

**KAMARAJ**  
**COLLEGE OF ENGINEERING & TECHNOLOGY**



®

**(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)**

**S.P.G.Chidambara Nadar - C.Nagammal Campus**

**S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).**

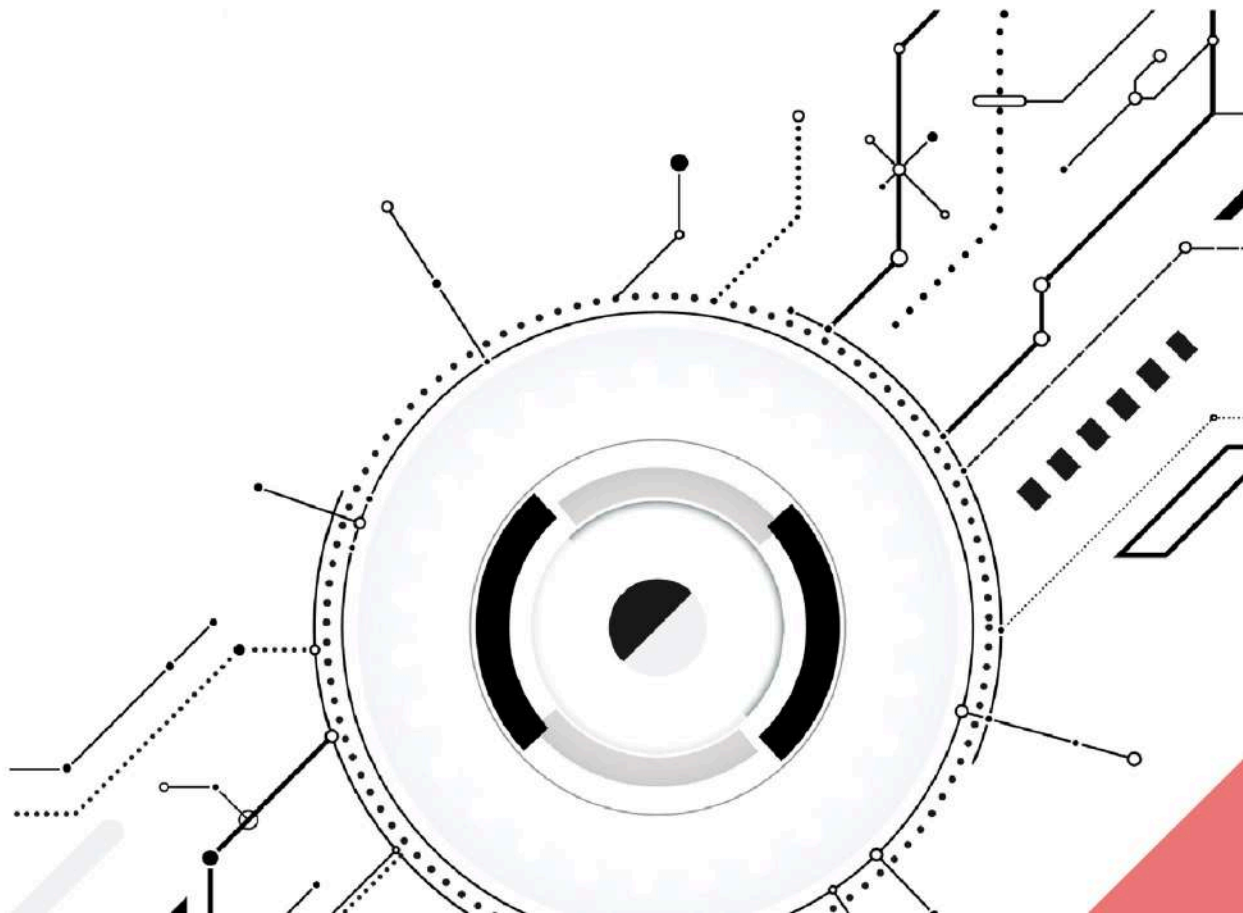
**DEPARTMENT OF MECHATRONICS ENGINEERING**

Accrediated by NBA, New Delhi

**VOL 5, ISSUE 1**

**MECHATRONZ**

*2024-2025*



# DEPARTMENT OF --- **MECHATRONICS ENGINEERING**

## **VISION**

To make the department of Mechatronics Engineering unique in the field of research and development towards industrial automation & robotics.

## **MISSION**

To impart highly innovative and technical knowledge in Mechatronics Engineering to the urban and unreachable rural students through "Total Quality Education".

## **PROGRAMME EDUCATIONAL OBJECTIVES**

- Graduates will be able to apply their multi-disciplinary knowledge to formulate, design, develop and analyse Mechatronics System.
- Graduates will be able to come up with solution for any real time problems in the field of Mechatronics Engineering and allied areas demanded by the Industry and Society.
- Graduates will be able to get familiarized with economical issues in Mechatronics Engineering and work in multi-disciplinary teams with ethical code of conduct.

## **PROGRAM SPECIFIC OUTCOMES**

- Graduates will be able to apply their knowledge in sensors, drives, actuators, controls, mechanical design and modern software & hardware tools to design and develop cost effective Mechatronics systems.
- Graduates will be able to become Technocrats and Entrepreneurs, build the attitude of developing new concepts on emerging fields and pursuing higher studies.



# PROGRAM OUTCOMES

*Engineering Graduates will be able to*

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**Engineering Knowledge:** Apply the knowledge of Mathematics, Science, Engineering Fundamentals, and an Engineering Specialization to the solution of complex engineering problems.

**Problem Analysis:** Identify, formulate, research literature, and analyze Electrical and Electronics Engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural Sciences, and Engineering Sciences.

**Design / Development of Solutions:** Design solutions for problems in the field of Electrical and Electronics Engineering and design system components or processes that meet specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

**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.

**The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**Environment and Sustainability:** Understand the impact of Electrical and Electronics Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for, sustainable development.

**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

**Communication:** Communicate effectively on Electrical and Electronics 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.

**Project Management and Finance:** Demonstrate knowledge and understanding of 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.

**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.

## ABOUT THE DEPARTMENT OF

# MECHATRONICS ENGINEERING

Our college, with a vision to promote quality technical education to rural communities, was established in the year 1998 with four engineering branches. Recognizing the importance of core engineering disciplines, our long-standing aspiration to introduce a Mechatronics Engineering program was realized in the academic year 2014–2015. Mechatronics Engineering is a well-recognized interdisciplinary course that is gaining significant importance in the industrial world. What sets this program apart from other B.E. programs are its unique features and practical approach. Students of this program are:

This program also provides exposure to Bio-Mechatronics, which integrates mechanical systems with human physiology. Students will undertake their final year projects in leading industries, enabling them to apply theoretical knowledge to real-life problems. This industrial exposure prepares them to tackle more challenging and innovative application-oriented projects based on real-world situations.

Through this project work, students develop decision-making skills, adaptability, and the ability to work in diverse team environments.

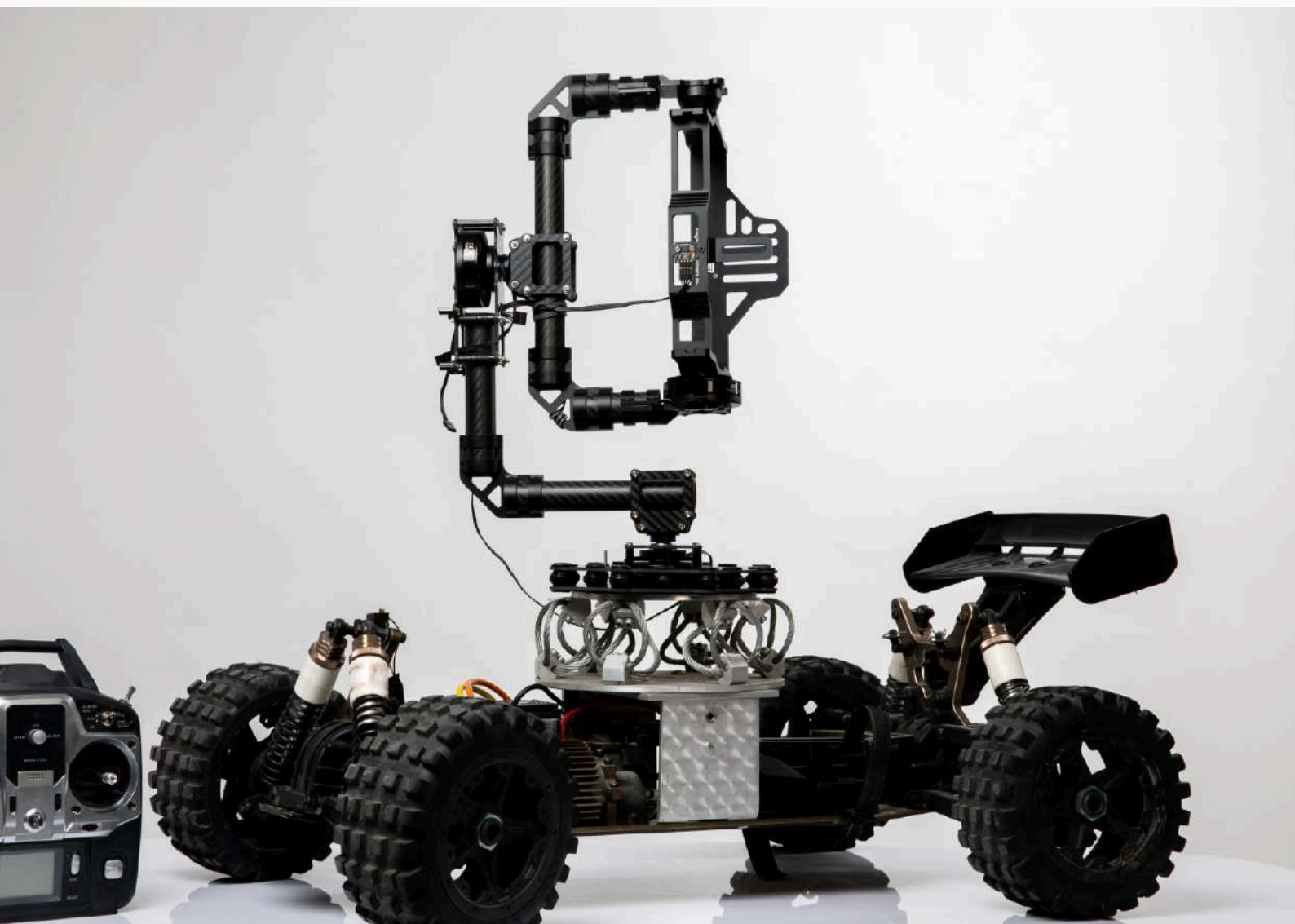


Well-equipped with computer skills. Trained in operating microcontrollers and programmable logic controllers (PLCs). Experienced in handling industrial sensors, as well as hydraulic, pneumatic, and electric drives. Skilled in mechanical structure design and learning various mechanisms involved in manufacturing processes.

# *about the* **MECHATRONZ**

This vol 5, Issue 1 presents a comprehensive overview of the Department of Mechatronics Engineering and its activities for **July to December 2024.**

*The structure of mechanics, The pulse of electronics,  
The brain of intelligence.*



# DEPARTMENT OF MECHATRONICS ENGINEERING

## FACULTY PROFILE

S.No	Name of the Faculty with Designation	Qualification	Specialization
1	Dr. K. Kannan, Professor & Head	M.E., Ph.D.,	Digital Image Processing, Machine Vision, Embedded System and Robotics
2	Dr.M.Sudalaimani, Associate Professor	M.E., Ph.D.,	Automation and Control Systems
3	Dr. S. Rajesh Babu Assistant Professor	M.E., Ph.D.,	Power Quality, Renewable Energy Systems, Machine Learning
4	Dr. P. Balasundar, Assistant Professor	M.E., Ph.D.,	Manufacturing, Composite Material, Tribology and Powder Metallurgy
5	Mr. A. Arul Kumar, Assistant Professor	M.E., (Ph.D),	Renewable Energy Source, Power Electronics Drives and Power Quality
6	Mr. S. Wesley Moses Samdoss, Assistant Professor	M.E., (Ph.D),	Robotics, Embedded Systems, IoT, and Machine Learning
7	Mr. A. Ganesan, Assistant Professor	M.E.,	Thermodynamics, Heat Transfer, Fluid Mechanics Refrigeration and Air Conditioning



## PUBLICATIONS

**Journal Name:** Materials Research Express.

**Authors:** BK Parrthipan, P Narayanasamy, Ramya Ranjit, Pratheesh Krishnankutty, Mohammed Raffic Noor Mohamed, **P Balasundar**.

**Title of Paper:** Tensile strength prediction in monel 400 weldments using classification and regression algorithms in machine learning.

**Journal Name:** Heliyon

**Authors:** S David Blessley, P Narayanasamy, **P Balasundar**, B Balavairavan

**Title of Paper:** Effect of Voltage and concentration of polyetherimide on surface morphology and corrosion properties of AZ91D by electro-spin coating.

**Journal Name:** Ceramics International

**Authors:** **P Balasundar**, S Senthil, P Narayanasamy, Peerawatt Nunthavarawong, Abhilashsharan Tambak, T Ramkumar, BK Parrthipan

**Title of Paper:** Tribo-mechanical performance of Al-nano TiC composites processed by microwave-assisted powder metallurgy.

**Journal Name:** Applied Science and Engineering Progress

**Authors:** Muthu Natarajan Shunmugam, Senthil Sankaranarayanan, Narayanasamy Pandiarajan, Balasubramanian Karthekeyan Parrthipan, **Balasundar Pandiarajan**

**Title of Paper:** Enhancing Mechanical Properties of PLA Filaments through Orange Peel Powder Reinforcement: Optimization of 3D Printing Parameters.

**Journal Name:** Biomass Conversion and Biorefinery

**Authors:** K Pratheesh, P Narayanasamy, R Prithvirajan, T Ramkumar, **P Balasundar**, S Indran, MR Sanjay, Suchart Siengchin

**Title of Paper:** Cenosphere filled epoxy composites: structural, mechanical, and dynamic mechanical studies.

**Journal Name:** International Journal of Advanced Networking and Applications

**Authors:** **M. Sangeethalakshmi, K. Kannan**

**Title of Paper:** Multi-focused Image fusion in HDWT Domain

**Journal Name:** 8th IET Smart Cities Symposium (SCS 2024)

**Authors:** **S Rajeshbabu**

**Title of Paper:** Greedy algorithm-based environmental impact analysis of renewable energy integration in smart cities.



## COPYRIGHTS

**Author(s):** Wesley Moses Samdoss S, Kannan K, Rajeshbabu S, Ganesan A

**Title:** Robotics Laboratory Manual for Mechatronics Engineering

**Reference Number:** L-152606/2024

**Remarks:** Granted

## PATENTS

**Title:** Slit Cutting Assembly For Instant Removal of Edible Oil From Defective Pouches

**Author(s):** Dr. K. Kannan, Dr. M. Prithviraj, Mr. N.R. Madhan, Dr. S. Senthil, Ms. M.Sangeetha Lakshmi

**Patent Number:** 414691-001

**Status:** Granted



Guest Lecture on Rise of the Robots:  
**Transforming Industries with Cutting-Edge Automation** - 12th August 2024



On 12th August 2024, the Department of Mechatronics Engineering hosted an engaging guest lecture titled “Rise of the Robots: Transforming Industries with Cutting-Edge Automation”. The session was delivered by Mr. Siva A., Project Manager (Automation & Robotics) at SSS Automation India, Madurai & Chennai. Mr. Siva shared his expertise on how robotics and automation revolutionizing in various industries by enhancing efficiency, precision, and safety.

## ACTIVITIES FOR THE ACADEMIC YEAR 2024-2025

Guest Lecture on  
**Cyber Security Essentials to Safeguard Your Digital Assets** - 2 nd August 2024



C.kathyayeni, Senior Cyber Security Consultant, Priyadarshini, Cyber Security Researcher, Hebesec Technologies Pvt.Ltd, Karaikudi.

Training Program on  
**Advanced Pneumatic Controls** - 2th to 13th September 2024

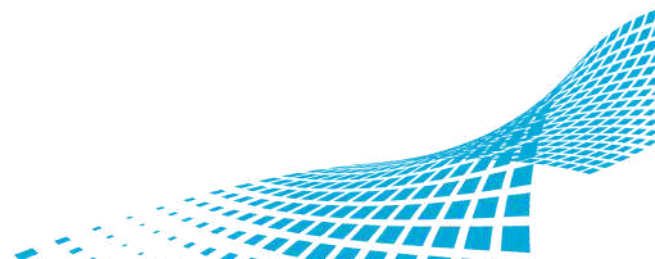


The Department of Mechatronics Engineering organized a two-day intensive training program on “Advanced Pneumatic Controls” from 12th to 13th September 2024. The sessions were conducted by Er. S. Sasikumar, Deputy Manager of Training & Marketing at SMC Corporation (India) Pvt. Ltd., Chennai.

Advanced Training on **Industrial Pneumatic Controls for ECE Students** 1st to 3rd August 2024



From 1st to 3rd August 2024, an advanced training program on “Industrial Pneumatic Controls” was conducted for Electronics and Communication Engineering (ECE) students. The training was led by Er. S. Sasikumar, Deputy Manager of Training & Marketing at SMC Corporation (India) Pvt. Ltd., Chennai.



## STUDENT'S INTERNSHIP DETAILS (2024-2025)

S.No	Roll No.	Name	Duration	No.of Days	Industry Details
1	22UMT001	SASHWANTH S	17-06-2024 to 03-07-2024	15	SNS Automobiles, Madurai
2	22UMT002	BIBAKS NOBAL A P	13-06-2024 to 27-06-2024	15	JAI Valves Centre, Pudukottai
3	22UMT003	ISAC STEPHEN V	31-05-2024 to 19-06-2024	20	Sugapriya paper & boards Pvt Ltd, Virudhunagar
4	22UMT004	TRISHNA K	13-06-2024 to 03-07-2024	15	J.K. Fenner (India) Limited, Madurai
5	22UMT005	JOTHEESWARAN A	30-05-2024 to 18-06-2024	20	ALFA Diaries PVT LTD, Sivakasi
6	22UMT006	MATHIYA VEDHA NIRANJAN R	20-06-2024 to 06-07-2024	17	HI-TECH ARAI PRIVATE LIMITED, MADURAI
7	22UMT007	SRIRAM A	27-05-2024 to 10-06-2024	15	SRI RAM PANELS, Tirunelveli
8	22UMT008	HARIRAJAN K	04-06-2024 to 20-06-2024	15	Sripathi Paper and Boards Private Limited, Sivakasi
9	22UMT009	GUHANESHVAR S	10-06-2024 to 26-06-2024	17	ACV Products Pvt Ltd, Theni
10	22UMT010	MUTHU JEYA SUNDAR S	28-05-2024 to 13-06-2024	17	VV Titanium Pigment Ltd, Thoothukudi
11	22UMT011	SAHAYA SANTHOSH RAJ S	27-05-2024 to 12-06-2024	17	S&S Engineers, Rajapalayam
12	22UMT012	RAGAVARSHINI S	05-06-2024 to 21-06-2024	17	Ruby Food Products Pvt Ltd, Madurai
13	22UMT013	LOGA ANJANA P	06-06-2024 to 23-06-2024	18	SATTUR SRI VENKATESWARA DUPLEX BOARDS (P) LTD, SATTUR

## STUDENT'S INTERNSHIP DETAILS (2024-2025)

S.No	Roll No.	Name	Duration	No.of Days	Industry Details
14	22UMT014	PRIYADHARSHAN S	17-06-2024 to 03-07-2024	16	TVS sensing and solutions, Madurai
15	22UMT015	MADHAN KUMAR R	27-05-2024 to 12-06-2024	16	S&S Engineers, Rajapalayam
16	22UMT016	SHIVA R	01-06-2024 to 21-06-2024	21	Siva poly packs, Sivakasi
17	22UMT017	VIJAI R	03-06-2024 to 19-06-2024	17	Shri ramalinga Mills Pvt Ltd, Aruppukottai
18	22UMT018	ARUNATH A	20-06-2024 to 06-07-2024	15	HI-TECH ARAI PRIVATE LIMITED, MADURAI
19	22UMT019	HARI KRISHNAN B	10-06-2024 to 26-06-2024	17	HI-TECH ARAI PRIVATE LIMITED, MADURAI
20	22UMT020	SRIRAM NARAYANAN K	27-05-2024 to 14-06-2024	18	Sega Plascan exports private limited, Virudhunagar
21	22UMT021	ABINESH S	17/12/2024 to 31/12/2024	15	HI-TECH ARAI PRIVATE LIMITED, MADURAI
22	22UMT022	RATHIKASHREE B	03-06-2024 to 17-06-2024	15	Shakti Cords Private Limited, Kappalur
23	22UMT023	BALAJI C	03-06-2024 to 20-06-2024	18	KAY JAY Forgings Private Limited, Hosur
24	22UMT024	PARTHIBAN M	19-06-2024 to 05-07-2024	17	Perfect Engineering works, Sivagangai
25	22UMT025	SANJAY KUMAR M	11-06-2024 to 27-06-2024	17	Geometric Precision Machining Technologies, Madurai

## STUDENT'S INTERNSHIP DETAILS (2024-2025)

S.No	Roll No.	Name	Duration	No.of Days	Industry Details
26	22UMT026	YOGACHARAN B	25-05-2024 to 14-06-2024	21	Thangabala poly pack, virudhunagar
27	22UMT027	MUTHUMANICKAM K	03-06-2024 to 20-06-2024	15	KAY JAY Forgings Private Limited, Hosur
28	22UMT028	GOKUL S	18-06-2024 to 02-07-2024	15	Gmmco-CAT, Chennai
29	22UMT029	SANGARESHWARAN B	05-06-2024 to 19-06-2024	15	RP Plastics, Madurai
30	21UMT022	NILESH A	04.06.2024 to 01-07-2024	28	Chemical Engineering Department, NIT, Trichy.
31	21UMT028	MITHUN KUMAR G S	03.06.2024 to 03-07-2024	30	ROBOMIRACLE, Coimbatore.
32	21UMT030	KISHOURE KUMAR D	10.06.2024 to 22-06-2024	14	Chemical Engineering Department, NIT, Trichy

# INTERNATIONAL CERTIFICATION

**SITRAIN Digital Industry Academy** recently conducted a specialized training program on **SIMATIC S7 1200 using TIA Portal**, hosted in Coimbatore from 30th September to 4th October 2024. The program was facilitated by Learning Consultant Mr. Jegathesan V.

S.No	Roll No.	Name
1	21UMT002	ARAVIND ARYA G
2	21UMT028	MITHUN KUMAR S
3	21UMT014	MOHAMMED AMMAR S
4	21UMT018	SIVANESHAKARTHIC RA K
5	21UMT030	KISHOURE KUMAR D
6	21UMT019	SANGEETHA LAKSHMI M
7	21UMT025	ARAVINTH V
8	21UMT029	ARSHAD PARWESH S

## TRAINING HIGHLIGHTS

The program focused on equipping students with hands-on knowledge in automation and PLC programming, vital for modern industrial applications. The key learning areas included: System Overview of SIMATIC controller families and hardware configuration of S7-1200. TIA Portal Training, covering license management, structure, and engineering workflows. Programming Skills in PLC tags, logic instructions, arithmetic and logic operations, analog value processing. Advanced Approaches including use of function/function blocks, organization blocks, and data block handling. Diagnostics & Troubleshooting with LED indication, cross-references, memory structure, and error analysis. Practical Applications such as forcing, renaming, rewriting concepts, and PLC drive communication.



## FACULTY NPTEL ONLINE CERTIFICATION DETAILS

S.No	Student Name	Name of the Course	Duration of the Course
1	DR. K. KANNAN	Industrial Automation and Control	12 weeks
2	DR. K. KANNAN	Automation in Manufacturing	12 weeks
3	MR. A. ARULKUMAR	Advanced Power Electronics and Control	8 Weeks

## STUDENT NPTEL ONLINE CERTIFICATION DETAILS

S.No	Student Name	Name of the Course	Duration of the Course
1	LOGA ANJANA P	Embedded System Design with ARM	8 Weeks
2	RATHIKASHREE B	Embedded System Design with ARM	8 Weeks
3	ARAVINDH AARYA G	User Interface Design	4 Weeks
4	ARAVINDH AARYA G	Introduction to Machine Learning	8 Weeks

## PRIZES WON LIST IN INTER INSTITUTE EVENTS

S.No	Name of the student	Type of the Programme	Date	Organizing Institution	Prizes own
1	SIVANESAKARTHIC RA K	TECH Vision	20/09/2024	PSR Engineering College, Sivakasi.	First
2	ARAVINDH AARYA G	TECH Vision	20/09/2024	PSR Engineering College, Sivakasi.	First
3	SANGEETHA LAKSHMI M	Paper Presentation	21/09/2024	Kongunadu College of Engineering and Technology, Trichy.	Third
4	ARSHAD PARWESH S	Paper Presentation	21/09/2024	Kongunadu College of Engineering and Technology, Trichy.	Third
5	KISHOURE KUMAR D	Paper Presentation	21/09/2024	Kongunadu College of Engineering and Technology, Trichy.	Third
6	DINESH K	Prototype Fair	20/09/2024	PSR Engineering College, Sivakasi.	First
7	HARIRAJAN K	Paper Presentation	04/10/2024	Sri Sai Ranganathan Engineering College, Coimbatore.	First
8	SAHAYA SANTHOSH RAJ S	Paper Presentation	04/10/2024	Sri Sai Ranganathan Engineering College, Coimbatore.	First
9	SAHAYA SANTHOSH RAJ S	Circuit Debugging	04/10/2024	Sri Sai Ranganathan Engineering College, Coimbatore.	First
10	GOKUL S	Intellimobility	Oct 2024	ARAI, Pune.	First



# HUMAN-ROBOT INTERACTION WEARABLE ROBOTICS AND INTUITIVE CO-BOTS FOR SAFER WORKPLACES

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Human-robot interaction (HRI) has emerged as a significant trend in Industry 4.0 and Industry 5.0, where the focus is shifting from automation replacing humans to collaboration between humans and robots. Recent advancements in wearable robotics and collaborative robots (co-bots) are transforming workplaces by enhancing safety, efficiency, and productivity. Wearable Robotics such as exoskeletons and robotic suits provide physical support, reduce fatigue, and minimize injuries caused by heavy lifting or repetitive tasks. In manufacturing and construction, exoskeletons reduce musculoskeletal disorders, while in healthcare, robotic wearables assist caregivers in handling patients safely. Moreover, wearable robotics empower people with mobility impairments, enabling participation in the workforce.

Collaborative Robots (Co-Bots) are designed to work side by side with humans in shared environments. Equipped with Sensors, vision systems, and AI-based control, co-bots can adapt to human presence, detect obstacles, and ensure safe interactions. Unlike traditional industrial robots, they are lightweight, flexible, and easy to program. Applications range from assembly lines and warehouses to healthcare and logistics, where co-bots assist with repetitive or hazardous tasks, allowing workers to take on creative and complex responsibilities. The benefits of HRI include:

**Safety:** Reduced exposure to dangerous environments and heavy loads

**Productivity:** Integration of human creativity with robotic precision.

**Development:** Workers gain experience in managing intelligent robotic systems.

**Inclusivity:** Support for individuals with physical limitations.

*M. Devi Priya*

2023 - 2027

# SWARM ROBOTICS COLLECTIVE INTELLIGENCE IN MACHINES

In nature, ants build complex colonies, birds migrate in flocks, and fish swim in schools—all without a central leader. Inspired by these natural systems, Swarm Robotics is an emerging field that applies the principles of collective intelligence to groups of robots. Instead of relying on a single powerful machine, swarm robotics focuses on deploying large numbers of simple robots that work together to perform complex tasks. This area of robotics has gained significant attention in recent years due to its potential applications in defense, agriculture, disaster management, and space exploration. By combining mechatronics with artificial intelligence, swarm robotics is redefining how machines can collaborate and adapt to dynamic environments.

## What is Swarm Robotics?

Swarm robotics involves multiple autonomous robots interacting locally with one another and their environment, while following simple behavioral rules. Together, they achieve global goals such as exploration, mapping, or object transport without centralized control. Key characteristics of swarm robotics include:

**Scalability:** The system can easily expand by adding more robots.

**Flexibility:** Robots can adapt to new environments and tasks.

## Core Technologies in Swarm Robotics

### Distributed Sensing and Communication:

Robots use local sensors and short-range communication (like infrared, Bluetooth, or Wi-Fi) to share information with neighbors.

### Self-Organization Algorithms:

Swarms rely on bio-inspired algorithms such as Ant Colony Optimization, Particle Swarm Optimization, and Boids Model to coordinate behavior.

### Multi-Agent Control Systems

Instead of one brain controlling all robots, each robot has a small controller. Collective decision-making emerges from their interactions.

### Miniaturized Mechatronics:

Advances in microcontrollers, sensors, and compact actuators enable small, low-cost robots to perform complex tasks collectively.



## Applications of Swarm Robotics

**Search and Rescue Operations:** Swarms of robots can explore disaster sites, detect survivors, and map dangerous environments without risking human lives.

**Agriculture:** Tiny swarm robots can monitor soil health, detect pests, and collectively spray fertilizers or water fields with high efficiency.

**Military and Defense:** Swarm drones are being developed for surveillance, reconnaissance, and coordinated strikes, offering greater resilience than single large systems.

**Space Exploration:** NASA is exploring robotic swarms for planetary missions. Hundreds of small robots could map Mars or explore asteroids more effectively than a single rover.

**Environmental Monitoring:** Swarm robots can track pollution levels, clean oceans, and monitor wildlife in remote ecosystems.

## Challenges in Swarm Robotics

**Coordination:** Ensuring hundreds of robots act in harmony without collisions.

**Energy Management:** Miniature robots face limited battery life.

**Security:** Swarm systems can be vulnerable to hacking or interference.

**Ethics:** Military use of swarms raises global concerns about autonomous weapons.

## Future Outlook

Swarm robotics is poised to be a game-changer in collective intelligence systems. By combining mechatronics, AI, and bio-inspired algorithms, swarm robots will become integral to smart cities, autonomous logistics, disaster recovery, and planetary exploration.

*Sasthi Ramanathan A*

2023 - 2027

# SOFT ROBOTICS THE FUTURE OF HUMAN ROBOT INTERACTION

In recent years, robotics has moved beyond rigid structures and metallic arms into a new and exciting field: Soft Robotics. Unlike traditional robots made of hard materials, soft robots are constructed using flexible and deformable materials such as silicone, polymers, and hydrogels. This emerging area is transforming the way robots interact with humans, the environment, and even living organisms. Soft robotics is inspired by nature octopus tentacles, starfish arms, and elephant trunks all demonstrate flexibility and adaptability that rigid robots cannot achieve. By mimicking biological systems, engineers are designing robots that are safer, more adaptable, and capable of working in complex, unstructured environments.

## Why Soft Robotics?

Traditional robots, while powerful and precise, are often dangerous around humans due to their rigidity and force. Soft robots, on the other hand, are:

**Safe for Humans:** Their compliant structures prevent injuries during collaboration.

**Adaptable:** They can squeeze into tight spaces or handle fragile objects without damage.

**Lightweight and Energy-Efficient:** Soft materials require less power for movement.

**Bio-Inspired:** They mimic natural motion, making them suitable for healthcare and wearable systems.

## Core Technologies in Soft Robotics

**Smart Materials:** Soft robots are made from elastomers, shape-memory alloys, liquid crystal polymers, and hydrogels. These materials allow stretching, bending, and even self-healing.

**Actuation Mechanisms:** Instead of motors, soft robots use innovative actuators:

**Pneumatic Actuators:** Air-filled chambers expand and contract to create movement.

**Dielectric Elastomers:** Electrical signals deform rubberlike materials.

**Magneto-Active Polymers:** Move in response to magnetic fields.

**Sensors and Control:** Embedded soft sensors can detect pressure, strain, and touch, enabling robots to interact delicately with their environment.

**AI Integration:** Artificial intelligence enhances motion control, allowing robots to "learn" how to grasp different objects or adapt to new tasks.

## Applications of Soft Robotics

### Healthcare and Surgery:

Soft robotic grippers assist in minimally invasive surgery.

Wearable exoskeletons support patient rehabilitation.

Flexible robotic catheters navigate inside blood vessels safely.

### Food and Agriculture:

Soft grippers harvest delicate crops like strawberries or tomatoes without damage. Automated food handling systems pack fruits, vegetables, and baked goods.

### Search and Rescue:

Soft robots can crawl through debris and collapsed structures to locate survivors. Their adaptability makes them ideal for hazardous environments.

### Assistive Technology:

Soft robotic gloves restore hand mobility to stroke patients.

Lightweight exosuits support elderly individuals in daily activities.

### Space Exploration:

NASA is exploring soft robots for planetary exploration because they are lightweight, flexible, and energy-efficient.



Soft robotics represents not just a new branch of engineering, but a paradigm shift in how we design and use robots. For mechatronics engineers, it opens exciting opportunities to create machines that are more human-like, adaptable, and life-changing.

*Aarthithya. r*

2023 - 2027

# Helix

## Advancing Humanoid Robotics Through Vision Language Action Models

### Introduction

In February 2025, Figure AI introduced Helix, a generalist vision-language-action (VLA) model designed to enhance the capabilities of humanoid robots by integrating perception, language comprehension, and high-precision motor control. Helix represents a new generation of intelligent robots capable of understanding complex instructions, perceiving dynamic environments, and performing intricate tasks autonomously. Unlike traditional robots that rely on preprogrammed sequences, Helix combines artificial intelligence, vision processing, and dexterous control, enabling operation in unstructured and ever-changing environments. This advancement marks a crucial step toward achieving general-purpose humanoid robots that can assist humans in industrial, healthcare, and research settings.

### Architecture of Helix

Helix is built on a dual-system architecture that separates perception from action while allowing seamless coordination. System 1 (S1) functions as a visuomotor policy, converting latent representations derived from sensory inputs into continuous motor actions. This enables precise control of the robot's upper body, including arms, hands, torso, head, and fingers, allowing it to manipulate objects, operate tools, and perform multi-step tasks fluidly. System 2 (S2) is an internet-scale vision-language model specialized in scene understanding and natural language comprehension, providing Helix with the ability to recognize and monitor task progress, ensuring rapid, adaptive, and coordinated execution in dynamic environments.



### Training and Data

Helix was trained on approximately 500 hours of robot teleoperation, paired with automatically generated text descriptions of each task. This dataset allowed the model to learn the correlation between visual observations, textual instructions, and motor actions, enabling it to generalize across a wide range of tasks. Unlike traditional robots that require task-specific programming, Helix can adapt to new scenarios, handle unexpected obstacles, and modify its behavior in real time. For example, if Helix observes a human performing an unfamiliar object manipulation task, it can infer the necessary actions through its vision-language-action model, replicate the task autonomously, and adjust movements to avoid collisions or errors, making it highly effective in dynamic and cluttered environments such as warehouses, laboratories, or healthcare facilities.

### Applications

The applications of Helix are diverse and impactful. In industrial automation, Helix can perform assembly, quality inspection, material handling, and packaging tasks, reducing human labor in repetitive or hazardous operations. Its high dexterity allows it to work safely alongside humans, handling delicate electronics or heavy mechanical parts with equal precision. In healthcare, Helix can assist patients with limited mobility, support rehabilitation exercises, or participate in surgical procedures under supervision, with natural language instructions enabling doctors and caregivers to guide it without programming. In research and exploration, Helix can navigate laboratories, handle sensitive experiments, and operate in unsafe or inaccessible areas. Its ability to understand natural language instructions allows for intuitive human-robot collaboration, adjusting its behavior in real time to assist humans efficiently and safely.



### **Advantages**

Helix provides several advantages over conventional humanoid robots. Its high-frequency motor control enables fluid, human-like movements for precise task execution. Integration with a vision-language model allows it to understand and act on complex instructions without explicit coding. Training with teleoperation data and automated text annotations provides scalable learning, allowing Helix to adapt to new tasks and environments. Its combination of adaptability, precision, and intelligence sets a new standard in humanoid robotics, enabling robots to perform multi-step operations autonomously with minimal human intervention.

### **Challenges**

Despite its advanced capabilities, Helix faces several challenges. Real-world generalization is difficult, especially in cluttered or unpredictable environments. Computational demands are high due to large-scale vision-language processing, requiring optimization or edge computing for real-time operation. Ensuring safety and reliability when interacting with humans or delicate objects remains critical. Furthermore, multi-task learning and collaboration capabilities must be enhanced to enable seamless switching between diverse tasks and effective coordination with humans. Researchers are also focusing on improving energy efficiency and autonomous decision-making to extend operational time in industrial and healthcare settings.

### **Conclusion**

Helix represents a transformative advancement in humanoid robotics by bridging the gap between perception, language comprehension, and motor control. By integrating AI-driven vision-language models with precise motor execution, Helix enables humanoid robots to perform complex tasks autonomously, safely, and efficiently. Its applications across industrial automation, healthcare, research, and human-robot collaboration demonstrate its versatility and potential. As development continues, Helix sets the stage for general-purpose humanoid robots capable of assisting humans in dynamic and unstructured environments, signaling a new era of intelligent, adaptive, and collaborative robotic systems that can significantly enhance productivity, safety, and human-robot interaction.

*B. Rathikashree*

2022 - 2026



## DIGITAL TWINS IN MANUFACTURING AND SMART CITIES

*Shaping the future*

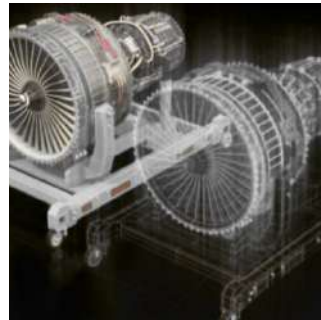
In today's rapidly changing world, technology is more than just a support system; it is a driver of transformation. One of the most fascinating technologies is the Digital Twin, which is altering how industries and cities operate.

### What is a "Digital Twin"?

A digital twin is a virtual replica of a physical system. It takes data from sensors, IoT devices and real-time inputs to simulate the state, performance and behavior of machines, buildings or even entire cities. This digital version enables engineers, city planners and decision-makers to test scenarios, foresee difficulties and optimize performance without interrupting the actual world.



### Digital Twins in Manufacturing:



Digital twins are revolutionizing production by enabling smart factories that can forecast issues, increase efficiency and save prices. Instead of waiting for machinery to fail, industries utilize digital copies to monitor performance and do predictive maintenance, resulting in less downtime and more reliability.

They also contribute to process optimization by detecting bottlenecks and optimizing procedures. Engineers may develop and test items online before creating physical prototypes, reducing waste and accelerating innovation. Simultaneously, digital twins improve supply chain management by monitoring inventories, logistics and demand in real time. Beyond production, digital twins help with quality control, energy savings, and employee training. They verify that items satisfy regulations, reduce excessive energy consumption, and provide a safe atmosphere for employees to learn. Overall, digital twins improve industrial efficiency, safety and sustainability, paving the path for the factories of the future.

### Digital Twins in Smart Cities:

Digital twins are becoming an essential part of smart city development, allowing cities to operate more smoothly and efficiently. They develop a virtual model of the city that displays real-time data from traffic lights, services. This enables municipal planners to monitor what is going on and respond more quickly to problems. One prominent application is in traffic control, where digital twins may highlight where roads are congested and assist in modifying traffic signals to reduce traffic jams. They also help manage energy and water systems, ensuring that resources are used efficiently. Urban planners can even use the digital model to simulate the impact of new buildings, parks or roads before they are built, saving time and money. Digital twins are also beneficial in handling crises and public safety. They can predict flood-prone areas, prepare evacuation routes and coordinate emergency responses. Overall, digital twins contribute to the development of safer, greener, and more sustainable cities, thereby increasing everyone's quality of life.

*P. Loga Arjana*

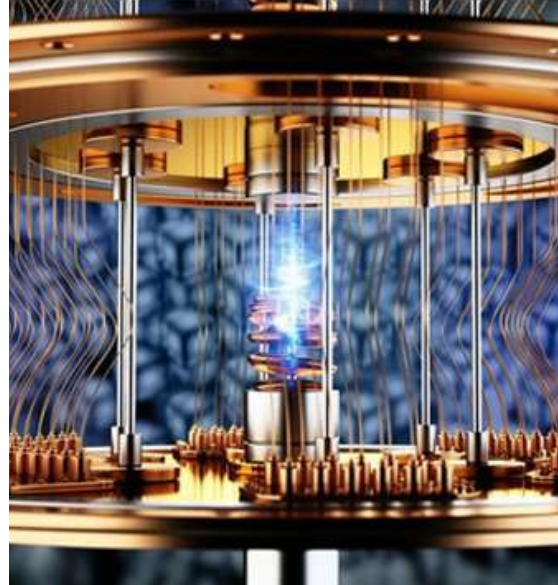
2022 - 2026

# QUANTUM COMPUTING

*S. Ragavarshini*  
2022 - 2026

## THE RISE OF QUANTUM COMPUTING:

A New Era of Innovation Quantum computing, once a theoretical concept confined to research labs, is rapidly emerging as a transformative technology with the potential to revolutionize industries. Unlike classical computers, which process information using bits (0s and 1s), quantum computers leverage quantum bits or qubits which can exist in multiple states simultaneously. This unique capability allows quantum computers to tackle complex problems at unprecedented speeds, opening doors to advancements in cryptography, materials science and artificial intelligence (AI). This article explores the current state of quantum computing, its applications and its potential impact on the future.

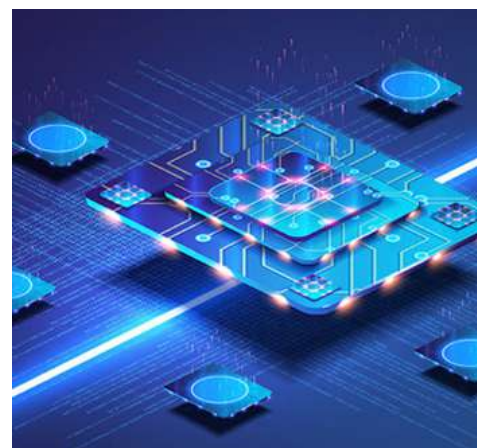


## HOW QUANTUM COMPUTING WORKS

Quantum computing harnesses the principles of quantum mechanics superposition, entanglement, and interference to process information. Superposition enables qubits to represent both 0 and 1 at the same time, exponentially increasing computational possibilities. Entanglement creates strong correlations between qubits, allowing coordinated computations across vast datasets. Interference manipulates quantum states to amplify correct solutions while canceling out errors.

## Quantum Computing Applications

Quantum computing revolutionizes industries by processing complex data rapidly. It simulates molecular interactions for drug discovery and personalized medicine, designs advanced materials like catalysts and solar cells and optimizes energy and carbon capture. In finance, it enhances portfolio optimization, risk analysis and fraud detection. For AI, it speeds up tasks like image recognition and pattern detection. It drives quantum-resistant encryption for cybersecurity, designs catalysts for climate solutions and optimizes supply chains and traffic management. The Future of Quantum Computing By 2030, quantum computing could become a cornerstone of technological innovation. Financial institutions like JPMorgan Chase are already testing quantum algorithms for risk analysis, while governments are investing heavily. China's quantum research budget exceeds \$15 billion, and the U.S. passed the National Quantum Initiative Act to fund development. As quantum hardware and software mature, we may see breakthroughs in climate modeling, renewable energy, and personalized medicine.



## Conclusion

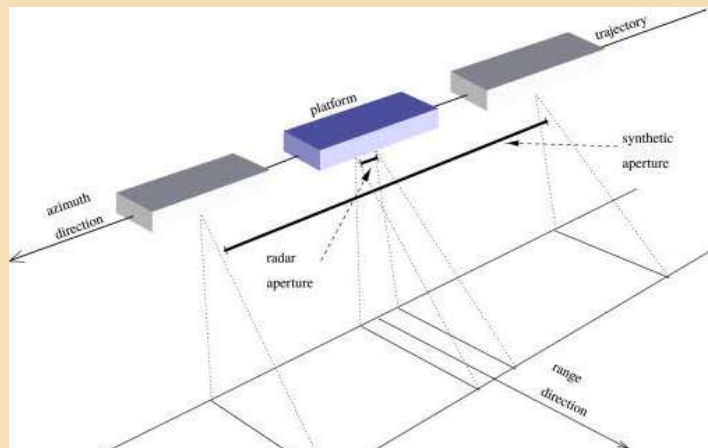
Quantum computing is still in the research and development phase, but there is significant ongoing investment and innovation in the field. Companies like IBM, Google, and Microsoft are developing hardware and software to harness its potential.

# INTRODUCTION TO SYNTHETIC APERTURE RADAR (SAR) TECHNOLOGY

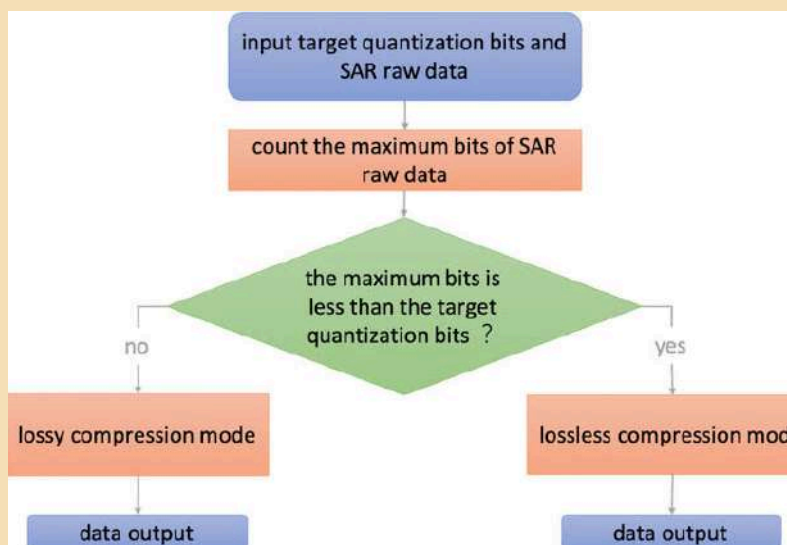
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## INTRODUCTION

Synthetic Aperture Radar (SAR) is an advanced remote sensing technology that uses radar signals to generate high-resolution images of the Earth's surface or other objects. Unlike optical imaging systems, which rely on sunlight or visible light, SAR is an active sensor that emits its own microwave signals and measures the backscattered echoes. This allows it to operate effectively in all weather conditions, including through clouds, fog, and rain, as well as in complete darkness. SAR achieves its high resolution by simulating a large antenna aperture through the motion of the platform (such as a satellite, aircraft, or drone) carrying the radar system.



The core principle of SAR involves transmitting short pulses of radio waves, typically in the microwave frequency range (from about 3 cm to 1 m wavelengths), toward the target area. The radar antenna moves along a path, collecting multiple echoes from the same scene at different positions. These echoes are then processed using sophisticated algorithms to synthesize a virtual "aperture" much larger than the physical antenna, resulting in images with resolutions down to centimeters or even millimeters in some cases. This process, known as synthetic aperture synthesis, compensates for the limitations of real aperture radar systems, which are constrained by antenna size and distance.



### The Need for Compression

To manage this volume, compression is critical. It must reduce size without losing phase information, which is vital for advanced processing like interferometry. Compression aims for high ratios (4:1 or more) while keeping quality high.

Key metrics include:

- Signal-to-Quantization-Noise Ratio (SQNR)
- Phase preservation
- Final image clarity

### Smart Compression for SAR Raw Data:

Keeping Quality, Cutting Size Synthetic Aperture Radar (SAR) is a powerful remote sensing technology used in everything from environmental monitoring and disaster response to agriculture and defense. It captures complex data even through clouds and darkness making it invaluable for applications like flood mapping, crop health, and tracking earthquakes or volcanoes.

### Why SAR Raw Data Is Huge:

SAR collects raw signal data in complex form (I/Q samples), leading to massive file sizes often gigabytes per scene especially for satellites like NASA's NISAR or ESA's Sentinel-1.

# AUTONOMOUS SYSTEMS AND ADVANCED MANUFACTURING IN MECHATRONICS

*Revolutionizing Industries with Smart Systems*

## INTRODUCTION

The 21st century is witnessing a revolution in manufacturing through the integration of autonomous systems with advanced mechatronics. These systems combine mechanical design, electronics, control engineering, and computing to achieve automation that goes beyond traditional robotics. Unlike conventional machines that require constant human supervision, autonomous mechatronic systems are capable of self-decision, learning, and adaptive control. This shift is not only improving efficiency but also transforming industries like automotive, aerospace, healthcare, and smart factories



## What Are Autonomous Systems in Mechatronics?

*Smart Factories Drive Sustainable Manufacturing:*

Autonomous systems are machines or robots that can sense, decide, and act with minimal human intervention. Sensors and IoT devices to gather real time data, AI and Machine Learning for decision making. Advanced control systems to adapt to dynamic environments, Connectivity (5G/IIoT) to integrate with smart manufacturing lines

*Digital Twin Integration:* Factories now use digital replicas of machines where autonomous mechatronic systems test operations virtually before real implementation.

*Examples include:* Self-navigating Automated Guided Vehicles (AGVs) in warehouses, Autonomous robotic arms in production lines, Smart inspection drones for quality checks.

## Role in Advanced Manufacturing

Advanced manufacturing focuses on precision, flexibility, and efficiency using cutting-edge technologies like CNC, additive manufacturing, and digital twins. Autonomous systems enhance this by:

*High Precision & Consistency:* Robots guided by sensors and AI maintain accuracy beyond human limits. For example, in sheet-metal rolling or semiconductor production, autonomous systems ensure micrometer-level precision.

*Productivity & Cost Reduction:* Factories can operate 24/7 with minimal downtime. Predictive maintenance supported by autonomous systems prevents costly breakdowns.

*Flexibility in Customization:* Autonomous systems can quickly adapt to produce small-batch or customized products without reprogramming entire production lines.

*Safety in Hazardous Environments:* Robots take over dangerous tasks such as heavy lifting, welding, or working in toxic conditions, protecting human workers.

*Recent Developments:* Digital Twin Integration in factories now use digital replicas of machines where autonomous mechatronic systems test operations virtually before real implementation.

## Future Outlook:

In the near future, factories will evolve into fully autonomous smart factories where machines communicate with each other, predict demand, and self-adjust production. The combination of AI, IoT, and mechatronics will define Industry 5.0, where humans and autonomous systems work together to deliver both efficiency and personalization.

## Conclusion:

Autonomous systems in advanced manufacturing represent the fusion of mechatronics with AI and smart technologies. They promise a future where production is not only faster and safer but also smarter and more sustainable. For engineering students, especially in mechatronics, this field opens up immense opportunities for innovation, research, and entrepreneurship.



*K. Sriram Narayanan*

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