AI-DRIVEN TECHNOLOGIES FOR SUSTAINABLE ENGINEERING

Editors:
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AI and Emerging Technologies for a Sustainable Future

(Volume 1)

AI-Driven Technologies for Sustainable Engineering

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CONTENTS

PREFACE i

LIST OF CONTRIBUTORS ii

CHAPTER 1 NANOMATERIALS IN THE AI ERA: REVOLUTIONIZING RESEARCH, DESIGN, AND APPLICATIONS 1

Rajni Sharma, Love Singla and *Gulab Singh*

INTRODUCTION 1

NANOMATERIALS AND THEIR APPLICATIONS 2

Applications of Nanomaterials in Various Sectors 3

Challenges in the Traditional Research and Development of Nanomaterials 4

Application of AI in Nanomaterial Research 5

Role of AI in Accelerating Nanomaterial Discovery and Synthesis 5

High-Throughput Screening and Data Mining in Nanomaterial Research Using Artificial Intelligence 6

Prediction of Material Properties and Behaviors Using Machine Learning Models ... 6

Applications of AI for Discovering New Nanomaterials with Desired Features 7

Usage of AI for Nanomaterial Design and Optimization 8

AI's Role in Optimizing Material Synthesis Processes 8

Preclinical Development Using Predictive Modelling of Nanomaterial Design 9

Optimisation via AI Platforms of Nanomaterials for Specific Applications 9

Case Studies on AI's Impact on the Design of High-Performance Nanomaterials 10

Application of AI for Nanomaterials Characterization and Imaging 11

Image Analysis and Interpretation at the Nanoscale Encouraged by AI-based Approaches 11

Enhanced Accuracy and Speed in Characterizing Nanomaterials Using AI 12

Automating and Optimizing Nanomaterial Imaging with the Help of AI 12

AI in Nanomaterial Applications 13

Nanomedicine: AI-Enabled Nanomaterials for Drug Delivery, Diagnostics, and Therapy 13

Drug Delivery 14

Medical Diagnostics 14

Medicine/Therapy 14

Nanoelectronics: AI-Enabled Design of Nanomaterials for Transistors, Sensors, and Semiconductors 15

Energy and Environment: AI in Designing Nanomaterials for Energy Storage and Environmental Solutions 16

AI-Driven Approaches for Sustainable Nanomaterial Design and Development 16

The Contribution of AI in Creating Green, Degradable, or Recyclable Nanomaterials 16

Optimizing Material Efficiency and Reducing Waste Using AI 17

Frontiers in Green Nanotechnology and Environmental Remediation Based on Artificial Intelligence 17

AI for Sustainable Nanomaterials 18

Developing Green, Biodegradable, and Recyclable Nanomaterials with AI 18

Optimizing Material Efficiency and Reducing Waste Using AI 19

AI-Driven Innovations in Green Nanotechnology and Environmental Remediation ... 19

AI-Driven Nanomaterial Integration and Fabrication 20

AI in Improving Precision and Scalability of Nanofabrication Techniques 20

Enhancing Nanoscale Process Control Using AI Models 20

AI for Integrating Nanomaterials into Complex Devices and Systems 21

CHALLENGES AND ETHICAL CONSIDERATIONS 21
Data Privacy and Intellectual Property Concerns in AI-Powered Nanomaterial Research 21
Ethical and Safety Challenges in the Deployment of AI in Nanomaterial Design and Applications 22
Regulatory Considerations for the Use of AI in Nanotechnology Industries 22
FUTURE DIRECTIONS AND EMERGING TRENDS 22
CONCLUSION 23
REFERENCES 24

CHAPTER 2 ARTIFICIAL INTELLIGENCE TECHNIQUE APPLICATION IN MAXIMUM POWER POINT TRACKING FOR SOLAR PHOTOVOLTAIC SYSTEMS 27
RamaKoteswaraRao Alla, Kandipati Rajani and *Poka Venkata Sai Jayanth*
INTRODUCTION 27
PV MODULE 28
BOOST CONVERTER 29
MPPT TECHNIQUES 30
Simulation Results 33
Comparison of ANN and P&O Methods at Constant Irradiance 34
Comparison of ANN and P&O Methods at Variable Irradiance 36
CONCLUSION 37
REFERENCES 37

CHAPTER 3 ARTIFICIAL INTELLIGENCE IN CURRICULUM DESIGN: SHAPING THE FUTURE OF EDUCATION 40
Ketanpreet Kaur, Nripinder Kaur and *Love Singla*
INTRODUCTION 41
AI-Driven Personalized Learning 44
Dynamic Curriculum Development 45
Differentiated Instruction and Inclusivity 45
Streamlining Administrative Tasks 46
Predictive Modeling and Future-Ready Curricula 47
Ethical Considerations in AI-Integrated Curriculum Design 48
CHALLENGES AND LIMITATIONS 48
CONCLUSION 49
REFERENCES 50

CHAPTER 4 ARTIFICIAL INTELLIGENCE AIDED OPTIMIZATION TECHNIQUES FOR MICROSTRIP ANTENNA DESIGN 53
Bimal Raj Dutta
INTRODUCTION 54
Types of AI 54
Applications in Telecommunications 54
Types of Machine Learning 55
Applications in Antenna Design 55
Advantages in Telecommunications 56
Key Elements 56
Applications in Antenna Design 56
Broader Applications in Telecommunications 57
The Significance of Intelligence in the Design of IoT Antennas 57
Integration of Artificial Intelligence into Micro Patch Antenna Design 60
Microstrip Antenna Research 61
Challenges in Antenna Design 64

Evaluation Metrics for Antenna Performance 65
Recommendations for Future Research and Applications 67
SADEA Algorithm for Antenna Optimization 68
CONCLUSION 71
REFERENCES 71

CHAPTER 5 REVOLUTIONIZING HEART DISEASE PREDICTION: A REVIEW OF MACHINE LEARNING TECHNIQUES AND CHALLENGES 75
Shifa Shah, Madhu Bala, Aashima, Anjum Rouf and *Tabassum Rahim*
INTRODUCTION 75
RELATED WORK 80
TECHNIQUES USED 84
Data Collection and Preprocessing 84
Feature Engineering 85
Machine Learning Algorithms 86
Model Training 86
Evaluation Metrics 87
Validation and Testing 88
COMPARATIVE ANALYSIS 88
DISCUSSION 88
CONCLUSION 89
REFERENCES 90

CHAPTER 6 ADVANCED GAIT ANALYSIS LEVERAGING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE: A COMPREHENSIVE APPROACH TO BIOMECHANICAL ASSESSMENT AND PREDICTIVE HEALTH MONITORING 94
Routhu Shanmukh, Rama Devi Gude, G. Madhavi and *Routhu Daswanta Kumar*
INTRODUCTION 94
AI's Role in Gait Analysis 95
Predictive Powers of Machine Learning 96
Wearable Sensors for AI and Constant Monitoring 96
EXPERIMENTAL WORK 96
LITERATURE SURVEY 102
APPLICATIONS 103
Early Neurological Disorder Diagnosis 103
Sports Performance Enhancement 104
Monitoring of Rehab 104
AI APPROACHES IN VARIOUS ASPECTS 105
Artificial Intelligence for Pattern Recognition 105
AI FUTURE ENHANCEMENT 105
Combining Multiple Data Modes 105
Improved Personalization 106
Combining Robotics and AI 106
RESULTS AND DISCUSSION 106
CONCLUSION 107
REFERENCES 107

CHAPTER 7 PREDICTIVE MODELING FOR GROUNDWATER CONTAMINATION USING ARIMA AS PREDICTIVE MODEL: A CASE STUDY OF THE INDIAN SUBCONTINENT 109
Love Singla and *Sheetal*
INTRODUCTION 110

The Growing Threat of Groundwater Contamination 110
Urgency of Removing Contaminants from Groundwater 110
The Role of Machine Learning in Groundwater Management 111
ARIMA as a Predictive Model for Groundwater Contamination 112
The Importance of Data-Driven Decision-Making 114
DATA COLLECTION 114
Code Run 115
RESULTS 115
DISCUSSION 115
CONCLUSION 116
REFERENCES 117

CHAPTER 8 ARTIFICIAL INTELLIGENCE IN NANOMANUFACTURING FOR OPTIMIZING DESIGN, FABRICATION, AND QUALITY CONTROL 120
Sunil Kumar and *Harbinder Singh*
INTRODUCTION 121
Nanomanufacturing 122
Nanomaterials 123
Digital Manufacturing 124
Artificial Intelligence 125
INTERRELATIONSHIP OF AI, DM, NANOMATERIALS, AND NANOMANUFACTURING 127
SYNERGIES BETWEEN NANOMANUFACTURING AND AI 127
Material Synthesis 128
Design Optimization of Nanomaterials 130
Accelerating Novel Material Discovery Using AI 131
Nanofabrication and Prototyping 132
Biomaterial Applications 133
Environmental Sustainability 134
CHALLENGES AND FUTURE PROSPECTS 134
Issues and Prospective Solutions 134
Future Prospects and Discussion 135
CONCLUSION 136
REFERENCES 136

CHAPTER 9 SMART MOBILITY THROUGH A HUMAN LENS: ADDRESSING URBAN TRANSPORTATION CHALLENGES WITH A PEOPLE-FIRST APPROACH 142
Ranjit Kumar Bindal, Vaibhav and *Vaibhav JaDon*
INTRODUCTION 142
LITERATURE REVIEW 145
Methodology 148
RESULT AND EVALUATION 150
CHALLENGE AND LIMITATIONS 152
FUTURE OUTCOMES 152
CONCLUSION 153
REFERENCES 154

CHAPTER 10 EMPLOYING ARTIFICIAL INTELLIGENCE WITH INTERNET OF THINGS FOR ADVANCED RURAL DEVELOPMENT - INNOVATIVE APPROACHES AND SOCIOECONOMIC IMPACT 156
Routhu Shanmukh, Cherukuri Gunalakshmi, G. Madhavi, P.S.G. Aruna Sri, Adepu Sree Lakshmi and *Routhu Daswanta Kumar*

INTRODUCTION 156
AI and IoT's Significance for Rural Development 157
New Era in Remote Healthcare 157
Precision Framing 158
Infrastructure and Management of Resources 158
Social and Economic Affect 159
Electronic Literacy 159
EXPERIMENTAL WORK 160
A LITERATURE REVIEW 164
APPLICATIONS 165
Precision Farming And Smart Agriculture 165
Remote Healthcare and Telemedicine 166
Intelligent Water Resources Management 166
RESULTS AND DISCUSSION 167
CONCLUSION 167
REFERENCES 167

SUBJECT INDEX 169

PREFACE

In an era where the world is racing with technological developments and simultaneously witnessing growing concerns for the environment, the need for AI in readjusting engineering practices to sustainability is at its most critical point. The interaction of AI-driven technologies and sustainable principles in engineering ensures that there is every opportunity to address complex environmental issues, with optimal resource efficiency and minimum carbon footprint.

This book, AI-Driven Technologies for Sustainable Engineering, investigates how AI may be used holistically to provide creative solutions while also promoting environmental stewardship, economic viability, and social well-being. Predictive analytics provides improved energy efficiency in smart grids, precision agricultural models supported by machine learning, decreased water loss through water-wasting reduction, and many more applications with wide application areas across industries.

We dive into this topic, not just to present current state-of-the-art AI-driven solutions but to encourage readers to question the long-standing paradigms of engineering. This book collects a collection of topics across interdisciplinary lines, such as applications of AI in IoT, education, healthcare, water resources, smart cities, and nanotechnology. Each chapter contains in-depth talks, real-world case studies, and future trends that will be demonstrated in the use of AI for sustainable innovation.

This book concept arose from the observation that while technology is frequently viewed as the source of deterioration when used intelligently, it can reverse these tendencies. With the ability of AI to process huge datasets, generate actionable insights, and automate complex processes, we are now armed with tools that can foster sustainable practices on a scale previously unattainable.

We are deeply thankful to the researchers, practitioners, and thought leaders who have given their expertise to this volume. Their pioneering work and thoughts have made this book extraordinarily rich, bringing enormous value to engineers, researchers, and students who care about a sustainable future.

We hope that this book will be both informative and inspiring.

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CHAPTER 1

Nanomaterials in the AI Era: Revolutionizing Research, Design, and Applications

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Abstract: Nanomaterials, distinguished for their unique properties and diverse applications, are at the forefront of scientific and technological innovation. A transformative development in this field is integrating Artificial Intelligence (AI) into nanotechnology to discover, design, and apply materials at the nanoscale. By harnessing AI's ability to process complex data sets, researchers can predict material behaviors and develop methods to manufacture nanomaterials with tailored functionalities. AI is also revolutionizing nanomaterial characterization, delivering unparalleled imaging, spectroscopy, and structural analysis precision. Simultaneously, nanomaterials are advancing AI hardware, especially in neuromorphic computing and energy-efficient processes. While this chapter explores various applications such as healthcare innovations, environmental monitoring, sustainable energy solutions, and next-generation electronics, it highlights that these represent only a fraction of the potential where AI and nanomaterials converge. However, this integration raises challenges, including ethical considerations, environmental impacts, and safety regulations. The synergy between AI and nanotechnology holds immense promise for driving the discovery of next-generation nanomaterials across multiple industries, shaping a more sustainable and innovative future.

Keywords: Artificial intelligence (AI), Machine Learning (ML), Material characterization, Nanomaterials, Nanotechnology, Neuromorphic computing, Sustainable energy.

INTRODUCTION

Nanomaterials, characterized by their dimensions in the nanoscale (1–100 nm), exhibit enhanced properties due to quantum effects, high surface area-to-volume ratio, and unique atomic arrangements. These attributes have made nanomaterials

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

essential across various industries, enhancing electrical, optical, and mechanical performance. Their applications span drug delivery systems, diagnostics, tissue engineering [1], energy storage solutions like batteries and supercapacitors, and sustainable energy technologies, including solar cells and fuel cells [2]. In environmental sustainability, nanotechnology addresses critical challenges, such as water purification, where materials like titanium dioxide play a vital role in photocatalysis, and graphene revolutionizes membrane technology for desalination. Similarly, nanoelectronics, a specialized branch of nanotechnology, has been pivotal in miniaturizing electronic components, enabling advancements in compact and efficient devices [3].

The rapid integration of Artificial Intelligence (AI) into nanotechnology has further transformed the field. AI excels in processing massive and complex datasets, enabling breakthroughs in predictive modeling, optimization, and materials discovery. While AI has revolutionized domains like biology, chemistry, and materials science, its specific integration into nanotechnology is particularly impactful. AI-driven Machine Learning (ML) models have significantly improved property predictions, optimized synthesis conditions, and accelerated the discovery of new materials [4]. Such advancements address the limitations of traditional material design approaches, which are often manual, slow, and costly. In nanomaterials research, AI enhances High-Throughput Experimentation (HTE) by efficiently analyzing intricate datasets from simulations or experiments, reducing the time required to identify materials with desired functionalities [5]. AI-based computational models also predict material behavior under specific conditions, minimizing costs associated with trial-an--error processes. These innovations enable the discovery of functional nanomaterials tailored for particular applications in healthcare, electronics, and energy [6]. By focusing on unique benefits, such as the functionalization of nanomaterials for optimized biological, electronic, and energy applications, AI-driven research promises to redefine the future of nanotechnology. This convergence of AI and nanotechnology accelerates discovery and addresses pressing challenges in sustainability and innovation [7].

NANOMATERIALS AND THEIR APPLICATIONS

Nanomaterials are materials that have been engineered to be extremely small at the scale of nanometers and, therefore, possess new functional properties vastly superior to bulk materials due to quantum effects and very high surface-area--o-volume ratios. This demonstration of properties such as increased strength, conductivity, and reactivity has made them very useful in many contexts [8].

There are several types of nanomaterials, which include:

- **Nanoparticles:** Spherical particles, commonly metal (gold, silver), oxides (zinc oxide, titanium dioxide), or polymers, have applications in catalysis, biomedicine, and energy storage [9].
- **Nanocomposites**: Hybrid materials with nanoparticles within a matrix improve their mechanical, thermal, or electrical properties. Nanocomposite materials are used in a broad range of applications, such as in the automobile, aerospace, and building industries [10].
- **2D Materials**: Thin sheets of materials such as graphene, molybdenum disulfide (MoS_2), and hexagonal boron nitride display unique electronic, optical, and sensing properties [11].

Nanoparticles also have potential applications in nanoscale technology, including components of quantum dots and other nanostructures. They exhibit different properties from the bulk material, which are generally expected to alter depending upon a specific size, such as Nanowires and nanotubes (such as carbon nanotubes). Nanorods (Dimensional structures) have beneficial properties like mechanical strength and high electrical conductivity, increased surface area for catalyzing reactions, and sensors, which make them attractive for use in certain application types like flexible electronics, energy storage, and drug delivery.

Applications of Nanomaterials in Various Sectors

Nanomaterials are used in various spheres of daily life, as shown in Fig. (**1**). Some of them are described below:

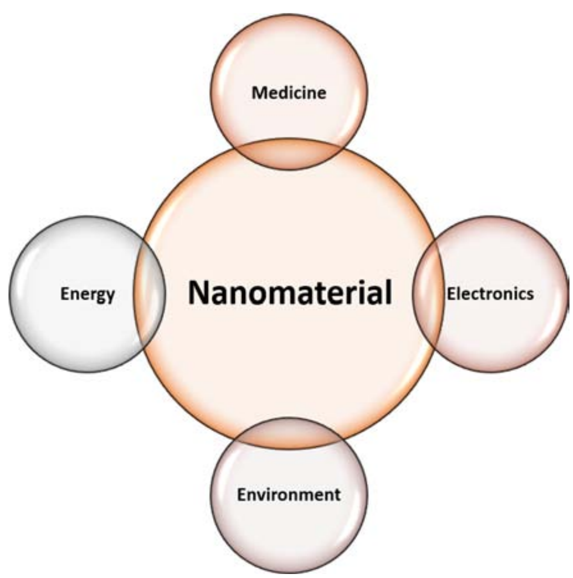

Fig. (1). Applications of nanomaterials in different fields.

CHAPTER 2

Artificial Intelligence Technique Application in Maximum Power Point Tracking for Solar Photovoltaic Systems

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Abstract: This work presents a comparative analysis of two Maximum Power Point Tracking (MPPT) methods used in solar energy systems. Artificial Neural Networks (ANN) and Perturb and Observe (P&O) are the methods considered in this work. P&O algorithm offers ease of implementation and performs well under uniform irradiance, but it exhibits oscillations around the steady-state operating point during rapid environmental changing conditions. Additionally, its efficacy in monitoring the MPP (Maximum Power Point) under shading conditions is not appreciable. To overcome these shortcomings and to enhance the system efficiency, an advanced MPPT technique, such as ANN based, has been used in this work. ANN-based MPPT technique can alleviate this burden by automatically learning these relationships through training data. However, the accuracy of MPP tracking is highly dependent upon the quality of the chosen data. By providing a comprehensive evaluation of these MPPT controllers, this chapter empowers the readers to select the most effective solution for maximizing solar power extraction.

Keywords: Artificial Neural Network, Maximum Power Point Tracking, Perturb and Observe, PV System.

INTRODUCTION

The rising demand for electrical energy, coupled with diminishing fossil fuel reserves, has propelled renewable energy sources to lead as a potential solution. Among these, solar energy has emerged as the leading one [1]. Photovoltaic (PV)

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

systems offer a clean and environmental friendly method for converting solar energy into electricity. Compared to other renewable energy sources, PV systems require minimal maintenance and generate minimal noise [2].

However, they are also subject to limitations such as expensive installation charges and poor efficiency. PV system's output depends on both irradiance (solar radiation) and temperature. To optimize power generation, the system must operate at its maximum power point. Using maximum power point tracking strategies, this is accomplished. For solar power systems to maximize their production, especially those that use PV panels, MPPT is essential [3].

Sunlight intensity fluctuates throughout the day due to factors like weather and shading. MPPT algorithms address these variations by continuously monitoring the system parameters [4]. The relationship between voltage and current produced by a solar panel is non-linear, with a specific voltage point corresponding to the highest power output. MPPT ensures that the panels operate at this MPP for optimal power generation. MPPT guarantees that the greatest amount of electricity from the solar panels is captured under various conditions by continually monitoring the MPP.

Several MPPT techniques exist in the literature, each suited to a specific application. Among these, the perturb and observe approach is broadly used because it is straightforward and simple. However, it exhibits limitations in tracking the MPP during rapidly changing environmental conditions. To address these shortcomings and ensure faster MPP tracking under dynamic environmental conditions, different MPPT techniques are introduced in a recent study [5]. These techniques include fuzzy logic control and artificial neural networks. This paper compares the P&O and ANN-based MPPT methods. Section II will explore PV module modelling, while Sections III and IV will explore DC-DC converter and MPPT principles. Section V presents the simulation results, followed by a concluding discussion in Section VI.

PV MODULE

Fig. (**1**) depicts the circuit model of a photovoltaic cell [6]. The primary current source, denoted by I_{ph} (photocurrent), represents the current generated within the cell due to the absorption of solar irradiance by photons. This current exhibits a near-linear relationship with irradiance, implying that higher irradiance levels result in a proportionally higher photocurrent. A junction diode is connected in parallel with the current source. This diode simulates the non-ideal behaviour of a p-n junction in the PV cell. A small leakage current, denoted by I_D (diode current), flows through this diode even under open-circuit conditions (when no load is connected). A shunt resistance (R_{sh}) represents a leakage path for current within the cell. A small current, denoted by I_{Rsh} (shunt current), flows through this resistor due to imperfections in the cell. The final output current (I), also known as the load current delivered by the PV system, is the summation of these three currents [7].

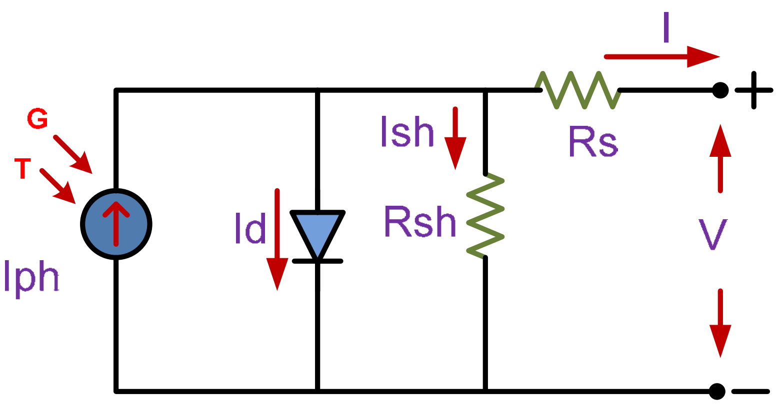

Fig. (1). Practical solar cell circuit.

Mathematically, the output current (I) can be expressed as in Equations 1 and 2

$$I = I_{L,cell} - I_d - I_{sh} \quad \textbf{(1)}$$

$$I = I_{L,cell} - I_D\left[\exp\left(\frac{V_{cell} + R_S I}{V_T a}\right) - 1\right] - \frac{V_{cell} + R_S I}{R_{sh}} \quad \textbf{(2)}$$

From the equation given above, Io is the reverse saturation current. This means that when there is no solar radiation or under dark conditions, the diode is reverse-biased, then the current flowing in the diode is the reverse saturation current.

BOOST CONVERTER

Fig. (**2**) illustrates a typical DC-DC boost converter circuit employed in photovoltaic (PV) systems. The goal of this converter is to raise the input DC voltage level to a higher output DC voltage level [8]. It is necessary to compute the inductor's ripple current in order to build a boost converter with optimal efficiency and dependability [9].

CHAPTER 3

Artificial Intelligence in Curriculum Design: Shaping the Future of Education

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Abstract: AI has the potential to revolutionize curriculum design by creating more personalized, flexible, and efficient educational systems. Curriculum development has traditionally been a cumbersome and time-consuming approach of creating curricular content, and has often been unable to tailor quickly to the varied needs of individual learners. AI can revolutionize this process, as it can make use of data analytics and machine learning algorithms to develop dynamic, adaptive curricula that are suited to the individual students' way of learning, their needs, and progress. This allows adjusting content and learning speed based on real-time interactions, which leads to a more student-centered teaching experience. In fact, AI-powered technologies could evaluate millions of pieces of educational information to find knowledge gaps, optimize learning paths, and recommend additional resources. This minimizes the blanket approach to teaching, which further supports differentiated instruction that can meet the needs of learners at different levels of proficiency.

All these together lead to administrative workloads in terms of content generation, assessment generation, and feedback analysis, which AI reduces in a significant way and enhances the curriculum design process. This enables educators to spend more time on mentoring and facilitating learning, as AI takes over repetitive tasks. AI also integrates into curriculum design in a way that can allow for predictive modeling, making it feasible for institutions to forecast trends in job markets and to adapt curricula accordingly. Despite such challenges, ethical issues including data privacy and the risk of excessive dependency on technology, AI's involvement in curriculum design is an exciting development that could transform the future of education.

Keywords: Artificial intelligence (AI), AI in Education, AI-powered tools, Dynamic curriculum, Machine learning (ML), Personalized learning.

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INTRODUCTION

With the fast-paced advancement of solo technology, some of the strategies have evolved as well. Artificial Intelligence (AI) is perhaps the most significant technology promoting curriculum innovation among these advancements. With promising potential, AI can be used to build personalized, flexible, and efficient learning plans instead of the traditional, one-size-fits-all systems of education. Historically, curriculum design has been a largely static and labour-intensive process in attempting to deliver a comparison on set of knowledge and skills to all learners. But this system has frequently failed to address the individual needs of students, resulting in failures and inequities in what students learn. AI can bridge this disconnect with its ability to create flexible, personalized learning experiences to meet the specific demands of every student. This chapter addresses AI revolutionizing curriculum design with an emphasis on personalized learning, differentiated instruction, administrative efficiency, and predictive modeling for future-ready learning experiences. We will also examine the ethical considerations of AI in curriculum design, the challenges faced, and potential future directions for AI-assisted curriculum development [1].

AI is changing many sectors, and education is one of the industries undergoing a major transformation. AI technologies are transforming how curriculum design is accomplished, providing educators and institutions with powerful new tools for developing, delivering, and optimizing educational content. Curriculum design has traditionally been a manual and time-consuming process, depending heavily on teachers' experience in designing courses that meet different learning objectives. But now, thanks to AI, this process is becoming much more dynamic, data- and personalisation-driven. Artificial Intelligence (AI) technology is able to comb through great lakes of data, detect trends in student performance, and modify material in real time; is aiding teachers in creating curricula that are more successful and customized to the characteristics of each student. This is ushering in an era of technology-driven transformations that promise to create more equitable, effective, and future-ready education systems, poised to equip students with proficiency across multiple learning pathways to meet the demands of an increasingly complex world [2]. One of the most important aspects of AI in curriculum design is its ability to personalize learning experiences. Traditional curriculum is designed with a one-size-fits-all policy, where all students are assumed to follow the same pace and need to benefit from the same materials. AI, on the other hand, provides an answer to this dilemma with customized learning journeys. Using AI-driven platforms, curricula can be tailored in real-time according to each student’s performance, preferences, and knowledge gaps [3]. Such an AI system can detect the way a student interacts with various forms of content, such as videos, quizzes, reading material, etc., and tailor future lessons to focus on the topics around which the student struggled the most. Not only does this provide a more engaging experience for the students, but it also leads to better learning outcomes since each learner is getting what is most relevant and useful for their development [4].

AI is also transforming how curricula are updated and maintained. It is imperative that curricula keep pace with the most current developments in knowledge domains such as technology, science, and engineering, where the rate of knowledge expansion is exponential. In the past, this has been a detail-burning task for teachers, who have to keep on editing course content to accommodate changing data. This is the process where AI can save probably the most time by automating the identification of which content is outdated and what should be updated. From a practical standpoint, AI can sift through academic publications, industry reports, and online resources to identify emerging trends or novel research findings for educators to weave into their curricula with minimal additional effort. This enables more time coverage and ensures students get to know and learn the latest in the field of their study [5, 6]. AI can facilitate educational change from the ground up in several ways: by personalizing and transcription curricula, by modernising the infrastructure and model of education, or by enabling a more bottom-up approach to educational structure. These intelligent, AI-driven systems have the ability to analyze data from thousands of students to determine which types of content and which learning strategies prove effective. Using big data can help teachers implement courses that are more suited for the students to succeed [7]. AI can suggest several topics to educators, for instance, what topics students find most perplexing, what teaching strategies result in the highest retention rates, or which types of assessments give the best picture of whether students understand the material. With this data in hand, educators are in a position to adapt these curricula to better explore pedagogical practices that are conducive to deep and meaningful learning for all students [8].

One of the major benefits of AI in curriculum design is its potential to improve accessibility and inclusivity. Tools powered by AI can help students with different needs to learn better, for example, students with disabilities or students whose first language is not the language of instruction. AI, for example, can automatically translate course materials to multiple languages, increasing accessibility to education for those who are not native speakers. Moreover, similar use of AI can provide auto-generating captioning for video content so students with hearing impairments can engage in online courses in full capacity [9]. Moreover, AI can customize the lesson's pace and format based on students with a learning disability(s) or other special needs, allowing them to enjoy classes

CHAPTER 4

Artificial Intelligence Aided Optimization Techniques for Microstrip Antenna Design

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Abstract: Artificial intelligence can be used in many walks of life; one such use is in designing and optimizing various antennas. The microstrip patch antenna uses AI for the same reason. In today's techno world, the various aspects of micro-patch antenna design and optimization can be performed using Artificial Intelligence (AI). Micro-patch antennas are compact, planar antennas and are mostly used in wireless communication systems. AI techniques can optimize the design of micro-patch antennas to enhance their performance. The designing of microstrip patch antennas, and specifically the antennas used in wireless communication and mobile phones, is challenging due to the presence of various physical limits. This chapter specializes in the usage of Artificial Neural Networks (ANN) and gadgets getting to know Machine Learning (ML) based on regression. Using ML and ANN, the challenges faced in the design of microstrip patch antennas are addressed, and solutions are provided for the analysis and synthesis of these antennas. The study is mainly focused on the calculation of resonant frequency, although the synthesis focuses on the mathematical geometrical dimensions of the antenna. These are two substantial processes that one will need for the precise designing of antennas, since these are mutually dependent. MATLAB and its graphical user interface have been used. Also, in order to minimize time duration and inaccuracy, the back-propagation technique has been used. In comparison with the standard simulation platforms and tools, this method provides a higher level of precision in calculating the geometric dimensions, along with minimizing the time required to calculate the dimensions. Usage of high-priced and prolonged software is not required along with the usage of the ANN method. ANN helps in achieving design attribute determination and parameter retrieval easily. The best performance of the Gaussian Process Regression model helps in determining the physical and electrical attributes. A prototype antenna is designed whose performance is close to the expected design, and with this prototype, the GPR model is verified.

Keywords: Artificial Intelligence, Microstip Antenna Design, Neural Networks, SADEA Algorithm.

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

INTRODUCTION

AI is a tool used for the performance of different machine tasks that are human intelligence-oriented. AI is performing various steps like reasoning, problem-solving, understanding language, recognizing objects, and making decisions for the accomplishment of the task. The task is performed automatically by AI systems due to learning data and providing new inputs accordingly. AI tools are able to handle problems ranging from rule-based modest systems to more sophisticated models [1 - 6].

Types of AI

• **Narrow AI (Weak AI):** Minor tasks like internet surfing or face detection are performed by this type of AI system. Different analogous attendants, for example, Siri and Alexa of the present day, are falling into this group.

• **General AI (Strong AI):** This category of AI systems is speculative and needs universal cognitive capabilities, the same as human intelligence. This system is in a position to complete different complex tasks that can be performed by humans. Presently, this type of AI system is in the exploration and theoretical stage.

Applications in Telecommunications

• **Network Optimization:** To estimate the traffic of a network in real time, automated structures and optimized networks of telecommunication are provided by AI systems. This system is useful for the recognition of bottlenecks and future failures. It also regulates the data flow of the network [7 - 11].

• **Periodical Maintenance:** The network equipment failure forecast can be done by an AI system after examining the equipment data. It also provides the reduction of failure time and costs of operation through periodical maintenance.

• **Customer Support Automation:** The AI machine regulates extraordinary customer services like chatbots and digital assistants, offering 24/7 customer support, answering ordinary questions, processing requests, and escalating complex problems to human marketers.

• **Intelligent Antenna Design:** Different antenna designs can be optimized after automation of typical parametric results using AI algorithms. The AI system is helping in the efficient and quick design of antennas.

• **Machine Learning (ML):** A subset of AI systems used for preparing machines from data is known as machine learning. For knowing the patterns from huge datasets, the ML system applies algorithms. It also uses these patterns for making forecasts or preferences without being explicitly programmed. A better forecast of the system relies on a large amount of data processing, as its model is regularly refined [12 - 14].

Types of Machine Learning

• **Supervised Learning:** When the algorithm training on a designated dataset is performed for each input with a corresponding output in an ML system, it is called supervised learning. The learning model of mapping inputs to outputs of these examples is used in this system. This system is mostly used in functions such as categorization (spam detection) and regression (as in forecasting prices of houses).

• **Unsupervised Learning:** In unsupervised learning, data is supplied to the model without specific tags, and the search for concealed designs and correlations in the data depends on the algorithm. The normal uses of unsupervised learning are assembling (grouping analogous elements) and exception exposure (ruling out outliers).

• **Reinforcement Learning:** A model determined by cooperation of its atmosphere and admitting guidance in the shape of rewards or punishments is known as reinforcement learning. This gadget is often applied in programs such as recreational gambling (e.g., AlphaGo), robotics, and self-sufficient structures.

Applications in Antenna Design

• **Parameter Prediction:** Unique ML fashions as aid Vector Machines (SVM) and Artificial Neural Networks (ANN), are given to analyze distinct antenna traits, like resonant frequency, bandwidth, and impedance, determined by training data from the preceding designs of antennas [15 - 18].

• **Optimization:** To enhance execution, different machine learning algorithms are used for improving different parameters of the antenna. The encircling parameters are minimizing size while maintaining or enhancing efficiency, enlarging bandwidth, and enhancing the radiation pattern.

• **Automation of Design Processes:** Different ML algorithms can be applied for the dimensions' calculation of an antenna automatically. This system of calculation leads to an exceptionally reduction in the duration and effort required in manual calculation.

CHAPTER 5

Revolutionizing Heart Disease Prediction: A Review of Machine Learning Techniques and Challenges

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Abstract: Cardiovascular diseases (CVD) are the foremost cause of death worldwide, leading to extensive research in prediction models for early prognosis and intervention. This study presents a comprehensive overview of Machine Learning (ML) approaches in predicting ischemic cardiovascular diseases, synthesizing insights from various studies. Key themes include dataset diversity, rigorous preprocessing, and the exploration of various ML algorithms like logistic regression, random forests, decision trees, and various deep learning models. Challenges such as data imbalance and model interpretability are addressed, with future directions emphasizing multimodal data integration and novel ML architectures. Overall, ML-based approaches offer significant potential to revolutionize heart disease prediction and management, driving improved risk assessment, treatment strategies, and patient outcomes in cardiovascular care.

Keywords: Cardiovascular Diseases, Heart Disease Prediction, Ischemic Cardiovascular Diseases, Machine Learning, Predictive Models.

INTRODUCTION

Heart disease, medically termed as cardiovascular disease, stands as a primary cause of mortality across the globe. Recent findings from the World Heart Federation reveal that one in every three fatalities is attributed to CVD [1]. Projections by the World Health Organization (WHO) suggest that by 2030, over 23.6 million individuals might succumb to CVD, predominantly due to strokes and heart failure. Various factors contribute to the onset of CVD, including stress,

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

alcohol consumption, smoking, poor dietary habits, sedentary lifestyle, and underlying health conditions such as hypertension or diabetes. However, early detection significantly enhances the chances of complete recovery from most CVD-related ailments [2]. Hence, there's a critical need for healthcare providers to prioritize the diagnosis and anticipation of heart failure. Advanced data analysis techniques applied to patients' health records can improve early CVD diagnosis [3]. Analysis of health status is done as a precaution against different fatalities, determining major anomalies and, therefore, arriving at a precise diagnosis (Fig. **1**). Establishing a diagnosis can be with genetic predispositions, socio-medical conditions, environmental situations, and personal lifestyle selection. Modern medical approaches rely more on risk assessment and factor analysis to

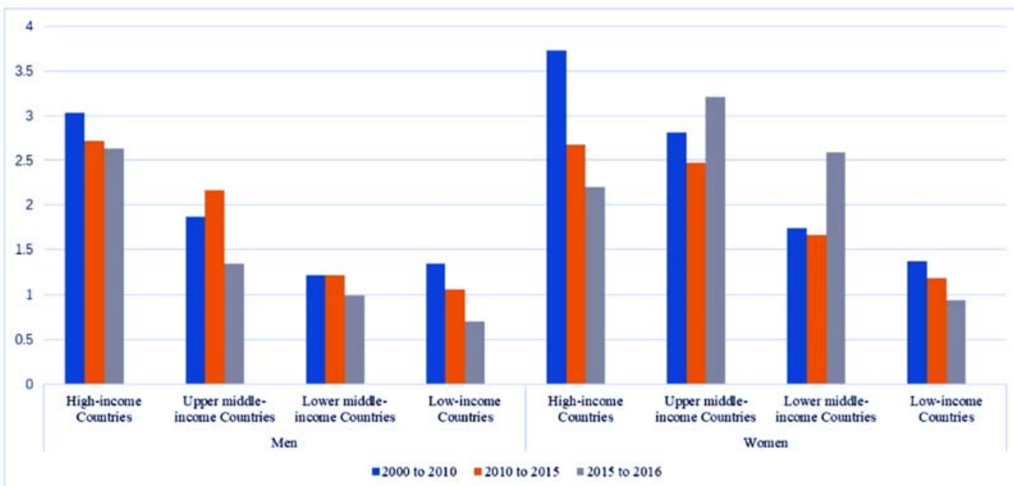

Fig. (1). Percentage decline in premature CVD deaths (2000–2016) by gender and national income group [5].

prevent conditions from deteriorating to acute stages, contributing to enhanced health results [4]. This raises the concern for developing an accurate clinical data examination system concerning HD to identify the extent of heart failure [4]. Many studies have used the ML approach for predicting CVD using clinical databases. However, these datasets are challenging due to class imbalances and high dimensionality. Failure to overcome these barriers undermines the effectiveness and reliability of ML techniques. Some earlier studies have focused on FS techniques and applied several ML systems for CVD prediction. For example, Long *et al.* [5] developed a CVD decision system combining Rough Sets (RS) with the Chaos Firefly algorithm (CFARS-AR) to identify optimal features, followed by the use of a type-2 fuzzy logic system for HD detection, which had an accuracy of 88.3%. Similarly, Dwivedi combined RS with a backpropagation neural network (BPNN) for CVD prediction, while Haq *et al.*

performed a comparative study on FS methods integrated with different ML models, highlighting the significance of feature retention for optimal model performance.

Amin *et al.* [6] worked on different ML models, and one hybrid model with feature identification, reporting the hybrid model's superior accuracy of 87.41%. Furthermore, efforts have also been made to improve the precision of prediction through hybrid models such as RF with a linear model (HRFLM), and new optimization techniques, for instance, those presented by Vijayashree *et al.* [7], demonstrating better CVD prediction techniques.

Cardiovascular diseases are one of the most serious global health crises, causing millions of mortalities every year and posing significant challenges to healthcare systems worldwide. According to the World Health Organization (WHO), there is a concern to underline the imperative to work on CVD, such as heart attacks and stroke, which cause a substantial portion of deaths in any given country. Scarily enough, it has been estimated that one person dies from cardiovascular disease every 34 seconds in the United States, and therefore, there is an ongoing need for more effective and earlier interventions to prevent this aspect [8].

Though there has been advancement in medical science, late diagnosis and limited monitoring of the ailment continue to hinder precise and actual management of CVD, exacerbating its impact on public health. To resolve this challenge, there has been a growing trend of leveraging Machine Learning (ML) techniques to develop accurate and useful models for predicting fatal diseases, including heart disease and stroke. By utilizing ML algorithms to analyze diverse patient data, encompassing factors such as sex, age, cholesterol levels, and blood pressure, researchers aim to improve risk management and facilitate timely interventions, thereby improving patient outcomes and reducing the load on the healthcare system [9]. Hybrid models integrated with the different ML techniques have also been shown to have better performance in predicting CVD. HRFLM has achieved up to 88.4% accuracy by incorporating Random Forest with a linear model [10]. Besides, novel strategies, such as the SVM using a novel PSO fitness function, have gained importance and provided accuracies up to 84.36% [11]. Some studies have proven the versatility of ML-based prediction models for detecting risky individuals and devising targeted treatment protocols. These advancements have led to the creation of powerful frameworks that outshine traditional methodologies, offering valuable insights into disease detection and prognosis. Moreover, with the proliferation of electronic health records and advancements in ML techniques, the prospects for developing efficient AI models for disease detection have never been more promising [12]. In this study, we explore the advanced ML-based approaches for predicting cardiovascular diseases. This study

CHAPTER 6

Advanced Gait Analysis Leveraging Machine Learning and Artificial Intelligence: A Comprehensive Approach to Biomechanical Assessment and Predictive Health Monitoring

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Abstract: Biomechanical Evaluation and health monitoring can be done by using gait analysis along with ML and AI. Using Artificial Intelligence (AI) and Machine Learning (ML) will enable us to analyze the anomalies and identify minute changes in the patterns, so that it can be helpful in real-world applications as well. It can identify minute variations and anomalies that standard techniques would overlook. The chapter examines potential artificial intelligence (AI)-powered algorithms that may diagnose diseases like Parkinson's disorder, evaluate flexibility, forecast damaging risks, along with offering prompt treatment techniques. It also helps to identify some diseases like Parkinson's Disease, and Forecast Damage Risks, and also to provide early intervention techniques. Combining Artificial Intelligence and sensors improves healthcare outcomes through patient monitoring. Implementing these techniques can be a better approach and can provide well-insulated healthcare.

Keywords: Artificial intelligence, Gait analysis, Machine learning, Medical diagnosis.

INTRODUCTION

A thorough evaluation of the body's mechanics, joint motions, as well as contractions of muscles during locomotion, is part of "gait analysis," the methodi-

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

cal study of someone's movement patterns along with motions. In the past, gait analysis has been widely employed in the domains of biomechanics, sports science, and promoting clinical health to identify anomalies, identify diseases, and improve athletic performance [1]. However, the potential applications of gait analysis have increased, and new study avenues have been made possible by the development of machine learning, also known as ML, and Artificial Intelligence (AI) technologies. By offering a real-time, remarkably precise understanding of a person's movement patterns and spotting subtle variations that the human eye or outdated mathematical instruments would miss, the marriage of AI and ML has revolutionized traditional methodologies.

Previously, gait analysis was restricted to laboratory environments and relied mostly on visual observation and basic mechanical devices such as force plates, motion-capturing cameras, and pressure sensors [2]. Despite such techniques helping obtain motion or gait data, they had some limitations, such as the demand for sophisticated apparatus, the need for expert interpretation, and the fact that the normal gait of a person during chores or daily work could not be assessed [3]. The increased popularity of smart portable gadgets and respective AI integrations has solved some of these problems in a way that allows for effective gait tracking in different environments without much stress on the subjects being observed. With the advancement of wearable technologies, AI algorithms capable of processing the large amount of information generated by these devices have emerged. Consequently, gait assessment can be applied in more clinical or non clinical activities in the present quality of life [4].

AI's Role in Gait Analysis

One of the areas that has benefited greatly from the advent of AI technology is gait analysis. AI allows AI models to more accurately identify and elaborate on the movements of people, more so than any human can comprehend. Depending on factors like musculoskeletal or neurological disorders or aging factors, these models, through AI, can anticipate possible alterations in a person’s gait. The ability of AI models to identify a gait anomaly has led to AI-powered solutions being able to help in the early diagnosis of Parkinson's. Parkinson’s disease is a disorder that has been noticed to affect one’s gait even before one starts to notice any apparent symptoms. These changes are more so identified by machine learning models that have been trained with large-scale gait datasets. This makes it possible to detect and administer treatment at earlier stages, which the conventional methods would not have made possible. Gait analysis has been transformed by artificial intelligence, enabling a more comprehensive and precise evaluation of human motion. Models driven by Artificial Intelligence (AI) can spot subtle variations in gait patterns that may be signs of a variety of illnesses, including neurological abnormalities, musculoskeletal ailments, and even early aging. The early diagnosis of Parkinson's disease is one of the most significant advancements made possible by AI-based gait analysis. Long before more obvious symptoms show up, Parkinson's disease, a neurological condition, can produce subtle alterations in walking patterns. These alterations can be identified by AI algorithms that have been trained on enormous amounts of gait data. This enables early detection and treatment, which was previously unattainable using conventional techniques. Furthermore, these AI and ML models' immediate time capacities allow for continuous surveillance, which helps doctors keep tabs on a patient's progress as time goes on. When the system notices a worsening of the prerequisites or a higher risk of adverse effects, the course of therapy can be quickly adjusted. This dynamic, continuous input loop encourages prompt treatment along with more individualized care, both of which greatly improve patient results [5].

Predictive Powers of Machine Learning

Machine learning is a branch of artificial intelligence that enhances the predictive capabilities of gait analysis by using historical gait records to identify trends and correlate them with potential impact on health in the future. Clinically, this ability to predict is key in preventive medicine. For instance, the computing strength of machine learning algorithms and the ability to constantly record and optimize a patient’s gait may allow the algorithms to predict possibilities of osteoarthritis and the chances of a patient falling in aged people [6].

Wearable Sensors for AI and Constant Monitoring

Combining wearable sensors with artificial intelligence is another ground-breaking advancement in modern gait analysis. Wearable technology has made it simple to collect information about activity across the day, including wristwatches, health monitors, and sensor-equipped shoes. AI algorithms then analyze this data to find patterns, make recommendations, and provide insight into an individual's stride. Because the effectiveness of therapy depends on continuous monitoring, this method is particularly helpful in managing the course of chronic disorders [7].

EXPERIMENTAL WORK

In order to identify latent connections that may be utilized for damage mitigation, efficiency enhancement, and early medical condition detection, machine learning algorithms examine gait data, which comprises a range of variables such as walking velocity, component viewpoints, stride width, including body orientation. Considering Machine Learning (ML) techniques rapidly analyse large amounts of data, find intricate patterns, and produce anticipated breakthroughs that are not

CHAPTER 7

Predictive Modeling for Groundwater Contamination using ARIMA as Predictive Model: A Case Study of the Indian Subcontinent

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Abstract: The availability of clean groundwater is critical for public health and economic development, especially in regions like the Indian subcontinent, where a significant portion of the population relies on this resource for daily use. However, increasing industrialization, agricultural practices, and urbanization have led to groundwater contamination, posing a severe threat to communities. Addressing this challenge requires innovative solutions for monitoring and predicting contamination levels to ensure safe water access. This study explores the use of machine learning models to predict groundwater contamination levels across the Indian subcontinent. Machine learning has emerged as a powerful tool in water resource management due to its ability to analyze large datasets, identify complex patterns, and make accurate predictions. By utilizing models like ARIMA (Auto-Regressive Integrated Moving Average), we aim to forecast the concentrations of key contaminants, such as fluoride and arsenic, prevalent in the region's groundwater. Our approach integrates historical data on groundwater quality and applies advanced predictive algorithms to estimate future contamination trends. These models provide reliable, data-driven insights that can inform policymakers and water management authorities, enabling them to take proactive measures to mitigate health risks and ensure sustainable water usage. By predicting future contamination levels, this research contributes to developing more efficient and informed strategies for groundwater management, ultimately improving water safety and public health outcomes in the Indian subcontinent. It has been shown that in the coming years, there might be a decrease in concentrations of contaminants (such as fluoride and arsenic).

Keywords: Artificial Intelligence (AI), Machine Learning (ML), Prediction Analysis, Predictive analytic models, Water scarcity, Water resource management.

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INTRODUCTION

Water from underground is critical to both human and ecological systems. It is one of the primary sources of water used for drinking by many people worldwide, especially those living in rural areas. Groundwater is also crucial for agriculture, industry, and sanitation. But groundwater across the world, especially in the Indian subcontinent, has been pushed into an on-the-edge regime where threats are more, and contamination is higher than before. The pollution of most aquifers because of industrialization, the increase in pace and scale of land cultivation transformation into certain types (intensive farming), and fast urbanization give rise to a significant public health problem. Nowadays, there is an urgent need to treat and clean any instances of groundwater being polluted or contaminated with modern novel ways that focus on safeguarding the sustainability and safety of this fragile resource [1 - 3].

The Growing Threat of Groundwater Contamination

Indeed, contamination of groundwater is one environmental issue that has been observed to have global and social relevance over the past decades. Water bodies are becoming increasingly contaminated with deadly pollutants due to this process, not only in India but on a global scale. Some common contaminants present in the environment include heavy metals from various sources (arsenic, excessive fluoride, nitrate from fertilizers/industrial pollutants). These poisonous effects on human health lead to thousands of diseases and many incurable illnesses, such as cancer, deficiencies, and tooth fluorosis, among the long-term fatal infections [4, 5].

In the Indian subcontinent, this is especially problematic, given that a significant proportion of its inhabitants, particularly in rural regions, mainly rely on groundwater for both drinking and everyday use. The pollution of these water bodies has posed a serious obstacle to providing millions with clean, safe drinking water. These heavy metal exemplars in several areas have shown that these pollutants seriously threaten public health [6]. If left unaddressed and if immediate action is not taken to mitigate the problem, contaminated groundwater could potentially spark extensive health emergencies, especially in vulnerable communities with limited capacity to tap into alternate sources of clean water.

Urgency of Removing Contaminants from Groundwater

Due to the gravity of groundwater contamination, procedures for the elimination and prevention of water pollution are urgently required. Conventional water treatment methods, including chemical and filtration, are generally expensive and difficult to scale up in low-income or rural areas. Furthermore, these methods are reactive in nature and are used to clean up after the contamination has already occurred. Proactive thresholds are required for tunable water managers and policymakers to anticipate possible contamination risks, thus taking measures before these reach alarming values [7].

This is where the need for predictive modeling and data-driven decision-making arises. With advanced knowledge of where contamination is most probable, governments and water management outfits do what they can to protect the quality of their water resources. In doing so, they not only ensure safe drinking water is readily available but also offset potential long-term health risks due to contaminated water supplies [8]. The approach is based on big data analysis of historical groundwater quality information and predictive modeling for forecasting how contamination in the future will develop.

The Role of Machine Learning in Groundwater Management

Machine Learning (ML) has been developed as a ground-breaking feature in environmental science and water resource management over the past years. Since machine learning provides sophisticated techniques for working with large and complex datasets that human cognition cannot, it offers an excellent opportunity to tackle issues of groundwater contamination prediction. Machine learning models can use historical data to predict contamination risks in the future through patterns and trends [9, 10].

Machine learning is highly successful in managing groundwater owing to its capability to process the complexity of data present within the environmental domain. Groundwater contamination arises due to a variety of factors and includes, but is not limited to, soil composition, weather patterns, but also farming practices, and industrial activities [11, 12]. Fig. (**1**) describes the flow of contaminated water from industrial effluents to the ponds. These variables interact non-linearly with each other, making it a challenge to conduct predictions on contamination trends by conventional statistical approaches. There is no limit to the number of relationships that can be taken into account, and machine learning has been in a better position, providing accurate predictions based on understanding such complex networks [13]. In addition, machine learning models can evolve and improve as new data comes in. In the context of groundwater pollution, we need to adapt quickly as land-use changes take place, a result partly driven by climate change and industrial development [14]. Through constant re-fitting of the predictive models with recent data, machine learning provides support to dynamic and real-time forecasting by helping in making decisions at the right time for proper intervention [15].

CHAPTER 8

Artificial Intelligence in Nanomanufacturing for Optimizing Design, Fabrication, and Quality Control

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Abstract: Together with nanomanufacturing, Digital Manufacturing (DM) is going to set the cutting edge for Industry 4.0, the fourth industrial revolution, as it enables the processing of materials over many dimensions of length. This overview outlines the development of nanomaterials and nanomanufacturing in the digital era, including use cases in consumer electronics, robotics, medical, sensory technologies, and semiconductors. It has also discussed the prospects of possible applications of complex AI algorithms, including expandable artificial intelligence (XAI), reinforced learning, and big data analytics in materials synthesis, innovation in industrial processes, and nanosystem integration. This work provides a thorough assessment of an amalgamation of AI in nanomanufacturing processes, thereby addressing a substantial gap in the field. The challenges of applying machine learning and deep learning to produce reliable and accurate predictions are explained in detail. This chapter examines how AI continues to evolve nanomanufacturing in Industry 4.0 through a thorough assessment, case studies, and data analysis. A detailed literature review is conducted to accumulate existing knowledge on nanomanufacturing, DM, and AI technologies. It also focuses on how AI may improve quality control and process control, including material synthesis in the nanomanufacturing industry. Additionally, it shows how AI may boost market relevance and competitiveness by lowering costs, speeding up time to market, alongside improving product quality. As a result, it provides key knowledge for businesses looking to improve and grow their production capacity.

Keywords: Cyber physical system, Digital manufacturing, Expandable artificial intelligence, Machine learning, Nanomanufacturing, Vapour phase deposition.

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

INTRODUCTION

Advances in technology that are used at the nanoscale level and have practical uses are referred to as nanotechnology. These technologies operate in dimensions ranging from 1 to 100 nm and include the control and manipulation of matter [1]. It can be further simplified as follows: a substance having a minute operational arrangement within the dimension of a meter can be designed, characterized, manufactured, and applied in a shape and size-controlled manner to create systems, devices, and matter with essentially new properties and functions. In numerous industries and real-life problems, including electronics [2], water treatment [3], nanomanufacturing, and target drug delivery [4], nanotechnology has produced ground-breaking breakthroughs. Nanomaterials, nanomanufacturing, and the use of several systems, including physical, chemical, and biological ones, to develop new materials and devices at the nanoscale exhibiting enhanced properties are the keystones of nanotechnology. The interconnection of various components, such as Digital Manufacturing (DM), Artificial Intelligence (AI), and nanomaterials, along with nanomanufacturing, is depicted in Fig. (**1**).

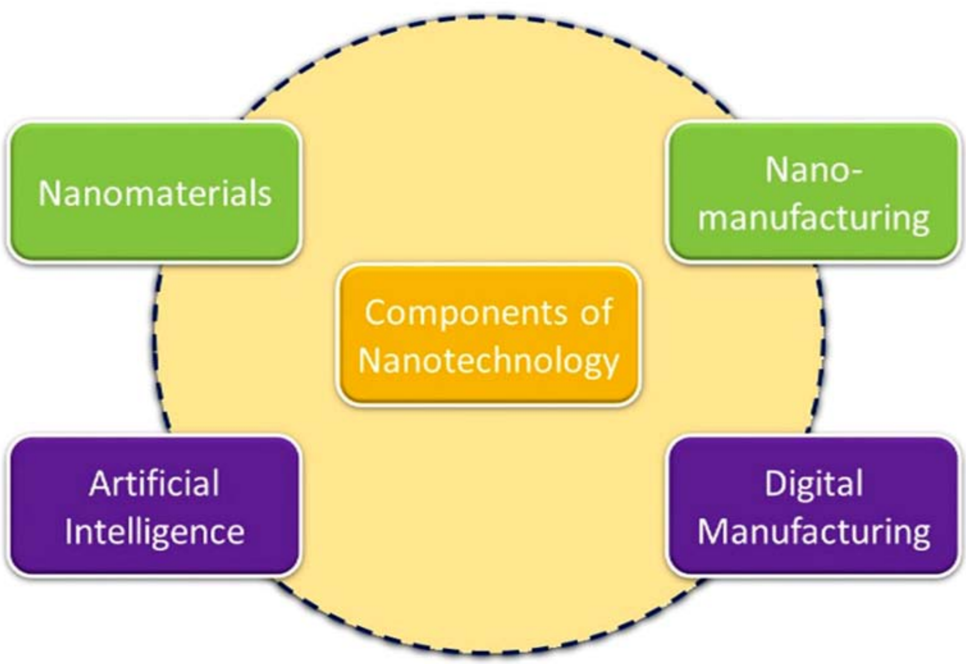

Fig. (1). Interleaved elements of nanotechnology.

Nanomanufacturing

As seen in Fig. (**2**), nanomanufacturing refers to the production techniques used to create nanomaterials, compositions, devices, along systems at a dimension of a billionth of a meter using two ways such as: top-down or bottom-up. The top-down approach begins with a minute substance and works its path down to a more minute point [5]. Top-down techniques such as lithography [6], micromachining, machining, as well as milling are some of the more popular ones [7]. During milling, a soaring energy mill is charged with a particular powder, constituting a suitable milling environment. It is done to mix the particles into new phases and decrease their size. Nanometric material removal, traditional cutting, grinding, and polishing are all included in machining. Top-down lithography works well for creating intricate, mass-producible designs. Using a technique called nanoimprint lithography, a mold's shape can be transferred to target materials by coming into contact with the mold. By employing scanning probe microscope information to supply materials *via* capillary transport, high-quality nanopatterns can be produced in dip-pen lithography [8].

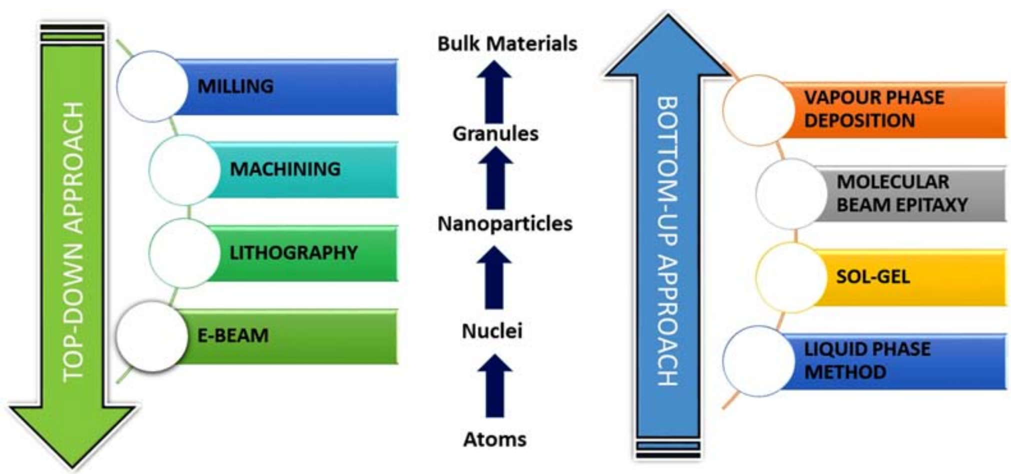

Fig. (2). Fabrication process of nanomaterials.

At the same time, bottom-up approaches start by generating and synthesizing the target molecules by a variety of nanomanufacturing techniques, including molecular beam epitaxy, Vapour Phase Deposition (VPD), liquid-phase techniques, and pulse-laser deposition, including self-assembly [9]. Following bottom-up processes, there are two fundamental techniques: gas-phase synthesis and liquid-phase creation. VPD, molecular beam epitaxy, sol-gel, pulse-laser deposition, as well as magnetron sputtering are a few of these often-used

CHAPTER 9

Smart Mobility through a Human Lens: Addressing Urban Transportation Challenges with a People-First Approach

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Abstract: Rapid urbanization comes with an increasing demand on transportation systems, which are increasingly being subjected to great environmental concerns and changing mobility needs. This paper advances a human-centric approach for smart mobility by concentrating the solution on user experience, accessibility, and community well-being. This study takes an outlook on how people-first design can transform the available technology into a different paradigm for reshaping urban mobility in light of current urban transportation challenges, such as congestion, pollution, and inefficiencies. By using case studies and data analysis, it is brought out how the integration of intelligent transportation systems, shared mobility solutions, and multimodal networks can create sustainable and inclusive urban environments. Our findings suggest that human-centered design-based smart mobility solutions provide not only user satisfaction but also support resiliency and addictiveness in the transportation ecosystem.

Keywords: Human-centric approach, Intelligent transportation systems, Multimodal networks, People-first design, Smart mobility, Sustainable mobility, Shared mobility, Transportation challenges, Urban transportation, Urbanization.

INTRODUCTION

Although the rate of growth is unprecedented, it is bound to put enormous strains on urban transportation systems in terms of accommodating increased population densities and mobility demands. It is estimated that nearly 70% of the world's population will live within an urban region-immersing the demand for efficient, reliable, and sustainable transportation solutions by 2050. The traditional models of urban transportation often fail, leading to a negative impact such as traffic congestion and much longer commute times, pollution, and so forth. To address

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these complex challenges, cities are reaching out to what has been known as "smart mobility": advanced technologies and data-driven approaches to renovate the urban mobility framework.

Smart Mobility involves the use of digital technologies, data analytics, and IoT to streamline transportation systems and enhance urban transit. It brings about a gamut of solutions: Intelligent Transportation Systems (ITS), shared mobility platforms, and electric or even autonomous vehicles, to name a few. While an important enabler of smart mobility, technology alone cannot fulfill the variety of needs that urban residents have. A human-centered approach, therefore, is to fold in principles into smart mobility systems, so they can be equally effective and inclusive. A human-centric approach to transportation is based on the main idea of designing systems around the needs, preferences, and behavior of people.

In a human-centric model, the real-world challenges of real people, such as accessibility, safety, and comfort, are tackled when designing transportation solutions. This is contrary to the traditional model, which focuses more on infrastructure and technology than end-user experience. This brings cities to create solutions to mobility issues that are not only technologically advanced but also adaptable for different user groups, including the elderly and people with disabilities, and those who are economically disadvantaged.

Fig. (**1**). Shows some important Aspects of smart mobility, i.e., artificial intelligence, vehicle-to-grid, intelligent system, among others. Cities often experience problems in urban transportation systems like traffic congestion, pollution, lack of safety, and a lack of decently reliable options for transit. Issues such as these reduce not only the quality of life for residents living in urban areas but also contribute to degrading the environment and creating inefficiencies in the economy. Moreover, many of the currently implemented transportation systems lack the ability to dynamically respond to the needs of modern urban populations. Human-centric smart mobility efforts address all these issues by basing transportation solutions on a holistic view of social, economic, and environmental factors, which are in tune with the needs of the communities in cities. While technology serves as the backbone of intelligent mobility, success depends on how well it is incorporated into human-centered design.

The emerging technologies of IoT, AI, and machine learning enable real-time collection and analysis; specifically, the deployment and design of these technologies should lead to maximized user experience and accessibility.

Smart mobility applications can be employed to provide real-time information and updates regarding public transit presence, routes, and traffic conditions, thereby making it easier for users to navigate their commute time and reduce the stress they experience while in transit. Human-centric smart mobility is also a pathway toward a more eco-friendly approach to urban transportation. Electric as well as shared vehicles, along with the promotion of multimodal transit networks, reduce carbon footprints in the city and also improve air quality. Another aspect of human-centred initiatives of mobility includes equity through distribution and equal access to transport services, with special attention given to the less privileged groups.

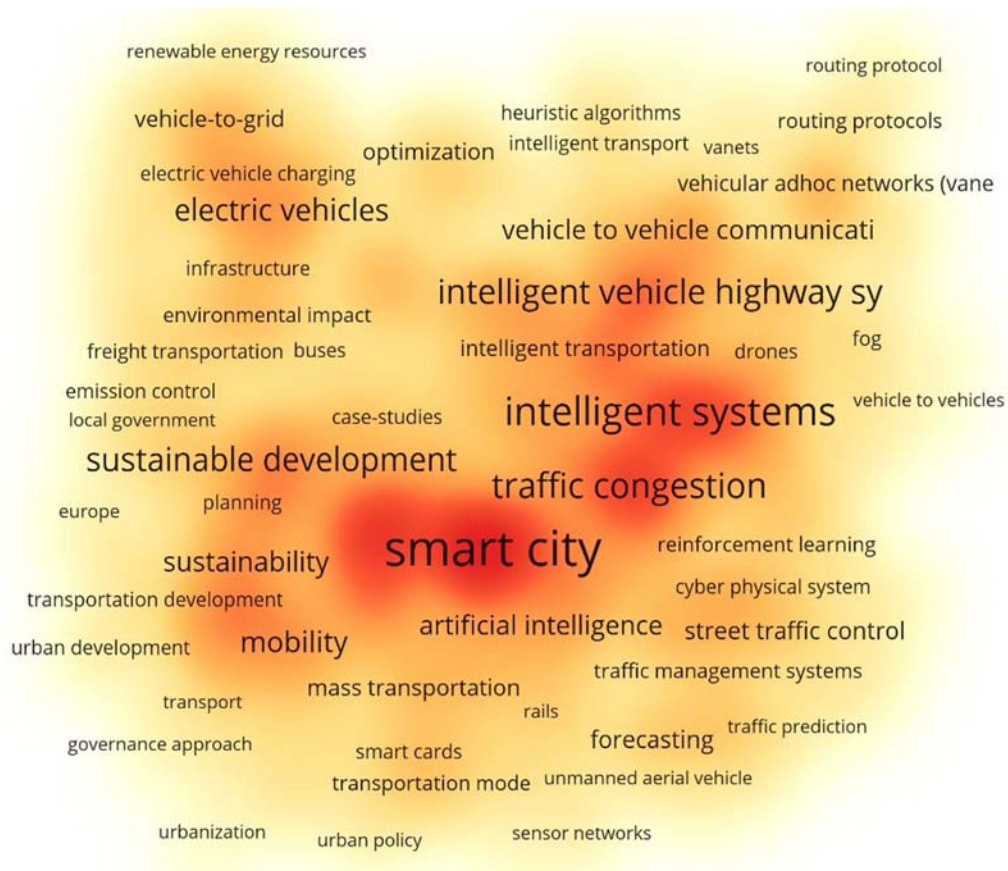

Fig. (1). Some important aspects.

Sustainable, inclusive urban mobility can be regarded as a structure that conceives moving people not only in its literal meaning but as a social equity and economic opportunity enabler. Shared mobility like car-sharing, ride-hailing, and bike-sharing is one of the transformative elements of smart mobility. These services provide alternative, flexible ways of transport. They reduce the dependency on private vehicles and decrease traffic congestion in general. Multimodal solutions

CHAPTER 10

Employing Artificial Intelligence with Internet of Things for Advanced Rural Development - Innovative Approaches and Socioeconomic Impact

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Abstract: The Internet of Things (IoT), along with Artificial Intelligence (AI), plays a crucial role in developing rural areas with advanced approaches based on technology for the major problems occurring. AI can bring a drastic change in various sectors. One of the main sectors is agronomy, which also develops the farmers of the rural areas along with the Indian economy, so it is a better thing to implement it. It can also play a crucial role in education along with healthcare. The best is like telemedicine, which is useful for the farmers now and then for crop and yield prediction and water usage. The research also aims to show how advanced technologies can play a crucial role in distinct aspects like education, job prospects, *etc.* At last, AI and IOT prove good development in rural areas based on trending and upcoming technologies.

Keywords: Artificial intelligence, Internet of Things, Rural Areas, Technology.

INTRODUCTION

The quick development of technology, especially in the fields of interconnected Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT), has drastically changed a number of sectors, including infrastructure devel-

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Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

opment, healthcare, education, and training. Even while these technologies are typically found in urban settings, rural areas stand to benefit just as much, if not more, through their continual advancement. Rural development, which has historically been associated with social and agricultural improvements, is about to undergo a technological revolution propelled by the Internet of Things and artificial intelligence. The coming together of these technologies offers a hitherto unseen chance to tackle persistent issues in remote regions, such as environmentally friendly agricultural managing resources, access to medical care, and opportunities for learning.

As technology grows rapidly in the fields of Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) based on these technologies, the industry sectors in different aspects like Education, Healthcare, etc. If the same technologies are applied in the rural areas, there will be drastic changes that were never assumed or unseen, so that better agriculture and other resource management, and better and good healthcare access will be available along with a bright education in the rural areas.

AI and IoT's Significance for Rural Development

The trending technologies like Artificial Intelligence (AI) and Internet of Things (IoT) play a well-versed role in different sectors and in distinct aspects in urban areas, but it is not going up to the rural areas, where this seems to be somewhat lagging behind the technology in rural areas. Here Artificial Intelligence (AI) and Internet of Things (IoT) two were implemented then which could be some different moments where it will bring a change in rural areas where it can like a bridge between urban and rural areas go parallel in the technological advancements and all, by applying this it can seem to be good environment as the rural area also develops using the emerging technologies.

New Era in Remote Healthcare

Access to high-quality healthcare is a major issue for rural development. The lack of medical professionals and health care services has proven to be one of the main issues in many rural towns. Here, cutting-edge substitutes are offered by telemedicine along with remote medical surveillance technologies made possible by AI and IoT. Portable health monitors, including intelligent diagnostic tools, are examples of Internet of Things technologies that enable real-time tracking monitoring patients' health indices. After that, data is analyzed by AI-driven techniques to yield diagnostic insights. These technical advancements enable video conferencing platforms, which link disconnected rural communities with distant metropolis healthcare facilities. IoT-enabled devices allow patients in remote areas to monitor their physiological conditions throughout the day and additionally communicate the data to medical professionals. AI programs can then analyze this data to search for anomalies or early warning signs of disease. This strategy can significantly reduce the death rate in isolated areas with limited chances of receiving immediate medical care. AI can assist with disease diagnosis, treatment suggestions, and even the prediction of neighborhood medical trends by evaluating combined information through IoT devices.

Precision Framing

Given how much agriculture depends on rural economies, combining IoT as well could potentially be quite beneficial. Farmers used to tend crops by themselves and rely on their intuition, which often led to unpredictable yields and resource loss. Precision farming is enabling farms to make data-based choices that maximize performance and utilize natural resources with the aid of AI and IoT. In outdoor environments, connected devices can measure soil conditions, temperature, and the amount of moisture. AI algorithms can then utilize this information to suggest pest control methods, watering schedules, and fertilization levels.

Internet of Things monitoring devices can react to variations in the moisture in the soil by initiating systems for irrigation without intervention, ensuring efficient water use. Similarly, Artificial Intelligence (AI) could assist farmers in planning when they should plant and pick their agricultural produce by combining data from many sensors to forecast weather trends. IoT and AI together can potentially aid in disease diagnosis. Systems using AI can examine drone or sensor photos of fields to identify disease symptoms before they proliferate. Therefore, precision farming increases agricultural output, reduces waste, and improves the overall durability of agriculture practices, all of which are critical for the prosperity of towns and villages.

Infrastructure and Management of Resources

By adding these AI & IOT along with the development of agronomy, it can also be helpful to make it more modern in various aspects. AI will be helpful in some different sectors, and IOT can be used in some different sectors. These developments and enhancements in rural areas will be much more beneficial to the Indian economy. Nonetheless, demand forecasting and pattern analysis are two ways Artificial Intelligence (AI) might maximize resource utilization. Energy management systems that use Artificial Intelligence (AI) may predict periods of high demand, which enhances load control and reduces the likelihood of power outages.

SUBJECT INDEX

A

Aerial vehicles 125
AI and nanotechnology 129
AI in curriculum development 43 AI-driven personalized learning 44
ARIMA 109, 112
Artificial intelligence 9, 11,14, 15,17,18, 19, 23, 27
Atomic force microscopy 11, 12
Augmented reality 43

B

Biomaterial applications 133
Biomedical applications 83
Boost converter 29

C

Cardiovascular diseases 75,77, 82, 89 Central pollution control board 114 Challenges in antenna design 64 Cleveland heart disease dataset 85 Compact microstrip antenna 69 Complex antenna structures 56 Convolutional neural networks 57, 68, 103, 126
Cyber physical system 120, 124

D

Data-driven Insights 145,
Decision trees 75, 81, 82, 86, 113, 161, Deep 82
belief networks 82
learning 82
Differentiated instruction and inclusivity 45
Digital manufacturing 120, 121, 124
Drug delivery 2, 3, 4, 8, 9, 10, 11, 13, 14, 23, 121, 125, 129, 132, 133

E

E-aircraft and H-couplings 71

Early neurological disorder 103 Electronic health records 77, 80
Energy storage 2 Environmental 16, 134
solutions 16
sustainability 134 Evaluation metrics for antenna performance 65
Expandable artificial intelligence 120

F

Feature engineering 85
Fraud detection 56

G

Gait analysis 95
Gaussian 69, 82
naïve bayes 82
process regression 69
General AI 54
Genetic algorithms 64
GNNs 81
GPS-Beidou dual mode microstrip antenna message 69
Gradient boosting 102
Growing threat of groundwater contamination 110

H

Heart disease prediction 81, 83, 85 HFSS or CST Studio 65
Human-centric approach 142 Hungarian heart disease dataset 84 Hybrid model 77, 82
Hydrogen production 10, 11

Shilpa Gupta, Ritika Sharma & Gokana Mohana Rani (Eds.)

I

Image conditions optimization 13 Improved personalization 106 Infrastructure and management of resources 158
Intelligent transportation systems 142

Internet of Things 68
Ischemic cardiovascular diseases 5

K

K-nearest neighbors 81, 82

L

Logistic regression 75, 81, 82, 86
Long 68, 85
beach heart disease dataset 85 short-term memory 68

M

Machine learning 2, 5, 6, 8, 9, 10, 11, 22, 40, 47, 53, 60, 75, 102
Material synthesis 128
MATLAB 53, 69
Maximum power point tracking 27, 28
Medical diagnostics 4 Microstrip antenna 53, 61
design 53
research 61
MPPT techniques 28, 30, 34

N

Nanocomposites 3, 7, 18, 123
Nanoelectronics 2, 5, 15, 21 Nanofabrication and prototyping 132 Nanomanufacturing 120
Nanomaterials 2, 3, 4, 5
Nanomedicine 13, 22, 23, 126
Nanoparticles 16, 123, 127, 128
Nanoscale 1, 3, 4, 11, 13
Nanotechnology 17, 19, 22,23
Narrow AI 54
Neural networks 52, 61, 62, 68
Neuromorphic computing 1, 40

O

Operators 57

P

Parameter prediction 55 Particle swarm optimization 62 Perturb and observe 28 Precision framing 158
PV 31, 37
module 31, 37

system 37

R

Random forest 75, 77 Recurrent neural networks 81 Reinforcement learning 136
Resonant frequency 64
Role of intelligence in IoT antenna design 58

S

Sadea algorithm 68
SADEA algorithm for antenna Optimization 68
Sensor-equipped shoes 96
Smart mobility 142
Social and economic affect 159 Solar panel module 31 Sustainable energy 1, 2
Support vector machine (SVM) 65, 69, 77, 80, 81, 82, 86, 89, 99, 100, 016, 111, 112, 113, 163, 164, 167
Switzerland heart disease dataset 84 Synthetic minority oversampling technique 83

T

Transmission electron microscopy 11 Transportation challenges 142

U

Urban transportation 142
Urbanization 142

V

Vapour phase deposition 120, 122

Virtual reality 43

W

Water 109
  resource management 109
  scarcity 109
Wearable sensors for AI 96
World Health Organization 75, 77

Y

Yagi microstrip antenna 69

Z

Zeolites 16
Zero-defect manufacturing 20

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