Evolution of Artificial Intelligence

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Abstract—In recent years technology has taken a giant step forward and what was once considered fiction is now becoming reality, but before we can thrive in a futuristic, AI-centered era we must examine the progress AI has made thus far. In this study we cover the technological advancements of artificial intelligence spanning over the past 50 years in two distinct fields - autonomous cars and medicine. We also investigate the origin of artificial intelligence and take a closer look at the components it encompasses. With the rise of machines people are becoming more concerned and uncertain of the future and thus we have researched the risks of creating various AI systems including artificial general intelligence(AGI) and these risks are discussed throughout several sections of this paper.

Index Terms—Artificial Intelligence

1 Introduction

In this section we will first examine the vast definition of artificial intelligence(AI), followed by reviewing the work of Alan Turing in section 2 which also includes the limitations of the Turing test. Section 3 covers the Allen AI Science Challenge and lastly, section 4 and 5 examines the impact of AI in autonomous cars and medicine respectively.

1.1 What is Artificial Intelligence?

The term artificial intelligence was first coined by John McCarthy, one of the founding fathers of AI, in 1956 at the Dartmouth Conference where the discipline was born [1]. There is no one singular definition of artificial intelligence that satisfies everyone, and discussions on the matter often lead to confusion and semantic arguments which is why it is vital to keep an open mind on the matter. Essentially artificial intelligence is an umbrella term encompassing the following; machine learning, artificial general intelligence, natural language processing, super-intelligence, video-game AI, artificial neural networks(ANN), pattern recognition, automation, robotics and others [2]. All of the above are considered subfields of artificial intelligence and ultimately they are ongoing the pursuit to render machines capable of preforming intelligent tasks.

1.2 Types of Artificial Intelligence

There are a number of ways AI can be categorized, however the most common and widely used methodology classifies AI systems as either weak or strong AI. Weak AI which is also known as narrow AI, is an AI system that is designed to preform a particular task. Although weak AI pales in comparison to strong AI, it should not be easily dismissed as a well designed system can replicate and in some cases possibly surpass human intelligence for a dedicated purpose [3]. Many current systems can be classified as weak AI. Siri is an excellent example of a weak AI and although it is an incredible invention, it lacks certain characteristics such as genuine intelligence and self-awareness in order to be more than a weak AI, in fact AI researcher Ben Goertzel stated in 2010 that Siri was "VERY narrow and brittle" [4] evidenced by pseudo output if asked questions outside the limits of the application like "What is the meaning of life?". Strong AI which is more commonly referred to as AGI or human-level AI, consists of a system that is capable of successfully preforming any intellectual task that a human being can such that is indistinguishable from a human. Creating a human-level intelligence is a much more complex task than creating a weak AI, and it is yet to be fulfilled, in fact some believe that it is an impossible task. Referenced research paper [3] states that in order to achieve AGI many narrow AI systems must be combined and when they are an unexpected outcome may occur. The idea of creating an AGI or simply taking the immense amount of weak AI systems into consideration, has sparked uncertainty of the future and unrest amongst humanity of being replaced by AI and other various problems [5] [6] that come with AI are briefly outlined in section 4 and 5.

2 Turing Test

Alan Mathison Turing whom is widely known for his achievements is now considered to be the father of theoretical computer science and artificial intelligence [7]. During World War 2 Turing worked at Bletchley Park where he devised numerous techniques for speeding the breaking of German ciphers and as a result enabled the Allies to emerge victorious in several key engagements including the Battle of the Atlantic. [8] At the end of the war it was estimated that his work concluded over 2 years earlier and saved over fourteen million lives [8]. After the war Turing started to play a founding role in the development of machine intelligence and subjective probabilistic reasoning. After numerous meetings at Bletchley Park with his colleagues, Andrew Hodges [9], Turing's biographer wrote the following:

> These meetings were an opportunity for Alan to develop the ideas for chess-playing machines that had begun in his 1941 discussions with Jack Good. They often talked about mechanisation of thought processes, bringing in the theory of probability and weight of evidence, with which Donald Michiewas

> by now familiar. ...He (Turing) was not so much concerned with the building of machines designed to carry out this or that complicated task. He was now fascinated with the idea of a machine that could learn.

In 1950 the Turing test was developed in order to test if a machine can exhibit intelligence that is equivalent to and indistinguishable from that of a human. The opening sentence of his paper declares [10]:

> I propose to consider the question, Can machines think?

The Turing test involves having a text only conversation between machine(A) and man(B), the tester(C) is informed that he/she will be communicating with A and B, if the subject(C) cannot reliably tell if it is communicating to either A or B, the machine is said to have passed the test.

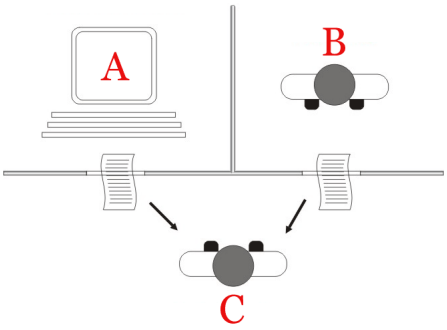

Image taken from the following source [11].

The Turing test has remained relevant to this day, one particular AI called CleverBot has undertaken the test in 2011 at the Indian Institute of Technology Guwahati where 1,334 testers participated and CleverBot was judged to be 59.3% human whereas the humans themselves only did slightly better by achieving 63.3% [12]. One could argue that CleverBot passed the test however that is in fact not the case as CleverBot is a chat-bot thats made to mimic human conversation possessing no actual intelligence of its own.

2.1 Turing Test Limitations

As the field of AI has grown more vast the Turing test has started to lose credibility. According to the Allen AI science challenge that started in 2015, the Turing test has become less meaningful as a challenge for several reasons [13]:

1) The test is binary, pass/fail is used over a score which provides no measure of progress towards an end goal which is mandatory for any challenge.
2) The details of the test are not clearly outlined, questions such as who is the person giving the test and what interaction constraints are present arise.
3) The past Turning test competitions have shown that if certain conditions are met, people can be fooled by systems that simply retrieve data and make no claim of being intelligent. A journalist of the New York Times, John Markoff wrote that the test itself is more a test of human gullibility rather than a test of machine intelligence.

3 Allen AI Science Challenge

The purpose of the Allen AI Science Challenge was to create a more diverse test for artificial intelligence, thus they decided to measure how well machines can preform when given science exams targeted for 8th graders. The test itself isn't a perfect measure of artificial intelligence but it does explore several traits associated with intelligence, these traits were language understanding, reasoning and the use of applying common knowledge, possessing these traits is an absolute necessity to achieve a futuristic AI. The test contains standard eighth-grade multiple choice science questions and from a practical point of view, exams are accessible, compelling, understandable and more importantly gradeable which lets us know how intelligent a particular AI system is and if it is improving/learning the more exams it completes. The questions asked weren't simple minded ones that could be easily answered by looking up facts but rather required utilizing the mentioned traits. An example of one such question would be the following [13]:

City administrators can encourage energy conservation by
(a) lowering parking fees
(b) building larger parking lots
(c) decreasing the cost of gasoline
(d) lowering the cost of bus and subway fares

In order for the AI to answer this question correctly, it must possess the knowledge that certain stimuli affect humans in a variety of ways e.g. significantly lowering the cost of bus and subway fares will motivate people to use public transportation. The AI should also be to differentiate between the different types of energy i.e. in this context energy refers to resource consumption for the purpose of transportation as opposed to other types of energy that one can come across in a science exam such as thermonuclear energy. [13]

3.1 Allen AI Science Challenge Conclusion

The science challenge was hosted at the Allen Institute for Artificial Intelligence which lasted for four months, from October 2015 to February 2016. Invitations were sent out to researchers worldwide to take part in this challenge. A total of 780 teams participated in the model building phase and 170 of those teams submitted a finished model. In order to test and train the AI systems, participants were given a set of 2,500 training questions. Since the test questions were all four-way multiple choice, a baseline score using random guessing was established at 25%. The institute also created their own baseline score using a Lucene search engine over the Wikipedia corpus which produced an average score of 40.2% on the training set and 40.7% on the final test set. The three winning teams scored very similar results with a spread of only 1.05% where the highest score was 59.31%. Each of their systems consisted of two general categories, the first one consisting of information retrieval features and the second was applying various machine learning algorithms to select the correct answer based on the information retrieved. In conclusion, the Allen AI Science Challenge demonstrated that in order to achieve a high score on a science exam, an AI system requires more than just sophisticated information retrieval. The three winners

said that the current AI systems are unable to go beyond the plain surface text to a deeper understanding of the meaning underlying each question which is vital to achieving scores above 80% and demonstrating what might be considered true artificial intelligence. [13]

4 Autonomous Cars

An autonomous car is a vehicle that is capable of navigating without human input. Autonomous cars use a variety of techniques and hardware to detect their surroundings, such as radar, laser light, GPS, odometry and computer vision. Advanced controls systems then interpret this data to follow the road rules, avoid obstacles and drive to the desired location. Reference [14] states that the idea of autonomous cars has been around for almost a century however the first attempts at truly creating autonomous cars appeared in the 1980s with Carnegie Mellon University's Navlab. A major milestone was reached in 1995 when CMU's Navlab 5 completed the first autonomous long distance drive between Pittsburgh and San Diego. Over the past decade autonomous cars have made a huge leap forward and there is a possibility that autonomous cars will become the norm in the not so distant future [3]. A firm called Waymo has taken over the self-driving car project in 2016 which Google had began in 2009, the firm aims to make autonomous cars available to the public soon. The official Waymo website states that [15]

> Our fleet has self-driven more than 3 million miles, mostly on city streets. It took our team just 7 months to reach our third million miles. By comparison, it took about 6 years to hit our first million. This builds on 1 billion miles we drove in simulation in 2016 alone.

The fact that there hasn't been any major news headlines that involved autonomous cars for those self driven miles except for one minor accident, which resulted in a minor fender-bender is a reassuring thought. Consulting firm McKinsey & Company renowned for conducting qualitative and quantitative analysis estimated that widespread use of autonomous vehicles could [16]

> Eliminate 90% of all auto accidents in the United States, prevent up to US$190 billion in damages and health-costs annually and save thousands of lives.

This is yet another reassuring thought as one of the purposes of autonomous cars is to reduce the amount of road accidents, however there is also a number of reasons as to why autonomous cars may not be such a good idea. The following list briefly outlines several problems associated with autonomous cars:

1) The current autonomous cars have between a 100 to 150 million lines of code and generate up to 4 terabytes of data daily. From a software developer point of view updating the software and pinpointing where an error occurs within those lines of code would require extensive knowledge of the system and even then it is not an easy task as one minor change might have a drastic impact elsewhere in the code that in turn might cause the system to fail leading to injury and/or death.
2) It may be possible to hack the system and do a number of malicious things such as change the destination, stop or crash the vehicle, steal sensitive information that can be used to exploit the driver/owner etc.
3) If autonomous cars reach the point where supervising drivers are no longer required to be in the car, taxi drivers, bus drivers and the like may lose their jobs as the system can preform a much better job that results in less accidents.
4) Who would be blamed if an accident does occur which causes injury or death - the driver, the owner, the company that made the vehicle, or someone else? These types of scenarios are still being discussed and reasonable regulations must be put into place before autonomous cars are available to the public.
5) There are ethical issues that are still to be addressed e.g. in a scenario where a crash is inevitable and two parties are at risk of injury and/or death the system must make the right decision and preform the lesser evil. These ethical issues can be quite debatable and morally challenging but alas are unavoidable.

As of 2017 no autonomous cars are permitted on public roads without a supervising driver that can take control of the vehicle at any time. It will remain like this until issues akin to the ones mentioned above and others are addressed as well as fixing and improving on the current limitations autonomous cars possess such as reduced performance during rain - which is expected to be fixed by 2020. A larger sample size is also required to provide efficient proof to the public that autonomous cars are indeed safer to use over cars operated by humans.

5 Medicine and Healthcare

The application of artificial intelligence in medicine and healthcare has surged over the past two decades and according to CB insights it is the top area of investment in AI. In this field AI systems are primarily used to assist the experts to formulate or confirm a diagnosis, apply the correct therapeutic decisions and predict the patient outcome. These systems acquire, analyze and apply large amounts of data to help solve complex clinical problems, without such systems it could take experts a tremendous amount of time to come up with the proper diagnosis or treatment methods and in the meantime the patient's condition may become worse or even fatal. The Luminata's graph-based analytics and risk prediction system is a perfect example of modern AI systems in medicine, as of 2014 it has [17]

> Ingested more than 160 million data points from textbooks, journal articles, public data sets and other places in order to build graph representations of how illnesses and patients are connected.

Big data can also play a big role in this field, approximately 90% of the world's data has been generated over the past 2 years and it is estimated that the data generated is expected to almost double every 2 years for the next decade, meaning there should be around 44 zettabytes or 44 trillion gigabytes by the year 2020 [18]. Researchers worldwide are constantly looking for ways to use big data and when AI systems improve and start utilizing big data, their enhanced performance and increased accuracy of

outcomes will become even more valuable. Some of the AI systems used in this field include artificial neural networks, fuzzy logic systems, evolutionary computation systems and hybrid intelligent systems. We have briefly outlined ANN however we will not tread in too deep as these systems are somewhat beyond the scope of this paper.

Artificial Neural Networks (ANNs): ANN is the most popular AI technique based on the volume of publication over the past two decades. This type of system is inspired by the biological neural network. ANNs consist of highly interconnected nodes called neurons that are capable of performing parallel computations for data processing and knowledge representation. ANNs progressively learn to preform tasks by examining examples. This technique was originally designed to replicate the human brain in terms of problem solving however over time the attention was shifted to matching specific mental abilities which in turn lead to deviations from biology such as backpropagation [19].

The following list briefly outlines some of the issues associated with using AI systems in this field [20]:

1) It is vital that AI systems are reliable and have consistent accuracy which is why they ingest so much data, but what if the system comes across an anomaly. If the anomaly is not handled properly it could corrupt the system causing it to output less accurate results which in turn put the patient's wellbeing at risk.
2) The educational curriculum for medicine should be adapted in order to demonstrate how these systems function and how to use them. The current curriculum encompasses minimal teaching of technologies that medical practitioners will come across and use.
3) A lot of systems store personal information belonging to patients, there is always a possibility that this information can be leaked thus the cybersecurity should be of high quality.

6 Conclusion

The Turing test was a commendable trial for artificial intelligence at the time despite having flaws, however a true artificial intelligence cannot be based entirely on one test. The Allen AI science challenge demonstrated that in order to achieve a true artificial intelligence the AI systems must possess more human-like attributes than just sophisticated information retrieval capabilities. It is of utmost certainty that AI systems have improved greatly over the past decade showing no motive of progress slowing down in the years to come. The benefits of AI systems are already extensively visible in various fields especially medicine and healthcare. However regulations, ethics and fear of being replaced by AI systems at work may eventually lead to retaliation which can hinder the development of AI systems.

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