Could you begin by explaining what is meant by ‘computer intelligence’ and the potential benefits it offers society?

Computer intelligence is a branch of computer science that aims to enable computers to mimic intelligent human behaviour. Perhaps the most intriguing aspect involves enabling computers to autonomously modify their program so that, over time, they can learn how to solve problems more effectively. Just as the machines of the 18th and 19th Centuries ushered in the Industrial Revolution and boosted the productivity of manual labour, nowadays computers can be harnessed to help us improve our understanding of the world, make more informed decisions and improve (or even save) lives. We research algorithms and data structures to enable computer intelligence, and we study how they can be used effectively in areas with the highest potential impact on society.

By what methods do you impart intelligence onto electronics using algorithms and data structures?

Our flagship methodology today is machine learning; this allows computers to learn, both from data and human guidance, how to make predictions and how to help us comprehend the data. Many real-world phenomena that are worthy of our attention turn out to be quite complex. We try to observe them with incomplete sets of imperfect sensors (including our own senses), which yield uncertain multi-aspect measurements that might form formidably convoluted data. Internalising these sorts of data quite often exceed the limits of human comprehension, so we lean on our computers for support. A trained machine learning model can help us understand causal relationships among data elements, highlight previously unknown patterns and even conduct simulations to evaluate the probable effects of actions we might consider taking.

Professor Artur Dubrawski heads a team investigating the widespread applications of machine learning and the potential beneficial impacts on our society.
How have these tools advanced since the turn of the century, and how do you see them progressing in the future?

Machine learning approaches have become more useful and applicable in solving real-world problems and have increased their capacity to process massive amounts of heterogeneous data (proverbially known as ‘big data’). However, I am particularly intrigued by ongoing research that explores including humans in the machine learning loop. In practice, data-driven analytic systems can be limited by shortages of information in the available data. After all, most real-world databases are just projections of reality. Many important aspects may therefore be missing and the resultant systems cannot perform any better than what the available data allow. Involve humans—with their awareness of the context and nuanced domain expert knowledge—and the information gaps in data could be remedied.

You teach data mining and business intelligence to graduate students at the Carnegie Mellon University’s (CMU) Heinz College School of Information Systems. What is the most important knowledge you attempt to communicate?

Practically all substantial organisations in industry, government, science and healthcare seek to leverage available data for the benefit of their stakeholders. Concurrently, data collected worldwide grow rapidly in terms of volume, variety and complexity. These processes create a huge demand for the services of skilled professionals, whom we often call ‘data scientists’. Multiple programmes at CMU and other universities actively train such specialists, providing them with theoretical foundations of machine learning and hands-on data skills. I am constantly looking for the optimal mix of foundational mathematical skills with the ability to define, design and deploy useful solutions, so that our students can impact society in a beneficial way soon after graduating. Many of them do.

Finally, do you have any plans for future applied computer intelligence endeavours?

We are always looking for new challenges and application areas where machine learning could make a plausible difference. Providing researchers with tools that enable them to quickly and comprehensively sift through huge piles of empirical data results in new insights and accelerates scientific discovery in astrophysics or biological sciences.

There is the potential to mine healthcare data for inaccuracies in coding of medical bills to eliminate hidden costs of care; optimising crop yields by identifying key factors among weather, soil conditions and crop maintenance procedures; and detecting and characterising unsafe radiation in buildings, cities and at border crossings.

These are just some of the multiple endeavours through which we are learning how applied machine learning can make a meaningful and beneficial impact on society.

The future now

Intelligent machines, capable of learning and improving human understanding, are an inevitable part of our future. Researchers at Carnegie Mellon University in Pittsburgh are using machine learning to improve our economy, society and quality of life, as well as medicine, science and food safety practices.

IN 1959, ARTHUR Lee Samuel pioneered a significant development in the fields of artificial intelligence and machine learning. His Samuel Checkers-learning Program became the world’s very first self-learning program, which ‘remembered’ every checkers position it had already seen. From there the machine was able to determine the value of each possible move, allowing it to make the most informed, statistically correct decision.

Fast forward to 10 February 1996 when IBM’s chess-playing computer Deep Blue defeated Russian chess Grandmaster Garry Kasparov, becoming the very first piece of artificial intelligence to win a game against a reigning world champion under regular controls. Indeed, the concept of artificial intelligence has proved enduringly appealing to the human imagination—and it even has its own genre in Hollywood. From Kubrick’s 2001: A Space Odyssey to Cameron’s The Terminator to the Wachowski Brothers’ The Matrix, artificial intelligence has always found its place on a spectrum ranging from fascination to suspicion, where humans (almost) bring about their own destruction as a result of making machines with autonomous thinking abilities.

In real life, though, artificial intelligence is a lot less sensational and a lot more positive. Building on Samuel’s legacy, over the past few decades scientists have capitalised on technological advances to develop the fields of robotics and artificial intelligence as a force for good. It is no exaggeration to suggest that humanity is on the brink of a new era, one that relies on computers and robots to significantly improve individual lives and society in general.

One group of researchers, based at Carnegie Mellon University School of Computer Science in Pennsylvania, USA, has been developing computer programs that can make predictions and calculations far beyond the capacity of humans. The findings from their ongoing experiments have significant societal impact, with broad applications for areas as diverse as clinical informatics, food safety and human trafficking.
SOCIETAL IMPACTS OF MACHINE LEARNING

OBJECTIVE
To apply computer intelligence to a range of endeavours, including bedside informatics, food safety measures and counter human trafficking intelligence.

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PROFESSOR ARTUR DUBRAWSKI
researches intelligent systems that are useful and impactful, and ways to effectively build and deploy them. For more than 25 years, his work has been driven by real-world applications. He investigates new machine learning algorithms and data structures to facilitate probabilistic modeling, predictive analysis, interactive exploration and understanding of large amounts of multisource data in complex hypothesis spaces. Dubrawski is a senior faculty member at the Carnegie Mellon University Robotics Institute, where he directs the Auton Lab, a machine learning research group of 35. He also regularly teaches graduate and executive courses on data mining and data science.

READING IN BED
Led by Professor Artur Dubrawski, the team has published extensive papers on a range of applied computer intelligence endeavours that make use of collected data and clinical informatics. Currently, when a patient is in a critical care department in hospital it is a standard procedure to routinely monitor their vital signs.

Dubrawski and his colleagues have investigated ways of using machine learning algorithms to take fast-paced, multimodal measurements of patients’ vital signs, and using these to predict the likelihood of complications. “Based on data collected from similar patients in the past, the machines will identify potential episodes of cardio respiratory insufficiency ahead of its actual onset,” explains Dubrawski. “This would buy clinicians precious minutes to pre-emptively treat the patient, as opposed to the all-too-common practice of reacting to a crisis that has already begun.”

The use of machine learning to identify patterns of disease earlier, with such precision and specificity, surpasses human capabilities and could lead to more effective therapies and better patient outcomes.

GOOD EATING
The team has also identified a machine learning application that addresses the significant problem of food safety. Incredibly, as many as 76 million Americans suffer from foodborne illness each year, with 300,000 admitted to hospital. Of these, around 5,000 die simply as a result of eating something bad. The tragedy is that a large proportion of these cases are easily preventable – thus the team has analysed the potential use of machine learning alongside routinely collected data. Applying computer intelligence to improve food quality and safety could vastly reduce the burden of medical costs on society.

Valuable data about food safety are already collected by government and industrial organisations and so using computers to process that information more quickly and comprehensively could help improve policies and practices, significantly reducing human exposure to foodborne illness. “Databases contain the results of microbial testing of food samples for bacteria such as Salmonella, Listeria and E. coli,” Dubrawski points out. “There are also results from sanitary inspections of food processing facilities or records of food consumer complaints. All these data, fused together, help detect breaches of food safety before they substantially impact the population at risk.”

Understanding and identifying the risks of the transmission of pathogens, allergens and pollutants from food to humans would reduce incidences of foodborne illness, potentially saving hundreds of lives and improving the health of society at large.

MAPPING HUMAN TRAFFICKING
Analysing vast and extremely complex datasets to come up with the best possible move in checkers is one thing, but capturing data that provide information about one of the most heinous crimes in our modern world is quite another. Human trafficking – namely, the trade of humans for sexual exploitation or forced labour, among other things – is a major global concern for governments, communities and individuals everywhere. In work that could signal real and significant social change, and assist criminal investigators, Dubrawski’s team has looked at ways of combining machine learning with readily available public information to measure and map human trafficking activities.

Currently, around 100,000 US children are believed to be vulnerable to sex trafficking each year. One typical scenario is for a runaway to be ‘rescued’ and given food and shelter by someone who appears to care for them. They are then coerced into repaying this favour by providing sexual services to strangers, with many pimps advertising their victims online. Yet machine learning has the capacity to use this information as a real force for good. “Identifying likely leads from millions of online ads each year can assist in tracking activities, as well as highlighting prostitution rings that may be involved in forced labour of minor subjects,” explains Dubrawski. “Several victims have already been rescued and offered a new start in their lives.”

ENHANCING QUALITY OF LIFE
Dubrawski’s work shows that machine learning has the capacity to make use of complex data to improve patient outcomes, increase food safety and reduce incidences of appalling criminal activities. Yet these are only three examples. The potential applications for robotics and artificial intelligence to improve the quality of life for current and future generations are virtually limitless, perhaps fettered by imagination only.

Artificial intelligence and machine learning no longer simply form part of science fiction. Instead, they are firmly rooted in the gritty realities of everyday life and hold the possibility of making tangible differences to society and its inhabitants.