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A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY BY THE CATHOLIC ARCHDIOCESE OF TRICHUR

JYOTHI HILLS, VETTIKATTIRI P.O, CHERUTHURUTHY, THRISSUR. PIN-679531 PH : +91- 4884-259000, 274423 FAX : 04884-274777



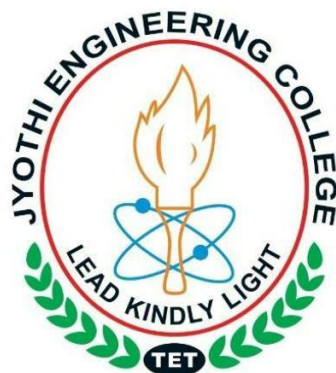
NBA accredited B.Tech Programmes in Computer Science & Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering and Mechanical Engineering valid for the academic years 2016-2022. NBA accredited B.Tech Programme in Civil Engineering valid for the academic years 2019-2022.

ELECONS

Department Of Electronics & Communication Engineering

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Department of Electronics & Communication Engineering
JYOTHI ENGINEERING COLLEGE, CHERUTHURUTHY
THRISSUR 679 531

VISION OF THE INSTITUTE

Creating eminent and ethical leaders through quality professional education with emphasis on holistic excellence.

MISSION OF THE INSTITUTE

- To emerge as an institution par excellence of global standards by imparting quality engineering and other professional programmes with state-of-the-art facilities.
- To equip the students with appropriate skills for a meaningful career in the global scenario.
- To inculcate ethical values among students and ignite their passion for holistic excellence through social initiatives.
- To participate in the development of society through technology incubation, entrepreneurship and industry interaction.

VISION OF THE DEPARTMENT

Create eminent and ethical leaders in the field of Electronics and Communication through quality professional education to excel in academia and industry.

MISSION OF THE DEPARTMENT

- To impart comprehensive knowledge and practical skills in the field of Electronics and Communication Engineering
- To provide an environment that nurtures a culture of innovation and entrepreneurship, to develop solutions to real-world challenges and explore opportunities for technology commercialization
- To foster socially responsible engineers and ethical leaders who drive positive change through innovative technology and a commitment to the betterment of society

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)

PEO I : Graduates shall have fundamental and advanced knowledge in electronics and communication engineering along with knowledge in mathematics, science and computing and get employed in national or international organizations or government agencies.

PEO II : Graduates shall have ability in analyzing, designing and creating innovative solutions which lead to a lifelong learning process or higher qualification, making them experts in their profession thus helping to solve electronics & communication engineering and social problems.

PEO III: Graduates shall have good organizing capabilities, presentation skills, communicating ability, leadership, team work and ethical practices.

PROGRAMME SPECIFIC OUTCOMES (PSO's)

- PSO 1:** Apply theoretical knowledge and practical skills in the field of Electronics and Communication Engineering to analyze, design, and implement electronic systems, communication networks, and signal processing solutions effectively.
- PSO 2:** To cultivate a culture of innovation and entrepreneurship among students, enabling them to identify and address real-world challenges in electronics and communication.
- PSO 3:** To instill a sense of social responsibility and ethical awareness in students by preparing them to use their technical expertise for the betterment of society and the environment.

PROGRAMME OUTCOMES (POS)

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Environment and sustainability: Understand the impact of the professional engineering



solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

LETTER FROM OUR HOD



Dear Readers,

I'm delighted to present to you the latest edition of our department's technical magazine. Packed with insightful articles, research updates, and innovative projects, this publication showcases the exceptional talent and dedication of our students.

I invite you to explore the diverse topics covered within these pages, from AI and machine learning to signal processing and communication systems. Your engagement and feedback are invaluable as we continue to push the boundaries of knowledge in our field.

Thank you for your support and enthusiasm for our department's endeavors.

Best regards,

DR. SINDHU S

HOD , ELECTRONICS AND COMMUNICATION DEPARTMENT

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EDITORS



JOE KOLATHINGAL



ARUNRAJ A.



AISWARIYA R.



ABNA I.P.



PRANAV PRASAD



KRISHNAJA K.



DR PRAJOON P.



SR JESNA CATHERINE

GENERATIVE AI: REVOLUTIONIZING INNOVATION AND CREATIVITY



PRANAV PRASAD

In the era of digital transformation, Generative Artificial Intelligence (AI) is redefining industries by generating high-quality content across multiple domains, including text, images, music, videos, and software code. Leveraging foundation models trained on massive datasets, generative AI enhances human creativity, automates complex workflows, and drives innovation by augmenting decision-making processes. This transformative shift began with the public release of ChatGPT by OpenAI in late 2022, which demonstrated advanced natural language understanding and context-aware responses, followed by DALL·E 2, which showcased text-to-image synthesis capabilities.

Generative AI relies on deep learning architectures, with Transformer-based models being the most prevalent. GPT (Generative Pre-trained Transformer) powers natural language processing (NLP) tasks, while DALL·E and Stable Diffusion utilize Variational Autoencoders (VAEs) and diffusion models to create photorealistic images. These models operate through self-attention mechanisms that process input sequences in parallel, enabling them to capture long-range dependencies and generate coherent, context-aware content. The core principle of generative AI lies in its ability to function as a probabilistic prediction engine, anticipating the next logical element in a sequence. For image synthesis, diffusion models iteratively refine noisy data to produce high-quality visual outputs, while in code generation, models like GitHub Copilot leverage training data to suggest efficient and optimized code. Generative AI is driving innovation across diverse industries by automating content creation, accelerating software development, and optimizing design processes.

In content creation and marketing, AI models personalize content at scale, generating high-quality product descriptions, ad copies, and blog posts. Software development benefits from AI-powered code generation and debugging tools that reduce development time and enhance software quality. In healthcare, AI models facilitate drug discovery by predicting molecular structures and simulating potential compounds, significantly reducing the time-to-market for new treatments.

They also assist in clinical decision-making by analyzing vast datasets and identifying patterns that enhance diagnostic accuracy. Manufacturing and product design leverage generative design algorithms that propose optimal prototypes, improving both cost-efficiency and performance.

The media and entertainment industry uses generative AI to create immersive virtual environments, automate video editing, and generate personalized recommendations, enhancing user experiences. AI models also streamline creative workflows by generating scripts and content tailored to audience preferences. Despite its transformative potential, generative AI introduces several technical challenges that require careful consideration. Bias and inaccuracy are critical concerns, as AI models trained on historical datasets may propagate existing biases, leading to skewed outputs. Ensuring fairness and accuracy demands rigorous model evaluation and continuous refinement of training data. Intellectual property (IP) and copyright issues complicate the ownership of AI-generated content, necessitating the establishment of legal frameworks to address content attribution. Privacy and data security risks arise when AI models inadvertently expose sensitive information, emphasizing the need for robust data governance protocols.

The proliferation of deepfakes presents cybersecurity threats, as generative AI can produce synthetic media that is virtually indistinguishable from reality. Deepfakes can be exploited for misinformation, fraud, and identity theft, highlighting the need for advanced detection algorithms and regulatory oversight. Moreover, the environmental impact of training large AI models, which consume substantial computational resources, underscores the importance of optimizing energy efficiency and adopting sustainable AI practices. The future of generative AI lies in multimodal models that seamlessly integrate text, images, audio, and video, unlocking richer and more immersive user experiences. AI-augmented creativity will empower designers, artists, and content creators by generating novel ideas and enhancing creative processes.

Autonomous AI agents capable of executing complex tasks without human intervention will redefine industries by automating high-stakes processes and improving operational efficiency. Advancements in quantum computing and edge AI will further accelerate the capabilities of generative AI, enabling real-time processing and reducing latency in AI-driven applications. Additionally, sustainable AI development will mitigate environmental concerns by optimizing energy consumption and utilizing renewable sources in AI model training.



VLSI TRENDS: FINFETS, GAAFETS AND BEYOND



AISWARIYA R

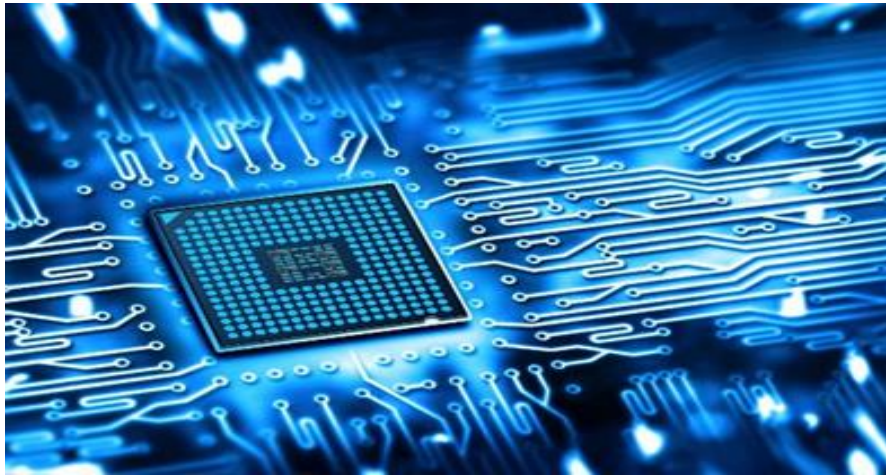
The field of very large scale integration, or VLSI, is changing dramatically. The semiconductor industry is being pushed to its material and physical boundaries as the demand for processors that are quicker, smaller, and more energy-efficient keeps growing. The progression of transistor architectures—from planar devices to FinFETs and now to GAAFETs is at the core of this change, and research is now exploring whole new paradigms.

FROM PLANAR MOSFETS TO FINFETS

Planar MOSFETs were used by the industry for many years, but as sub-22nm technology nodes drew closer, these transistors started to exhibit significant leakage, short-channel effects, and decreased performance. FinFET (Financial Field-Effect Transistor) technology was developed to solve these problems. FinFETs use a vertical fin-shaped channel with the gate wrapping around three sides, which improves electrostatic control and lowers leakage current in contrast to planar transistors. Leading semiconductor firms like Intel, TSMC, and Samsung are currently using FinFETs in advanced CPUs at 16nm, 10nm, 7nm, and even 5nm nodes due to their success. They were perfect for contemporary high-speed, low-power applications, like as servers and smartphones, because they could fit more transistors into a chip while still remaining efficient.

GAAFETS: GATE-ALL-AROUND IS THE FUTURE

FinFETs start to run into issues with gate control and variability as technology advances to 3nm and 2nm nodes. As a result, GAAFETs (Gate-All-Around FETs), a logical progression of FinFETs, were created. The channel, which can now be either nanowires or nanosheets, is entirely encircled by the gate in GAAFETs. They are more tunable for performance and power efficiency because to this architecture, which also offers even better electrostatic control, further minimises leakage, and permits configurable channel widths.



GAAFETs offer multiple advantages:

- Higher drive current and better channel control
- Lower leakage, critical for battery-powered devices
- Customizable gate and channel dimensions for performance scaling

BEYOND GAAFETS: WHAT'S NEXT?

While GAAFETs represent a major leap, the quest for improvement continues. Several emerging technologies are being explored:

- 2D materials (like graphene, MoS₂, and other TMDs) for ultra-thin channels with high mobility and reduced short-channel effects.
- Tunneling FETs (TFETs) that use quantum tunneling for ultra-low power operations.
- Spintronic devices that leverage electron spin instead of charge.
- Carbon nanotube FETs (CNTFETs) for high-performance, low-power computing.

In addition, monolithic 3D integration is being researched, where multiple layers of logic and memory are stacked on a single chip, improving performance and reducing interconnect delay.

THE ROAD AHEAD

In addition to being a change in technology, the transition from FinFETs to GAAFETs and maybe post-CMOS devices represents a new area of VLSI engineering. It creates a lot of chances for research and development in fields including device modelling, simulation tools, materials science, and fabrication.

NEURAL IMPLANTS: THE FUTURE BRAIN OF THE COMPUTER INTERFACES



EDWIN ROSHAN N.

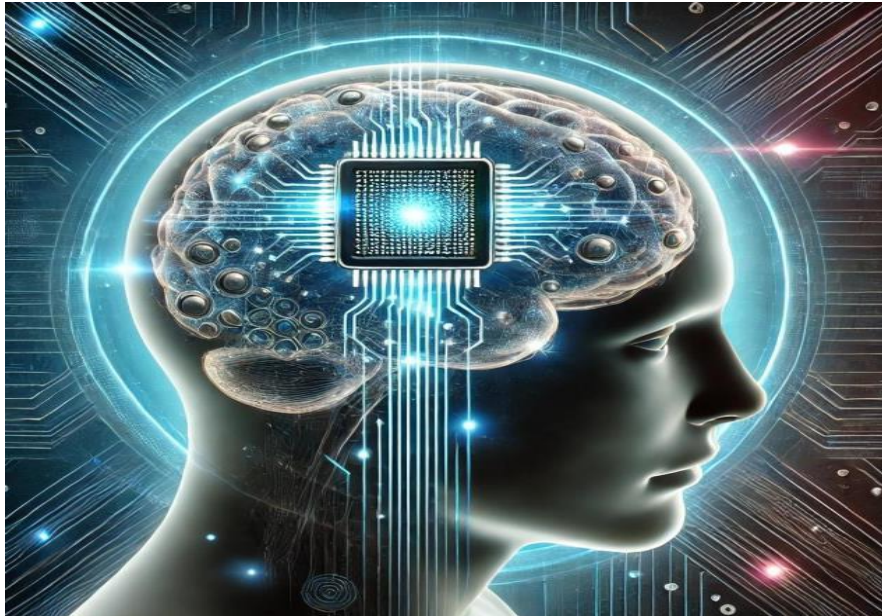
Imagine a world where you can control your computer, send a message, or even move a robotic arm just by thinking. What once seemed like pure science fiction is now becoming reality, thanks to neural implants. These tiny devices, implanted in the brain, act as a bridge between human thoughts and machines. While still in the early stages, neural implants are already showing immense potential in medicine, communication, and even human cognition. The core of this technology is the ability to read and interpret brain signals. The human brain communicates through electrical impulses, and neural implants pick up these signals using tiny electrodes.

These signals are then processed and converted into commands that can control external devices. One of the biggest impacts of neural implants is in healthcare. For individuals who have lost movement due to spinal cord injuries, these implants could help them regain control of their limbs by bypassing damaged nerves. People suffering from neurological disorders like Parkinson's disease and epilepsy are already benefiting from Deep Brain Stimulation (DBS), a technique that uses implanted electrodes to regulate abnormal brain activity. In the future, scientists believe neural implants could even help restore lost memories in Alzheimer's patients.

Beyond medicine, neural implants open up fascinating possibilities. Companies like Neuralink, founded by Elon Musk, are developing advanced brain-computer interfaces that could eventually allow people to control smartphones and computers just by thinking. Some experts even believe that, one day, we might be able to communicate brain-to-brain without the need for speech or typing. This technology could redefine the way we interact with the digital world, making human-computer communication faster and more intuitive than ever before. However, as exciting as this sounds, neural implants also come with serious challenges. Implanting a device in the brain is not a simple procedure, it involves surgery, which carries risks like infections and long-term complications.

There are also ethical concerns about data privacy and security. If brain activity can be recorded and interpreted, what happens if this data is hacked or misused? Could neural implants be used to enhance intelligence or memory, creating a divide between those who can afford them and those who can't? These are questions that scientists, ethicists, and policymakers will need to address as the technology advances.

Despite these challenges, neural implants represent a giant leap forward in the way we interact with technology. While we are still in the early days of development, the potential is enormous. In the coming years, we could see these implants helping people overcome disabilities, improving communication, and even unlocking new levels of human capability. What once seemed impossible is now within reach.



However, as exciting as this sounds, neural implants also come with serious challenges. Implanting a device in the brain is not a simple procedure it involves surgery, which carries risks like infections and long-term complications. There are also ethical concerns about data privacy and security. If brain activity can be recorded and interpreted, what happens if this data is hacked or misused? Could neural implants be used to enhance intelligence or memory, creating a divide between those who can afford them and those who can't? These are questions that scientists, ethicists, and policymakers will need to address as the technology advances.

Another concern lies in the psychological impact of such intimate human-machine integration. Constant awareness that one's thoughts could potentially be accessed or monitored might lead to mental stress or altered behavior. People may become overly cautious, fearing judgment or surveillance, which could influence natural thought processes. Balancing the power of this technology with individual autonomy and mental well-being is a crucial area of ongoing research. Despite these challenges, neural implants represent a giant leap forward in the way we interact with technology. While we are still in the early days of development, the potential is enormous. In the coming years, we could see these implants helping people overcome disabilities, improving communication, and even unlocking new levels of human capability. What once seemed impossible is now within reach.

IOT AND ITS APPLICATIONS: MAKING THE WORLD SMARTER



ARUNRAJ A.

The world around us is becoming smarter every day and not just because of people. From refrigerators that tell you when the milk is low to streetlights that dim when no one is around, everyday objects are learning to think, communicate, and act. This is the power of the Internet of Things, or IoT. While the term might sound technical, the idea is simple: connect physical objects to the internet so they can collect data, share it, and respond intelligently. This transformation isn't just about technology it's about changing the way we live, work, and interact with the world.

At home, IoT is already part of many people's daily lives. Smart assistants like Alexa or Google Home can play music, control lights, or remind you of your schedule just by listening to your voice. Thermostats adjust temperatures based on your routine, helping save energy and money. Even appliances like washing machines or ovens can now be controlled from a smartphone. These smart devices not only make life more convenient, but also help reduce waste and improve energy efficiency. For elderly or differently abled individuals, smart home technologies offer new levels of comfort, independence, and safety. Imagine a home that knows when you've fallen and sends help, or a pillbox that reminds you to take your medicine. IoT is quietly making life better behind the scenes.

Beyond the home, IoT is doing powerful work in industries that touch everyone's lives. Take agriculture, for example. Farmers today can use sensors in the soil to check moisture levels, track weather conditions, and monitor crop health all in real time. This information helps them use water and fertilizers more efficiently, leading to higher yields and lower costs. With all these devices connected to the internet, privacy and security are major concerns. A smart device that collects data about your habits or health must be protected from hackers. That's why cybersecurity is becoming a central part of IoT development. Engineers and designers are working hard to build systems that are secure, encrypted, and regularly updated. As 5G networks grow and AI continues to evolve, the possibilities for IoT will only expand.

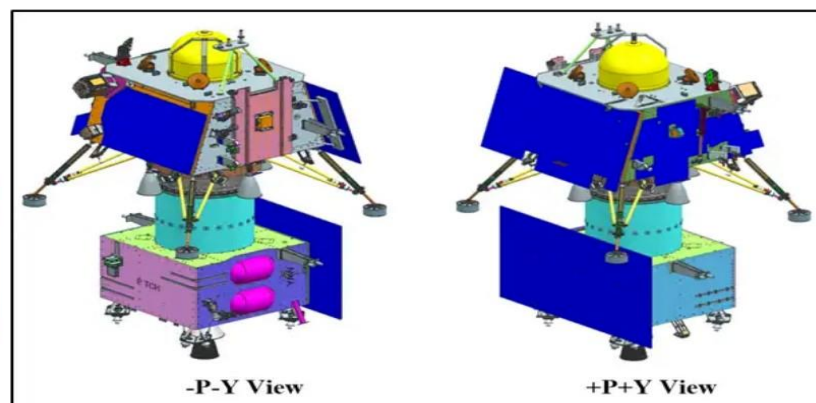
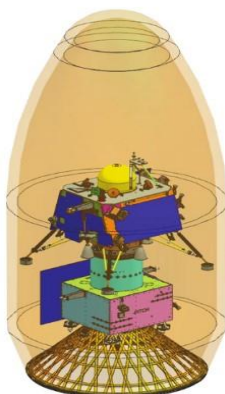
SPACE ELECTRONICS: POWERING INDIA'S JOURNEY TO THE STARS



ABNA I. P.

In the modern space age, electronics forms the silent but essential engine behind every space mission. From the moment a satellite is launched to the instant it beams back data from thousands of kilometers away, electronics is at the core of operations, control, and survival in the extreme environment of space. As India forges ahead in the global space race through landmark missions like Chandrayaan-3 and the upcoming Gaganyaan project its capabilities in space electronics have become central to its ambitions. This article explores what space electronics is, why it is so critical, and how India is emerging as a leader in this high-tech domain. Space electronics refers to the design and deployment of electronic components that can operate under the harsh and unforgiving conditions of outer space. Unlike commercial electronics used on Earth, space-grade systems must survive radiation exposure, vacuum conditions, extreme temperature variations, and high G-forces during launch. These electronics are engineered to deliver high reliability, often for years, with little to no maintenance. Even the slightest malfunction can compromise entire missions, which is why space electronics undergo rigorous testing and are built to the highest standards of durability and precision.

The applications of space electronics span across nearly every subsystem of a space mission. In satellites, electronics handle power distribution, data transmission, signal processing, and thermal management. Launch vehicles rely on complex avionics systems—like flight computers and telemetry units that guide and monitor the vehicle through its ascent. In deep space missions, such as India's Mars Orbiter Mission, autonomous decision-making systems onboard spacecraft use electronic sensors and processors to navigate vast, unpredictable interplanetary terrain.



India has made remarkable strides in the field of space electronics through both public and private initiatives. The Indian Space Research Organisation (ISRO) has successfully developed and deployed indigenous avionics systems for its launch vehicles and spacecraft. Chandrayaan-3, for instance, carried advanced guidance and navigation systems developed in India that demonstrated high reliability even during the complexities of a lunar landing. ISRO's missions are supported by institutions like the Semi-Conductor Laboratory (SCL) in Mohali, which works on fabricating radiation-hardened chips used in satellites.

Additionally, organizations such as Bharat Electronics Limited (BEL) and the Defence Research and Development Organisation (DRDO) contribute to developing mission-critical electronic components. In recent years, the private sector has also entered the arena with great enthusiasm. Startups like Pixxel are designing next-generation Earth observation satellites equipped with hyperspectral cameras, while Skyroot Aerospace and AgniKul Cosmos are developing their own launch systems with custom electronic avionics. These efforts are aligned with the Government of India's "Aatmanirbhar Bharat" (self-reliant India) vision, which emphasizes domestic innovation in semiconductor manufacturing and electronics. The announcement of semiconductor fabrication units in India is a major step forward in reducing reliance on foreign suppliers for critical space hardware.



In conclusion, space electronics is much more than just a support system; it is the very foundation upon which modern space exploration is built. As emerging technologies like AI, quantum systems, and edge computing become part of this ecosystem, the boundaries of what is possible in space are rapidly expanding. For India, mastering this domain is not only a matter of technological pride but also of strategic, scientific, and economic importance. As the country continues to break barriers in space science, the invisible force of electronics will continue to guide its way silently, precisely, and powerfully into a bold and intelligent future beyond Earth.

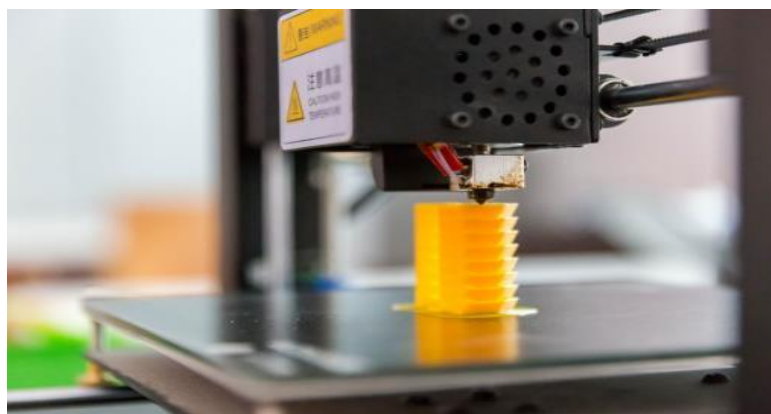
INTRODUCTION TO 3D AND 4D PRINTING



KRISHNA K.

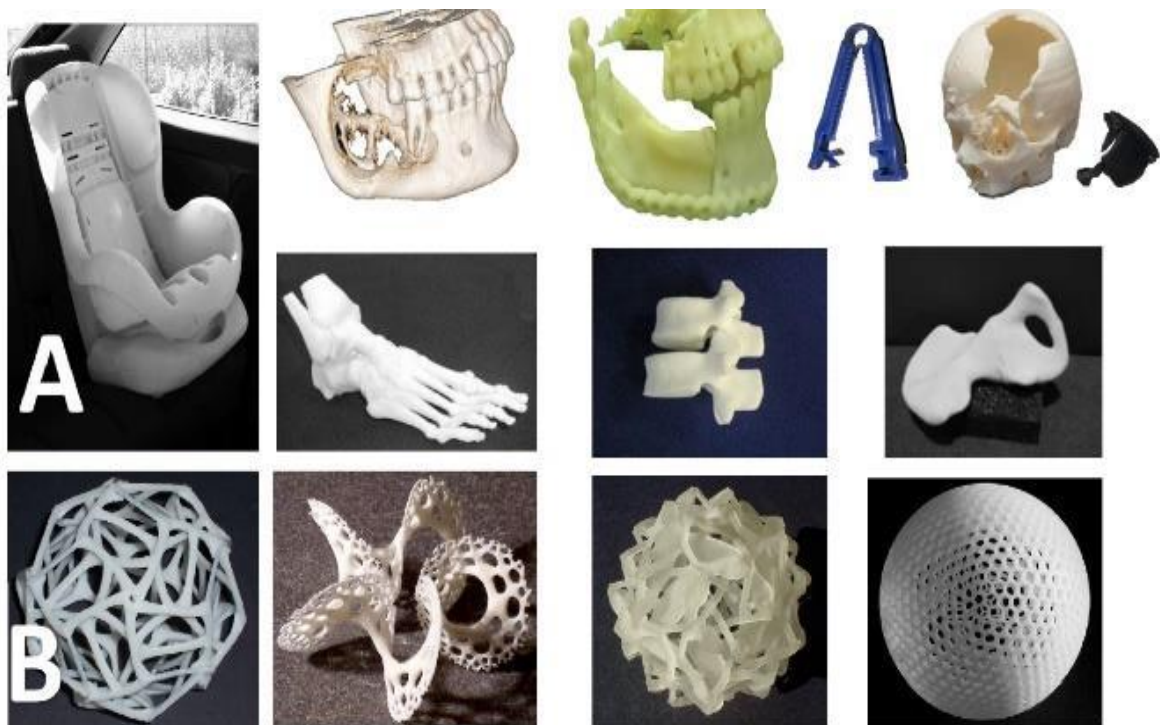
In recent decades, manufacturing technology has undergone a massive transformation, largely driven by the advent of additive manufacturing techniques. Among these, 3D printing has become an innovative technology that enables the quick production of real-life models and components straight from digital designs. Technically referred to as additive manufacturing, 3D printing has found use in a variety of industries, such as education, healthcare, automotive, and aerospace. With the advent of 4D printing, which introduces a new dimension-time into the manufacturing process, researchers and engineers have recently pushed the envelope even further. Smart materials that can change their shape or characteristics in response to environmental stimuli like heat, moisture, or light are used to fabricate objects in 4D printing. This article provides insight into how 3D and 4D printing technologies are influencing the future by examining their fundamentals, uses, advantages, and drawbacks.

3D printing is essentially a process where three-dimensional objects are created layer by layer from a digital file, using materials such as plastic, metal, resin, or even ceramics. A digital 3D model, frequently produced using computer-aided design (CAD) software, is the first step in the process. Then, using slicing software, this model is divided into many thin horizontal layers. The 3D printer receives the sliced file and uses precise material deposition to create each layer until the entire object is constructed. 3D printing employs a number of different processes, such as Selective Laser Sintering (SLS), which fuses powdered materials using a laser; Stereolithography (SLA), which cures liquid resin using ultraviolet light; and Fused Deposition Modeling (FDM), which melts plastic filament and extrudes it through a nozzle.



The efficiency and adaptability of 3D printing are its primary benefits. Engineers and designers can quickly iterate their designs thanks to its rapid prototyping capabilities. It is perfect for one-off or low-volume production runs because it allows customization without requiring costly moulds or tooling. With uses like patient-specific implants, prosthetics, and anatomical models for surgical planning, sectors like healthcare have profited immensely. 3D printing is used in the automotive and aerospace industries to create intricate and lightweight parts that are challenging to produce using conventional techniques.

It is a useful instrument for experiential learning and experimentation in the classroom. 4D printing presents a new model, while 3D printing deals with producing static objects. The ability of a printed object to change over time under specific conditions is the fourth dimension in 4D printing. The use of smart materials, sometimes referred to as programmable matter, which can react to stimuli like light, magnetic fields, pH, humidity, and temperature, makes this possible. These materials can expand, contract, bend, or even assemble themselves without the need for human assistance once they have been printed. During the design stage, the transformation is frequently pre-programmed into the geometry or material composition.



4D printing has significant real-world applications. For example, 4D-printed stents in the biomedical field can expand on their own once they enter the human body, removing the need for invasive surgeries. Components in the aerospace sector could be made to change shape in response to temperature variations while in flight, enhancing both performance and safety. Comparably, in the field of wearable technology, apparel composed of 4D materials might be able to adjust to the ambient temperature, providing more comfort. Adaptive furniture, fluid system responsive valves, and self-assembling construction structures are just a few of the expanding list of possible uses.

Both 3D and 4D printing technologies have their own set of drawbacks despite their captivating potential. Compared to traditional manufacturing, 3D printing has fewer material options, slower production speeds for large-scale manufacturing, and post-processing needs to enhance mechanical strength or surface finish. Due to its infancy, 4D printing is subject to additional limitations. There are currently few smart materials available, and creating transformations is difficult due to its complexity. Furthermore, 4D printing's use is currently limited to research and specialized applications due to the high cost of materials and equipment.

Nonetheless, the future of these technologies is highly promising. With ongoing research and development, 3D printing is becoming faster, more affordable, and more accessible. Material science innovations are expanding the types of materials that can be printed, including composites and biological tissues. Meanwhile, 4D printing is expected to play a critical role in next-generation robotics, self-healing materials, and programmable matter. As industries continue to seek sustainable and smart solutions, additive manufacturing is poised to become a cornerstone of modern engineering and production systems.



In conclusion, 3D and 4D printing are more than just manufacturing tools; they mark a fundamental change in the way we consider functionality, materials, and design. Although 3D printing has already established itself through useful and commercial applications, 4D printing paves the way for a time when objects will be able to change, adapt, and react to their surroundings. When taken as a whole, these technologies represent a new era in industrial innovation and the shift toward more flexible, intelligent, and efficient production techniques.

SECURE DATA WITH QUANTUM COMPUTING



JOE KOLATHINGAL

Quantum computing is a groundbreaking technology that promises to solve problems far beyond the reach of classical computers. However, this same power introduces a double-edged sword in the realm of cybersecurity. While quantum computers can process information faster, they can also break many of the encryption methods currently used to secure digital data. As digital threats grow and data breaches become more severe, understanding how quantum computing affects data security is more important than ever. Most current encryption techniques are based on complex mathematical problems that are difficult for classical computers to solve. For example, the RSA algorithm depends on the difficulty of factoring large prime numbers, while elliptic curve cryptography (ECC) relies on solving complex equations. These methods keep our online communications, banking, and government systems secure because breaking them would take traditional computers millions of years.

Quantum computers, particularly those running Shor's algorithm, can solve problems like factoring and discrete logarithms exponentially faster than classical machines. This means that once quantum computers become powerful and stable enough, they could easily crack RSA, ECC, and other widely used encryption systems. This poses a serious threat to the privacy and security of sensitive data across the globe. One growing concern is the idea of "Harvest Now, Decrypt Later" attacks. Malicious actors could capture encrypted data today and store it until quantum computers are powerful enough to break the encryption. This makes even current encrypted data vulnerable in the long term, especially in sectors like healthcare, military, and finance, where data must remain confidential for decades.



But Post-Quantum Cryptography (PQC) refers to cryptographic algorithms that are believed to be secure against quantum attacks. Unlike classical encryption, PQC methods rely on mathematical problems that quantum computers cannot solve efficiently, such as lattice-based or code-based cryptography. Organizations like NIST are currently working to standardize PQC algorithms to replace vulnerable systems before quantum computers pose a real threat. Quantum Key Distribution (QKD) is a method of securely sharing encryption keys using the principles of quantum physics. With QKD, any attempt to intercept the key alters its quantum state and reveals the eavesdropping attempt. Protocols like BB84 allow two parties to detect interference in real-time, making QKD an incredibly secure method for exchanging encryption keys over long distances.

Several countries have begun to explore QKD and quantum-secure communication networks. China successfully demonstrated QKD via the Micius satellite, enabling secure communication between ground stations over 1,000 km apart. Similarly, European nations and the U.S. are investing in quantum-secured systems for government agencies and financial institutions. These real-world trials show that quantum-secure communication is already moving from labs to actual deployment. Despite its potential, there are still major challenges in implementing quantum-secure systems. Quantum computers are extremely fragile, require precise environments to operate, and are still not scalable. QKD networks are expensive and require special infrastructure like quantum repeaters. Moreover, transitioning from classical to post-quantum systems will take time, effort, and international collaboration.

As quantum computing evolves, governments and industries must prepare now. This includes upgrading existing encryption systems, educating cybersecurity professionals, and integrating post-quantum cryptography into digital infrastructure. Countries that fail to adapt may find their communications and sensitive data exposed in the quantum age. The development of a quantum-secure internet may also become a global priority within the next decade. Quantum computing poses significant challenges to modern cybersecurity but also offers powerful tools to enhance it. While the threat to classical encryption is real, emerging technologies like PQC and QKD provide a path forward. Securing data with quantum computing involves both defending against quantum threats and using quantum mechanics to our advantage. By investing in quantum-safe technology today, we can build a more secure and resilient digital world for the future.

As quantum hardware improves and post-quantum algorithms are standardized by organizations like NIST, quantum-safe security will become essential. Ultimately, securing data with quantum computing is not just about defence but also about embracing a new generation of cryptographic tools that promise a more secure digital future. Rather than fear quantum computing, we must use it as a force for securing the world's most sensitive and valuable information.