Are you worried that by the time you graduate with a computer science degree, your potential jobs might all have been automated by todays computer scientists?

The cerebral cortex is a superhighway of information with each lobe analogous to processing cores, networked to produce the highest functions of the nervous system in the form of cognition, emotion and consciousness [1]. This ease of analogy shows the inevitable link between the human brain and computation as we seek to replicate and perfect our own problem-solving mechanisms. It is then, no wonder that research into artificial intelligence has multiplied in previous years, thus changing the landscape of computer science forever. However, questions still remain around the viability of artificial intelligence and its ability to replace human cognition. In the light of this, I will focus my efforts initially on a definition of automation that centres around artificial intelligence, and the potential future of self-sufficient, self-aware and creative processes within computers.

To answer the question of whether the computer scientist graduate will one day be obsolete, we must first turn our minds to the qualities and need for the discipline. Computer Science is inherently mathematical, with the first computer science department being founded as a mathematical laboratory for work on mechanical calculators and analogue computers, which in application aided those working on scientific research [2]. From this starting point we can view the discipline as an aid to human-centric problem solving, as data is used to aid human ideas. This shows how the direction of computer science evolves with the society it serves and relies on a ‘cause’. Therefore, we must look deeper into how automation would replace the driving forces of human creativity, inspiration and emotion to create ‘cause’ to assess if the computer scientist could one day be replaced. I argue that, due to the fundamental disparity of technological equivalents to these ‘causes’, the computer science graduate has nothing to worry about in regard to automation.

The Mathematics of Creativity

The more mathematics we understand the more closely it can be linked to the art and culture that dominates our society. An example of this is the Fibonacci sequence, made up of a sequence of numbers $\{F_n\}^{\infty}_{n=1}$ that is defined by the linear recurrence equation $F_n = F_{n-1} + F_{n-2}$ [3]. Despite its simplicity this equation underpins some of the most recognisable shapes in nature, more importantly some of the greatest feats of human achievement such as the Great Pyramid at Giza (through the connection of Fibonacci and The Golden Ratio [5]) [4]. Nevertheless, its connection to artificial intelligence exists in the broader considerations of mathematics in creativity. The Fibonacci sequence can show how we apply mathematics onto creativity but also how the obverse of this application is not true.

In 2018 the piece ‘Edmond De Belamy’ was the first piece of art created by artificial intelligence to be sold. It was made by the art collective Obvious. Their goal of exploring the notion of creativity in a machine, exploits its greatest weakness of data inputs and stimulus. The process uses two competing algorithms, one in a form of generation and another in the form of validation. It works to create an image using a large number of input images with common visuals to create a new sample which shares these features. If the second algorithm is ‘fooled’ into believing the image is a real painting not created by the machine, then it achieves its goal of creating an independently recognisable piece of artwork [6][7]. Whilst the process of creating the image can be likened to that of human creativity, in which inputs help to define what art is to the artist, the discrete parameters of the input data set is incomparable to that of human experience. The brain receives thousands of hours of constant and unique input in a variety of forms such as audio or visual, and these experiences serve to form our creativity. Artificial intelligence creates based on a data set created by humans for a specific purpose and therefore can only create within the realms of what has gone before. This creates a limit on the creativity of artificial intelligence and ultimately the worth of the artwork must be ascertained by people. Limited creativity is not creativity at all. I argue that the idea that computers have the scope to take in the same input as humans is a mirage.

The process of creating art can be set akin to the creative process within computer science. Our need to solve problems comes from our experience and outlook on society. Artificial intelligence cannot feel the world as we do. It can be used as a powerful tool to give solutions to fragments of problems that humans pose, but its reliance on input means that it will never operate with the authenticity needed to create genuine advancement within computer science.

The Notion of Inspiration

To understand creativity, we first need a fundamental understanding of inspiration. Inspiration denotes how we take seemingly unlinked ideas and connect them to our vision of application. It can be seen that in our brains that when we feel subjective inspiration more blood flows to part of the brain that senses intuition and 'gut feeling'. The very notion of inspiration ignites the elements of our bodies that sustain our biological survival [8].

Therefore, it can be seen how the binary of computer systems cannot compete with the concepts of evolutionary survival that exists on the spectrum and rewards our motivation and achievement. It is not that a computer could not source a form of stimulus from the world, only that the irrationality and unplanned genius of the brain often comes from the very concept of mortality. In comparison, much like the fundamentals of binary encoding an artificially intelligent machine, its mortality is also decidedly switched on and off by humans. Machines cannot experience the higher concepts of death and mortality but instead relate to an exponential loss of power or functionality only superficially comparable to human experience.

The Illusion of Intelligence

The Chinese Room Argument reasoned by the philosopher John Searle is a thought experiment which shows the disparity between assumed understanding and real understanding in computers. The experiment provides us with a perspective of a computer's perception of human nuances such as mortality and language. The basis of the experiment is formed around a machine that has the ability to create seemingly Chinese characters that are good enough to fool the person running the experiment. It allows us to draw the conclusion that computers create their outputs on syntax and not on the semantics of the world around them [9]. If we apply this to the creation of artwork in artificial intelligence, we can see how the computer can only use a syntax-based approach to approve the artwork for production. It does not, however, have the ability to contextualise its message within the semantics of the situation.

The experiment also throws controversy on the famous 'Turing Test'. The 'Turing Test' proposed by Alan Turing has one fundamental flaw: it relies on a computer passing as a human. It is important to note that under Turing's definition of artificial intelligence the superficial factors of intelligence are valued more highly than accurate imitation of the human brain. Since then, the 'Turing Test 2.0' has been proposed with visual challenges to assess intelligence [10]. However, these tests still deny that the fundamental factors of intelligence are deeply connected to the human condition and not the impressiveness of appearance.

Instead I believe that a level of creativity and development independent of human interference must be achieved in order for a computer to be truly artificially intelligent. Therefore, I propose that the job of a potential computer science graduate is not at risk of automation until sufficient advances in the realm of our understanding and replication of the brain are attained, as the gap between true artificial intelligence and human intelligence is far from being breached.

The Rate of Technological Advance

The question posed allows a time frame to be extrapolated. I will have completed a computer science degree within the next 5 years (2019 – 2024). This provides an important time frame to be conscious of when looking at development and research into computers that could one day replace the problem solving and creative abilities of a computer scientist. For the sake of consistent reasoning it is important to note that in this part of the investigation it must be assumed that true artificial intelligence is an achievable aim (despite my contrary position on the matter).

A note on Moore's law is fitting when considering the rate of technological advance. In simple terms overall processing power for computers (in the form of the number of transistors on a chip) will double every two years according to Gordon Moore [11]. Despite this the exponential rate of growth predicted could soon reflect a pattern of natural growth, as the economic and social time frames demanded could soon show Moore's law to be unrealistic. Without the implication of Moore's law, it is still technologically possible to create the artificial intelligence that could lead to the replacement of the computer scientist. However, the size of these machines would be enormous and their practical and portable applications, non-existent. This would mean that despite the technology hypothetically existing it could be redundant without the physical hardware advances that are crucial to widespread technological use. The smartphone revolution creates a powerful example of the technologies that users value, as portability and price often outrank speed and storage.

Consequently, if we are to follow a line of reasoning similar to that of the mobile phone, the answer to how automation will affect the world of computer science could lie in cloud computing. From this point on I will dismiss the concept of the total redundancy of the computer scientist. In favour I will instead explore how the job market and the process of industry-based computer science could change and address the realistic concerns that could arise in the next 5 years.

Automation as a service

Software as a service is a section of cloud computing that allows software and computer functionality to be accessed over the internet. It allows for a lower hardware capability for the local user as they can access the functionality through 'the cloud' on remote servers [12]. It has many benefits for cost and productivity, but it also solves the issues surrounding the infrastructure needed for the heavy processing of automation. The future of all of our services lies in the networks that govern our connectivity. Currently, the emergence of new technologies can only make cloud computing more engrained in our society as network capabilities such as 5G are set to revolutionise our social and economic habitats [13]. Therefore, in lack of a replacement of the computer scientist one must instead focus on their displacement within the changing eco-system of the industry as automated services are now becoming more widely accessible.

The Next Generation of Programming Languages

Programming has long been recognised as a key connotation of computer science and is often a learner's first venture into understanding the discipline. Presently most programming takes place within a third-generation high level programming language (Python, Java, C#, etc.) meaning the code produced resembles human language and uses syntax structures like those of learning a modern foreign language. Now we are on the precipice of a fourth generation which are known as domain specific. Although this definition is still in its infancy, languages such as SQL and HTML should be pointed to as the building blocks for the next generation [14]. These languages are task specific meaning that in the future new languages will govern more niche areas much like how SQL governs database requests.

To develop this idea further we can look at how automation would benefit these languages. As has been previously explored artificial intelligence within automation is seen to work best when it is given a narrow and specific task. IBM's open-domain question-answering system Watson, won the game show 'Jeopardy!' (2011). This provides evidence of how a large data set can create the best answers to completing an expected yet open ended problem. Watson works iteratively to produce the most probable answer for success after analysing and verifying its interpretation of the question. At the same time the second and third choices of Watson can be accessed meaning Watson might have found the answer even if it has not been outputted [15][16]. If this level of task specific automation could be applied to disciplines such as application development, it could wipe out a cohort of developers who are no longer necessary as examples of the functionality they wish to create can be sampled and produced much faster through an automated machine. Natural language processing [17] could then be applied to mean these specific tasks could be interpreted more broadly interpreted by the computer (such as Watson does) to produce a plethora of outcomes thus creating a second layer of automation and further displacing the need for a computer scientist within the process.

This could lead to these programming areas becoming less fundamental to computer science as this could easily be rendered as a cloud computing service and made widely accessible. We can see this as indicative to the shifts that automation will create within industry. However, shifting does not mean that there will be no industry left, just that it will have a different focus as there must be people to develop and sustain these new technologies.

Developments in programming languages is just one way that automation could develop computer science, and it gives an indicator of how we should be teaching the subject. A person trained only to program in one language epitomises why education should be centred around skills and not software. If one chooses a software specific degree, then it is clear how with the rapid pace of new technologies they should be worried about automation within computer science. On the other hand, if one chooses a degree base in skills then the fundamental aspects of computer science such as creativity, problem solving, and logical thinking will provide a tool kit with which one can evolve with the industry of computer science.

Conclusion

The field of computer science continues to be one of the most exciting disciplines across academic and industry work. Scholarship on computer science is prone to assuming an end point only to make subsequent discoveries that challenge a previously assumed boundary. This assumption that no more progress can be made is simply not the case. Technology's inability to fully emulate human intelligence is reassuring for computer science graduates, it means that they will have to adapt their skills rather than find them redundant. Computer science serves our society's need for connection through creative problem solving, and those skills gained through a computer science degree will therefore always be in high demand.

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