The development of artificial intelligence in relation to Quantum computing, with a focus on real-world implementation and ethics.

Striving for greatness and overwhelming curiosity are intrinsically human attributes, which have catalysed the development of technology and the perception of abstract physics concepts over the years. An AI system is often regarded as the pinnacle of all technology [1]; in fact, I.J. Good, who was a famous statistician in Alan Turing's code breaking team, once referred to AI as "the last invention that man need ever make". There is an inseparable connection between AI systems and quantum computers, due to the vast processing power required to implement such a system.

Scientific Process:

There are a number of different methods that can be used to produce an ultra-intelligent sentient machine, and most scientists switch between these models consistently. There are a number of different methods that can be used to produce an ultra-intelligent sentient machine, and most scientists switch between these models consistently.

An organic neuromorphic approach can be used to replicate artificial intelligence. Neural networks could be used in order to produce AGI seeing as they could learn from experience and use graceful degradation, where a small amount of damage to a neural network causes a small degradation in its performance rather than a total crash [11]. These networks could find hidden statistical patterns in the input making them very proficient when working with larger data stores. The development of the Backpropagation algorithm is a pivotal part of the organic approach to AGI, as it allows for the training of multi-layered neural networks, with multiple hidden intermediate layers of neurons between input and output layers enabling for machines to be developed based on neural maps and networks. A limitation to this method is that the 'computational resources required to simply replicate the relevant evolutionary processes on Earth that produced human-level intelligence are severely out of reach – and will remain so even if Moore's law were to continue' [direct quote from [12]] e.g. it takes approximately 1000 floating point operations per second to stimulate one neuron in simple neuron models.

A possible neuromorphic path to AGI is via the use of whole-brain emulation, which involves the scanning and modelling of the brain to produce a computational structure of the biological brain. In order to emulate the brain, a detailed scan of the brain needs to be produced. This can be completed by using vitrification techniques to dissect the brain into thin slices that can be scanned via microscopes and processed in parallel using multiple scanning machines to produce multiple brain slices simultaneously. The data from the scans will have to be analysed via image processing in order for the 3D neuronal network reconstruction, which can be combined with computer libraries of neuro-computational models in order to produce a neuro-computational structure of the brain. This structure can be implemented on a powerful computer to produce a 'digital reproduction of the original intellect, with memory and personality intact' [11]. This is an example of the 'mind uploading' idea that is commonly presented in sci-fi films and works.

The idea of 'whole brain emulation' will require a huge advancement in technology in order to implement it; for example, scanning techniques using high-resolution and

high throughput microscopy, translation techniques using automated image analysis turning raw scanning data into interpreted 3D models and simulation techniques need to be developed before this technique is possible. The requisite enabling technology will take a very long time to be developed, however this method is a lot simpler than other methods as it doesn't require understanding of human cognition or the theory of AI programming – it only requires the understanding of low-level functional characteristics of the basic computational elements of the brain [11].

Another method of achieving AGI is through the enhancement of human beings collective intelligence. This can be achieved by reducing communication overheads making it easier for new ideas to be spread or by improving the world economy and reducing poverty allowing for more people to have access to education. Additionally brain-computer interface (Cyborg Effect) [11] implants can be used to allow humans to exploit the advantages of digital computing (eidetic memory, and fast and accurate arithmetic) increasing the general intelligence of human beings, which will put human beings in a better mind frame to produce AGI. Such a technology will revolutionise education seeing as connections can be established between two brains enabling concepts, ideas and memories to be downloaded. The problem with this type of technology is that infections, haemorrhage and cognitive decline are all serious medical issues that can arise from inserting electrodes into a person's brain, and this problem hasn't been addressed [11].

A physical approach can be used to replicate artificial intelligence using enormous processing power. A quantum computer was initially hypothesised by Richard Feynman, by using the superposition of particles (in Quantum mechanics) allowing for a qubit to be both 0 and 1 or 0 or 1. The two states 0 and1 are examples of binary digits, and a qubit can exponentially increase the number of calculations possible producing an incredibly powerful supercomputer [3]. The idea of quantum computing can be used to easily implement recursive learning and decision algorithms allowing for an AI system, which is continually learning and absorbing knowledge at an exceptional rate, to be produced.

Both methods (synthetic and neuromorphic) have palpable limitation. An organic approach is limited by the lack of understanding of the brain and neural networks [4]. Although neuroscience has progressed very quickly in the last century, scientists are still not able to fundamentally understand the brain and why it is able to produce human intelligence; for example, in 1970 the idea of using networks and circuits to simulate intelligent behaviour (connectionism) was abandoned due to a lack of progress and this was a pivotal factor leading to the major AI winter of 1974 -80 [5]. Additionally some of the technology required to make neuromorphic methods to develop AGI hasn't been developed delaying the possibility of developing AGI through organic processes into the distant future. The synthetic GOFAI system is criticised due to the lack of evidence that symbols are the atomic unit of cognition [14] in the brain and also due to the fact that it is very easy to stimulate a combinatorial explosion through the use of this system. By contrast, neuromorphic approaches are considered by critics to offer a 'much closer model of human intelligence by using the artificial neuron as its atomic unit' [direct quote from [13]]. Also the physical approach stated above is limited due to cost and the problem of creating a quantum computer, which has arisen from the inability to create the conditions needed in order to produce such a system. The main reason as to why a quantum computer hasn't

been built is due to the difficulty in creating stable qubits; one of the closest attempts was led by a Yale research team, which managed to produce 3 solid state qubits [6].

The ethics of AI

When Isaac Asimov devised the 3 laws of robotics [7], it got the world thinking about the future of machines and artificial intelligence. A topic that usually accompanies AI is the ethics of AI; many ethical conundrums and questions have arisen following the introduction of the concept of artificial intelligence.

The problems with creating a sentient AI machine have been reflected in many of the popular post-apocalyptic films, most notably SkyNet in the Terminator films. The most prominent problem would be the possibility of this system deciding that the world would be better off without human beings present, resulting in the wiping out of the whole entire human race. The theory of super intelligence states that a self-aware intelligent system will be able to truly understand their technological make-up resulting in the creation of other even more superior AI systems [8]. Using tools such as the internet, such a system will be able to learn at an incredibly rate and it can spread to any computer connected to the internet. Such a computer system will be a formidable enemy to human beings. Although some argue that human beings can program the system to be more caring or even submissive to human beings (a system that obeys Asimov's rules), however any truly sentient AI system will not be bound by such restrictions. Notable computing professionals consider AI to be a threat to human beings; for example, Bill Gates considers himself to be "in the camp that is concerned about super intelligence" [10].

The singularity paradox according to Roman V Yampolsky [2] can be "described as follows: Super-intelligent machines are feared to be too dumb to possess common sense". This can be illustrated through a request such "make all people happy". A super-intelligent machine can respond by killing all people, seeing as with 0 people, all of them are happy. The main focus for such a machine is to produce a solution to the problem that is efficient as possible, and may not take human beings wellbeing into consideration. In order to overcome the singularity paradox, the computer scientist proposed the creation of a "big brother AI" monitoring system with the purpose of observing the world and ensuring that no technology is created capable of posing a risk to humanity [2]. Another solution to the paradox would be to use AI boxing to restrict the AI software into a single machine so it won't be able to have any effect on the outside world. Some scientist, most notably Vernor Vinge, argues against such a method of confinement suggesting that a confined AI "could come with helpful advice that would incidentally set it free".

Another ethical conundrum involved with these AI systems, concerns their ability to resist manipulation. If an experienced hacker were able to control and manipulate these powerful systems, they will be able to inflict a lot of damage as illustrated in the paragraph above. The AI systems will have to be able to be protected against cybercriminals using some form of security mechanism [8]. However this is a 'double-edged sword', in the sense that it will prevent governments or scientists to actually control these systems in the event that they start to rebel. Furthermore, in the event that AI systems fail, who would take responsibility for the failure? The system

produced is not human so do you blame the person who built the system or the system itself?

The creation of true artificial intelligence could possibly be the most significant achievement ever in scientific history. It will lead to the creation of very many other systems that will be pivotal in the growth and development of human beings. Having said this, there are some dangers to such a system, which simply cannot be ignored. I think that the production of a sentient AI system could prove to be catastrophic and that the benefits do not outweigh the risks. The coming of AI is inevitable, with some surveys (from PT-AI, AGI, EETN, and TOP100) suggesting that there is 50% chance of artificial general intelligence being attained in 2040. Although the future of AI seems bleak, with the creation of secure restrictive measures it should be possible to contain AGI allowing for it to be utilised in a way that benefits human beings.

References:

1. Kurzweil R (2006), The Singularity Is Near, Gerald Duckworth & Co Ltd
2. Yampolskiy R (2015). Artificial superintelligence, Chapman and Hall/CRC.
3. Anthony A, Has the age of quantum computing arrived? [online] Last accessed: 22 June 2015. URL: https://www.theguardian.com/technology/2016/may/22/age-of-quantum-computing-d-wave
4. Will the intelligence of a biological computer be artificial or organic intelligence? [online] Last accessed: 7 July 2016. URL: https://www.researchgate.net/post/Will_the_intelligence_of_a_biological_computer_be_artificial_or_organic_intelligence2
5. AI Expert Newsletter-Winter [online] Last accessed: 7 July 2016. URL: http://www.ainewsletter.com/newsletters/aix_0501.htm#w
6. Simonite, T, Google's Quantum Dream Machine [online] Last accessed: 7 July 2016. URL: https://www.technologyreview.com/s/544421/googles-quantum-dream-machine/
7. I, Robot (2013), Isaac Asimov, Harper Voyager; 01 edition
8. Bostrom N, Yudkowsky E (2011), 'The ethics of Artificial Intelligence', pp 1 – 20
9. Hammond, K, Ethics and Artificial Intelligence: The Moral Compass of a Machine [online], Last accessed: 7 July 2016. URL: http://www.recode.net/2016/4/13/11644890/ethics-and-artificial-intelligence-the-moral-compass-of-a-machine
10. Rawlinson K, Microsoft's Bill Gates insists AI is a threat [online], Last accessed: 7 July 2016. URL: http://www.bbc.co.uk/news/31047780
11. Bostrom N (2014) ,Superintelligence: Paths, Dangers, Strategies, OUP Oxford
12. Watkins T, 'The Fifth Generation Project In Japan' [online], Last accessed: 7 July 2016 URL: http://www.sjsu.edu/faculty/watkins/5thgen.htm
13. GOFAI [online], Last accessed 7 July 2016, URL: https://www.cs.swarthmore.edu/~eroberts/cs91/projects/ethics-of-ai/sec3_1.html
14. 'IBM unveils plans for Watson supercomputer' [online], Last accessed: 7 July 2016, http://money.cnn.com/2014/01/09/technology/enterprise/ibm-watson/