Artificial Intelligence and Robotics

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Review article for CS275 2015

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A review article was submitted in partial fulfillment of the requirements for the continuous assessment of the Directed Reading in CSSE module CS275 on the B.Sc. Computer Science and Software Engineering

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Declaration

I hereby certify that this material, which I now submit for assessment on the program of study as part of the continuous assessment for module CS275, is *entirely* my own work and has not been taken from the work of others - save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: Godstime Osarobo Date: 14th November 2015

Acknowledgements

I would like to thank Mr. Joe Duffin for all his help throughout this module. Without his teaching and guidance this module would have been more difficult.

Abstract

This review article will cover Artificial Intelligence and Robotics. It will analyze the definition and history of AI and Robotics. The AI and Robotics industry have greatly benefited from each other. For this reason, this review article will also explain why AI and Robotics synergize well with each other by using Robot Soccer and Google's Driverless Car as examples. As more robots are being made there is more and more tension on what the fields of AI and Robotics have in store for the world. Many challenges such as the fear of AI, social awareness and affective interaction face the AI and Robotics Industry. In order to overcome these challenges, more research must be done. As computers get more powerful more progress and breakthroughs will be made in the Artificial Intelligence and Robotics industry.

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Introduction

This article will focus on the area of Artificial Intelligence in Robotics. Throughout the review this article will examine what exactly AI is and how and why it is being applied in particular to the field of Robotics. It will discuss what it has done and what it is still doing. It will do this by discovering and looking at real life examples of Artificial Intelligence in Robotics. It will also do this by looking at the amazing progress and impact Artificial Intelligence has had on Robotics in recent times and at present. According to MIT Technology Review, "*Huge progress has been made in AI over the past few years, due to the development of very large and sophisticated "deep learning" neural networks that learn by feeding on large amounts of data, and this trend continued in 2015.*" (Knight, 2015) This article will vividly illustrate how Artificial Intelligence and Robotics are easing the lives of many people and will continue to do so. It will do this by presenting examples of projects such as Robot Soccer, Ubirobots and self-driving car's which Google have worked on and are still working, and what things current scientists in the field plan, for the future of Robotics and AI.

This review will chart the progress of Artificial Intelligence in Robotics and it will also cover the ethics behind Robotics and Artificial Intelligence. It will try to help us understand what exactly is acceptable, what is unacceptable and where to draw the line when it comes to creating such things. Will Robotics and AI ever completely dominate humanity? According to the New York Times "*concern is that further advances*

could create profound social disruptions and even have dangerous consequences. " (Markoff, 2009) Many things have emerged from Artificial Intelligence in Robotics. Nevertheless there are still plenty of things, both good and bad, to emerge from AI in the near future.

ScienceDirect, IEEEXplore, Google Scholar and Google Search were used to find the resources for this article, using the search terms 'Robotics' and 'Artificial Intelligence'.

What is Artificial Intelligence?

"*Artificial Intelligence (AI) is usually defined as the science of making computers do things that require intelligence when done by humans.*"(Copeland, 2000) Artificial Intelligence enables the computer to sense its environment in different ways e.g. visual, tactile, perception, and speech recognition.

But to truly understand what Artificial Intelligence is we must first understand what natural intelligence is and how it works. After studying the natural habits of some insects and animals, researchers discovered that human intelligence does not consist of a single ability or cognitive process but rather a group of separate components. For this reason, "*Research in AI has focussed chiefly on the following components of intelligence: learning, reasoning, problem-solving, perception, and language-understanding.*" (Copeland, 2000)

Learning

From the component of learning, researchers decided to create programs that can utilise the trial and error method. Which is known to be a method that many if not all species utilise.

Reasoning

From the component of reasoning, researchers were able to make a computer to draw inferences. However, just because a computer can draw inferences does not mean it can therefore reason. A computer has to be able to draw inferences related to the task at hand. In fact it has been said that "*One of the hardest problems confronting AI is that of giving computers the ability to distinguish the relevant from the irrelevant."* (Copeland, 2000)

Problem-Solving

From the component of problem-solving, researchers were able to discover that problem-solving methods split into two categories which are, special purpose and general purpose. *"A special-purpose method is tailor-made for a particular problem and often exploits very specific features of the situation in which the problem is embedded. In contrast, a general-purpose method is applicable to a wide variety of problems.*" (Copeland, 2014) Other than that, the robot would be made to solve problems from a list of basic functions given to it.

Perception

From the component of perception, researchers were able to make robots sense the environment using cameras and microphones. This is similar to the way in which we use our eyes and ears to sense the environment. For example we use our eyes to watch movies and our ears to hear the movie.

Language-Understanding

From the component of perception, researchers were able to make speech recognition programs to interpret what people say. This was done through the understanding that, "*A language is a system of signs having meaning by convention. Traffic signs, for example, form a mini-language, it being a matter of convention that, for example, the hazard-ahead sign means hazard ahead.*" (Copeland, 2000)

The history of Artificial Intelligence

The earliest research in thinking machines was inspired by a group if ideas that became popular in the late 30s, 40s and early 50s. At the time, research in neurology showed that the brain was an electrical network of neurons that sent out pulses. Norbert Wiener's cybernetics described control and stability in electrical networks. (Wiener, 1948) Claude Shannon's information theory described digital signals. (Shannon, 2001) These two ideas in addition to Alan Turing's theory of computation (Turing, 1936), which showed that any form of computation could be described digitally, lead to the suggestion that it might be possible to create an electronic brain.

Alan Turing was known for his theory on whether it was possible for machines to have intelligence. One of his famous phrases which is "*"Can machines think?" This should begin with definitions of the meaning of the terms 'machine' and 'think'* " (Turing, 1950) led to what we know as the Turing Test or as he liked to call it The Imitation Game. The Turing Test was a test created by Alan Turing in 1950 to see if there is intelligence in a robot. For a robot to pass the Turing Test it would have to make the judge unable to distinguish the difference between it and a human. Despite the failure of many computers in passing the Turing Test, many computer scientists progressed on in the hope that Turing's future 'imaginable machine' would be created.

In 1956, the Dartmouth Conference was organized by Marvin Minsky, John McCarthy, Claude Shannon and Nathan Rochester of IBM. It was here that John McCarthy coined the term “Artificial Intelligence”. As a result of this conference Artificial Intelligence was an actual field in universities.

After the Dartmouth Conference, Artificial Intelligence entered into a golden era. This era lasted from 1956 to 1974. During this time government agencies such as ARPA provided substantial amount of funding into research on Artificial Intelligence. Many successful programs were created during the time period. These included ‘searching programs’ which consisted of problem solving in algebra and geometry and ‘natural language programs’ which consisted of programs that could communicate with humans in languages such as English and solve algebra word problems.

In 1974 the first Artificial Intelligence Winter occurred. The extreme optimism raised expectations extremely high and many promises failed. As a result of this, funding for research ended. The problem was due to limited computer power, common sense knowledge and reasoning, and Moravecs Paradox. Moravecs Paradox talks about how computers can easily prove theorems and solve geometry problems but have a hard time crossing a room without bumping into anything. It is for this reason that research in Computer vision and Robotics, made little progress back then. Computers back then were simply not powerful as they did not have memory to store all the information needed. Many important artificial intelligence applications like vision or natural language require enormous amounts of information about the world. For example, the program needs to have some idea of what it might be looking at or what it is talking about. This requires that the program know most of the same things about the world that a child does. Simple tasks such as recognising a face or crossing a room without bumping into anything was an extremely difficult task for computers

to do. For these reasons many companies became frustrated because of the lack of progress and stopped all funding to Artificial Intelligence.

In 1980 there was a boom for Artificial Intelligence as a result to the Japanese government funding Artificial Intelligence research because of a form of AI programs called "expert systems" which were adopted by many companies. They also answered and solved many problems using logic rules, which were as a result of these systems being loaded with the knowledge of real life experts.

Now Artificial Intelligence has achieved many goals. It has also been used successfully in the technology industry due to the increase in computer power. Some of these achievements came from Robot Soccer. "*Kim and Kim proposed a navigation method for the autonomous mobile robot using limit cycle characteristics. Springer et al. presented strategic collision avoidance in the robot soccer competition. Jeong and Lee described an approach based on genetic algorithm for designing MAS.*" (Jolly, Ravindran, Vijayakumar, & Sreerama Kumar, 2007)

What is Robotics?

Robotics is the area of technology that deals with the design, operation and application of robots. "*Robotics is a very young field, which is interdisciplinary due to its nature of developing and building systems that, following its science fiction roots that preceded the real technology, combine electrical and mechanical body components with computer brains.*" (Birk, 2011)

There are many different types of robots and they are all used in different environments for different reasons. Although there are so many different robots, they all share three basic similarities. They all have some form or shape, electrical components which power and control the machinery, and some level of computer programming code.

Discussion

Why do Artificial Intelligence and Robotics work well together?

Artificial Intelligence and Robotics work so well together because together they allow robots to accomplish so many things. Artificial Intelligence in robots allows us to automate all the menial jobs in life. Many amazing projects have and are still in progress concerning the combination AI and Robotics.

Google Driverless Car

Google's Self-Driving Car is one great example of what happens when you combine Artificial Intelligence with Robotics. The driverless car uses many sensors to navigate its way on the roads. According to Google "*...the "heart of our system" is a laser range finder mounted on the roof of the car. The device, a Velodyne 64-beam laser, generates a detailed 3D map of the environment. The car then combines the laser measurements with high-resolution maps of the world, producing different types of data models that allow it to drive itself while avoiding obstacles and respecting traffic laws.*" (Guizzo, 2011)

Robot Soccer

Another great example of Artificial Intelligence and Robotics working well together is in Robot Soccer. Robot soccer provides a dynamic environment with a very random outcome, making AI play a very important role. For this reason it has become "*an active field of research in the area of intelligent multi-agent systems (MAS).*" (Jolly et al., 2007) Artificial Intelligence works so well in Robot Soccer because "*the major concern in robot soccer is the planning and execution of game strategy and the related issues like cooperation, coordination, learning, sensing, communication, decision making, path planning and control.*"(Jolly et al., 2007) Artificial Intelligence is so important in making robots for Robot Soccer because communication is so important. According to (Maravall, de Lope, &

Domínguez, 2013) "*obtaining a common lexicon or vocabulary is a basic step towards an efficient performance of the whole system*" in multi-robot system. Robot Soccer has been such a success that competitions have been made in support of it. According to RoboCup@Home, RoboCup is the "*largest worldwide competition for domestic service robots*"(Iocchi, Holz, Ruiz-del-Solar, Sugiura, & van der Zant, 2015) RoboCup Soccer began in 1996 and has held with official games since 1997.

RoboCup has become so popular because first of all soccer is a popular sport worldwide so soccer competitions get a lot of attention from spectators since a lot of people enjoy watching soccer matches. Secondly, playing soccer with robots is a huge challenge on the field of software, which is where AI plays a part in. RoboCup has even made competitions to try and involve the younger generation. "*RoboCupJunior is an international educational robotics initiative, aiming to promote STEM content and skill learning among participating youth through educational robotics competition inaugurated in 2000. What makes RoboCupJunior quite unique is its relationship with RoboCup which aims to promote robotics and AI research, by offering a publicly appealing, but formidable challenge including development of soccer robots, search and rescue robots, and robots functions at home and at work.*"(Eguchi, 2015)

Future Development

The future of Artificial Intelligence and Robotics depends on whether the public accepts it in normal life and whether researchers will be able to overcome the current challenges in AI.

The Fear of AI

It is no secret that many people are afraid of the progress of Artificial Intelligence and Robotics. As robots become more intelligent and popular in the lives of humans, they become

increasingly involved in everyday tasks known to be done by the humans. *"Humans should expect that robots will take on tasks to simplify our lives, by working with humans just as other humans do, in normal societies or organizations.*"(Chibani et al., 2013) Ever since movies such as 'Terminator' and 'A Space Odyssey' were released, the public have had their suspicions on the progress of robots in the future. According to review "*Why is AI so scary?*" "*It is doubtless the case that the many "AI takes over the world" stories have something to do with it, but I'd like instead to consider two possibilities less often explored. Remember that there are actually three things in play here: the technology, its designers, and the public. If there is nothing uniquely dangerous about the technology itself, then maybe there is something about AI scientists, or about the public, that can make it seem, or perhaps actually render it so.*" In the case of where AI scientists are the problem, ethics is the key thing that needs to be applied. Ethics is the correct rules of conduct necessary when carrying out research.

Challenges faced in AI and Robotics

Ubiquitous robots also known as Ubirobots are a branch of robots that use AI and Robotics to "*overcome the limitations of stand-alone robots by integrating them with web services and ambient intelligence.*" (Chibani et al., 2013) There are three main challenges in Ubirobotics.

> "*The first one aims at making Ubirobots more autonomic by endowing the robots with the following fundamental features: context and activity recognition, context and intention awareness, semantic reasoning, multi agent coordination and organizations, and autonomic (self-*) properties. The second one regards social awareness and affective interaction.*"
>
> "*The last topic concerns the Ubirobots' engineering, in particular, the following issues: (i) the design of new*

> *engineering tools and middleware to create Ubirobot services as plug and play applications; (ii) interoperability among robots and smart devices, i.e., going beyond remote control, voice and web services, abstracting the robotic functionalities and providing means for utilizing them; (iii) extending Ubirobots' sensors and actuators through the network; (iv) how Ubirobots will get their intelligence from the cloud.*" (Chibani et al., 2013)

The challenges faced in these robots, are not only challenges in this branch of robotics but are also challenges in other branches such as Robot Soccer, which was aforementioned. These challenges will help drive computing and robotics in the next decade and beyond.

Cloud robotics, another area of robotics, also have challenges which include communication, computation and security. The challenges faced in these robots, are not only challenges in this branch of robotics but are also challenges in other branches such as ubiquitous robotics as stated above. These challenges will help drive computing and robotics in the next decade and beyond.

Conclusion

In conclusion, this article illustrates that Artificial Intelligence and Robotics have progressed so far and still have yet so far to go. Despite the challenges in the past, AI and Robotics have managed to prove themselves to be very important fields in Computer Science. Examples of these can be seen in the Robot Soccer competitions and in the Ubirobots which can be used to help elderly people and people with disabilities. It is clear that these fields in

Computer Science have plenty of potential to do more and most likely will be a major factor in the technology of the future.

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