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Australia's AI future

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Abstract

How can Artificial Intelligence (AI) improve the economic, societal and environmental well-being of Australia? I explore why AI is now able to take on a range of cognitive tasks. I discuss the technological challenges remaining to build intelligent machines. In addition, I identify some of the ethical and societal obstacles that this is, and will be, creating.

Introduction

It is nearly impossible to open a newspaper today without reading a story about Artificial Intelligence (AI), and how AI is taking on some new cognitive task: an AI that can play the ancient Chinese game of Go better than any human player; an AI that can read X-rays faster, cheaper and more accurately than a human doctor; or an AI that can translate English into Mandarin. Where will this end? And how might it impact on life in Australia?

Why now?

You might wonder why AI is starting to gain traction today. Why was it not in 1956 at the end of the famous Dartmouth Summer Project which launched the field of Artificial Intelligence? The proposal for that project promised "*a significant advance can be made in one or more of these problems (of getting computers to solve cognitive tasks) if a carefully selected group of scientists work on it together for a summer.*" (McCarthy et al. 1955). But at the end of that summer, little progress had been made by the illustrious group of scientists who had met in Dartmouth to launch the field.

And why was it not 30 or so years later when AI had its first boom — the Expert Systems revolution — during which money and people first flooded into the field? Unfortunately for AI, that boom didn't last. An AI Winter followed in the late 1980s and early 1990s as funding was cut back in the face of disappointing progress.

It is clear now that early researchers in AI severally under-estimated the scale of the scientific challenge in emulating the cognitive abilities of humans. Seymour Papert famously gave Gerald Sussman the task of coordinating a group of 10 undergraduate students over the summer of 1966 with the goal of constructing "*a significant part of a (human) visual system*" (Papert 1966). Susan and his fellow students failed. But fifty years later we have made significant progress towards Papert's goal. Indeed, on the ImageNet benchmark, deep learning systems can now outperform humans in identifying objects in images.

The reason for this recent progress can be traced to four exponentials. Strangely enough, each of these exponentials has approximately the same doubling time: every two years or so. There's no technical or other reason why these four exponentials should double at the same rate. It is just an empirical observation that they have been doing so.

The first exponential has a well known name: it's called Moore's Law. Every eighteen months to two years, transistor counts on chips have been doubling. This roughly equates to a doubling in compute power. For example, our smartphones today have more compute power than took us to the moon and back in the time of the Apollo space race. As a result, some tasks that AI researchers dreamed about even 10 years ago are now technically possible. And if we don't have enough compute power on our devices, we have almost unlimited compute power to call upon in the cloud.

It is worth noting that Moore's Law is officially dead. Chip companies like Intel are no longer aiming to double transistor count every two year. Indeed, it doesn't just become financial difficult to double transistor counts, it becomes physically impossible as you run into quantum limits. Intel and the other chip manufacturers do not have plans any more to build the billion dollar fabrication plants to continue Moore's Law. As a result, there's absolutely no chance at all that we will continue to have a regular doubling in transistor count.

I am, however, not worried that we're going to run out of compute power. We're now designing more interesting architectures like GPUs and TPUs specialised to AI tasks like machine learning. These new architectures will provide improved performance that will continue to drive improvements in AI. Interestingly, chip manufacturers like Intel are looking instead to reduce power consumption, enabling more to be down on our devices.

The second exponential that has been driving improvements in AI is the amount of data we are collecting. Many corporations and governments are waking up to the idea that one of the most valuable things to enable better decisions is data A lot of progress in AI today is driven by the subfield of AI called machine learning. We write programs that learn to do cognitive tasks. We don't know how to write a program to recognise a stop sign. But we can give a program lots of examples, and it can learn, much like humans do, to recognise such a sign. This requires lots of data — thousands if not millions of examples of stop and other traffic signs. Increasingly, we have that data as enterprises collect lots of data about their operations, and individuals collect data via their smartphones and other devices.

The third exponential driving improvements in AI is a doubling in performance of many AI algorithms. This exponential trend has not been running for as many years as the last two exponentials. However, in the last decade or so, we've been making good improvements in the performance of many AI algorithms. One example of this is deep learning, a machine learning algorithm that has powered many recent advances in tasks like perception.

The fourth and final exponential driving progress in AI is nothing technological. It is an exponential increase in the amount of money being invested in the field. This has also been doubling every two years. If you put those four factors in a pot together, you have a recipe for making significant progress towards the challenging problem of building machines to do cognitive tasks.

How much longer?

So, how much longer before we can build machines that match humans in their cognitive abilities? The AIs we can write today only do narrow tasks. For instance, one of the most recent breakthroughs, AlphaZero taught itself to play Go, chess and shogi (Japanese chess) at grand master level (Silver et al. 2018). But it can still only play two player, complete information board games. It cannot play a game of incomplete information like poker. And it certainly cannot translate English into Mandarin, or read an X-ray.

The median estimate of experts in AI and Robotics is that it will take at least 40 more years to match human cognitive abilities (Walsh 2018). When and if we build machines to match the cognitive abilities of humans, we likely have little to fear despite what Hollywood would have us believe. Computers do only what we tell them to do. They have no desires of their own. They are not conscious. And it is not at all clear that they ever will have anything resembling consciousness or free will of their own.

Putting aside such issues, we still have a long way to go to match the full breadth of abilities of humans. For example, it is trivial for most us to fold a towel. But the best towel-folding robot from University of California in Berkeley takes 5 minutes to fold a single towel. That is down from 25 minutes at the start of the project but still nothing like human level at this task.

Towel-folding is an example of Moravec's Paradox: the easy things for humans are often hard for machines to do, whilst the hard things for humans to do are often easy for machine. So it's easy to get a machine to do a hard thing like play Go or Chess, but it's hard to get it to do an easy thing like fold a towel. We have had millions of years of evolution to develop the motor and perception skills to fold a towel. It will take us a while before it is as easy for machines to replicate these.

Whilst human level AI is still some way off, we should be worried about stupid AI. We are already giving algorithms that aren't capable and smart enough the right to make decisions that impact on people's live. Algorithms are already deciding who gets a loan, welfare and even prison sentences. We should be very careful in handing over such decisions to computer.

What can AI do today?

Even if we have some time before AI can match all our cognitive capabilities, there is much that AI can do today that can improve our lives. One of the problems is that AI is already entering our lives but in a hidden way. Every time Google translates some German into English for you, Siri answers one of your questions, or Amazon recommends a book, that is AI at work.

Let me give some Australian examples. If you filed your tax return recently you might have noticed that the Australian Tax Office has a little chatbot called Alex to help you complete the form. Alex is a chatbot, a little AI program. It requires a little bit of intelligence to be able to understand your written questions and that's where Alex comes in.

As a second example, the Sydney Harbour Bridge has been instrumented with thousands of sensors to listen to its vibrations. Machine learning is then used to make predictions as to where and when it needs to be repaired. The goal is to extend the life of this asset indefinitely. This is probably a good idea because we likely can not afford to build a second bridge.

Another example in New South Wales is that a machine-learning algorithm is being used to predict which individuals are most likely to commit crime. This raises serious questions about ethics. One problem here is that we don't have ground truth. We don't know where crime takes place. We have lots of historical data of where we found crime taking place. But that isn't where all crime took place, just where we happened to be looking. The machine-learning algorithm will learn those patterns, but those patterns may reflect biases that exist within our society. It may be that we sent more police patrols into particular, perhaps poorer neighbourhoods. That doesn't mean more crime actually took place there. We have to be very careful then when we hand over these sorts of decisions to machines as they may perpetuate historical biases.

As a final example in my own work, we have been optimising supply chains for some big multi-national corporations. We have a rule of thumb that we can shave around 10 percent from a company's transport costs. That saves the company a lot of money, but also it saves the planet. The company's trucks will be producing 10 percent less carbon dioxide which is a significant benefit for all of us.

AI in Australia

It is likely that AI will have a large impact on Australia's economy. In 2017, Price Waterhouse Coopers estimated that AI will about 15 per cent to the world's GDP in inflation-adjusted terms by 2030. Some countries will, however, receive greater returns. Top of the list is China where AI may grow the economy by 26 per cent, whereas in Africa, AI might only be growing the economy by five per cent or less. AI may therefore widen inequalities between countries, which is a matter for grave concern.

Many countries around the world have decided to make significant investments in AI to ensure that they get more of the benefits. Most recently, Germany announced that they will be investing 3 billion euros in AI by 2025. This comes after other announcements such as the UK investing 1 billion pounds, and France investing 1.5 billion euros.

Australia has so far made an announcement of just $22 million towards AI. However, the Australian Council of Learned Academies (ACOLA) is writing a report at the request of Government identifying the opportunities and challenges that AI pose. The report focuses on how AI can improve Australia's well-being: economic, societal and environmental. I should declare that I chair the Expert Working Group preparing this report. At the same time as this report, Data61 is writing an AI road map and ethics framework. A similar horizon scanning exercise for precision medicine last year was met by a significant response in the 2018 budget. I am optimistic that the Australian Government will seize the opportunities and challenges that AI now offer to improve our well being.

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