Excellence in Higher Education
AKSHAYA COLLEGE OF ENGINEERING AND TECHNOLOGY
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DEPARTMENT OF MECHATRONICS ENGINEERING

TECHNICAL MAGAZINE

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Message from the Head of Department

The Department of Mechatronics Engineering, established in 2013 at Akshaya College of Engineering and Technology, offers a four-year B.E. degree program with an intake of 30 students. It provides an integrated curriculum that spans electrical engineering, electronics, computer science, mechanics, robotics, and modern courses. The department strives to produce highly skilled professionals who are prepared to tackle real-world challenges and contribute to technological advancements.

The program's strength lies in its innovative curriculum, which meets international quality standards. The department focuses on continuous improvement to address stakeholders' needs and is supported by a team of exceptional faculty members from various professional and academic backgrounds. The Department of Mechatronics Engineering has modern, advanced equipment and features specialized labs, including Sensor and Instrumentation, Industrial Automation, and Robotics laboratories.

Dr. P.Ravikumar
Professor & Head
Department of Mechatronics Engineering

VISION AND MISSION OF THE DEPARTMENT

VISION OF THE DEPARTMENT

Developing competent Mechatronics Engineers with a focus on employability, research capability, entrepreneurship and human values.

MISSION OF THE DEPARTMENT

DM 1: To adopt transforming teaching-learning strategies in the field of Mechatronics Engineering by providing innovative and value-based education with relevant industrial exposure in basic domain and interdisciplinary areas.

DM 2: To nurture entrepreneurial skills with social and ethical values and develop the students for life-long learning to achieve professional excellence.

DM 3: To provide the facilities for implementation of automation techniques in real-life environment to meet the needs of industry and society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: The graduates will be able to apply Mechatronics systems and components to promote automation as per the needs of industry and society.

PEO 2: The graduates will be able to pursue higher studies with a specific interest towards research and innovation in Mechatronics and allied areas.

PEO 3: The graduates will be able to nurture ethical values and generate employment for the social and economic development.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Professional skills: Students shall have skills and knowledge in mechatronics domains like robotics, electronics, computer science, telecommunication, systems, controls and product engineering for innovative products incubation.

PSO 2: Competency: Students shall qualify at the State, National and International level competitive examination for employment, higher studies and research.

PROGRAM OUTCOMES (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 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.

PO 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

PO 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.

PO 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.

PO 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.

PO 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.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and Team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 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.

PO 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.

PO 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.

MESSAGE FROM EDITORIAL TEAM

We are delighted to present the third issue of our technical magazine, continuing our exploration of Robotics, Automation, and Mechatronics. Your enthusiasm and engagement with our previous editions have been truly inspiring, and we deeply appreciate your continued support.

In this issue, we bring you a collection of articles that dive into advanced topics, offering a deeper understanding of cutting-edge technologies and innovative methodologies. From advanced robotic systems to embedded solutions, our contributors have meticulously crafted content that bridges theory and application, helping you stay ahead in this ever-evolving field.

We encourage you to actively engage with the articles, share your perspectives, and apply the insights gained. Your feedback plays a crucial role in shaping future editions, ensuring that we deliver content that aligns with your interests and professional aspirations.

Thank you for being a valued part of our growing community. We hope this issue enhances your knowledge, sparks curiosity, and fuels your passion for mechatronics and automation.

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CHAPTER I - ADVANCED ROBOTICS SYSTEMS

Advanced robotics involves robotic systems capable of taking commands and reacting to them in an intelligent way. For example, a robot that is carrying out a task of transporting material within a warehouse and, upon facing an unexpected obstacle, takes the decision to redefine the optimal route to complete its mission. In the evolution of advanced robotics, the progress of disruptive technologies such as the Internet of Things (IOT), Big Data, Artificial Intelligence, or cognitive automation, among others, plays a significant role. These technologies are increasing the capabilities of mobile robots, which now reach higher levels of intelligence and autonomy.

Kinematics and Dynamics of Robots

A kinematics model is a representation of the motion of the robot manipulator without considering masses and moments of inertia; a dynamics model is a representation of the balancing of external and internal loads acting on the manipulator whether it is stationary or moving. The description of the motion itself is called kinematics. This just sets up the relevant degrees of freedom, represented as variables in a relevant mathematical form. The description of the causes, and how these causes affect the motion is called dynamics. These causes are often divided into forces and torques.

Robotics Programming and Simulation

Robotics simulation allows engineers to try ideas and construct manufacturing scenarios in a dynamic virtual environment, collecting virtual response data that accurately represents the physical responses of the control system. Offline Programming (or Off-Line Programming) means programming robots outside the production environment. Offline Programming eliminates production downtime caused by shop floor programming. Simulation and Offline Programming allows studying multiple scenarios of a robot work cell before setting up the production cell. Mistakes commonly made in designing a work cell can be predicted in time.

Introduction to Robotic Vision and Sensors

The computer contains a processing software program that helps the robot interpret what it sees. Then, the robot follows the program's instructions—specified by the manufacturing facility's staff—to complete the specified task. These sensors differ from image inspection "systems" in that the camera, light, and controller are contained in a single unit, which makes the unit's construction and operation simple. The benefits of using robotics with computer vision include improved productivity, task automation, better quality control, and enhanced data processing.

Case Studies: Industrial and Medical Robotics Applications

Industrial robots, designed for performing operations quickly, repeatedly and accurately have a long heritage in the manufacturing industry, operating in relatively static environments and in large numbers. Trends in the oil and gas industry to improve safety and efficiency and reduce environmental impact suggest the use of industrial robotics. New developments in regions difficult or dangerous for humans to work in could be enabled with maintenance, inspection and repairs carried out by remotely-controlled industrial robots.

This new application area highlights some difficulties with today's robots, as they do not adapt well to dynamic environments, do not offer rich human-robot interaction and are not simple for end-users to program. In addition, the oil and gas context presents a challenging work environment for robots as they are exposed to variable and often extreme weather and need to be safe for use alongside explosive hydrocarbons. As robots are introduced, issues of trust and accountability come to the fore as well as how they fit into organisational structures.

If robots have too little autonomy, human operators will waste time attending to robots instead of attending to their work tasks. If robots are highly autonomous, situational awareness of plant activity is diminished. A balance needs to be struck to find a level of autonomy suitable for the task, the realistic capabilities of the automation, and the need to actively engage human operators in a constructive fashion. These issues also relate to what form the interface takes for remote or co-located robot control, as well as how information and activity is represented for remote operators. The contribution of this paper is a discussion of issues relating to human-robot interaction for future industrial robotics, in particular for the oil and gas industry

By,

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R. Pugazhendhi-IV MCT

CHAPTER II - AUTOMATION SYSTEMS AND CONTROLS

Automation Systems and Controls (ASC) are an Australian owned automation engineering services and electrical automation equipment sales company, supplying a broad range of industries with Automation, Machine Vision & ID, Robotic and Safety Solutions. In 2018 ASC's Engineering Team was contracted to 46 projects, either for the total project management or a key specified automation engineering scope.

These were primarily across Pharmaceutical, Food, Beverage, Building Product, Packaging, Logistic and Railway industries. As a leader in automation engineering, products and systems, Automation Systems and Controls' aim is to provide our customers with a competitive marketplace advantage, benefiting from our applied knowledge, willingness to work together, value-added engineering services, competitive pricing and innovative control solutions.

Programmable Logic Controllers (PLCs)

A PLC receives or senses data from input devices like proximity and photoelectric sensors, keyboards, level meters, timers, counters, console lights, electric motors, and temperature and pressure switches. The concept of sensing data refers to the nature of PLC input data which comes in the form of electronic signals.

It uses function blocks to depict operations, such as comparisons or timers, with inputs and outputs conducted by lines. Contacts and coils symbolize input conditions and output actions.

An industrial PLC can be used in many different applications such as process control functions, manufacturing production, mobile automation, monitoring machine tool, steel industry, robotic automation system, glass industries, food processing systems, paper industry, and more. Students achieve at higher levels in schools with positive PLCs. PLCs encourage and build effective leadership and management.

Human-Machine Interfaces (HMIs)

A Human-Machine Interface (HMI) is a user interface or dashboard that connects a person to a machine, system, or device. While the term can technically be applied to any screen that allows a user to interact with a device, HMI is most commonly used in the context of an industrial process.

HMIs are similar in some ways to Graphical User Interfaces (GUI) but they are not synonymous; GUIs are often leveraged within HMIs for visualization capabilities.

Similar to how you would interact with your air-conditioning system to check and control the temperature in your house, a plant-floor operator might use an HMI to check and control the temperature of an industrial water tank, or to see if a certain pump in the facility is currently running.

Introduction to SCADA Systems

The term **SCADA** stands for supervisory control and data acquisition. A SCADA system is a common process automation system which is used to gather data from sensors and instruments located at remote sites and to transmit and display this data at a central site for control or monitoring purposes. The collected data is usually viewed on one or more SCADA Host computers located at the central or master site.

Common analog signals that SCADA systems monitor and control are levels, temperatures, pressures, flow rate and motor speed. Typical digital signals to monitor and control are level switches, pressure switches, generator status, relays & motors.

Automation in Manufacturing and Production Lines

Automation handles the tasks that are easily prone to error, that are difficult for humans to handle without injury, and the tasks that humans don't necessarily wish to perform.

Robots and machines operate continuously, eliminating interruptions caused by human fatigue. In addition, automated production lines are designed to provide a specific time to produce the finished product. This means that manufacturing tasks can be performed at a much higher level than what a human worker could do, leading to faster production times and increased output.

Experts in the robotics sector agree that autonomous mobile robots and manipulators are intended to take on tasks that are dangerous, repetitive or tedious for people.

By,

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CHAPTER III - MECHATRONICS DESIGN AND DEVELOPMENT

Engineers use Model-Based Design to model, simulate, and verify multidisciplinary mechatronic systems from initial development to production.

This can include anything from robotic arms and automated machinery to consumer products like cameras with auto-focus mechanisms. The subjects taught include topics such as Industrial Management, Mechatronic Systems and its applications, Wireless Communications, Control systems, Signal processing etc.

Degree holders can apply for Mechanical, Electronics, Computer Science and Instrumentation & Control system jobs. Improve existing production processes by implementing automation. Develop and build various products related to mechanical and/or electrical needs.

Design Process of Mechatronic Systems

This paper concerns applications of system approach in mechatronic engineering. Mechatronics is defined like a science and technical branch and one possible definition of mechatronic system is presented, too. The problems of analysis, synthesis and control of mechatronic systems are also discussed, as well as their “so called” concurrent designing, including CAD systems.

Mechatronics is a methodology used for the optimal design of electromechanical products. A methodology is a collection of practices, procedures and rules used by those who work in a particular branch of knowledge or discipline. The familiar technological disciplines include thermodynamics, electrical engineering, computer science and mechanical engineering, to name several.

Integration of CAD/CAM in Mechatronics

Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. CAM uses geometrical design data to control automated machinery.

The single model of supporting both design and manufacturing functions in a CAD CAM system improves the likelihood of product manufacturing meeting budget and timeline. Mechatronics has three main lines of action: automating machinery (to speed up and optimize production processes), creating intelligent products (adapted to the needs of consumers) and harmonizing electronic and mechanical components.

Modeling and Simulation Techniques

Modeling and simulation involves a process of designing a model of a real- world or anticipated system such as a design concept, then conducting experiments with the model for the purposes of understanding the performance of the system under different operating conditions and evaluating alternative management

It involves creating meaningful simulation models based on existing knowledge to test theories and hypotheses about how a system works.

Case Studies: Automotive and Consumer Electronics

All the systems developed in automotive electronics are adapted to withstand the harsh operation conditions in a car. Concerns about the environment and climate change are driving customer behavior or and increased regulations—and the industry is pivoting to meet new standards.

Typical automotive applications include mechanical testing, vibration analysis, ultrasonic inspection, data logging, component testing, RADAR ranging, telematics, engine performance and ignition monitoring, CAN communication monitoring, infotainment systems (RF, audio, video, navigation, etc.), and anti-lock braking.

An example of a case study is when a software company analyzes its results from a client project and creates a webpage, presentation, or document that focuses on high-level results, challenges, and solutions in an attempt to showcase effectiveness and promote the software.

By,

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CHAPTER IV - INTRODUCTION TO EMBEDDED SYSTEMS

We can broadly define an embedded system as a microcontroller-based, software-driven, reliable, real-time control system, designed to perform a specific task. It can be thought of as a computer hardware system having software embedded in it. An embedded system can be either an independent system or a part of a large system. In this tutorial, we will explain all the steps necessary to design an embedded system and use it.

An embedded system can be thought of as a computer hardware system having software bedded in it. It can be an independent system or it can be a part of a large system. An embedded system is a microcontroller or microprocessor-based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke.

The Embedded system hardware includes elements like user interface, input/output interfaces, display and memory, etc. Generally, an embedded system comprises power supply, processor, memory, timers, serial communication ports and system application specific circuits.

Standalone embedded systems do not require a host system like a computer, it works by itself. It takes the input from the input ports either analog or digital and processes, calculates and converts the data and gives the resulting data through the connected device-Which either controls, drives and displays the connected devices. Examples for the stand-alone embedded systems are mp3 players, digital cameras, video game consoles, microwave ovens and temperature measurement systems.

As its name suggests, Embedded means something that is attached to another thing. An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system can be an independent system or it can be a part of a large system. An embedded system is a microcontroller or microprocessor-based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke.

Basics of Embedded Systems in Mechatronics

Embedded system is also called the “Electronic Control Unit” – ECU or “production control unit. These units are designed with respect to minimum production costs in serial production.

This can include anything from robotic arms and automated machinery to consumer products like cameras with auto-focus mechanisms.

The processor is the heart of the embedded system. It is a central processing unit (CPU) that allows all the integrations of the embedded system. Hardware: Remote, Display & buzzer, Infrared Sensors, electronic circuitry. b. Software: It has a chip on the circuit that holds the software which drives controls & monitors the various operations possible.

This is because an embedded system is typically contained in a larger electronic or mechanical system - whereas a laptop is a computer in its own right.

Use of embedded systems is practically unlimited and new products with embedded systems are daily introduced in the market. This fact still causes the price of microprocessors, microcontrollers and FPGA chips, to fall down. Developing a new product with implemented flexible embedded systems is much cheaper than developing a complicated control structure.

Developing a control system via the use of embedded systems became a very simple thing. Standard personal computer is usable for more purposes (text processing, image processing, internet, email, listening to music, watching the video, playing game etc. but embedded systems are used only for one purpose related to the product.

Striking impact of embedded systems is visible in the automotive industry. One car includes several tenths of embedded systems used for various activities as battery management, blind spot detection, air suspension system, parking assistant and self-parking system, security system, tire pressure monitoring system, seat control, window lift, emergency brake system, internal combustion motor control, engine cooling system, cruise control, cross-traffic alert system, lane change assistant, collision avoidance system, air condition etc.

Microcontrollers and Microprocessors

Microprocessors support versatile computing operations in personal computers and enterprise servers. Meanwhile, microcontrollers allow embedded systems to analyze and respond to inputs in real-time. When engineers develop systems with microprocessors and microcontrollers, they're mindful of differences like these.

A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. The structure of the hardware and software of an Arduino board is simple.

Microprocessors support versatile computing operations in personal computers and enterprise servers. Meanwhile, microcontrollers allow embedded systems to analyze and respond to inputs in real-time. When engineers develop systems with microprocessors and microcontrollers, they're mindful of differences like these.

On the other hand, the structure of the hardware and software of a Raspberry Pi board is complex It was binary compatible with the more-famous Intel 8080 but required less supporting hardware, thus allowing simpler and less expensive microcomputer systems to be built The microprocessor contains the arithmetic, logic, and control circuitry required to perform the functions of a computer's central processing unit (CPU).

Microprocessors and microcontrollers are the internal components of electronic devices. A microprocessor is a very small processing unit inside a CPU. It's a single integrated circuit on a computer chip that performs various arithmetic and logic functions on digital signals. Several dozen microprocessors work together inside high-performing servers for data processing and analytics.

On the other hand, a microcontroller is the basic computing unit inside smart electronic devices like washing machines and thermostats. It's a very tiny computer with its own RAM, ROM, and I/O systems, all embedded on a single chip. It can process digital signals and respond to user input, but its computing capacity is limited.

Microprocessors and microcontrollers are centralized computer chips that provide intelligence to personal computers and electronic devices. They're built with semiconductor integrated circuits and share certain internal parts.

Integrated circuit

Both microprocessors and microcontrollers are semiconductor components built on an integrated circuit. An integrated circuit is a very tiny square or rectangular chip that contains thousands or even millions of electronic components. Integrated circuits allow engineers to reduce the size of electronic circuits.

CPU

Both microprocessors and microcontrollers have a CPU. A CPU is the centralized part of the computer chip that processes instructions provided by applications or firmware. The CPU also has a special arithmetic-logic unit (ALU) module. An ALU calculates mathematical values and evaluates logic problems based on computer instructions.

Registers

Registers are memory modules that the CPU uses for processing. The CPU temporarily stores instructions or binary data before, during, and after they're processed. Both microprocessors and microcontrollers are built with internal registers, although microcontrollers often have more registers than microcontrollers.

Simple Programming for Embedded Systems

The most widely used programming language for embedded devices is C. It is a low-level language made to be quick and effective. C is used to develop software for microcontrollers, which are small computers that are embedded in a wide range of devices.

Common functionalities can be encapsulated in classes and reused across various parts of an application or even in different projects. This Embedded Systems course is jam-packed with 60 days of lessons that take you from complete Embedded systems novice to feeling confident making your own Embedded systems products or starting a career in the industry.

Microcontrollers (MCUs) have restricted resources, which might restrict the development and application possibilities. Since they frequently require more memory and computing capacity, it is challenging to implement heavy algorithms and features.

Digital cameras, smartphones and laptops are examples. Networked embedded systems are connected to a network to provide output to other systems. Examples include home security systems and point-of-sale systems.

Web development, on the other hand, is easy, relaxed, mainly concerned with making things pretty and throwing CSS, java script frameworks, and SQL at a CRUD application.

C++ is essential for embedded systems due to its efficiency, performance and flexibility, making it well-suited for resource-constrained systems and necessary for IOT and embedded tech. It is important to evaluate and consider project objectives, constraints, and access to required toolchains and libraries.

Most embedded applications are in real time, meaning they respond to an outside event in a predictable way. Therefore, embedded systems frequently use real-time operating systems (RTOSES) to ensure that applications can handle data fast. Many embedded systems also require the system to process data within a set period. The RTOS measures processing delays in tenths of a second as the smallest delay can cause a system failure.

The two popular OS concepts for real-time systems are known as *event driven* and *time sharing*. If the new task has a greater priority than the old one, an event-driven operating system (OS) will switch to the new task. In an event-driven system, the OS controls the functions based on their level of importance. A time-sharing OS changes function frequently using a clock interrupt. There is no priority level given to the jobs and to ensure that each duty is finished, the embedded software often switches between them.

While many embedded operating systems are suitable for various devices, the choice of OS for an embedded system can be considerably influenced by the hardware layout and personal preferences of the programmer. Two typical ways to categorize embedded operating systems are whether they run on microprocessors or microcontrollers and whether software engineers use them, especially for certain industries or devices.

Application Examples: Home Automation and Consumer Devices

The global smart home automation market is under the sway of advanced technologies. Still, many people perceive smart homes as a luxurious lifestyle rather than a necessity, so it can be challenging for users to relate the high costs of smart home appliances and their actual necessity. Though on a staggering basis, the market is growing.

IOT for smart home automation implies utilizing internet-connected devices with sensors and actuators controlled through a centralized system (e.g., a smartphone) to manage home appliances and automate household routines. Smart home automation allows residents to control lighting, heating, air conditioning, and security from a single point of access.

Smart lighting systems provide remote centralized control of all lights in the house, allowing users to set up automatization and switch the lights on or off using a smartphone app. Integration of lighting systems with a smart assistant, like Amazon Alexa or Google Assistant, lets users interact with light bulbs using their voice. For example, the system can be tuned to turn down all the lights automatically when no one is at home. Vice versa, IoT sensors can turn on the lights if they sense that it is too dark in a room. In addition, the lighting systems can follow specific patterns, like dimming the lights in a bedroom after 11 pm or in the dining room when the TV is on.

Benefit

IoT-connected intelligent lighting systems can significantly change how residents perceive their houses, adding much to their comfort and helping save energy and reduce electricity bills.

Home automation is the smart management of all aspects related to security, well-being, and comfort of a home or building. Through a set of technologies, different systems are automated, controlled, administered, and optimized.

Having a smart home is quite easy. To do this, the user needs to have a home automation installation (wired or wireless) and Internet connection in the home. This will allow them to connect all appliances and devices in the home to the Wi-Fi network to send and receive information throughout the system.

All these devices communicate with the home automation system, where the control panel is. Users can configure the software options to meet their needs, although this already includes many pre-established tasks such as turning on or off home appliances, lighting devices, etc.

By,

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