ARTIFICIAL INTELLIGENCE

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MEDICINE & DENTISTRY

LEAD EDITOR: NAATHIM DRSKA

THE USE OF ARTIFICIAL INTELLIGENCE IN SURGICAL ROBOTICS

By: Yamin Chowdhury

ABSTRACT

Artificial Intelligence – loosely defined as the development of computer systems to be able to complete tasks that historically required human intelligence – is revolutionising medicine. AI can be used to advise doctors, predict diseases, analyse medical imagery; the list of its capabilities is endless. One of its most exciting applications is its use in surgical robotics – a field of medicine with rising popularity. There were 22,700 robot-assisted procedures in the first quarter of 2024 in the NHS, a 45% increase from the previous quarter. But how does it use AI?

Since the introduction of robotics in surgery in the UK in 2004, it has mainly been used for the suturing and dissection of tissues. These surgeries were often done using a robotic arm fitted with a high-definition camera, controlled by a surgeon receiving the footage. Whilst these surgeries were usually conducted with the surgeon present, they were also possible with the surgeon absent. This allowed patients to receive care from experienced surgeons, no matter where they were. This became known as the “da Vinci surgical system”. As of now, over 76,000 surgeons have been trained on these systems- completing more than 14 million successful procedures, under precision control, and minimal damage to surrounding tissue.

The expansion of AI has been used to further improve the da Vinci system. AI is being used to analyse data in real-time during surgery to aid the surgeons and enhance procedures. Using the data, AI can optimise the surgeon’s movements and filter out tremors, reducing the risk of human error. It can also combine the surgical data with the patient’s existing medical history to alert the surgeon to any potential risks of the surgery. Using machine learning, AI can learn from past surgeries and predict the optimal surgical method that can decrease the recovery time for the patient.

Using footage recorded from the camera, AI can generate a 3D image of the surgical site, providing the surgeons with a more detailed view. The 3D image can also be used to train medical students, helping them to be prepared for exceptional surgeries. Additionally, AI can be used to create simulations of surgeries, which surgeons can practice before operating on patients. This allows them to improve their technique in a risk-free environment.

Despite the uses of AI in surgical robotics, it divides opinions within the medical community. Ultimately, it does have disadvantages. As with any technology, there is a risk of technical malfunction that could delay or even compromise the surgery, leading to ethical concerns. From a legal perspective, it can become complicated to conclude who is liable for the **malpractice**: the software manufacturer or the surgeon.

Finance is also a drawback- particularly for state-run hospitals with a low budget, including the ones in the NHS- which has been, within the past decade, overrun with a cascade of difficulties regarding the recent COVID-19 pandemic, staff shortages and insufficient salaries. This dire position the NHS is currently situated in prohibits the expenditure on revolutionising but expensive medical technology. Surgeons will also require additional training to be able to use the robotic systems, which will require further resources, further staff, further money- which the NHS simply doesn’t possess. There is also the risk of surgeons becoming over-reliant on the technology, reducing their ability to handle cases without robotic assistance. This may not appear problematic, but the sole reliance on technology such as AI, which thrives on recourses such as the internet, may pose a serious threat to the patient’s wellbeing, if these recourses become compromised.

In conclusion, I believe AI can help improve surgical robotics due to its ability to advise and train surgeons, reduce human error and optimise surgeries. However, in order for the technology to flourish, it must become more financially accessible, and the legal framework must be improved.

Robotics – the production of machines that can perform jobs autonomously
Suturing – stitching up a cut in a person’s body
Dissection – cutting open a tissue
Tremors – an uncontrolled tremble in your body
Malpractice – failure to act correctly when doing your job

videos

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AI: PERSONALISED MEDICINE

By: Sanvi jangam

ABSTRACT

All people are different and will respond differently to illness and treatment. Medicine has always relied on a one-size-fits-all approach. However, with the rise of AI, customised treatments can be created by analysing genomic data, medical history, and real-time biometrics. Could this make medicine more precise and effective?

For decades, medical treatments have been developed for the "average" patient. However, this approach can lead to ineffective treatments or severe side effects. A striking example is Clopidogrel (Plavix), a widely used blood thinner. If a patient has a specific mutation in their CYP2C19 gene, their body cannot properly metabolize the drug, rendering it useless. Conversely, some individuals metabolize it too efficiently, increasing the risk of excessive bleeding. AI is changing this by analysing a patient's entire genome to predict, with around 80% accuracy, how they will respond to a treatment. By leveraging machine learning to compare millions of patient records, AI can detect patterns far beyond human capability and recommend the safest, most effective treatment.

AI-powered personalised medicine isn't just theoretical—it's already in use. In oncology, AI analyses tumour DNA to identify the most effective immunotherapeutic drugs for individual patients. At Memorial Sloan Kettering Cancer Center, IBM Watson helped doctors match patients with targeted cancer treatments, improving survival rates by 20-30%.

In pharmacogenomics, AI models assist in tailoring drug dosages. Warfarin, another common blood thinner, carries a high risk of dangerous side effects, as the ideal dosage varies significantly between individuals. AI-driven genetic analysis allows doctors to predict a patient's optimal dosage, reducing adverse drug reactions by up to 50%.

Non-communicable diseases like Alzheimer's, diabetes, and cardiovascular disease can also be predicted years before symptoms develop. Google's DeepMind AI can detect diabetic retinopathy from retinal scans with a 94% accuracy rate, enabling early intervention and preventing blindness.

AI isn't just predicting treatments—it's designing them. By combining AI with CRISPR gene-editing technology, scientists can identify and edit genetic mutations responsible for inherited diseases like sickle cell anaemia and cystic fibrosis. AI helps determine the safest and most effective gene edits, reducing the risk of unintended genetic changes.

Additionally, AI played a crucial role in designing mRNA vaccines at unprecedented speed. Traditional vaccine development takes 10+ years, but with AI assisting in sequencing and modelling, COVID-19 vaccines were developed in under a year, saving millions of lives.

Despite its promises, AI-powered medicine leads to ethical debates. AI-driven treatments are expensive and may remain so, exacerbating healthcare inequality as not everyone will have access to life saving technology. Data used for research can be shared, raising privacy concerns as to whether or not corporations and governments should have access to an individual's entire genetic blueprint. AI models are trained on biased datasets, similar to clinical trials.

AI is making healthcare more precise, predictive, and personalized. Instead of treating patients based on averages, medicine is shifting toward individualized care. While challenges remain, the potential for longer, healthier lives is undeniable.

video

Gene - a base sequence of DNA that codes for the amino acid sequence of a polypeptide or a functional RNA molecule.
Oncology - Study and treatment of tumours
Immunotherapy - Stimulating or suppressing the immune system to aid the body in treating disease
Non-communicable diseases - Illnesses that are not caused by pathogens. Can be genetic or related to lifestyle.
Retinopathy - disease of the retina.
Clinical trials - research studies that test a medical, surgical, or behavioural intervention in people

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THE FUTURE OF AI AND ROBOTICS IN SURGERY

By: Yomna Awad

ABSTRACT

AI, the once considered "science fiction" is now expected to reshape medicine, benefiting both healthcare professionals and patients. Machine learning is expanding its footprint in a variety of surgical specialities, improving the accuracy and precision of many surgical procedures, while also reducing complications and improving recovery times which further improves the quality of healthcare. In the following article we will be diving deep into the world of AI and Robotics, and how these tools will help shape autonomous surgical procedures in the future.

AI has been seen in several surgery sectors such as neurosurgery and orthopaedic surgery. In neurosurgery, a worldwide survey revealed that 18% of neurosurgeons reported using robotic assistance for spinal instrumentation. Not only that, but neuronavigation, machine vision and image fusion help control the removal of mass lesions and subsequently precision radiotherapy. On the other hand, orthopaedic surgery is one of the medical specialities with the most cutting-edge technology. Machine learning may be used to estimate the rate of post-operative complications for each patient and forecast injury risk patterns. In several situations, machine learning doesn't only outperform orthopaedic doctors in fracture identification of the upper limb, ankle and spine but it can also aid in cartilage thickness analysis. Moreover, the remarkable accuracy with which AI models can determine implant models can be of immense value in planning surgeries, thus saving more time while taking everything into consideration as AI analyses patient's data. This showcases that the goal of machine learning and AI is not to replace healthcare professionals and surgeons but rather to improve their workflow and its accuracy to ensure the best care is given to the patient.

Although AI helped with several breakthroughs in the surgical sector, as with any new technology and its subfields, it's susceptible to unrealistic expectations that can lead to significant disappointment and disillusionment, as well as raising significant ethical concerns. One major issue is the liability and accountability of a patient's safety as when a human surgeon makes an error, accountability is clear. However, AI-driven surgical systems involve multiple stakeholders, including the software developers, the hospital, the AI manufacturer and the surgeon operating the surgery. Another challenge is cybersecurity risks, as internet-connected robotic systems could be vulnerable to hacking, potentially leading to data breaches or even surgical malfunctions. Furthermore, cost and accessibility raise concerns about healthcare equity, as AI-driven surgical technologies remain expensive and may only be available to wealthy patients or well-funded hospitals, widening the gap in medical care. To help address these challenges, clear legal frameworks are required to define AI liability as well as evolving medical training to incorporate AI-assisted techniques while maintaining human oversight, and strong cybersecurity measures must be enforced to protect sensitive patient data.[4]

While AI and robotics offer unprecedented advancements in surgery, they also pose serious ethical dilemmas that must be carefully managed. The key is balance-embracing AI's benefits while maintaining human oversight, fairness, transparency, and accessibility. By addressing these ethical challenges now, we can ensure AI-assisted surgery is not just innovative, but also responsible and equitable.

Machine learning - a subfield of artificial intelligence which is broadly defined as the capability of a machine to imitate intelligent human behaviour.
Spinal Instrumentation - the use of metal devices like rods,screws,and plates during spine surgery to stabilize the spine and facilitate bone fusion,helping to hold the vertebrae in place while they heal.
Neuronavigation - like a "GPS for the brain" that helps neurosurgeons navigate and precisely target specific areas within the brain or spine during surgery, using computer-guided imaging.
Mass lesions - abnormal growths or areas of tissue that form a lump or swelling in the body, potentially caused by injury, infection or disease.

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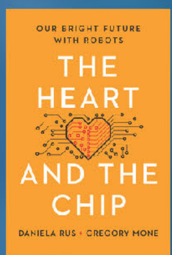

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ARTIFICIAL INTELLIGENCE IN DRUG DISCOVERY AND DEVELOPMENT

By: Abdiraman Mahamed

ABSTRACT

Artificial intelligence is a revolutionising instrument in many fields including its transformative and significant impact in drug discovery and development. Traditionally, finding and designing new drugs is a time consuming, expensive, and complicated process. Thanks to the emergence and advancement of AI, this process is no longer constrained by the slow pace of manual research carried out completely by humans. AI is currently able to analyse large amounts of data in a short period- beyond human's capabilities to do it under adequate pace.

Drug discovery and development, often takes ten to fifteen years from initial research to market approval and public use. Notably, the most used drug globally is paracetamol; it is used as an "over the counter" medication for pain relief. It is currently considered one of the safest and most effective medications. Paracetamol was first synthesised in 1852 by chemist Charles Gerhardt, but it was not studied further. It was then rediscovered in 1948 as an effective fever reducer and pain reliever and then became widely available in the 1950s. Overall, the discovery and development of paracetamol took almost a century. In today's era, AI could drastically shorten this process.

Drug discovery and development involves several stages, including identification of potential drugs, preclinical trials, clinical trials, and market approval from agencies like the FDA (food and drug administration). According to a recent report by the Information Technology and Innovation Foundation (ITIF), AI has the potential to cut drug development times in half, enhancing the productivity of the pharmaceutical industry. Moreover, AI can simulate toxicological effects and predict reactions in patients to particular drugs, potentially reducing the need for animal testing, which is a controversial and ethical issue in drug development.

Furthermore, a study in 2020 estimated that the median cost of getting a new drug into the market was $985 million, and the average was $1.3 billion. According to the Tufts Center for the Study of Drug Development, the average cost of bringing a new drug into the market almost doubled between 2003 and 2013 to $2.6 billion. Costs vary depending on the complexity of the drug, the country, and the disease being targeted. Accelerates several key stages. For example, AI can quickly identify possible drugs, reducing the need for expensive trial and error experiments. Additionally, AI can be used for drug repurposing by identifying existing drugs that could be effective for different conditions, therefore bypassing the high costs of developing new drugs from scratch.

In addition, AI can increase the number of drugs that make it to the market by improving various stages of drug development. As reported by the Tufts Center for the Study of Drug development in 2016, ninety percent of drugs fail during the development process so do not make it to the market. This is due to most failures occurring during the clinical trial phase, including factors like safety and efficacy issues. The Tufts Center for the Study of Drug Development has been studying the development of drugs for over forty years. Their research on why most drugs fail plays a big role in discussions regarding how AI can make drug discovery and development more efficient. A 2024 analysis highlighted that drugs discovered by AI demonstrate higher success rates in early clinical trials, between 80 and 90%, significantly surpassing previous averages of 40 to 65%. These findings clearly suggest that AI can enhance the likelihood of clinical trial success, consequently leading to more drugs reaching the market.

In conclusion, AI has the potential to redefine the drug discovery and development process by dramatically reducing the time, cost and complexity associated with bringing new drugs into the market. While this is still a complicated and intricate process, AI is undoubtedly a powerful tool and a game changer in the pharmaceutical industry.

Artificial Intelligence - Ability of machines or computers to perform tasks that normally require human intelligence. For example, human learning, problem solving, decision-making etc.
Preclinical trials - Trials about drugs or treatment for a disease that occurs before it is tested on humans. Typically done on animals to test for safety and effectiveness.
Clinical trials - Trials about drugs or treatment for a disease that are carried out humans to test for safety, effectiveness, and dosage
Pharmaceutical industry - Medical industry that discovers, develops and produces pharmaceutical goods such as medications and medical devices.
Toxicological - Refers to toxicology, which is a branch of science concerned with the nature, effects and detection of poisons

book

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INTEGRATING AI INTO ONCOLOGICAL IMAGING

By: Chloe Alcazar

ABSTRACT

The collaboration of AI in healthcare continues to evolve, particularly in the field of diagnostic radiology and oncology. It builds on the algorithm's ability to enhance the efficiency and quality of patient care. However, with such influential technological advancements, there comes a numerous amount of resistance and ethical dilemmas. This article will explore how AI has been developed to be used in CT and MRI scans to detect and diagnose.

Within the world of oncological imaging exist three main clinical image-based radiology tasks. These occur to detect abnormalities and tumours within the body: abnormality detection, characterisation, and the subsequent monitoring of any changes.

Detection requires radiologists to rely on their manual perceptive skills to identify possible abnormalities, alongside their analytical abilities which informed decisions about their findings. Radiologists are trained to spot unusual patterns by scanning through stacks of images and radiographs. Radiologists detect abnormalities using visual perception and cognitive expertise. Eye-tracking studies show they identify anomalies within seconds, demonstrating "gestalt perception." This ability stems from their familiarity with normal anatomy and common pathologies. Radiology research further reveals they combine rapid intuition with analytical reasoning to enhance accuracy. This evidence underscores their reliance on both perception and analysis for precise diagnoses.

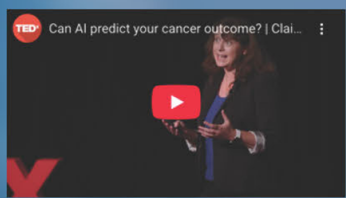
Although, as dependence on computers has increased, identification and processing has been automated- known as computer-aided detection (CADe). Although you would think that the use of algorithms in this case would make detection less time-consuming, the accuracy of CADe systems remains questionable. So, radiologists must monitor the outputs of what these algorithms discover to reduce false positives. This defeats the purpose of AI usage, and instead makes this process more labour-intensive. Evidentially, whilst examining mammograms, studies have reported that radiologists rarely altered their diagnostic decisions after reviewing results from predefined, feature-based systems CADe systems. Their clinical integration had no statistical significance on the radiologists' performance. This highlights that while AI can assist in detection, it cannot replace the expertise of radiologists, reinforcing the need for human oversight in medical imaging.

Next, during characterisation, there are three subsections: segmentation which defines the boundary extent of an abnormality for subsequent diagnosis and treatment planning, then to evaluate and classify the abnormality, deciding if it is malignant or benign, and lastly staging, which is to classify abnormalities into multiple predefined categories. Finally, monitoring. Monitoring involves change analysis. During this task, the radiologist or AI tracks object characteristics across temporal scans for diagnosis, alongside evaluating treatment response. It monitors the risk in correlation-time.

There is a number of benefits for AI integration and clinical application in oncology. Evidentially, thoracic imaging, in which lung cancer screening can help identify pulmonary modules, with early detection being lifesaving in many patients. AI can help to identify these nodules and categorise them as being malignant or benign. Additionally, with abdominal and pelvic imaging, CTs and MRIs identify liver lesions. AI can aid in characterising these lesions as benign or malignant, alongside prioritising a follow-up evaluation for patients with these lesions. This demonstrates how AI can enhance diagnostic efficiency and accuracy, supporting radiologists in making timely, informed clinical decisions.

There is debate about the ethics and timeframe of how AI will eventually be implemented, and when clinical tasks will be fully automated. The 21st Century shows a significant increase in the use of computer programs and algorithms in medical workforce enhancement. The potential for misdiagnosis and liability poses as a significant ethical concern with AI-assisted radiology; although AI offers promising diagnostic capabilities, it is not always perfect. It is susceptible to errors and biases, which could lead to incorrect diagnosis and patient harm. Furthermore, AI does not have the empathy and compassion that traditional clinical care possesses, so it is important to preserve the human element within patient care. AI should not overshadow the expertise and experience of trained medical professionals. Therefore, as AI continues to grow exponentially in its ability, we should remain responsible about the application of transformative technology in healthcare.

CT - a computerised x-ray imaging procedure in which a narrow beam of x-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed by the machine's computer to generate cross-sectional images.
MRI - a medical imaging technique that uses a magnetic field and computer-generated radio waves to create detailed images of the organs and tissues in your body.
Oncology – the study of cancer
Nodules - a small swelling or aggregation of cells in the body, especially an abnormal one.
Lesions - a region in an organ or tissue which has suffered damage through injury or disease, such as a wound, ulcer, abscess, or tumour.



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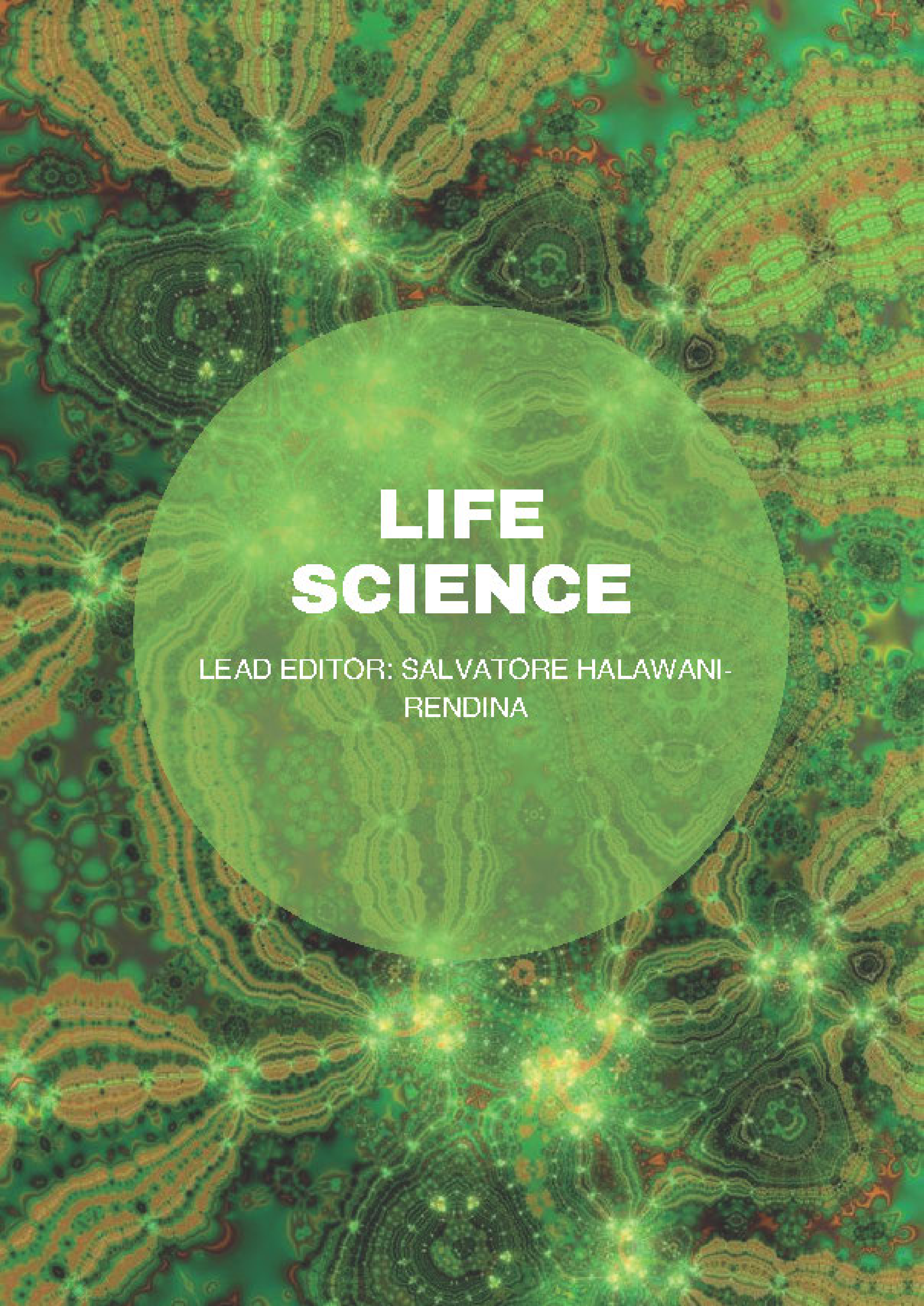

LIFE SCIENCE

LEAD EDITOR: SALVATORE HALAWANI-RENDINA

THE PUZZLE PIECES OF LIFE

By: Natsumi Ao

ABSTRACT

Proteins. They form the strands of hair on your scalp and the antigens on every cell in your body. As fundamental building blocks of life, their potential to revolutionize science and industry is immense. Yet, despite their importance, proteins have remained elusive and expensive to study— until now. With the introduction of AlphaFold AI, this could all change.

At first glance, proteins might seem like an easy avenue for scientific progress. The reality, however, is far more complex. Proteins fold in countless ways, often in mere milliseconds, assembling into intricate structures with incredibly high specificity. Identifying their shapes using traditional methods like X-ray crystallography is both time-consuming and imprecise, particularly for hydrophobic membrane proteins. Moreover, complex structures can yield low-resolution data, thus, the need for computational strategies to predict the shape of a protein arose, in hopes of streamlining this process.

Enter CASP (Critical Assessment of Structure Prediction), a competition designed to evaluate the accuracy of protein structure prediction. Using the Global Distance Test (GDT) on a scale from 0 to 100—where a score of 90 equates to experimental accuracy—computational methods struggled for years to surpass 60, rendering them impractical for real-world applications.

That changed in 2020 with the arrival of AlphaFold 2.0, developed by DeepMind. AlphaFold utilised deep learning and pattern recognition to predict protein structures, much like a human assembling a jigsaw puzzle. Trained on a dataset of over 300,000 known protein structures, it outperformed all competitors, achieving GDT scores consistently around 90. For the first time, computational predictions were level with experimental techniques, opening new frontiers in our knowledge of molecular level biology.

So, what does this mean for practical applications? What are proteins used for?

Take vaccines, for example. Traditional vaccines often rely on live-attenuated pathogens to trigger an immune response. While effective and widely used, it can be associated with weaker immune responses (than exposure to the original live disease) or pose risks for individuals with compromised immune systems. Subunit vaccines could elicit stronger immune reactions without risking the receiver's life. These subunit vaccines have had difficulty progressing in terms of their research, because they require the synthesis of proteins, relying on mechanisms found within other organisms- such as insect cells.

One promising approach involves ferritin nanocages- protein molecules derived from ferritin. Mammalian-derived ferritin has limitations in flexibility, making it difficult to display certain antigens effectively. With AlphaFold, scientists can now explore ways to modify ferritin at the molecular level, optimizing its structure without compromising its function.

While the full mystery of protein folding remains unsolved, AI-driven modelling is already transforming nanotechnology and biochemistry. By unlocking new capabilities in protein engineering and identification, AlphaFold is not just accelerating scientific discovery; it is redefining what is possible for humanity's future.

National Library of Medicine
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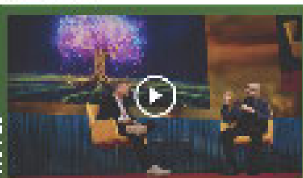
article

AlphaFold - an open-source AI program that can predict protein structures with higher accuracy.
X-ray Crystallography - a method of obtaining a 3D molecular structure from a crystal.
Subunit Vaccines - vaccines which, rather than including the whole pathogen, only include the parts with antigens, to stimulate an immune response.
Ferritin Nanocage - an effective method of drug delivery and antigen expression; formed from 24 ferritin subunits, which are usually used to store iron in tissue.
Nanotechnology - a branch of technology that mainly deals with manipulating atoms and molecules.

Ted Talk



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HOW AI HAS INFLUENCED THE MEDICAL WORLD: PREDICTIVE ANALYTICS

By: Loraine Nombo

ABSTRACT

Predictive models powered by AI can analyse vast amounts of patient data to predict the progression of diseases, patient readmission risks, and potential complications from surgeries and administered drugs. This helps healthcare providers make more efficient, informed decisions and personalise treatment plans.

How They are Made

Creating predictive analytics models in medicine involves several key steps, each of which plays a crucial role in developing a system that can accurately forecast healthcare outcomes. Here's an overview of the typical process:

- Defining the specific healthcare problem or question that the predictive analytics model aims to address. This can involve things like forecasting disease risk or predicting treatment outcomes.
- Collecting necessary data from various sources, such as: Electronic Health Records (EHRs), clinical trials, and analysing genetics.
  - o The quality of the data collected must be verified, and the findings need to be checked as relevant, and representative; this usually involves cleaning the data by removing duplicates, addressing missing values, and correcting inaccuracies.
- Processing data in preparation for analysis. This is done through: Normalisation, Feature Selection and Encoding Categorical Variables.
- Selecting, refining, and evaluating the model for the data.
  - o First, an appropriate predictive modelling technique is selected based on the problem and the nature of the data. Then, the model is trained to tune its parameters which, as a result, will enhance its performance. Lastly, the model is assessed for many criteria - including accuracy, sensitivity, and precision - to determine its efficiency in predicting a patient's outcomes.

After this process, the model can be implemented into aiding doctors with their patient's healthcare, however, the model must be continuously monitored and updated to maintain its relevance and accuracy. By following these steps, healthcare organisations can develop and implement predictive analytics models that help improve patient outcomes, enhance decision-making, and optimise resource utilisation.

Challenges and Controversies

In light of the transformative potential that predictive analytics withhold, there are some challenges, which involve the following:

- Data Quality: The accuracy of predictions heavily depends on the quality and comprehensiveness of the data inputted.
- Integration: Integrating predictive analytics into clinical workflows can be complex and requires collaboration between data scientists and healthcare providers.
- Ethical Considerations: Respecting patient privacy is a difficult feat to accomplish when AI is introduced to the medical world; furthermore, there is a lot of pushbacks from scientists as well as the public, who are discomforted by the growing use of AI within various sectors of society.

The Bigger Picture

On a much broader scale, predictive analytics can examine epidemiological data to forecast disease outbreaks, evaluate the impact of public health interventions, and even help allocate resources. Despite the barriers of using this system, careful refinement and regulation can ensure becomes an innovative for improving enhance healthcare outcomes and supporting informed decision-making.

Epidemiological - the study of how often diseases occur in different groups of people and why

Predictive analytics – Predictive analytics in medicine refers to the process of using statistical algorithms, machine learning techniques, and historical data to identify the likelihood of future healthcare outcomes for individual patients or populations.

Forecasting – Predicting health situations or disease episodes and forewarning future events

Clinical Trials – The rigorous process a drug/treatment must go through in order to be approved by medical bodies for patient use

Normalisation - scaling data to a standard format

Feature Selection – Identifying the most important variables that influence the outcome, which can improve model performance

Encoding Categorical Variables - converting non-numeric categories into numerical forms that algorithms can use.

Administered Drugs – Delivering a drug to the body in a suitable way for treatment

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PHYSICAL SCIENCE

LEAD EDITOR: BRYONY COOK

DARK MATTER: AS ELUSIVE AS IT ONCE WAS?

By: Bryony Cook

ABSTRACT

Dark matter has escaped scientists since it was first theorised. Its elusive nature makes it hard to observe as light seems to pass straight through it. This article is going to explore what it is, how we detect it and how AI has advanced both our understanding but also our technology to help us learn more about this mysterious matter that makes up our universe. So, what exactly is dark matter and what does it mean to us?

Dark matter is a mysterious substance that affects and shapes the cosmos, as it is invisible it can only really be described by the effect is has on the universe. Studies show that stars and galaxies move as though there is a lot more mass than we can see pulling them along. In short, dark matter is a theoretical matter that accounts for mass that we know to exist from these examples and Newton's Law of Universal Gravitation but we cannot observe it. We can also observe the dark matter by seeing how its gravity affects light; this is called gravitational lensing. Dark matter exists in the universe to, in some way, balance it out, and recently researchers have made major breakthroughs using AI.

Space is an overwhelming thought, and it is very hard to access all of it, this means researchers have to rely upon models that mimic space and the processes that occur. A few months ago, they experienced a stroke of luck in building a project model using AI that models galaxy clusters under various dark matter and active galactic nuclei (AGN) feedback scenarios.

This AI solves the problem of the AGN mirroring the effects of dark matter self-interactions, when it pushes matter around; as it is able to differentiate between the effect of dark matter and AGN's, this means that we can better understand dark matter.

How does it do that?

As we know the AI will be fed a lot of data but what exactly is it looking for to make this distinction? The algorithm learns to recognise the subtle differences in the distribution of matter within galaxy clusters. It analyses weak gravitational lensing data. This in turn reveals the overall mass distribution and X-ray observations, this provides information about the hot gas in galaxy clusters. The recent research found that weak-lensing information primarily helps differentiate self-interacting models and the X-ray data proves more useful for disentangling different models of AGN feedback. Using this multiwavelength approach, a more comprehensive analysis of galaxy cluster dynamics can be conducted.

What does that mean for science in the long term?

With this new technology, all the data that is currently being collected can be analysed quicker and more efficiently allowing us to better understand the universe around us and the true laws that govern it. Not only the development occurring with AI but the development in the production of telescopes entails a less cryptic universe for scientists to untangle.

Is there anything left to develop?

The hunt for the history of the universe is not over yet and there is much to be revealed. AI technology is far from being sorted. For example, with this algorithm it still needs to be tested on actual astronomical observations rather than just the simulations made by the scientists. Furthermore, its limits are yet to be tested with it only currently having run on simple algorithms rather than more complex and velocity-dependent models.

Despite the technological advancements in the field of AI, our scientists have not found the whole story yet, dark matter which was once elusive has revealed a little more of itself to us but we are not done yet.

Newton's Law of Universal Gravitation - describes gravity as a force by stating that every particle attracts every other particle in the universe with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between their centres of mass.
Gravitational Lensing - when a celestial body causes a sufficient curvature in spacetime for the path of light around it to be visibly bent, as if by a lens.
Active Galactic Nuclei - a small region at the centre of some galaxies that is far brighter than can be explained by the stellar population alone
Spacetime - the concepts of time and three-dimensional space regarded as fused in a four-dimensional continuum.

articles

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THE PHYSICS BEHIND QUANTUM COMPUTING AND ITS ROLL IN ARTIFICIAL INTELLIGENCE

By: James Hackett

ABSTRACT

In recent times, we are almost constantly hearing about advancements in quantum computing technology, as well as the development of AI, with AI's progress being widely considered to be one of the problems humanity is going to face in the upcoming years and decades. Quantum computing too has been recently featured in the news, with Microsoft's Majorana topological quantum computing chip being focused on especially for the invention of a 'New State of Matter'. So, what physics makes quantum computing so powerful, and how does this aid Artificial Intelligence?

Quantum computers, as opposed to 'classical' computers, take advantage of quantum effects to improve efficiency of certain algorithms, allowing quantum computers to do things that classical computers cannot. In a classical computer, the data and instructions are processed using electrical transistors. These transistors work by taking in electrical signals, using high and low voltages to represent 'bits' and with a collection of many of these, any finite set of data can be represented. Transistors act as logic gates, where the transistor outputs an electrical signal based on the values of the inputs. Quantum computers use 'qubits' that can take both the value 1 and 0 simultaneously, until observed, to store and process data. (1)

What allows them to do this? Qubits take advantage of the principle of quantum superposition, which dictates that particles (or qubits) can take multiple states (spins and positions) simultaneously, with all the states combined being the 'quantum state' of the particle. This quantum state forms what is known as a 'wave function', a complex function that can determine the probability of a particle being in any given state.

When observed, the particle/qubit stops being in quantum superposition, the wavefunction 'collapses' and the particle acts as one would expect in daily experience (100% probability for 1 state), allowing for a single output for a quantum computer to be determined. In simple terms, the qubits choose a 1 or a 0 to represent the data it has stored. (2)

On top of this, qubits take advantage of quantum entanglement, which means the states of two qubits can be interlinked, so when observed, both qubits would have the same state. (1) This means qubits within a quantum computer can be interlinked, allowing the quantum computer to do things classical computers are unable to do in a similar time frame.

What does this all mean for AI? AI language models, currently require a massive amount of energy expenditure as well as data for training. GPT-3, one of the most famous AI models is estimated to use 1300 MWh of electricity, (3) however quantum computing promises to change this. Using Quantum Computing optimised algorithms, quantum computing company Quantinuum claims that the computers cost 30,000x less energy to complete a task known as "random circuit sampling" as well as being able to complete it in less time, with a similar result being predicted for the use in AI. (4) With the decrease in significant performance improvements for classical computers, quantum computing is assumed to be one of the major breakthroughs in AI.

Bits - units of data that can be 2 different values, 1 or 0

Qubits - quantum bits

Superposition – the ability of a quantum system to exist in multiple states simultaneously until a measurement is made

Wavefunction - a mathematical description of a quantum state of a particle as a function of momentum, time, position, and spin

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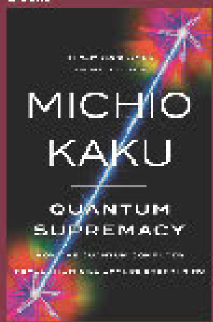

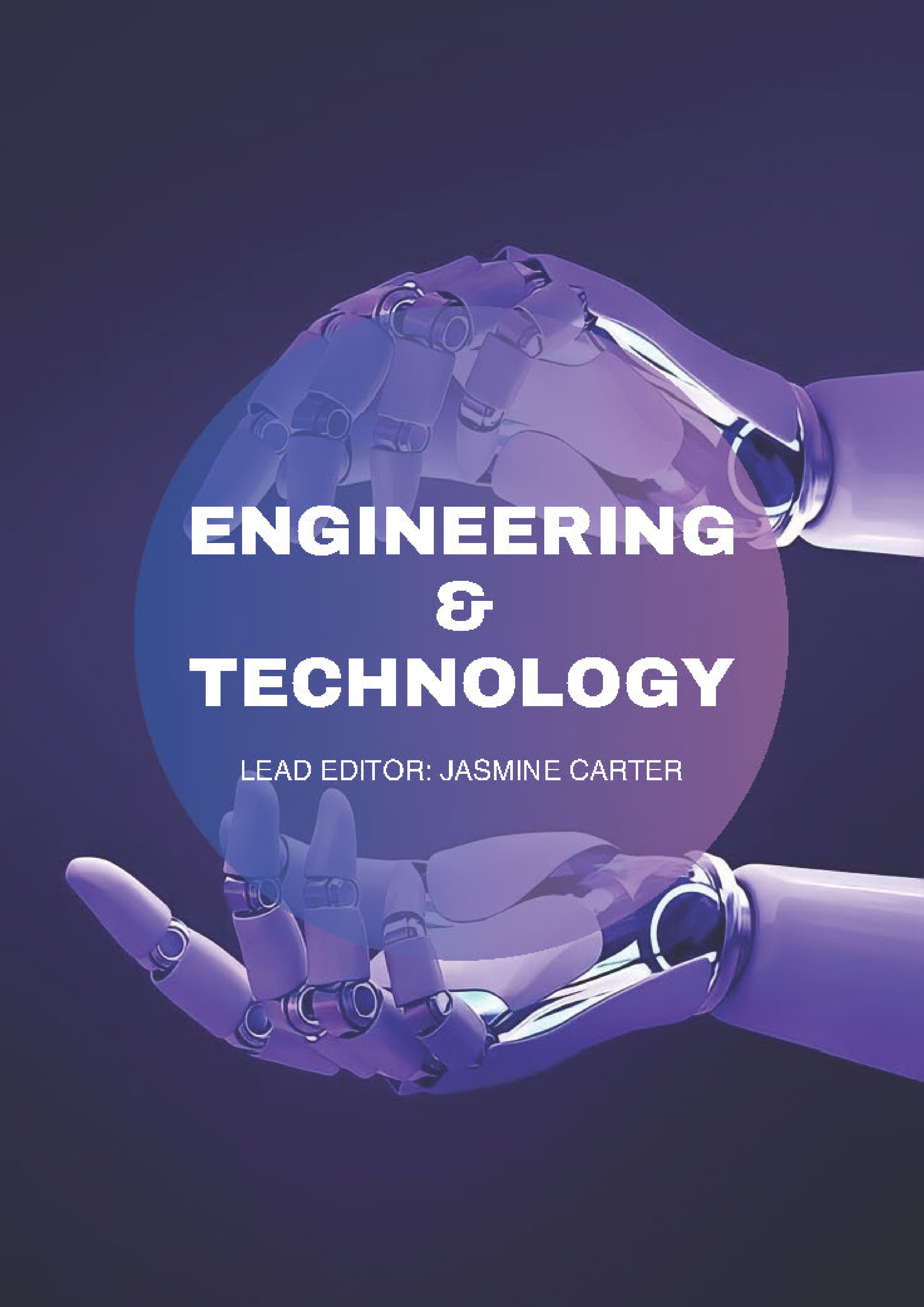

ENGINEERING & TECHNOLOGY

LEAD EDITOR: JASMINE CARTER

THE IMPACT OF AI IN HUMANOID ROBOTICS FOR CARE AND INDUSTRY.

By: Leon Sloanes-Ford

ABSTRACT

Commercial robotics has been developing at a rapid pace in the last 70 years, going all the way back to 1954, where George Devol had just invented the Unimate, the first commercially available, and digitally programmable robot. It was clunky, slow and manually programmed, which required a lot of manual labour to keep in shape, and active throughout its lifespan. With all the developments in AI in the last few years, the biggest question people have is how these robots will make life easier for humanity.

Recently, there has been a decrease in manual labour roles, especially more undesirable and tedious, or potentially dangerous jobs, such as caring for the elderly, waste management, dealing with radiation, and managing dive bell. One of the biggest reasons for decreases in these areas is due to education becoming more accessible, causing many to turn away from this type of employment and start focussing on more tertiary and quaternary roles instead. This decrease in employment in these unpleasant roles are leaving some industries pushed to their limits, which is where autonomous robots come into play. Two weeks ago, I watched a video released by Figure AI (a predominant AI and robotics company) demonstrating two of their Figure 02 robots working together under their VLA (Video Language Action) model, Helix. The two robots were able to pick up groceries, which they had never seen before, and store them in the correct places. While the task may seem simple, it is revolutionary for a robot to be able to complete a task such as this entirely autonomously.

The reason why this demonstration was so revolutionary was because it highlighted its capabilities when it came to helping in caring based roles, especially in the case of the elderly or people with mobility issues. While the video only depicted the robots putting away groceries, further videos on Figure AI's website show the model being able to distinguish between items and follow tasks based on those items in real time, allowing for more advanced tasks in the home, such as retrieving clothes, shoes and other items, cleaning, and even cooking for those in need. Also, thanks to developments in health sensors, another feature of humanoid robotics would entail being able to recognise whether a life-threatening accident had occurred or not, leading to automatically being able to contact emergency services, or even perform first aid themselves. According to ROSPA, accidents cause approximately 6000 deaths per year in the UK, with over-65s accounting for 19% of all A&E home attendances. Many of these deaths and accidents are said to be easily avoided or treated with proper care.

Beyond caregiving, robots powered by AI are stepping into jobs that are just too dangerous for people. Take nuclear power plants or deep-sea diving operations, places where humans risk exposure to deadly radiation or extreme underwater pressure. Now, robots – such as Figure 02's model with smart sensors and the ability to learn due to the Helix model – on the job can handle tasks like cleaning up toxic waste, fixing underwater equipment, or dealing with radioactive materials, all without putting workers in harm's way. For example, they could enter radiation zones to fix leaks or shut down reactors safely. In waste management, they could sort through dangerous rubbish. Since these robots make decisions in real time, using cameras and sensors, they would be able to adapt to surprises, like sudden leaks or equipment failures, and assess the situation. Of course, these robots may be very expensive to purchase, but the potential is huge. These machines could solve labour shortages while preventing countless workplace deaths. As the technology improves, robots might soon take over the riskiest jobs entirely, making industries safer and more efficient than ever.

Autonomously – Capable of doing tasks and reasoning on its own
Tertiary – A category of employment which relates to providing services such as healthcare to others
Quaternary – A category of employment which relates to providing information services such as consultancy to others.
Distinguish – Being able to identify and choose between things
Tedious – Repetitive, tiring and dull
Revolutionary – Something which causes a dramatic and large change to society

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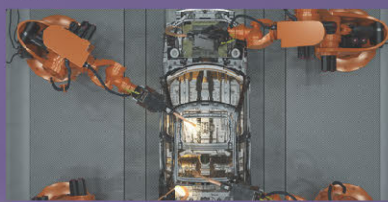

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IS THE FUTURE OF TECHNOLOGY DESTINED TO RUN OFF "VIBES"?

By: Karl Edochie

ABSTRACT

Andrej Karpathy, the co-founder of OpenAI and a former AI leader at Tesla, came up with the term 'vibe coding' in February 2025. The concept describes a method of coding, by which programmers prompt LLMs (Large Language Models) to create functional code by using natural language. Previously, Karpathy has described the idea of 'vibe coding', referring to English as "the hottest new programming language". Karpathy describes his approach as conversational, using voice commands while AI generates the actual code. "It's not really code—I just see stuff, say stuff, run stuff, and copy-paste stuff, and it mostly works."1

AI has developed rapidly in recent years and there is continuous concern for the potential of AI to replace the job of the programmer. Integrating 'vibe coding' into production-level code has enabled for smaller teams of engineers to build, iterate and deliver technology in a fraction of the time previously required.

Despite the rapid transition towards vibe coding, there are several limitations with the technique. One of the core principles of vibe coding lies in fully trusting LLMs and "forgetting the code even exists", therefore, troubleshooting errors is particularly difficult in cases where LLMs are unable to fix their own errors1. Moreover, LLMs aren't perfect, issues have been raised about understanding and accountability—whilst code may work, best practices can be neglected in vital areas (including security) therefore developers may use AI-generated code without fully comprehending its functionality, making them be liable for an unknown black box of code2.

Alternatively, others argue 'vibe coding' sets a bad precedent for other professions. What would you assume of a self-proclaimed 'vibe surgeon' or a 'vibe anaesthetist'—perhaps a 'vibe lawyer' or a 'vibe firefighter'? Attaching these principles onto existing professions can be very dangerous, as people who rely on the services provided by these professions may not be comfortable with their personal information (such as credit card information, phone numbers, home address etc.) being managed based on 'vibes'2. Or rather, patients may not want their surgeon precariously watching AI-controlled machinery perform life-saving operations from computer screens.

Although throwing 'vibe coding' into production-level software has its problems, there is certainly merit for the non-programmer. With the rise of vibe coding, software has become more accessible, providing people who do not speak the language of code, a way to envision ideas and watch them come to life through natural language – whether that is small programs to automate everyday tasks, or implementing a backend for a local business3.

Is 'vibe coding' a step in the right direction? Well, that is hard to say. Change is inevitable, and sizeable changes in technology, along with the way that we use technology calls into question—what is the goal of human advancement? Often, the obvious response describes humans reaching a level of advancement where we aren't required to work—one where all tedious tasks aren't compulsory and the only activities remaining are recreational. But, perhaps advancement in technology (such as AI) drives us towards redundancy, taking away the things we find value in.

Large Language Model (LLM) – A type of machine learning model trained with large databases of human language and designed to processing natural language for performing tasks such as language generation.
Black Box – A usually complicated electronic device whose internal mechanisms is hidden from or mysterious to the user.
Troubleshooting – A systematic approach to trace and correct issues with machines, electronics, computers and software systems.
Backend – The part of a computer system or application that is not directly accessed by the user, typically the responsibility for storing and manipulating data.

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AUTONOMOUS SYSTEMS AND THE ROLE OF AI IN ROBOTICS AND SELF-DRIVING VEHICLES

By: Moumin Yassin

ABSTRACT

AI (artificial intelligence) has not only changed our lives but has undergone significant changes since the day of its inception. As AI continues to evolve, with other emerging technologies, the role of AI in autonomous systems is an exciting area to explore. From self-driving cars navigating city streets to robots performing intricate tasks in manufacturing plants, AI inference capabilities are enhancing safety, precision, and productivity. This article attempts to decipher what lies beneath the hood Role of AI in Autonomous Systems.

The future of modern organizations is being shaped by the combination of AI and autonomous systems. While AI serves as the "seat of intellect," autonomous systems serve as the "physical parts" of the body. The integration of AI and autonomous systems is essential for creating systems that operate without human intervention. There are several ways in which AI is contributing to the realization of fully autonomous systems. The most notable being, autonomous vehicles, which use AI to process various types of data, including visual, radar, and LiDAR (light detection and ranging) data to navigate through.

The significance of AI in autonomous systems lies in its ability to enhance functionality, efficiency, and safety. For instance, self-driving vehicles leverage machine learning algorithms and sophisticated sensors to navigate complex environments, while autonomous drones and robotic systems perform tasks ranging from precision agriculture to hazardous material handling.

The development of AI chips has revolutionized the field of robotics, enabling more sophisticated and efficient systems. One of the most critical aspects of autonomous vehicle technology is the ability to process massive amounts of data captured by various sensors. AI chips play a crucial role in this process, handling inputs from cameras, LiDAR, radar, and ultrasound sensors. This data processing requires high TOPS (Trillions or Tera Operations per Second) to perform multiple challenging tasks simultaneously, such as object extraction, detection, segmentation, and tracking.

Waymo's LiDAR technology, for example, provides a 360-degree view of the vehicle's surroundings. The AI chips process this data in real-time, allowing the vehicle to perceive its environment accurately. However, the sensors and chips required for this level of processing are currently expensive, which poses a challenge for widespread adoption.

To address the high computational demands, many autonomous vehicles currently use GPUs (Graphics Processing Units) for their core AI processing. While GPUs are powerful, they are not as fast or cost-effective as custom ASIC chips (Application-Specific Integrated Circuits) designed specifically for autonomous driving tasks.

Despite the many advantages of the integration of AI chips in autonomous systems and robotics, it also presents significant challenges, particularly in thermal management. As these devices become more sophisticated, they generate substantial heat during operation. This heat buildup can lead to the deterioration of the device if not properly managed. Electronics have a narrow temperature range for efficient functioning, making thermal management crucial for maintaining performance and longevity.

Researchers are exploring various materials to transfer heat away from critical components without adding weight or increasing manufacturing costs. One promising option is phase change materials, which absorb or release heat during transitions between melting and solidifying states. However, current solutions like thermal greases have limitations of their own that need to be considered before their introduction into AI operations.

Inception - the establishment or starting point of an institution or activity.
Decipher - interpret, succeed in understanding.
Leverage - use something to maximum advantage.
Algorithms - a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.
Computational - the use of computers, especially as a subject of research or study.
Integration - the action or process of combining one thing with another to form a whole.

ARTIFICIAL INTELLIGENCE IN ROBOTICS: FROM AUTOMATION TO AUTONOMOUS SYSTEMS

research paper

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THE MATHEMATICS BEHIND A GPT

By: Aaron Chen

ABSTRACT

The recent rise in generative artificial intelligence has been almost impossible to ignore. However, the gap between those who use it and those who acknowledge how it works is vast. Whilst AI indeed has immense potential in a range of fields, its practical value remains uncertain without a deep understanding of its mechanisms. This article will simplify how these models work, as well as how they were trained using mathematics (vectors, probability, and calculus).

Generative Pretrained Transformers (more commonly known as GPTs) are a form of neural network that spots patterns within data, and constructs something new based on these patterns. Whilst their applications are diverse, from language translation to video captioning, their most prominent use today has been within large language models (generating human-like text in response to a prompt or question). Although this seems like an overwhelming task for a machine, companies that train these models begin by splitting the process into manageable portions.

Speaking of splitting, the first step is to break the question into 'tokens' (words, syllables or punctuation, depending on the context). Each of these tokens has a vector, which can be thought of as a 'code' for the actual meaning of the token. For instance, GPT-3 uses 2048 vectors, each being 12,288 numbers long.

A common way to visualise these tokens is for them to be points on an extremely sophisticated graph (if a point on a 2-dimensional graph had only an x and y coordinate, tokens on this graph would have 12,288 coordinates). Words with similar meanings – such as 'happy', 'joyful', and 'content' – would share certain coordinates, meaning they would cluster close together in the same space. Remarkably, using mathematical operations can reveal relationships between words. If you calculate the distance between the words 'France' and 'Paris', it would be almost identical to the distance between the words 'Japan' and 'Tokyo'.1

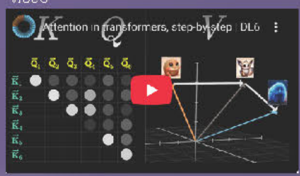
Once all the tokens are mapped out, the model utilises a 'softmax function', which assigns a probability to each token. Initially, without any input, the probabilities are essentially random. However, as the AI learns from pre-existing text, it gradually recognises more about context and the relationships between words. Consequently, probability distributions begin to take place.2 When writing a response, the AI utilises these probabilities to determine which words would fit well within the context of the question. For example, if finishing the statement, 'the colour of the sky is _____', the tokens 'colour' and 'sky' would increase the probability of the adjective 'blue' dramatically, meaning it would be more likely to be picked. Crucially, after every iteration, the values update depending on the new token added.

With such a complex system with several parameters, forming a satisfactory response may be tricky. For instance, how do you compromise between the response being too predictable and completely irrelevant? To minimise these errors, large language models use calculus, specifically through an algorithm called 'gradient descent'.3 During training, the model employs a 'loss function', which measures how different the AI's predicted token was compared to the real thing. If the loss is high compared to how relevant the token is within the sentence (which the AI calculates using partial derivatives), the error margin – or 'cost' – for that prediction will be high too. The AI then uses the chain rule to backpropagate the error made, reducing the likelihood of it occurring a second time.

These large language models are far from perfect. Even within ideal conditions (such as being free from false information), there are ethical concerns regarding ownership of work, as well as human prejudices inadvertently causing the AI to repeat certain biases. However, the more we understand how the model works, the closer we can get to perfecting the system, as well as unchaining its potential.

Calculus – a branch of mathematics that deals with rates of change
Neural network – AI that is taught to process data similar to the human brain
Vector – a way to show a point's position and direction within a space
Function – a relation or expression involving one or more variables
Iteration – the repetition of a process
Backpropagate – trace back to the start to update its values

video



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HOW HAS AI REVOLUTIONISED MANUFACTURING?

By: Gerrard Robertson-Mccaffery

ABSTRACT

Within this article I will be discussing how Artificial Intelligence (AI) has impacted our manufacturing industry and changed what jobs are valued in modern day society. This article aims to touch on 3 main points: the shift away from manual labour in factories, increasing integration of AI to design solutions, and how AI could change manufacturing in the future.

In the past, many quality control and design processes were completed with humans at the helm, although this is now changing with more than 50% of European manufacturers using some form of AI within factories. So, this posits the question of "How is AI making industry better and is it better than humans?". This can be difficult to answer as on one hand, AI can iterate thousands of designs in a short span of time such as with General Motors using an AI tool to design a 3D-printed seat bracket that consolidated eight different parts into one that was 40% lighter and 20% stronger than the previous one made by humans. Despite the significant benefits that implementing AI into manufacturing processes would reap, it would not be without its own drawbacks. Effective AIs require large volumes of data to produce accurate and relevant results in its tasks. These data sets still employ human work to generate them, so it doesn't fall foul of GIGO (Garbage in Garbage Out). In addition, humans are required to filter out any bad solutions that the AI may generate. This is because an AI might make the most efficient solution and fail to consider human comfort without human reinforcement and intervention, thus making it more suited to designing individual parts rather than the entire product. Currently, AI is used to build products in large manufacturing lines, and to generate better solutions with heavy human input and parameters for what is wanted. Overall, AI has allowed products to be built quickly and efficiently without human interaction and has allowed for untold innovation that assists human output, though in the end humans won't be pushed out of the design cycle just yet!

Now that you know how it affects us today, how will AI affect us in the future and what could this mean for our jobs? Will we all end up like the humans from Wall-E? Although I doubt our world would ever mirror a world quite as drastic as the dystopia presented in Wall-E, it is inevitable that AI will continue to improve, especially thanks to Microsoft's new Majorana 1 chip that has more power than every computer combined. Such computational power could propel our LLMs (Large Language Models) to become very powerful and intuitive when it comes to solving problems of the future. The future is bright with more advances made every year due to improvements in research and development. Perhaps we will be able to eliminate the need for menial labour altogether, who knows!

Integration - Combining or incorporating different elements into a unified whole.
Iterate - The process of repeating a set of operations, often with the aim of approaching a desired goal or result.
Consolidated - To combine several things into a single, more effective or coherent whole.
Dystopia - An imagined place or state in which everything is unpleasant or bad, typically a totalitarian or environmentally degraded society.

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