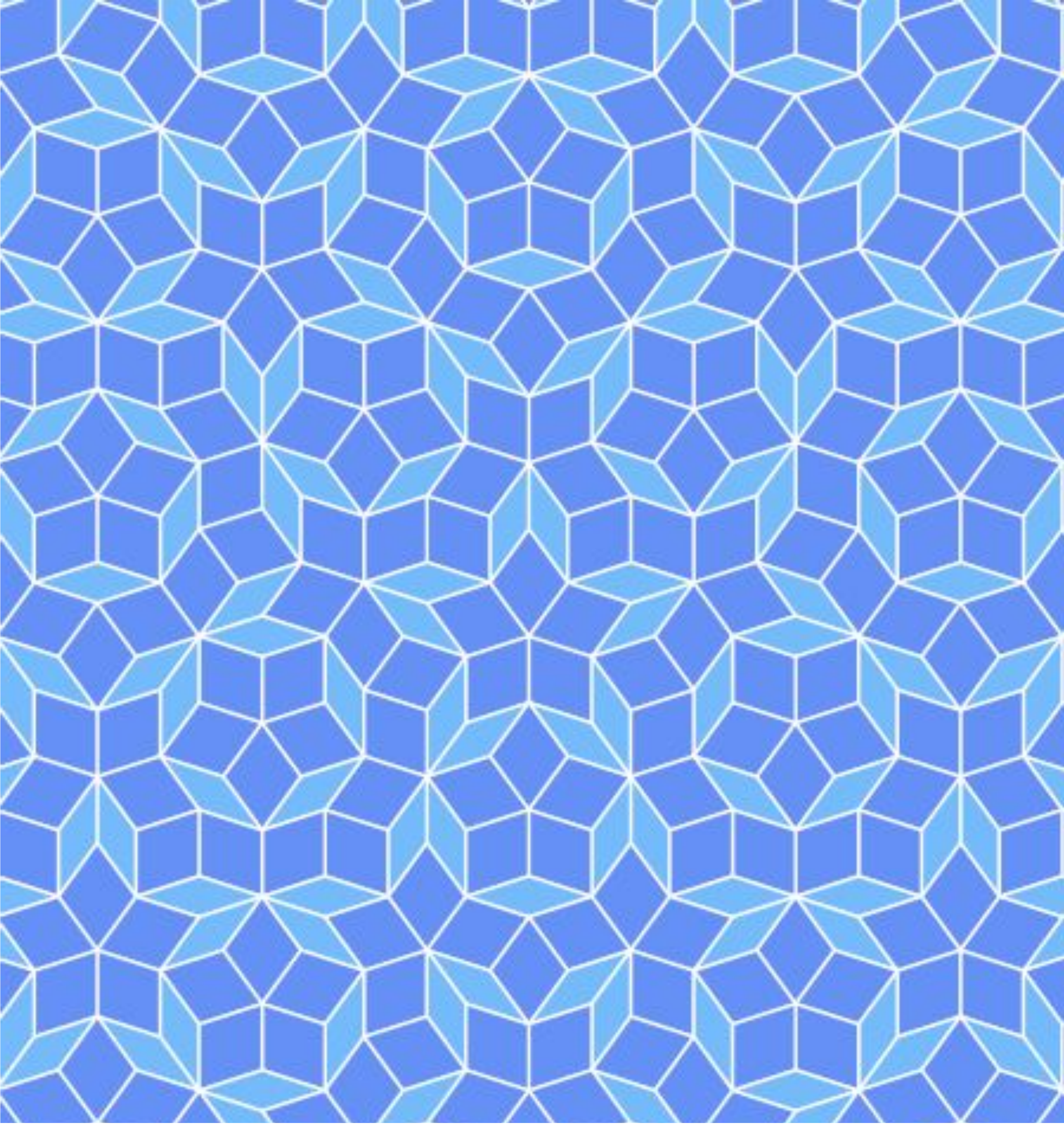

THE PENROSE MAGAZINE

Science, Technology, Engineering, Math

Issue 1, 24 Nov 2025

Welcome to the First Issue of Penrose Magazine!

Penrose is a student led STEM magazine where we hope to establish a community of young people who are passionate about STEM and want to share with their peers and further their knowledge to beyond their curriculum. In this instalment of the magazine, students have researched a variety of difficult topics from the effects of time dilation on GPS to the usefulness of robot surgeons. We hope to continue fostering an environment where people are encouraged to push themselves to create pieces of work and support each other to grow. Thank you so much for choosing to read Penrose and we hope you enjoy.

This publication is named after Sir Roger Penrose, British physicist, mathematician, and nobel prize laureate in physics for "the discovery that black hole formation is a robust prediction of the general theory of relativity."

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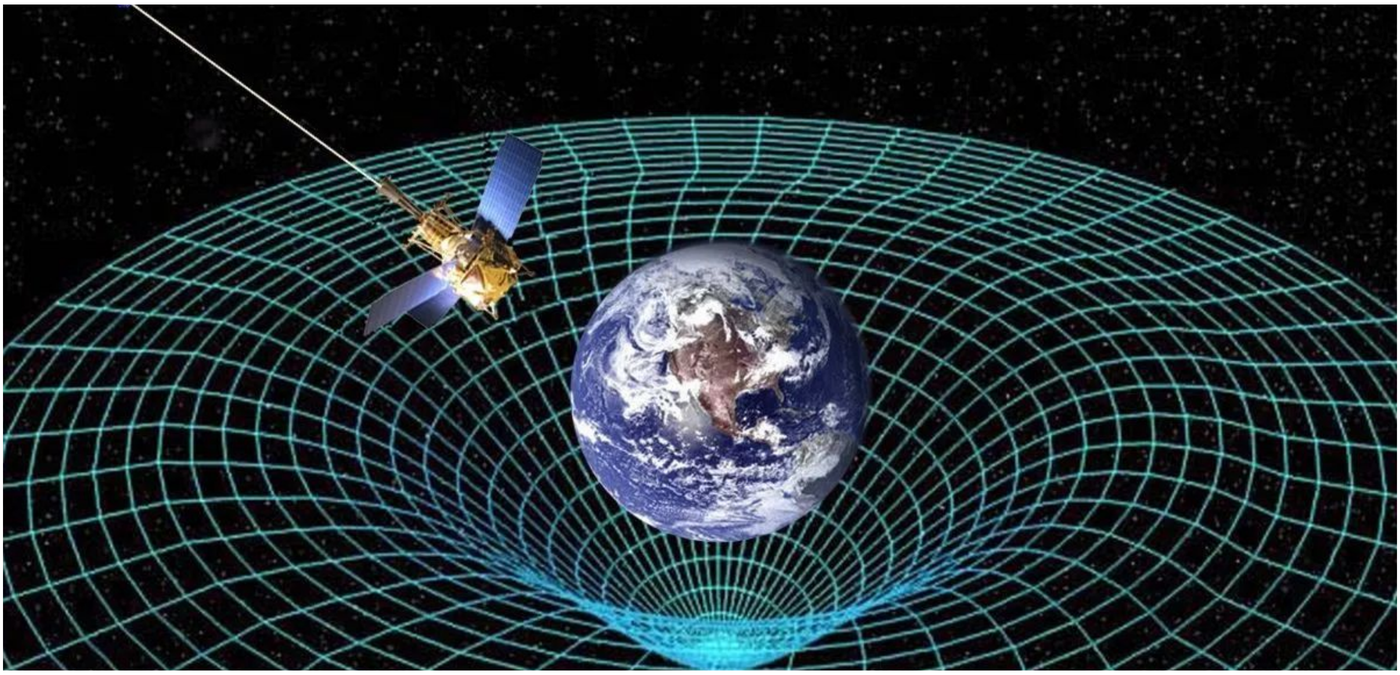

The Effects of Time Dilation on GPS

The GPS began in 1973 as a joint civil and military technical programme headed by the US Department of Defence. With a complete constellation of 24 satellites operational by 1993, GPS can now pinpoint a three-dimensional position to meter-level accuracy and time to the 10-nanosecond level anywhere in the world [1]. In bringing about the project of the GPS, engineers had to think about many things from signal strength and multipath interference to orbital mechanics and satellite positioning. Among these issues was the practical concern of the predictions of Einstein's theory of relativity regarding time dilation [2].

Time dilation is affected by two things: a relative velocity between two objects (kinetic time dilation) or a difference in the gravitational potential between their two locations (gravitational time dilation).

Time dilation due to a relative velocity is when an observer will measure a moving clock as ticking more slowly than a clock at rest in the observer's own frame of reference, after compensating for signal delays such as the Doppler effect – an effect caused by the changing distance between the observer and moving object, i.e. clock. Whilst time dilation due to a difference in the gravitational potential between two locations is where a clock experiencing a higher gravitational potential (i.e. further out from a massive body) will have time ticking faster than the same clock experiencing a lower gravitational potential (i.e. nearer to a massive body) [3].

To better understand kinetic time dilation, an example can be used. With our frame of reference being the surface of the Earth, If a man standing on throws a ball at 10 m/s while on a skateboard going at 5 m/s, that the ball would appear to be moving at 15 m/s. However, the ball's speed would appear to remain at 10 m/s to the main on the skateboard.

Additionally, differing frames of reference between an observer and an object can result in gravitational time dilation. If a pilot shined a flashlight out of the window of a grounded field in which no gravitational field exists, it would appear the light was travelling at 299 792 458 m/s (c). If this plane took off, flying at a constant speed of 150 m/s, the light would now appear to be moving at 150 + c m/s. Conversely, this logic does not hold true with regards to the speed of light as Einstein found it: the speed of light is constant no matter the frame of reference [4].

Einstein discovered from his theory of special relativity that light has an absolute speed of 299 792 458 m/s regardless of any frame of reference. This works as time moves slower for those moving faster, and faster for those moving slower.

In the case of the plane travelling at 150 m/s, the pilot would experience time at a slower rate than a man on the surface of the earth observing the plane, making the speed of light coming out from the torch the same for both the pilot and the man.

Einstein expressed the concept that time is a subjective experience in the formula below "by deriving the Lorentz transformation under the assumptions of the principle of relativity and the constancy of the speed of light in any inertial reference frame, and by abandoning the mechanistic aether as unnecessary [5]."

$$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

As GPS is a system which uses satellites travelling with an average orbital speed of roughly 3,900 m/s, time dilation will have a significant effect on it. In fact, the result is an error of about -7 microseconds per day in the satellite. Though the net effect when gravitational time dilation for satellites which orbit at an altitude of 20 (183 km above the surface of Earth) is only approximately only 38 microseconds per day, a positional error of up to 11.4 kilometres may occur within the same period [6].

In order to counter the effect of time dilation on the positional accuracy of GPS systems, three main measures can be considered: pre-programming the atomic clocks, continuous monitoring and corrections, and relativistic modelling in GPS algorithms.

Pre-programming the atomic clocks on the GPS satellites before launch to run slightly slower than clocks on Earth could counter the time gain from net effect of their high velocity and higher gravitational potential [7]. Additionally, continuously monitoring and correcting GPS ground control stations allows clocks to synchronize. This is achieved by tracking the satellites' positions and their clock performance, and if any drift is detected, it is corrected via commands sent to the satellites. Relativistic modelling in GPS algorithms can also be used through picking of signals from satellites through GPS receivers on the ground. These signals can be used to incorporate special relativistic time corrections into their calculations [8].

The GPS system also accounts for the fact that Earth's gravitational field is not uniform, so additional corrections are made for other factors that might influence the satellites' clocks and orbits [9].

In conclusion, without the necessary corrections being made to adjust GPS for the effects of time dilation, its positioning precision would be rendered useless within minutes. The countless number of people who use it on a day to day basis would be left stranded due to their trust and dependency on the reliability of the precision of the GPS.

By Max Yu '26

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ImageNet: The Data Behind AI

In recent years, AI has been assimilated into modern society, from being used as a product itself, to being used to enhance an existing product. However, the growth in research and development of technologies have made it difficult to elevate AI further. Many Large Language Models (LLMs) like GPT or visual models like Midjourney are struggling to find new, diverse, and high-quality data to be trained on.

Despite the improvements AI has made, this is not the first time its progression has faced a similar issue. In 2006, researchers were attempting to improve AI's capability in performing computer vision tasks. Most believed that improving the algorithms the AI used was the key to solving this problem, yet despite their best efforts, little changed. This is when an existing technology known as WordNet was used to create a solution.

In 1985, WordNet, a database of English words, was developed by Professor George Armitage Miller while at Princeton University. Unlike a normal dictionary, WordNet grouped synonyms together to create synsets: a collection of words representing the same concept [1]. Synsets allowed the smallest group of words that uniquely identified with a certain idea to be stored together, thus reducing the chance of error by the misuse of ambiguous wording in language models. This minimalist principle creates complete representations of each concept within the database, allowing words to be interchangeable with another when in the same synset [2].

WordNet's main use was to create a lexical database – a structured database containing information about words which abided with the theories of human semantic memory [1]. Specifically, WordNet took inspiration from the portion of memory involved with storage and retrieval that organizes concepts by their relations to each other. WordNet was also used to train a branch of AI that focuses on the relation between technology and linguistics known as natural language processing (NLP) models. As a result, WordNet was a factor in transforming NLP models into what they are today: LLMs. WordNet would remain entirely a linguistic database until utilized and built onto by Dr. Fei-Fei Li roughly 20 years after its creation.

Dr. Fei-Fei Li is a computer scientist and researcher who moved from China to the USA when she was a teenager. In 1999, she graduated from Princeton with a bachelor's degree in physics before obtaining her PhD in electrical engineering from California Institute of Technology (CalTech) in 2005. During her PhD at CalTech, Li was advised by her professor to research visual learning models. It was then that she noticed there was a lack of accuracy provided by visual models. Unlike many computer scientists who had found the same problem, Li believed that the issue was the lack of useful training data supplied to the models, rather than the quality of the models themselves. In 2007, Li met Christiane Fellbaum, a WordNet researcher from Princeton University, leading her to develop the idea of ImageNet. Li believed that visual data organized according to the same hierarchy used by WordNet would allow AI models to overcome their lack of accuracy.

ImageNet was created with the goal to populate the 80,000 synsets preestablished by WordNet with 500-1000 clean images each. This would result in a dataset of diverse high-quality images that AI models could use to create higher quality results [3]. Combining images with language, ImageNet helped curate accurate descriptions for different visual concepts. To further establish the diversity of the data, synsets in other languages such as Spanish and Chinese were used [3]. When ensuring the data collected was clean and up to standard, Amazon Mechanical Turk, a software that enables businesses to hire users to do simple online tasks, was used to crowdsource human verification to determine the usability of the data. This method decreased the possibility of human error, as several users were required to label and rate the usability of a single image. From this, only the most practical data was permitted to be stored in the dataset, therefore reducing the chance of hallucinations: incorrect output results made by AI models.

ImageNet's precision and accuracy led to its use in several areas quickly after its creation. This included tree-based image classification, automatic logic localization, and non-parametric object recognition. Tree-based classification allows synsets to be displayed as subsets of broader synsets, useful for more specific categorizations and improved accuracy in models. Automatic logic localization allows a model to recognize where and how a subject is spatially located in an image. This contributed to advancements in contextual understandings from models. Though these methods were significant in the evolution of visual AI models, non-parametric object recognition is often recognized as the most important.

ImageNet's application in non-parametric object recognition allows images with unknown subjects to be related and classified based on images already stored in the ImageNet database. For example, if a photo is input of a rare species of bird, the model will use ImageNet to find photos that are visually similar, identify the labels assigned to this image, and output what type of species that bird is. This allowed models to recognize both low- and high-quality images, even recognizing objects completely new to the model by comparing it to similar concepts, also known as its 'neighbors', using the Naive Bayesian Nearest Neighbor approach [2].

In this day and age, AI has hit another roadblock. Though the technology has improved since 2006, AI continues to provide inaccurate and biased results causing a lack of trustworthiness in language intensive and highly regulated areas such as finance, health and law. In the past 15 years since ImageNet was originally developed, most image datasets have been exhausted by AI models, causing them to reach a stagnation in their growth. The lack of a new and diverse range of data has resulted in AI models relying on synthetic data, artificially generated data, instead of authentic data. This has increased the risk of hallucinations rather than improving AI models as intended.

Though ImageNet provided the next step in contributing to what AI is today, it, like most other data sets, has been exhausted by AI learning models. This suggests that the next step may be to enhance the algorithms and processing power capabilities which AI models use, rather than struggling to find more data. A higher computational power may allow AI to analyze data, including images, more precisely. While we may push past this boundary again and create new breakthroughs in both LLMs and visual models, the cyclical structure of AI growth suggests we may be faced with similar challenges in coming years.

By Eleanore Shiner '26

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The Nature of Dark Matter

Fritz Zwicky was a Swiss astronomer born in 1898 who is mainly celebrated as the 'father of dark matter [1].' In the early 1930s, while studying Hubble's observations of the Coma Cluster of galaxies, he noticed an anomaly [2]. Zwicky noted that galaxies in the cluster were orbiting one another much faster than expected given the amount of visible mass they had [3]. He proposed, in the journal of the Swiss Physical Society, the existence of an unseen substance which he called dunkle Materie (dark matter). Zwicky theorised the high orbital speeds may be due to dark matter tugging gravitationally on these galaxies.

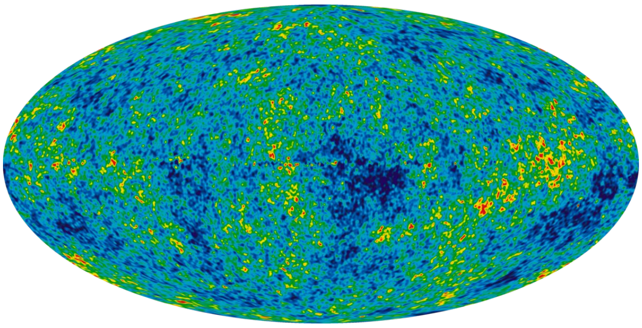
Since then, researchers have confirmed that this mysterious material is roughly six times more abundant than the normal matter which makes up approximately 27% of the universe [3], [4]. Yet despite seeing dark matter throughout the universe, its nature is still unknown. Unlike normal matter, dark matter does not interact with the electromagnetic force. This means it does not absorb, reflect or emit light, making it extremely hard to spot. In fact, researchers have been able to infer the existence of dark matter only from the gravitational effect it seems to have on visible matter [4].

However, there are several theories of what dark matter might be. One is that it consists of weakly interacting massive particles called WIMPs. WIMPs are theorized to be a type of heavy, electromagnetically neutral subatomic particles that make up most dark matter [5]. As the amount of baryonic substances has been determined by measuring the abundance of elements heavier than hydrogen that were created in the first few minutes after the Big Bang, WIMPs are assumed to be "non-baryonic" (i.e. protons and neutrons) [5].

Additionally, they are assumed to be electromagnetically neutral as they do not leave tracks of ionized particles or curve in magnetic fields [6]. Furthermore, WIMPs interact through gravity and weak nuclear force, which is the mechanism of interaction between subatomic particles responsible for the radioactive decay of atoms. This type of interaction results in the production of gamma rays when WIMPs collide. NASA's Scientific Visualisation Studio has created an animation to represent this phenomenon [7]:

https://svs.gsfc.nasa.gov/10955#:~:text=Weakly%20Interacting%20Massive%20Particles%20%2C%20or,annihilate%20and%20make%20%20gamma%20rays

When WIMPs interact with gravity they are theorized to clump together and exert gravitational attraction. This would explain the anomaly that Zwicky noticed, since the dark matter particles attracted the galaxies in the Coma Cluster, causing them to orbit each other faster.



The second possible type of dark matter is Massive Compact Halo Objects (MACHOs). MACHOs are made of ordinary matter, like protons, neutrons and electrons. They include objects like faint stars (red, white and brown dwarfs), neutron stars, and a type of hypothetical black hole that formed in the first second after the Big Bang known as a primordial black hole [8], [9]. Therefore, dark matter seems to be composed of both baryonic and non-baryonic matter, where the component that consists of regular matter does not give off much light, making it hard to detect in the Universe [10].

In terms of testing for dark matter, researchers use large, sensitive detectors located deep underground to directly search for the dark matter particles that may continually pass through the Earth. Researchers can also search for dark matter indirectly through specific signatures in cosmic rays and gamma rays [11].

Therefore, although its nature is still mostly unknown, there are a few theories of what dark matter could be. According to Earth.com; "As technology progresses, the hope is to directly detect dark matter particles or to find new evidence that could either confirm or challenge our current theories about the composition of the universe."

By Maria Zenchenko '26

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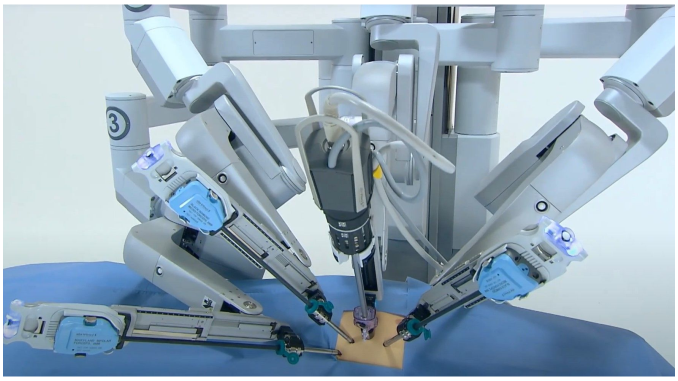
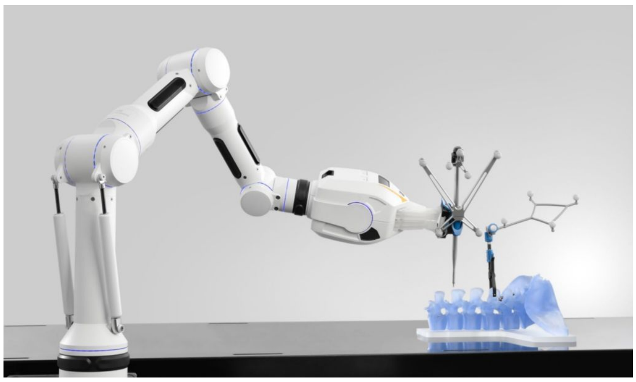


Robot Surgeons: How Soft Robotics is used in Minimally Invasive Surgery

Robotics has revolutionised a multitude of industries and is now on the way to conquering the medical field. Many desirable traits of robots can now be utilized to improve the safety, comfort and recovery of patients. The role of soft robotics in minimally invasive surgeries is a concept that recently emerged but has made significant progress since.

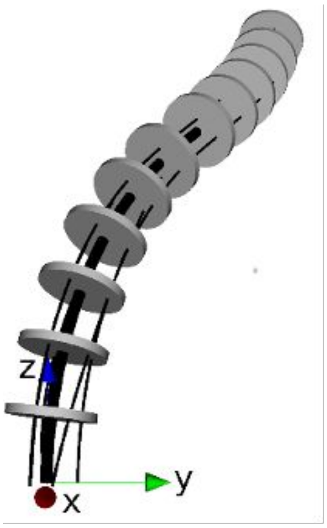
Minimally invasive surgeries (MISs) are prominent in modern medical procedures as they are safer, less painful and offer patients quicker recoveries with minimal tissue damage [1]. The surgery works by inserting slender instruments through small incisions, as opposed to traditional surgeries where large open cuts are made [2]. As demand for these surgeries increase, the use of robots proves essential due to the high levels of accuracy and reliability required. In common MIS procedures, a surgeon guides a rigid robot, such as the widely used Da Vinci robot, using a console and high-resolution camera, while the robot in turn controls the movement of surgical tools [3]. The system has high precision and stability, but due to a traditional robot's large, inflexible shape, it is incapable of navigating complex routes and tight spaces, potentially causing damage to surrounding tissues. This inspired the development of soft robots for safer operations, with EU project 'STIFF-FLOP' in 2012 leading the shift away from traditional robots [4].

Soft robots are made of cushiony, flexible materials, typically silicone and rubber. This gives them a wide range of movement, as they can deform, bend, expand and change stiffness [4]. As a result, they are able to easily navigate a human body and reach confined spaces that were previously inaccessible without causing damage. These robots enhance the precise movements of a surgeon's hand, which reduces surgical errors; this dexterity is invaluable in complex surgeries, such as neurosurgery and tumour removal, where very subtle, intricate manoeuvres are needed. The real-time feedback and visualisation features allow a surgeon to adjust the force and pressure they apply [1]. This process allows critical structures in the path to be easily identified, an instrumental tool in minimising surgical complications. Additionally, the use of soft robots in the medical industry benefits surgeons by enhancing their comfort. A surgeon can operate with ease as their hand movements are translated into finer, more controlled motion by the robot, which reduces the surgeon's fatigue, allowing for more consistent performance [1]. As with most robotic applications, key advantages of using soft robots include 24-hour operation, which is vital in high-demand surgeries, and the reduction of human error.

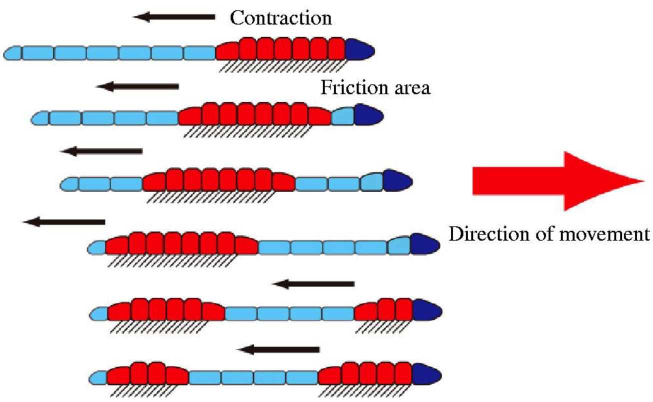


Fluid actuators are the most common mechanism used to control the motion of soft robots [1]. It utilises the controlled flow of pressurised fluids to inflate certain hollow channels in the robot's structure to change shape and move flexibly with control. This mechanism gives soft robots high levels of adaptability as their stretchy elastomer body can deform in response to internal pressure changes. The design of fluid-actuated soft robots includes many channels, sacs and chambers through which fluid can be pumped in or out; based on how the fluid enters, the structure can bend, twist, stretch or grab objects. Pneumatic actuators, which use air flow, are mainly used for delicate, precise tasks as they are highly compliant to small changes in air pressure. Conversely, hydraulic actuators, which use water flow, create more forceful movements, and are used in tasks requiring strength, such as tissue manipulation [2]. The modern versions of these fluid-actuated manipulators have developed to have greater range of motion, higher precision and generate higher forces, making them more suitable for use in surgery.

There are three common design approaches for soft robots in surgery: continuum robots, peristaltic robots and serial robots.



Continuum robots have a flexible structure that can bend, stretch, and twist in all directions, as they are considered to have infinite joints. Since there are no distinct joints, they operate with fluid motion and can adapt to explore complex, tight environments, such as body cavities [3]. They are ideal to perform procedures with high dexterity, such as neurosurgery and endoscopy, where a robot must navigate narrow, tortuous paths. Despite being flexible, these robots can stiffen at certain points to create 'virtual joints' by using materials like electroactive polymers and shape memory alloys [2], [1]. This gives them more precise control on their movement and allows them to exert a greater force. Continuum robots can also be modular, where the structure is composed of smaller segments made of different materials, a useful feature for assigning roles to specific parts of the robot [2].



Another design is peristaltic robots, which are self-propelled robots that replicate the motion of peristalsis in the digestive tract and are inspired by the motion of inchworms [5]. They have a tube-like structure which has many air chambers that successively inflate and deflate, creating a wave-like propulsion to move forward. Despite their slow speed, their smooth and flexible movement allows them to travel through constrained pathways in the human body with little interference to surrounding tissues, and they can achieve high propulsion efficiency. Their movement makes them ideal for capsule endoscopies, to see inside the digestive tract, and they have the potential to conduct automated, routine tasks with minimal human intervention.

Serial robots are less commonly used in MISs but can be useful in robot assisted surgeries and spinal surgeries. They consist of a series of rigid links, connected by joints, which gives them precise control of movement as well as a wide range of motion. Hard serial robots, commonly used for robotic arms, have incredible stability and strength but limited flexibility, making it difficult for them to navigate irregular spaces. In contrast, soft serial robots use actuators and stretchy materials which enhances flexibility, allowing them to reach spaces that rigid robots cannot. However, the lack of discrete links and a rigid structure makes them difficult and time consuming to manufacture.

Although soft robotics in surgery offers exciting potential, there are some limitations that restrict its popularisation. One of the main drawbacks is the low force exertion [2]. The flexible actuators in soft robots generate less power than rigid robots, making them unsuitable for high force tasks. Additionally, soft robots have poor controllability, as their complex structures are difficult to manipulate in a desired way [4]. This means that intensive training is required for surgeons to learn to operate them [3]. Manufacturing the robots has proven costly and challenging as the materials must be flexible yet strong, and the several degrees of freedom in the device makes them hard to design with predictable behaviour [1].

Despite these challenges, soft robotics in minimally invasive surgeries is promising as it offers extraordinary levels of compliance, accuracy and adaptability, making it possible to enter complex areas in the body with ease. In the future, advancements in real time modelling and simulation will allow surgeons to operate robots with minimal training [4], while technological innovations will improve the strength and controllability of robotic systems. Additionally, the growing use of AI and machine learning will enhance control mechanisms for more efficient and autonomous robotic operations [1]. Ultimately, soft robotics is a cutting-edge development that has the potential to transform minimally invasive surgeries amongst other aspects of healthcare.

By Sreya Janardhan '26

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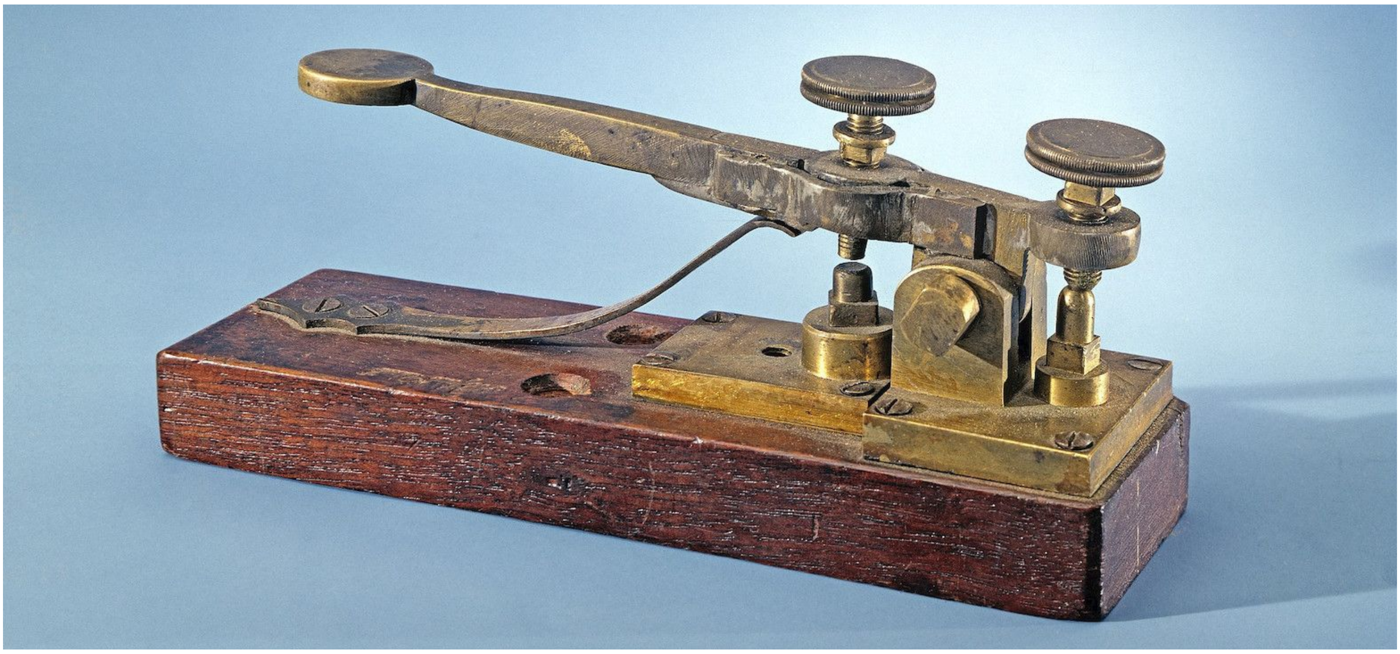


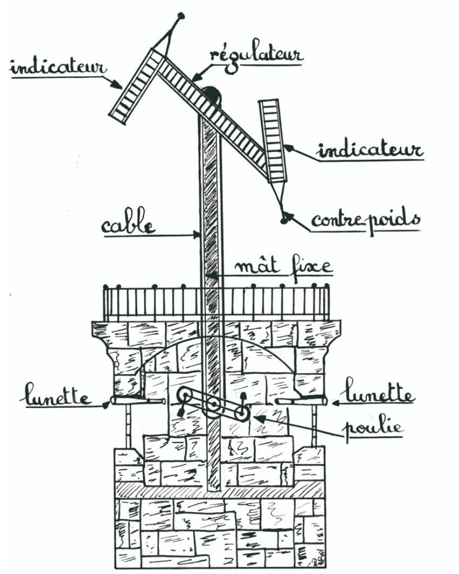
The Evolution of Electric Telegraphy

Electric telegraphy can be considered the first form of electrical engineering. A telegraph is any device used to communicate over long distances through coded symbols. An electric telegraph carries out this process through the use of electricity and magnetism. The word 'telegraph' came from Claude Chappe's primary visual telegraph, meaning 'far-writer' in Greek origin.

Before the electric telegraph

Long before the electric telegraph, visual systems were used for communications. For example, using smoke, fire and drums over long distances, and flags and flares for shorter ones [1]. In Ireland, news of victory or defeat in a war would be telegraphed across the Irish Channel using fires lit on cliffs [2]. Many other civilisations used visual or auditory communication as a form of telegraphy, but the most notable predecessor to the electric telegraph is Chappe's telecommunication network.

In 1791, Chappe devised a version of an optical semaphore, a means of communication using lights and flags [3]. Chappe and his brothers conducted experiments and found that the use of bars of wood as linear arms was more visible across longer distances. Accordingly, they created a telegraph which worked with beams and counterbalances to orient the arms. This consisted of one long beam in the middle (regulator) and two shorter beams on either side (indicators). They could be oriented in different ways to make a total of 98 different combinations [4].



Some modifications had to be made in terms of practicality. For example, painting the beams black to allow increased contrast, changing the transmissions to 92 distinct combinations which could be seen more accurately. Otherwise, this was the first complete telecommunication that was standardised and used between Paris and Lille, operating for military purposes only. It made it possible to transmit a message between these two cities in under 9 minutes. In addition to the Paris-Lille network, the use expanded across Europe in Holland, Italy, Germany, Algeria and Tunisia [5]. The Chappe telegraph system played a key role in Napoleon's conquest of Europe and provided the first demonstration of the power of instantaneous communication. It was in use for 61 years.

As good as Chappe's optical telegraph was, the success of it was limited. This was because it was expensive to run, could only be used for governmental purposes, and operated by visual means – this meant when it was foggy or misty or even just at night, it could not be used [4]. As a result, in 1846 France, the decision was made to replace the optical telegraph with the electric one.

Electromagnetism and the Telegraph

In 1820, Professor Oersted, in Copenhagen, found that a magnetic needle suspended in proximity to a wire through which a current passed deflected that needle from its initial position [6]. French scientist Andre-Marie Ampere conducted some experiments and discovered the concept by which this is governed; known as electromagnetism.

Any wire with a current flowing through it has a magnetic field; this is an electromagnet. The magnetic field lines of an electromagnetic wire are circular and are closer together nearer the wire [7]. A current-carrying wire in the presence of a magnetic field will experience a force – this is the law that Oersted accidentally uncovered [7].

A coil of wire with many turns is called a solenoid. A soft iron core is usually placed inside a solenoid as it makes the electromagnet stronger – this is the principle that was used in electric telegraphs. Similarly to how an electric current is moving through a metal will generate a magnetic field, if a magnet moves through a wire such as a solenoid, it will induce an electric current.

The discovery of electromagnetism was quickly followed by attempts to employ its use for the telegraph. The basic electric telegraphs thought of primarily by Ampere himself worked using 26 magnetic needles, line wires to represent the letters of the alphabet, a battery, and connections with wires. This allowed communication to be made with a person controlling the device[6].

The press of a key representing a letter would complete the circuit, sending the electric current down the wire. This would produce an electromagnetic force which would move the needle-pointer into position.

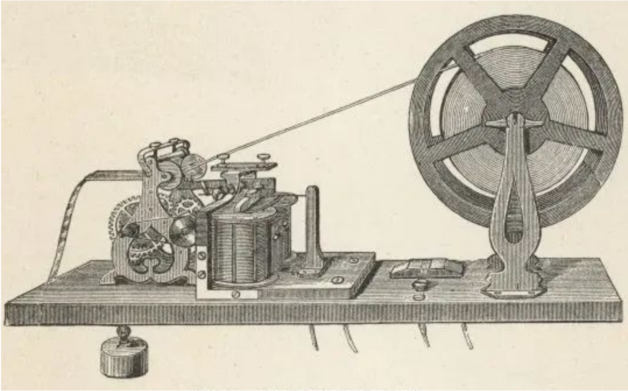
However, Ampere's and many others' initial telegraph ideas were never put into practice because the number of line wires (26 suggested here) was too great. Many versions of electric telegraphs similar to, but better than, the model above began emerging from around the world. The two most notable ones that will be discussed further are the Cooke and Wheatstone Telegraph and the Morse telegraph.

The Cooke and Wheatstone Telegraph

William Fothergill Cooke and Charles Wheatstone patented the first commercial electric telegraph [8]. This meant that their needle-based telegraph could be used across Britain.

Five needles lay in the middle of the device, and on pressing a letter, the needles would point to the letter in the diamond-shaped pattern. For example, the letter 'A' is at the very top of the diamond; so the first and fifth needles would point towards the middle, and the needles would look like /|||\. This application of the electric telegraph systems seen before meant that only 5 or 6 line wires were used to transmit the messages, and the visual aspect allowed the device to be used by untrained messengers. It was successfully introduced on railways to transmit messages, signals and times of trains in Britain in the 1830s.

The Morse Telegraph



Around a similar time that Cooke and Wheatstone were developing their needle telegraph(s), Samuel F. B. Morse also started developing his own idea for transmission of communication in America. Similarly to other inventors of his time, his device used an electromagnet – however, instead of looking for pointing needles, Morse's device would make markings on a strip of paper using a lever which could then be interpreted as letters and words. At the time of its creation, Morse had not thought to use the device with human input in the way it is now known for. Instead, blocks would be placed in the Port Rule and a machine arm would roll over them, interpreting a grove or hole as a dot and a bump upwards as a break. These would be marked on the paper by the movement of the electromagnet, and be seen as a line of dots, dashes (which were long dots) and breaks [9]. These were translated back into the alphabet by Morse code and can be seen in the table below.

Later on, he improved this invention to take in the input of a skilled user by pressing the key. The system was essentially very similar, as on each press the electromagnet would form a connection to the circuit, turning the electromagnet on, and then make a lever press down, marking the paper.

An auditory morse code system may also be used as opposed to a written one. In fact, the movement of the lever due to the electromagnet being turned on and off made a noise as it moved up and down.

Operators were so skilled at the translation that they had no need to read the strip of paper but instead used the audible sounds the machine produced [10]. Thus the receiver was changed to a sound-based focus, removing the paper and improving the audio outputs as it continued to play an important role in electro-communications across the world.

Conclusion

Telegraphy, from fires and flares to more sophisticated visual semaphores to electric telegraphs, have been essential for human communication. In the modern world, it is easy to forget the ingenious inventions that came previously and allowed telecommunications such as smartphone texting and computer emailing. Electric telegraphs provided the basis for modern communications today, credited to the work of thousands of scientists that dedicated their research to communication.

By Sara Bjelanovic '26

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The Evolution of Pre-Electric Vehicles

The birth and evolution of vehicles was one of the largest and most significant innovations of the 20th century. In this period most people would not have spent their lives at any great distance from their homes. Nowadays, we can see how much these inventions have changed our lives. However, modern vehicles come from a series of evolution of some of the oldest and most basic means of transportation, such as the cart or chariot.

In the 12th Dynasty of Egypt, the first foreign rulers there, the Hyksos, took over Egypt. The Hyksos were recorded as strangers who came clad with colorful new clothing, new traditions, and more importantly new inventions. As many details about them were confusing and misleading, the Hyksos were put down in history as a mystery. The dozens of new creations they brought include the khopesh, composite bow, horse, and chariot. This group took over in the period that Egypt's structure was crumbling. Nevertheless, this was still looked upon as one of the most stable, wealthy and well-preserved dynasties.

Later on there were more frequent appearances of chariots and carts in other civilisations, such as the Greek. The uses of transportation by the Greek are well known, especially chariots as they are depicted in many paintings. Chariots were often used to ride into battle and show the newest leaders. The chariot was a representation of the prowess of the Greek in battle or chariot races. Many graves and tombs within the Greek empire showed how long this invention had been around for.

Chariots were used by the Romans as forms of punishment rather than prowess and attack. As repeatedly shown in history, the defeated general would be paraded in those chariots around the city as if they were animals. The Romans would typically ride horses into battles instead of chariots. Instead of hosting races like the Greek would have, the idea of glorifying chariots was eliminated in this period of time.

Chariots continued to evolve in the time of Anglo, and later on Boudica, one of the strongest enemies of the Romans. There are theories about what Boudica's chariots looked like, each of which created better weapons for a more influential image of the warrior queen. There is evidence that the size of the chariot in this period shifted to become more minimalistic yet powerful on the battlefield with wooden planks on wheels pulled by horses. Others claimed her chariots had large spikes out of the wheels to spear her enemies. Those ideas also influenced design in the Roman age as well as chariot racing.

In 1769, Nicolas-Joseph Cugnot was behind one of the most influential inventions: a steam engine that powered a three-wheeled vehicle with its front holding the heavy engine and its back weighed out by what it would pull around. This prototype was first designed to carry cannons around, in the hope of attaining an advantage in warfare. Since then, they have gone through significant transformations and vehicles have become an integral part of our daily lives.

However, these new innovations came with a darker side: war. The more recent case where vehicles were used as the most powerful weaponry was World War I. This led to the creation of flying machines by the Wright brothers in 1903, and the tanks by Sir William Triton and Major Walter Gordon Wilson in 1919.

As technology advanced, more vehicles became steam powered. This soon led to an increased amount of pollution. As vehicles burned coal, oil and other natural resources, new reactants were produced and released into air: greenhouse gases including carbon dioxide, nitrous oxide, hydrocarbons, and sulfur dioxide. Nitrous oxide and sulfur dioxide build up smog and acid rain, and hydrocarbons built-up in fuel emissions. This contributed to the current climate issues and destruction of the environment.

Nowadays there are many large car sellers, including BMW, Subaru, Porsche, Honda, and Lexus. The IEA states how nearly 25% of vehicle pollution comes from vans and cars, suggesting that improvements should be made to lower that percentage.

Thousands of newly bought and owned cars are either electric or hybrid. This shows the improvements that are being made, but more could be done. Switching to electric vehicles may not be enough. Electric energy is not as efficient to produce and is commonly created by burning fossil fuels. This makes it difficult to depend on electric cars to lower the carbon emissions produced by vehicles.

By Zane Edwards ‘28

Thank You!

That concludes the first issue of the Penrose Magazine. Thank you so much for reading and we hope you enjoyed!

Finally, we would like to thank our writers for taking the time to write the articles, as this magazine would not have been possible without them.

If you would like to write for the next issue of the Penrose Magazine, please check out our website or socials:

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