“In the future, could A.I. replace human scientists and why?" (Feature article)

Why artificial intelligence is destined to change the soul of science

The point at which artificial intelligence overtakes that of humans is often called “the singularity”. This is when A.I. is able to replace humans completely and outperform us in all activities, and seems to be drawing ever nearer. The media speculates continuously: predictions range from less than two decades in the future to sometime in the 22nd century.

A.I. is playing an ever greater role in our lives, outperforming humans in a myriad of tasks. From manufacturing to finance, it is transforming industries and replacing workers. A.I. can even write jokes that are indistinguishable from human ones. Because of this, a growing fear is that we are moving towards a future where two fundamental scenarios may happen: A future where humans are made completely redundant, or one where humans merge with A.I. to create a new species, from which a new breed of scientist might emerge. In either scenario, today’s scientists will be replaced.

When I first encountered this question, I tried to convince myself that human scientists, let alone the whole of the human race, could never be replaced. I naively hoped, as I guess a part of me still does, that we would never reach the singularity, that humans are too unique, too necessary. As I delved deeper into the issue, the inevitability of a future that will fundamentally break with the past 10,000 years of cultural evolution started to dawn on me.

Why a machine can be the perfect scientist

In order for human scientists to be replaced, A.I. must be able to carry out the three main operations of a scientist: 1) Forming hypotheses, 2) Designing efficient experiments that can falsify the hypothesis, and 3) Carrying out the experiments and analysing the results.

A.I. already plays a part in conducting experiments, saving time and resources. From carrying out mundane tasks like pipetting liquids, to more complicated processes, such as making polypeptides, A.I. is already replacing the practical side of scientific research.

The second operation, of designing experiments, can ultimately be done with a set of appropriate algorithms and selection of required know-how and methodology from existing published work. So this too can be quite easily taken over by technology.

However, formulating a relevant hypothesis is a more difficult task that can be approached in two ways. The first is to use existing science and define where there are gaps in our understanding and knowledge. For example, by finding proteins whose 3D structure has not yet been solved, but where comparisons with similar proteins may generate ideas with respect to the structure and functional components. The second way is to *creatively* generate a hypothesis or an idea. Creativity is based on many inputs fusing together, from which a hypothesis emerges. Human scientists’ emergent ideas are generated from a vast collective of different aspects of the human psyche, including memories, existing knowledge, collective problem-solving, memes, instincts, thoughts, feelings, logic, personal experience and even dreams, something Dmitri Mendeleev, the scientist responsible for the creation of the Periodic Table himself experienced. “In a dream I saw a table where all the elements fell into

place as required. Awakening, I immediately wrote it down on a piece of paper." The input parameters for these ideas are complex and so a complex being is required to create them.

Complex problems need a complex problem solver

It is important to draw a distinction between complex and complicated systems. Complicated systems are deterministic as all the components react to eachother and to changing conditions in a predictable way, with little overlap of the different influencing factors. These systems can be analysed by breaking them down into simpler components. Calculating the trajectories of balls on a snooker table is an example of a complicated problem. In contrast, complex systems have components that are interlinked and exhibit different behaviours based on delicately different starting positions. There can be ambiguous decision processes that are difficult to disentangle, making a system much more unpredictable and therefore difficult to break down into independent components. For example, humans have so far not been able to design or create a stable closed ecosystem because functioning ecosystems are too complex, with too many influencing factors and feedback loops. The same can be said about analysing the weather, or the human brain.

This type of very complex reasoning is currently beyond the ability of A.I. as it is not complex enough to productively integrate the multitude of complex influences and inputs, in order to "think outside the box". Take 3D image recognition for example, which is a simpler version of complex problem solving. It requires interpreting a rich set of factors such as perspective, hue, shadow and overlap. Each body must also be classified, even though reality lacks platonic objects, so A.I. finds this very difficult. By changing a few pixels, the best computers today can still confuse a bus with an ostrich.

The complexity and computing power of A.I. technology is now equivalent to that of a mouse brain but is steadily increasing. At the historical rates of development, A.I. can be expected to reach the level of humans and even develop further within the next decades. The stronger the computing power and the more complex computers become, the more they can successfully tackle complex problems, presumably replacing human scientists. Importantly, this development would not even require A.I. to become conscious, which is typically a key component of the "singularity".

The possibility of "the enhanced scientist"

Humans might not be replaced by A.I. entirely, but rather be enhanced by technology, combining the best of both worlds. Of course, there is no way of knowing what this scenario would look like and often predictions sound like something out of a science fiction novel. And yet, the fusion between humans and computers could be a solution, a way of progressing science without threatening the role of humans within science. Today, technology-brain interfaces already exist, such as artificial retinas, and multiple rat brains have been connected to improve their problem solving ability.

The inevitable result of human curiosity

The singularity may be theoretically possible, but why do humans not just stop developing A.I. in order to prevent human scientists from ever being replaced?

Past human progress, such as the agricultural and industrial revolutions, has always led to a significant increase in economic productivity. The singularity will be no different. This is why we are, as a species, catapulting ourselves towards the singularity: we are slaves to productivity. A.I. is already increasing efficiency within all areas of life, including science; computers and robots are

increasingly cheaper and easier to manage than their human counterparts. Therefore, the strong financial incentives for using and developing technology, even though it may not be in everyone's best interests, are strong enough to drive A.I. forward, inevitably leading to the singularity.

Technology is already greatly increasing the productivity and efficiency within science - from recognising tumours on scans to predicting disease outbreaks on social media. Just imagine what leaps could be made in scientific discovery with exponentially greater help from advanced A.I..

In 2017, a computer called AlphaGo was able to beat the best human player at the ancient Chinese game of Go. In a matter of hours, it came up with strategies that humans have not invented over the past 2500 years. Interestingly, computers proved superior to the top human players of Chess, which has a much lower complexity than Go, much earlier. This breakthrough illustrates the potential of A.I. to produce significant advances in science. Just like the way a computer exhaustively evaluates all the possible games on a chessboard, A.I. could read and analyse all the scientific literature that exists, something that is far beyond the scope of a scientist's brain. The accuracy of the scientific research conducted would also increase. Humans are easily swayed by biases and may unknowingly deviate from the scientific method, but A.I. would not succumb to such human error.

Ultimately, the inevitability of the singularity is not only because of productivity, but because we, as humans and as scientists, have the curiosity to push the development of A.I. to its very limit, regardless of the implications. The future is far from certain, but one thing is for sure; we are heading into a new era of science, one which promises to have dramatic implications for the progress of human knowledge.