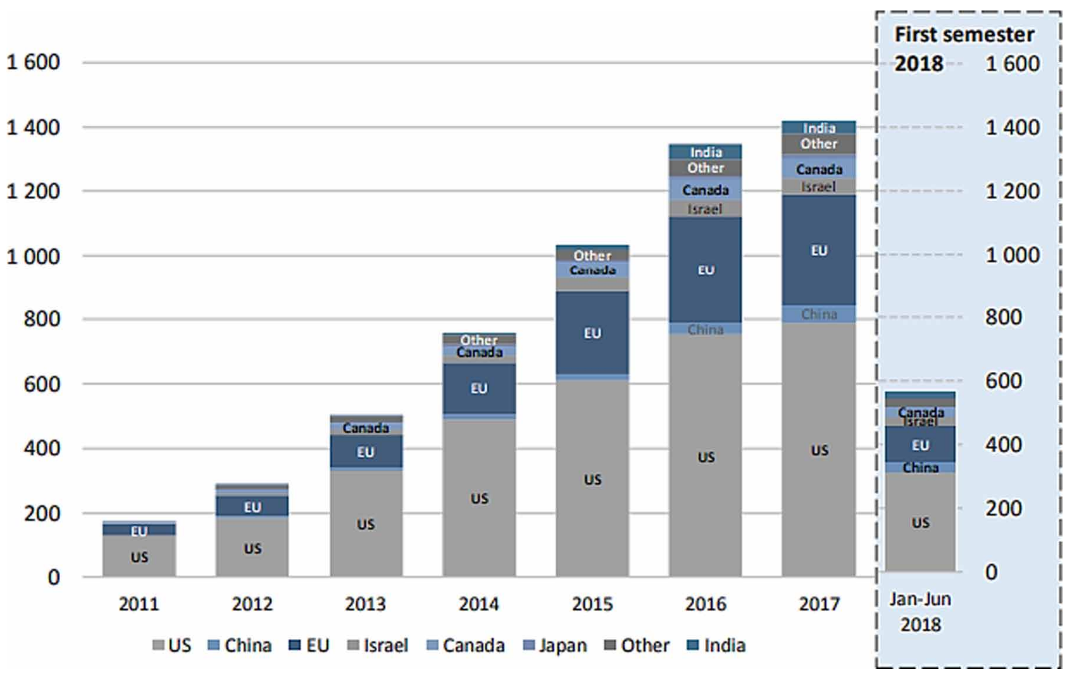


Figure 5. Number of private equity investments in AI start-ups, by start-up location 2011-17 and First Semester 2018 (OECD, 2018)



that these capabilities can transform current health care systems and medical research. Research in top AI firms is centered on the development of systems that are able to reliably interact with people. Interaction takes more natural forms through real-time speech recognition and translation capabilities. Robo-advisor applications are at the top of the AI market with a globally estimated 255 billion in US dollars by 2020 (Inc, 2016). There are already several virtual assistants offered by major companies. For example, Apple offers Siri and Amazon Alexa, Microsoft offers Cortana, and Google has the Google Assistant.

2016, Apple Inc. purchased Emotient Inc., a start-up using artificial-intelligence technology to read people's emotions by analyzing facial expressions. DeepMind created WaveNet, which is a generative model that mimics human voices. According to the company's website, this sounds more natural than the best existing Text-to-Speech systems. Facebook is also considering machine-human interaction capabilities as a prerequisite to generalized AI. Recently, OpenAI, a non-profit organization, has been funded as part of a strategic plan to mitigate the risks of monopolizing strong AI. OpenAI has re-designed evolutional algorithms that can work together with deep neural networks to offer state-of-the-art performance. It is considered to rival DeepMind since it offers similar open-source machine learning libraries to TensorFlow, a deep learning library distributed by Google DeepMind. Nevertheless, the big difference between the technology developed at OpenAI and the other private tech companies, is that the created Intellectual Property is accessible by everyone. Although several companies and organizations, including DeepMind and OpenAI, envision the solution to the creation of intelligence and the so-called Strong AI, developing machines with self-sustained long-term goals is well beyond current technology. Furthermore, there is vigorous debate on whether or not we are going through an AI bubble, which encompasses the paradox that productivity growth in USA, during the last decade, has declined regardless of an explosion of technological progress and innovation. It is difficult to understand whether this reflects a statistical shortcoming or that current innovations are not transformative enough. This decline can be also attributed to the lack of consistent policy frameworks and security standards that can enable the application of AI in projects of significant impact (Table 1).

10. PROGRAMMING LANGUAGES FOR AI & ROBOTICS

Programming languages played a major role in the evolution of AI since the late 1950s and several teams carried out important research projects in AI; e.g. automatic demonstration programs and game programs (Chess, Ladies) (McCarthy, 1959). During these periods researchers found that one of the special requirements for AI is the ability to easily manipulate symbols and lists of symbols rather than processing numbers or strings of characters. Since the languages of the time did not offer such facilities, a researcher from MIT, John MacCarthy, developed, during 1956-58, the definition of an ad-hoc language for logic programming, called LISP (LISt Processing language). Since then, several hundred derivative languages, so-called "Lisp dialects", have emerged (Scheme, Common Lisp, Clojure); Indeed, writing a LISP interpreter is not a hard task for a Lisp programmer (it involves only a few thousand instructions) compared to the development of a compiler for a classical language (which requires several tens of thousands of instructions). Because of its expressiveness and flexibility, LISP was very successful in the artificial intelligence community until the 1990s.

Another important event at the beginning of AI was the creation of a language with the main purpose of expressing logic rules and axioms. Around 1972 a new language was created by Alain Colmerauer and Philippe Roussel named Prolog (PROgramming in Logic). Their goal was to create a programming language where the expected logical rules of a solution can be defined and the compiler automatically transforms it into a sequence of instructions.

Prolog is used in AI and in natural language processing. Its rules of syntax and its semantics are simple and considered accessible to non-programmers. One of the objectives was to provide a tool for linguistics that was compatible with computer science. Since 2008, the Python community has been

Table 1. Major companies in AI (Perez et al., 2017)

	Technology/Platforms	AI Applications of significant impact	Open-Source
Apple Inc.	Computer hardware and software Consumer electronics Online services	**Siri:** AI Virtual Assistant **Self-driving car:** AI technology that could drive a car without human interaction.	
amazon	Cloud Computing Online retail services Electronics	**Alexa:** AI virtual assistant **Amazon AI platform:** Cloud software and hardware AI tools	**DSSTNE:** Deep Scalable Sparse Tensor Network Engine
Microsoft	Developing, manufacturing and licensing computer hardware and software Consumer electronics	**Microsoft Azure:** Cloud services **Cortana:** AI virtual assistant	**CNTK:** Cognitive Toolkit **Microsoft Azure:** Cloud computing platform offered as a service.
Google DeepMind	Search engine, Maps, Ads, Gmail, Android, Chrome, and YouTube	**Self-driving cars:** Technology that allows a car to navigate in normal traffic without any human control.	**TensorFlow:** Construction of Deep Neural Networks
Google DeepMind	Deep Q-network: Deep Neural Networks with Reinforcement Learning at scale.	**AlphaGo:** The first computer program to beat professional players of Go. **DQN:** Better than human-level control of Atari games through Deep Reinforcement Learning. **Wavenet:** Raw audio form impersonating any human voice	**DeepMind Lab:** 3D game-like platform for agent-based AI research **Sonnet:** Constructing Deep Neural Networks based on TensorFlow
OpenAI	Non-profit organisation Evolutionary Algorithms Deep Neural Networks	**Evolutionary Algorithms** tuned to work with Deep Neural Networks **Testbeds for AI:** Benchmarking tools and performance measures for AI algorithms.	**Gym:** Toolkit for developing and comparing reinforcement learning algorithms. **Universe:** Measure an AI's general Intelligence
IBM	Manufacturer of computer hardware and software Hosting and consulting services Cognitive Computing	**Deep Blue:** First computer program to defit world champion chess player **Watson:** Won top players on 'Jeopardy!', a popular quiz show.	**Apache SystemML:** Distribution of large-scale machine learning computations on Apache Hadoop and Spark. **Apache UIMA:** Unstructured Information Management
facebook	Social Networking Service	**Applied Machine Learning:** Spot suicidal users **Human Computer Interaction:** Image Descriptions for Blind Users	**CommAI-env:** A Communication-based platform for training and evaluating AI systems. **fbcunn:** Deep learning modules for GPUs

trying to catch up with specific languages for scientific computing, such as Matlab and R. Due to its versatility, Python is now used frequently for research in AI. However, although python has some of the advantages of functional programming, run-time speeds are still far behind other functional languages, such as Lisp or Haskell, and even more so from C/C++. In addition, it lacks of efficiency when managing large amounts of memory and highly-concurrent systems. In the 1990s, the machine languages with C / C ++ and Fortran gained popularity and eclipsed the use of LISP and Prolog. Greater emphasis was placed on creating functions and libraries for scientific computation on these platforms and were used for intensive data analysis tasks or artificial intelligence with early robots. In the middle of the 1990s, the company Sun Microsystems, started a project to create a language that solved security flaws, distributed programming and multi-threading of C++. In addition, they wanted a platform that could be ported to any type of device or platform. In 1995, they presented Java, which took the concept of object orientation much further than C++. Equally, one of the most important additions to Java was the Java VM (JVM) which enabled the capability of running the same code in any device regardless of their internal technology and without the need of pre-compiling for every platform. This added new advantages to the field of AI that were be introduced in devices such as cloud servers and embedded computers. Another important feature of Java was that it also offered one of the first frameworks, with specific tools for the internet, bringing the possibility of running applications in the form of java applets and javascripts (i.e. self-executing programs) without the need of installation. This had an enormous impact in the field of AI and a set the foundation in the fields of web 2.0/3.0 and the internet of things (IoT). From 2010 and mostly driven by the necessity of translating AI into commercial products, (that could be used by thousands and millions of users in real time), IT corporations looked for alternatives by creating hybrid languages, that combined the best from all paradigms without compromising speed, capacity and concurrency. In recent years, new languages such as Scala and Go, as well as Erlang or Clojure, have been used for applications with very high concurrency and parallelization, mostly on the server side. Well-known examples are Facebook with Erlang or Google with Go. New languages for scientific computation have also emerged such as Julia and Lua. However, the development of AI using purely procedural languages was costly, time-consuming and error prone. Consequently, this turned the attention into other multi-paradigm languages that could combine features from functional and procedural object-oriented languages. Python, although first published in 1991, started to gain popularity as an alternative to C/C++ with Python 2.2 by 2001. The Python concept was to have a language that could be as powerful as C/C++ but also expressive and pragmatic for executing "scripts" like Shell Script. It was in 2008, with the publication of Python 3.0, which solved several initial flaws, when the language started to be considered a serious contender for C++, java and other scripting languages such as Perl. Although functional programming has been popular in academia, its use in industrial settings has been marginal and mainly during the times when "expert systems" were at their peak, predominantly during the 1980s. After the fall of expert systems, functional programming has, for many years, been considered a failing relic from that period. However, as multiprocessors and parallel computing are becoming more available, functional programming is proving to be a choice of many programmers to maximize functionality from their multicore processors. These highly expensive computations are usually needed for heavy mathematical operations or pattern matching, which constitute a fundamental part of running an AI system. In the future, we will see new languages that bring simplifications on existing functional languages such as Haskell and Erlang and make this programming paradigm more accessible. In addition, the advent of the internet-of-things (IoT) has drawn the attention to the programming of embedded systems. Thus, efficiency, safety and performance are again matters for discussion. New languages that can replace C/C++ incorporating tips from functional programming (e.g. Elixir) will become increasingly popular. Also, new languages that incorporate simplifications as well as a set of functions from modern imperative programming, while maintaining a performance like C/C++ (e.g. Rust), will be another future development (Table 2).

11. RISKS AND FEARS OF AI AND ROBOTICS

Given the exponential rise of interest in AI, experts have called for major studies on the impact of AI on our society, not only in technological but also in legal, ethical and socio-economic areas. This

Table 2. Lists of AI and robotics programming language (Perez et al., 2017).

Logo	Language	Date	Type	Infuenced by	AI resources
	Lisp	1958	Multi-paradigm (functional, procedural)	IPL	• Homoiconic: easy to deal with large amount of data. • Good mathematical alignment. • Lots of resources for symbolic AI (Eurisko or CYC)
	C++	1983	Procedural	C, Algol 68	• Fast execution times. • Some compatible libraries for AI such as Alchemy for Markov logic and Mlpack for general ML
C#.net	C#	2000	Multi-paradigm (functional, procedural)	C++, Java, Haskell	• Easy prototyping and well elaborated environment. • Most used language for AI in games as provides good compatibility with popular games engines such as Unity.
Clojure	Clojure	2007	Functional	Lisp, Erlang, Prolog	• Easy design and cloud infrastructure that works on top of the JVM. • Rapid interactive development and libraries for development of behaviour trees (alter-ego)
ERLANG	Erlang	1986	Functional Concurrent	Lisp, Prolog	• Good framework to deal with concurrency and elastic clouds (scalability). • Libraries for logic programming such as erlog.
	Go	2009	Procedural Concurrent	Algo, CSP, Python	• Easy concurrency and asynchronous patterns with a decent runtime. • A few libraries for machine learning such as Golearn.
	Haskell	1990	Functional	Lisp	• Easy parallelization and possibility of handling infinite computations. • A few utilities to implement neural networks (LambdaNet) and general ML (HLearn).
	Java	1995	Procedural Concurrent	C++, Ada 83	• VM provides efficient maintainability, portability and transparency. • A myriad for libraries and tools for AI such as Tweety and ML (DeepLearning4, Weka, Mallet etc.)
julia	Julia	2012	Multi-paradigm	Lisp, Lua, Matlab, Python	• Easy integration with C and Fortran. Scientific oriented language. • Several ML packages such as Mocha, or MLBase.
Lua	Lua		(procedural, functional)	C++, Scheme	• Versatile and lightweight language. • It is the de-facto language used for the machine and deep learning framework Torch.
	Matlab	1993	Multi-paradigm	APL	• Solid Integrated environment. Matrix, linear algebra oriented language. • A selection of toolboxes and utilities for machine learning, statistics and signal processing.
SWI Prolog	Prolog	1984	(procedural, functional)	Planner	• Good set of utilities for expressing the relationships between objects and symbolic computation. • Large set of internal functionalities to perform logic programming.
	Python	1972	Procedural	C++, java, haskell, perl	• Highly useful standard library that makes the language versatile and flexible. Focus on rapid development. • Plethora of frameworks and utilities for AI, ML, deep learning, scientific computing, natural processing language etc.
R	R	1972	Declarative	Lisp, Scheme	• Most comprehensive sets of statistical analysis functions and packages. • Rich community of tools for AI or ML provided freely through the CRAN repository.
Scala	Scala	1993	Multiparadigm (procedural, functional)	Erlan, Haskel, Java, Lisp, Lisp (Scheme)	• Fast run time (almost as C). It runs on top of the JVM. Very good support for distributed systems. • Several libraries and frameworks for AI, ML and numerical computing (ScalaNLP).

response also includes the speculation that autonomous super artificial intelligence may one day supersede the cognitive capabilities of humans. This future scenario is usually known in AI forums as the "AI singularity" (Spinrad, 2017). This is commonly defined as the ability of machines to build better machines by themselves. This futuristic scenario has been questioned and is received with scepticism by many experts. Today's AI researchers are more focused on developing systems that are very good at tasks in a narrow range of applications. This focus is at odds with the idea of the pursuit of a super generic AI system that could mimic all different cognitive abilities related to human intelligence such as self-awareness and emotional knowledge. In addition to this debate, about AI development and the status of our hegemony as the most intelligent species on the planet, further societal concerns have been raised. For example, the AI100 (One Hundred Year Study on Artificial Intelligence) a committee led by Stanford University, defined 18 topics of importance for AI (Horvitz, 2014). Although these are not exhaustive nor definitive, it sets forth the range of topics that need to be studied, for the potential impact of AI and stresses that there are a number of concerns to be addressed. Many similar assessments have been performed and they each outline similar concerns related to the wider adoption of AI technology.

11.1 The 18 Topics Covered by the AI100 (Horvitz, 2014)

11.1.1. Technical Trends and Surprises

This topic aims at forecasting the future advances and competencies of AI technologies in the near future. Observatories of the trend and impact of AI should be created, helping to plan the setting of AI in specific sectors, and preparing the necessary regulation to smooth its introduction.

11.1.2. Key Opportunities for AI

How advances in AI can help to transform the quality of societal services such as health, education, management and government, covering not just the economic benefits but also the social advantages and impact.

11.1.3. Delays With Translating AI Advances into Real-World Values

The pace of translating AI into real world applications is currently driven by potential economic prospects (Lohr, 2012). It is necessary to take measures to foster a rapid translation of those potential applications of AI that can improve or solve a critical need of our society, such as those that can save lives or greatly improve the organization of social services, even though their economic exploitation is not yet assured.

11.1.4. Privacy and Machine Intelligence

Personal data and privacy is a major issue to consider and it is important to envisage and prepare the regulatory, legal and policy frameworks related to the sharing of personal data in developing AI systems.

11.1.5. Democracy and Freedom

In addition to privacy, ethical questions with respect to the stealth use of AI for unscrupulous applications must be considered. The use of AI should not be at the expense of limiting or influencing the democracy and the freedom of people.

11.1.6. Law

This considers the implications of relevant laws and regulations. First, to identify which aspects of AI require legal assessment and what actions should be undertaken to ensure law enforcement for AI services. It should also provide frameworks and guidelines about how to adhere to the approved laws and policies.

11.1.7. Ethics

By the time AI is deployed into real world applications there are ethical concerns referring to their interaction with the world. What uses of AI should be considered unethical? How should this be disclosed?

11.1.8. Economics

The economic implications of AI on jobs should be monitored and forecasted such that policies can be implemented to direct our future generation into jobs that will not be soon overtaken by machines. The use of sophisticated AI in the financial markets could potentially cause volatilities and it is necessary to assess the influence AI systems may have on financial markets. Safety and Autonomy: For the safe operation of intelligent, autonomous systems, formal verification tools should be developed to assess their safety operation. Validation can be focused on the reasoning process and verifying whether the knowledge base of an intelligent system is correct (Gonzalez & Barr, 2000) and also making sure that the formulation of the intelligent behaviour will be within safety boundaries (Ratschan & She, 2007).

11.1.9. AI and Warfare

AI has been employed for military applications for more than a decade. Robot snipers and turrets have been developed for military purposes (Alston, 2011). Intelligent weapons have increasing levels of autonomy and there is a need for developing new conventions and international agreements to define a set of secure boundaries of the use of AI in weaponry and warfare.

11.1.10. Loss of Control of AI Systems

The potential of AI being independent from human control is a major concern. Studies should be promoted to address this concern both from the technological standpoint and the relevant framework for governing the responsible development of AI.

11.1.11. Criminal Uses of AI

Implementations of AI into malware are becoming more sophisticated thus the chances of stealing personal information from infected devices are getting higher. Malware can be more difficult to detect as evasion techniques by computer viruses and worms may leverage highly sophisticated AI techniques (Young & Yung, 1997; Kirat et al, 2014). Another example is the use of drones and their potential to fall into the hands of terrorists the consequence of which would be devastating.

11.1.12. Collaboration With Machines

Humans and robots need to work together and it is pertinent to envisage in which scenarios collaboration is critical and how to perform this collaboration safely. Accidents by robots working side by side with people had happened before (Bryant & Waters, 2015) and robotic and autonomous systems development should focus on not only enhanced task precision but in also being able to understand the environment and human intention.

11.1.13. AI and Human Cognition

AI has the potential for enhancing human cognitive abilities. Some relevant research disciplines with this objective are sensor informatics and human-computer interfaces. Apart from applications to rehabilitation and assisted living, they are also used in surgery (Andreu-Perez, 2016) and air traffic control (Harrison et al., 2014). Cortical implants are increasingly used for controlling prosthesis, our memory and reasoning are increasingly relying on machines and the associated health, safety and ethical impacts must be addressed.

11.1.14. Safety and Autonomy

For the safe operation of intelligent, autonomous systems, formal verification tools should be developed to assess their safety operation. Validation can be focused on the reasoning process and verifying whether the knowledge base of an intelligent system is correct (Gonzalez & Bar, 2000) and also making sure that the formulation of the intelligent behavior will be within safety boundaries (ratschan & She, 2007).

11.1.15. Psychology of People and Smart Machines

More research should be undertaken to obtain detailed knowledge about the opinions and concerns people have, in the wider usage of smart machines in societies. Additionally, in the design of intelligent systems, understanding people's preferences is important for improving their acceptability (Broadbent et al., 2009; Smarr et al., 2012).

11.1.16. Communication, Understanding and Outreach

Communication and educational strategies must be developed to embrace AI technologies in our society. These strategies must be formulated in ways that are understandable and accessible by non-experts and the general public.

11.1.17. Neuroscience and AI

Neuroscience and AI can develop together. Neuroscience plays an important role for guiding research in AI and with new advances in high performance computing, there are also new opportunities to study the brain through computational models and simulations in order to investigate new hypotheses (O'Reilly & Munakata, 2002).

11.1.18. AI and Philosophy of Mind

When AI can experience a level of consciousness and self-awareness, there will be a need to understand the inner world of the psychology of machines and their subjectivity of consciousness.

Moreover, due to the above premises and others, as I have stated on the abstract, currently and may be on the coming few decades, robotics and AI become the predator and risk of worlds' creatures and they may inherit full nature of creatures as well as they might be converged with other natural creatures. Thus, finally they will create their new universe or the destiny of our universe will be in danger.

12. CONCLUSION

There are many lessons that can be learnt from the past successes and failures of AI. To sustain the progress of AI, a rational and harmonic interaction is required between application specific projects and visionary research ideas. Along with the unprecedented enthusiasm of AI, there are also fears about the impact of the technology on our society. A clear strategy is required to consider the associated ethical and legal challenges to ensure that the society as a whole will benefit from the evolution of AI and its potential adverse effects are mitigated from early on. Such fears should not hinder the progress of AI but motivate the development of a systematic framework on which future AI will flourish. Most critical of all, it is important to understand science fiction from practical reality. With sustained funding and responsible investment, AI is set to transform the future of our society - our life, our living environment and our economy.

13. RECOMMENDATIONS

The following recommendations are relevant to the world's research community, industry, government agencies and policy makers**:**

Robotics and AI are playing an increasingly important role in the world's economy and its future growth. We need to be open and fully prepared for the changes that they bring to our society and their impact on the workforce structure and a shift in the skills base. Stronger national level engagement is essential to ensure the general public has a clear and factual view of the current and future development of robotics and AI.

A strong research and development base for robotics and AI is fundamental to the countries, particularly in areas in which we already have a critical mass and international lead. Sustained investment in robotics and AI would ensure the future growth of the countries research base and funding needs to support key Clusters/Centers of Excellence that are internationally leading and weighted towards projects with greater social-economic benefit.

It is important to address legal, regulatory and ethical issues for practical deployment and responsible innovation of robotics and AI; greater effort needs to be invested on assessing the economic impact and understanding how to maximize the benefits of these technologies while mitigating adverse effects.

The government needs to tangibly support the workforce by adjusting their skills and business in creating opportunities based on new technologies. Training in digital skills and re-educating the existing workforce is essential to maintain the competitiveness of the countries.

Sustained investment in robotics and AI is critical to ensure the future growth of the countries research base and its international lead. It is also critical to invest in and develop the younger generation to be robotics and AI savvy with a strong STEM foundation by making effective use of new technical skills.

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