

ADVANCED IMAGE PROCESSING AND VIDEO INTELLIGENCE APPLICATIONS



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Advanced Image Processing and Video Intelligence Applications

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CONTENTS

FOREWORD	i
PREFACE	ii
LIST OF CONTRIBUTORS	iv
CHAPTER 1 INTEGRATING IMAGE PROCESSING AND DEEP LEARNING FOR EFFECTIVE IMAGE DEHAZING	1
<i>Sandeep Vishwakarma, Anuradha Pillai, Deepika Punj and Preeti Yadav</i>	
INTRODUCTION	2
Scientific Principles behind Haze Formation and the Challenges	4
Overview of Dehazing Method	6
<i>Traditional Image Processing Methods</i>	6
<i>Dark Channel Prior (DCP)</i>	6
<i>Guided Filtering</i>	7
<i>Deep Learning for Image Dehazing (ImDe)</i>	7
<i>U-Net-based architectures</i>	7
LITERATURE REVIEW	8
Traditional Image Processing Techniques: Pioneering Efforts	8
Deep Learning Revolution: A New Era of Dehazing	9
PROPOSED FRAMEWORK	14
ARCHITECTURAL DETAILS	15
Generator (G) Architecture	15
Discriminator (D) Architecture	15
EXPERIMENTS AND RESULTS	15
Evaluation Metrics	15
CONCLUSION	21
REFERENCES	21
CHAPTER 2 DEEP LEARNING-BASED APPROACHES FOR ADDRESSING IMBALANCE IN BREAST CANCER IMAGE DATASETS: CHALLENGES, OPPORTUNITIES, AND OPEN ISSUES	26
<i>Rekha Baghel and Ela Kumar</i>	
INTRODUCTION	27
IMBALANCED MEDICAL DATASETS: AN OVERVIEW	28
REVIEW OF DEEP LEARNING-BASED IMAGE PROCESSING FOR IMBALANCED DATASETS	30
UNDERSTANDING THE ARCHITECTURE OF DEEP LEARNING MODELS	39
CNN	39
RESNET	41
AlexNet	42
VGG-16	42
CHALLENGES IN DEEP LEARNING-BASED IMAGE PROCESSING FOR IMBALANCED DATASETS	43
CONCLUSION	43
REFERENCES	44
CHAPTER 3 ANCIENT INDIAN SCRIPTS IDENTIFICATION: A MACHINE LEARNING AND NLP APPROACH	47
<i>Subhajit Ghosh</i>	
INTRODUCTION	48
HISTORICAL BACKGROUND OF ANCIENT INDIAN SCRIPTS	49

Brahmi Script	49
Devanagari Script	50
Tamil-Brahmi Script	50
Kharosthi Script	50
Bengali Script	50
Assamese Script	51
MACHINE LEARNING AND NLP TECHNIQUES	51
PROPOSED METHODOLOGY	53
Data Collection and Preprocessing	53
Model Selection and Training	54
Post-processing and Validation	54
ML ALGORITHMS FOR TEXT IDENTIFICATION	54
NLP TECHNIQUES FOR TEXT IDENTIFICATION	56
CHALLENGES AND SOLUTIONS	58
Script Variability	58
Data Scarcity	58
Noisy and Degraded Texts	58
Multilingual and Multi-script Scenarios	58
Lack of Standardization	59
Error Analysis	59
EVALUATION METRICS AND BENCHMARKING	60
CASE STUDIES	60
FUTURE DIRECTIONS AND CONCLUSION	61
REFERENCES	62
CHAPTER 4 A DEEP LEARNING APPROACH FOR GEOPOLITICAL ENTITIES	
EXTRACTION FROM INDIAN ELECTION DATA	66
<i>Seema Shukla and V N Shukla</i>	
INTRODUCTION	67
APPROACHES FOR NER	68
Rule-Based Approaches	68
Learning Based Approaches	69
Hybrid approaches	70
Deep Learning Approaches	70
METHODOLOGY	72
Phase I – Initial Model Building Testing	73
Phase II - Gazetteer Generation	78
Phase III - Incorporating Gazetteer Features	80
RESULTS	81
CONCLUSION	85
REFERENCES	86
CHAPTER 5 AN EFFICIENT REMOTE PATIENT MONITORING: THE CONVERGENCE	
OF BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE	90
<i>Inderpreet Kaur, Mohammad Mudassir, Sanjay Kumar and Kirti Seth</i>	
INTRODUCTION	91
Background and Literature Survey	91
<i>Patient Information Processing</i>	<i>93</i>
<i>Blockchain Infrastructure</i>	<i>93</i>
<i>Information Verification and Block Generation</i>	<i>93</i>
<i>Data Preservation and Administration</i>	<i>94</i>
Blockchain Interface for Healthcare Providers	94

REMOTE PATIENT MONITORING (RPM): AN OVERVIEW	94
PATIENT-FOCUSED HEALTHCARE SYSTEMS	96
Data Management and Integration	97
Patient-Centric Care	97
Operational Efficiency	97
Regulatory Compliance and Reporting	97
Cooperation and Information Sharing	98
<i>i. FHID (Fast Healthcare Interoperability Databases)</i>	98
<i>ii. HL7 (Health Level Seven Protocol)</i>	98
<i>iii. DICOM (Digital Imaging and Communications in Telemedicine):</i>	98
<i>iv. IHE (Integrating the Healthcare Enterprise)</i>	98
<i>v. IEEE 11073</i>	98
<i>vi. SMART on FHIR</i>	99
<i>vii. Blockchain Platforms</i>	99
<i>viii. OMOP (Observational Medical Outcomes Partnership):</i>	99
CHALLENGES AND SOLUTIONS IN IMPLEMENTING RPM	100
FUTURE TRENDS IN RPM, BLOCKCHAIN, AND AI	100
Advanced AI Personalization and Analytics	101
Improved Interoperability and Data Integration	101
Decentralized Health Platforms	101
Improved Patient Engagement and Compliance	101
Enhanced Security and Privacy	102
AI-Driven Remote Diagnostics and Decision Support	102
Integration with Telemedicine	102
Predictive and Preventive Care	102
Automated and Efficient Workflow	102
International Exchange of Health Data	103
NEED FOR BLOCKCHAIN AND AI TOGETHERNESS	103
Enhanced Data Integrity and Security	104
Improved Data Quality and Trustworthiness	104
Simplified Data Administration	105
Enhanced Privacy and Compliance	105
Automation and Efficiency	105
Superior Decision-Making and Understanding	105
Fraud Detection and Prevention	105
Increased Flexibility and Scalability	106
Creative Use Cases	106
Collaborative Environments	106
APPLICATIONS IN THE REAL WORLD AND CASE STUDIES	106
CONCLUSION	107
REFERENCES	107
CHAPTER 6 HANDWRITTEN ENGLISH CHARACTER AND DIGIT RECOGNITION	
USING DEEP LEARNING TECHNIQUES (CNN AND SVM)	110
<i>Shradhanwita Mukherjee and Sumanta Kuila</i>	
INTRODUCTION	110
RELATED WORK	112
TERMINOLOGIES USED IN TEXT EXTRACTION	115
Optical Character Recognition (OCR)	115
Image Pre-processing	115
<i>Gray Scaling</i>	116

<i>Binarization</i>	116
<i>Inversion</i>	116
<i>Normalization</i>	116
Dimensionality Reduction using LDA	116
Feature Extraction	117
Classification	117
PROPOSED WORK	117
Description of the Dataset	118
<i>MNIST Dataset</i>	118
<i>The Kaggle Dataset</i>	118
Steps in Preprocessing	118
<i>Gray Scaling</i>	118
<i>Binarization</i>	118
<i>Inversion</i>	119
<i>Normalization</i>	119
Reducing Dimensions using LDA	119
Convolutional Neural Networks (CNN) for Feature Extraction	119
Common Architectural Design	119
Support vector machines (SVM) for classification	119
RESULTS	120
Model Performance	120
The Confusion Matrix of This Model	120
Graphs:	120
<i>Interpretation of the Graph: Initial Decrease</i>	121
<i>Divergence</i>	121
<i>Stability</i>	121
<i>Interpretation of the Graph: Initial Increase</i>	121
<i>Convergence and Stability</i>	122
LIMITATIONS	123
FUTURE WORKS	124
CONCLUSION	124
REFERENCES	124

CHAPTER 7 ARTIFICIAL NEURAL NETWORK APPLICATIONS FOR INTELLIGENT TRANSPORTATION SYSTEMS	128
<i>Ajeet Kumar Bhartee and Surendra Singh</i>	
INTRODUCTION	128
INTELLIGENT TRANSPORTATION SYSTEMS	129
Components	130
Communication	130
Traffic Management	131
ARTIFICIAL NEURAL NETWORKS	131
Categories of Neural Networks	132
Advantages of Using ANNs	132
INTELLIGENT TRANSPORTATION SYSTEM WITH ARTIFICIAL NEURAL NETWORKS	133
SMART CITY	136
Challenges	137
Solutions	137
<i>Environmental Monitoring</i>	137
<i>Infrastructure Monitoring and Maintenance</i>	138

<i>Smart Parking Systems</i>	138
<i>Smart Energy Management</i>	138
TRAFFIC MANAGEMENT	139
Challenges	140
Solutions	140
<i>Traffic Monitoring and Management</i>	140
<i>Traffic Light Control</i>	141
<i>Traffic Violation</i>	141
<i>Incident Detection</i>	142
<i>Safety</i>	142
<i>Surveillance</i>	143
<i>Traffic Insights</i>	143
AUTONOMOUS DRIVING	144
Challenges	145
Solutions	145
CASE STUDIES	146
A Smart City	147
Implemented ITS	147
Autonomous Driving	148
CONCLUSION	148
REFERENCES	149
CHAPTER 8 ADVANCED IMAGE ANALYSIS TECHNIQUES USING MACHINE LEARNING AND TRANSFORMERS	152
<i>Sulaxan Jadhav, Harsimran Singh, M. Masilamani, Abhijeet Gajanan Chimankar, T Sivamani and Atowar Ul Islam</i>	
INTRODUCTION	153
MACHINE LEARNING AND DEEP LEARNING APPROACHES	153
THE RISE OF TRANSFORMERS IN IMAGE ANALYSIS	154
RECOGNITION OF OBJECTS IN IMAGES, THE PROCESS OF SEGMENTATION, AND CLASSIFICATION OF IMAGES	156
TRANSFORMERS' CAPACITY IN GLOBAL DEPENDENCIES' POTENTIAL TO REPLACE OR IMPROVE CNNs IN SOME APPLICATIONS	159
THE FUTURE OF ADVANCED IMAGE ANALYSIS TECHNIQUES USING MACHINE LEARNING AND TRANSFORMERS	161
CONCLUSION	163
REFERENCES	164
CHAPTER 9 INTELLIGENT AGRICULTURAL MONITORING FRAMEWORK BASED ON MACHINE LEARNING TECHNIQUES	167
<i>Isha Sood, L. Karthick, Ashutosh C Kakde, Punam Dattatray Gawali, Ankush Patil and Ayushi Godiya</i>	
INTRODUCTION	168
ARTIFICIAL INTELLIGENCE APPLICATION IN AGRICULTURAL MONITORING TOOLS	169
THE DIFFERENT COMPONENTS THAT MAKE UP A SMART AGRICULTURAL MONITORING SYSTEM THAT USES MACHINE LEARNING (ML)	173
MACHINE LEARNING TECHNIQUES UTILISED IN INTERCONNECTED AGRICULTURE: NEURAL SYSTEMS, RANDOM FORESTS, DECISION TREES, AND ASSISTANCE VECTOR MACHINES	177
CONCLUSION	179
REFERENCES	179

CHAPTER 10 ARTIFICIAL INTELLIGENCE FOR IMAGE-BASED WEED IDENTIFICATION IN AGRICULTURE	182
<i>Sapna Nigam, V. K. Choudhary, Akshay Dheeraj, Madhu, Rajni Jain and Sudeep Marwaha</i>	
INTRODUCTION	182
THE NEED FOR AUTOMATED WEED IDENTIFICATION	184
Challenges with traditional methods	184
Role of AI in addressing these challenges	185
METHODOLOGY FOR IMAGE-BASED WEED IDENTIFICATION	186
OVERVIEW OF MACHINE LEARNING ALGORITHMS USED IN WEED IDENTIFICATION	187
CHALLENGES AND LIMITATIONS IN WEED DETECTION	188
EXISTING CASE STUDIES	189
IMPLEMENTATION OF AI-BASED WEED IDENTIFICATION SYSTEMS	190
Dataset Descriptions	190
Model Implementation	191
Hardware Requirements:	191
Data Collection and Annotation:	192
Integration with Existing Agricultural Practices:	192
CASE STUDIES OF WEED IDENTIFICATION	192
Rice Weed Identification	192
Wheat Weed Identification	193
CONCLUSION	195
REFERENCES	195
CHAPTER 11 A MACHINE LEARNING-BASED APPROACH FOR SMART AGRICULTURE MONITORING AND DECISION SUPPORT	199
<i>Ankit Jain, Anita Shukla and Imran Ullah Khan</i>	
INTRODUCTION	200
RELATED WORK	201
SMART FARMING SYSTEM	203
ROLE OF MACHINE LEARNING (ML) IN AGRICULTURE SYSTEMS	204
CHARACTERISTICS OF THE SUGGESTED SYSTEM	204
ALGORITHM AND IMPLEMENTATION	206
Node MCU ESP8266 Pin Out	207
Main Sensors/Components	208
DISPLAY PANEL AND ALGORITHM DEVELOPMENT OVER IOT	210
Implementation of PCB and Circuit	212
Implementation of Soil Moisture Sensor	214
RESULTS AND ANALYSIS	217
Performance Comparison	218
CONCLUSION	219
LIMITATION	220
FUTURE SCOPE	221
REFERENCES	221
CHAPTER 12 THE INDISPENSABLE CONTRIBUTION OF SATELLITE IMAGERY TO DISASTER MANAGEMENT: INSIGHTS AND PERSPECTIVES	225
<i>Shivam Shukla, Mayank Dixit, Prateek Kumar Yadav, Anshul Khanna and Vipul Kumar Mishra</i>	
INTRODUCTION	226

Remote Sensing	226
DATASETS FOR DISASTER MONITORING	228
HARNESSING REMOTE SENSING FOR EFFECTIVE DISASTER MANAGEMENT	230
DISASTER MITIGATION THROUGH REMOTE SENSING TECHNOLOGY	231
Earthquake	231
Flood	233
Forest Fire	233
Tsunami	234
Tornado	234
METHODOLOGY	235
CNN (Convolution Neural Network)	235
Random Forest (RF)	236
Support Vector Machine (SVM)	237
U-Net	238
Generative Adversarial Network (GANs)/Cyclic-GAN	239
YOLOv5	240
Transfer Learning	240
Optimization Strategies	240
ALGORITHM ANALYSIS FROM A DISASTER PERSPECTIVE	241
CHALLENGES AND FUTURE DIRECTION	244
CONCLUSION	245
REFERENCES	246
CHAPTER 13 PYROVISOR D3ML-BASED INTELLIGENT DE-HAZING ALGORITHM	249
<i>Aryan Vashisth, Akshansh Mishra and Meena Kumari</i>	
INTRODUCTION	249
HAZE IMAGING FORMATION MODEL	251
VARIOUS DE-HAZING METHODS AND GAPS	252
PROBLEM STATEMENT	252
LITERATURE REVIEW	253
PROPOSED METHODOLOGY	256
IMPLEMENTATION	259
Experimental Setup	259
Image Quality Evaluation Metrics:	260
RESULTS	260
Quantitative Results	260
Qualitative Analysis	261
Performance on Fire Rescue Scenarios	263
Discussion	264
CONCLUSION	264
LIMITATIONS	265
FUTURE SCOPE	265
REFERENCES	266
CHAPTER 14 INTEGRATION OF COMPUTER VISION SYSTEMS IN ROBOTICS AND ASSEMBLY LINES	269
<i>M. Babu, Dler Salih Hasan, Aneesh Kumar Mishra, L. Karthick, T. Prabhu and Surrya Prakash DilliBabu</i>	
INTRODUCTION	270
ENHANCING PRODUCTIVITY AND QUALITY: INTEGRATING COMPUTER VISION SYSTEMS (CVS) IN ROBOTICS FOR ASSEMBLY LINES	271

REVOLUTIONIZING PRODUCTION: COMBINING CVS, IOT, AND AR FOR ENHANCED HUMAN-ROBOT INTERACTION	275
OVERCOMING CHALLENGES IN INTEGRATING CVS INTO ROBOTICS	277
SOME POTENTIAL STRATEGIES TO TACKLE THESE CHALLENGES	278
CONCLUSION	281
REFERENCES	281
CHAPTER 15 SMART FARMING WITH DEEP LEARNING: ENHANCING CROP MANAGEMENT THROUGH ADVANCED IMAGE ANALYSIS	285
<i>Ravi Prakash Chaturvedi, Annu Mishra, Poorva Nayyar, Sameer Asthana, Mohd Shaliyar and Rajneesh Kumar Singh</i>	
INTRODUCTION	286
LEARNING MODELS	287
CNN	288
DNN	288
RNN	288
DCNN	289
AlexNet	289
ResNet	289
CaffeNet	289
Inception Model	290
R-FCN	290
VGG16	290
VGG19	290
DRL	290
LSTM	291
LeNet	291
USAGE OF DEEP LEARNING IN THE FARMING SECTOR	291
DEEP LEARNING TECHNIQUES	292
Unresolved Issues with DL Methods Applied to the Farming Sector	292
APPLICATION IN FARMING	294
Deep Learning-based Estimation of Crop Yield	294
Identification of Diseases	298
Stress Detection using Deep Learning	304
Weed and Pest Detection	305
DISCUSSION	306
CONCLUSION	308
REFERENCES	309
SUBJECT INDEX	317

FOREWORD

We are living through a silent visual revolution in the digitally-first world of today. Previously merely capturing memories or information, images have evolved into rich, dynamic data sources that impact decisions, mold industries, and enhance the human experience. The strong, and frequently unseen, engine of image processing technologies, a field that has developed quickly and now affects almost every part of our lives, is responsible for this change.

Insightful and up to date, "Advanced Image Processing and Video Intelligence Applications" delves into this fascinating topic. From the basic ideas of image processing to its most advanced uses, which include smart surveillance, immersive entertainment, healthcare diagnostics, and even satellite imagery-based climate monitoring, it takes readers on an educational trip.

This book is unique because it carefully strikes a balance between technical complexity and readability. Both beginners and experts can relate to the authors' deft demythologizing of difficult subjects like machine learning, statistical techniques, and huge language models by placing them in relatable real-world scenarios. By doing this, they make it possible for a wide range of people to interact with one of the most influential technologies of our day, including students, teachers, business professionals, and inquisitive minds.

The book also seeks to delve deeper into the sociological and ethical ramifications of image processing, moving beyond the algorithms and mechanics. It is our duty to employ automated visual systems responsibly and equitably as our reliance on them increases. Because of this contemplation, Image Intelligence is more than just a technical guide; it is a credo for ethical innovation. I recommend this book with a great deal of gratitude and excitement. Image Intelligence will enlighten, inspire, and challenge you to view the world both literally and figuratively from a different perspective, regardless of whether you are new to image processing or looking to expand your knowledge.

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PREFACE

In today's digital era, both images and videos dominate how we communicate, learn, and interpret the world around us. From social media and entertainment to healthcare, agriculture, security, and scientific research, the ability to create, enhance, and analyze visual content has become indispensable. *“Advanced Image Processing and Video Intelligence Applications”* is a comprehensive exploration of the technologies that empower this visual transformation, offering readers insights into the methods and innovations that are shaping modern life. This book emerges from the recognition of a profound shift: the move from simple image enhancement techniques to advanced, AI-driven frameworks capable of extracting knowledge, detecting patterns, and enabling real-time decision-making from massive streams of visual data. It highlights the dual dimensions of progress: image processing, which refines and restores static visuals, and video intelligence, which unlocks dynamic understanding from continuous frames. Together, these fields are redefining automation, efficiency, and intelligence across industries.

The primary aim of this book is to make advanced concepts in image and video intelligence accessible to a wide readership. It is designed for students, researchers, and professionals in computer science, engineering, and related disciplines, as well as practitioners in fields where visual technologies play a critical role. Each chapter balances technical rigor with practical application, beginning with foundational principles and advancing to deep learning-based approaches, transformer architectures, and emerging multimodal methods. Case studies drawn from domains such as healthcare, transportation, agriculture, and disaster management illustrate how these technologies are solving real-world challenges.

KEY FEATURES

- This book is designed to offer a panoramic view of the current state and future prospects of image processing technologies, emphasizing their transformative power across various domains. The book aims not only to educate its readers on the technical aspects but also to provoke thoughtful consideration of the broader impacts of these technologies on society.
- The aims of this book are to demystify the complex field of image processing and showcase its profound impact on modern society. This book intends to bridge the gap between the intricate technical concepts of image processing and their practical applications across various aspects of everyday life, using image processing technologies such as statistical methods, Machine Learning/Deep Learning Methods, Transformers, and Language Models, including Large Language Models and Small-scale models.
- This book targets a broad audience, ranging from students and educators in the field of computer science and engineering to industry professionals and technology enthusiasts keen on understanding how image processing technologies are revolutionizing the way we live, work, and interact with the world around us. Further, the book aims to not only educate its readers on the technical and practical aspects of image processing but also to inspire them to consider the future possibilities and ethical dimensions of this rapidly evolving field.

This book certainly motivates the reader to work in the field of Image and Video Intelligence using computer vision. This book may also be used as a reference book for graduates/postgraduate students studying computer science, information technology, and electronics and communication engineering.

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CHAPTER 1

Integrating Image Processing and Deep Learning for Effective Image Dehazing

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Abstract: This chapter delves into the cohesive integration of conventional image processing methods with deep learning techniques to address the complex problem of image dehazing. Atmospheric haze often degrades the quality of outdoor imagery, reducing clarity and obscuring scene details. While conventional image processing techniques have historically been employed to mitigate haze effects, recent advancements in deep learning present promising prospects for enhancing the efficacy and resilience of dehazing algorithms. Within this chapter, an overview is provided encompassing both traditional image processing methodologies and deep learning architectures tailored for dehazing tasks, encompassing discussions on their respective strengths and limitations. Furthermore, strategies for amalgamating these methodologies are explored with the objective of achieving superior dehazing performance. The adverse effects of haze, fog, and smoke on outdoor image quality significantly impede various tasks, including computer vision and visual perception. This chapter meticulously examines the fusion of image processing techniques and deep learning models to effectively combat image haze. Commencing with an examination of the atmospheric scattering physics underlying haze formation and the ensuing challenges, the chapter proceeds to evaluate conventional image processing techniques for dehazing, highlighting their inherent limitations. Subsequently, a comprehensive exploration of deep learning-based dehazing methodologies ensues, encompassing diverse convolutional neural network (CNN) architectures and their respective advantages. The chapter elucidates how deep learning capitalizes on image processing principles to acquire haze-relevant features, thereby achieving enhanced dehazing outcomes. Finally, the chapter addresses existing challenges and future prospects within this dynamic research domain.

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Keywords: Convolutional neural network, Deep learning, Image dehazing, Polarization, Vision in bad weather.

INTRODUCTION

This chapter explores the fusion between traditional image processing methodologies and the burgeoning realm of deep learning (DL) techniques, all in pursuit of mitigating the pervasive challenge posed by atmospheric haze in outdoor imagery. Atmospheric haze, caused by the scattering and absorption of light due to airborne particles and moisture, poses a significant challenge to capturing clear and visually appealing outdoor images. These haziness effects not only obscure fine details but also diminish overall visibility, significantly impeding tasks ranging from computer vision applications to human visual perception [1].

Historically, traditional image processing techniques have served as the bedrock for addressing the issue of image haze. These methods, like dark channel prior (DCP), atmospheric scattering model (ASM), and guided image filtering, operate on established principles of image manipulation to enhance clarity and contrast in hazy scenes. While effective to a certain extent, these conventional approaches often exhibit limitations in handling complex scenes, varying lighting conditions, and may introduce undesirable artifacts or loss of image details [2].

In recent years, deep learning has rapidly emerged as a revolutionary force in computer vision. Convolutional neural networks (CNNs), in particular, have shown exceptional ability in capturing complex patterns and representations directly from data. By utilizing the vast information contained in large-scale datasets, deep learning models can identify intricate relationships between hazy and clear images, significantly advancing dehazing performance [3].

Against this backdrop, the chapter provides a comprehensive overview of both traditional image processing techniques and deep learning models for image dehazing. By elucidating the strengths and limitations of each approach, the chapter sets the stage for a nuanced exploration of strategies for integrating these methodologies to achieve synergistic improvements in dehazing performance. Through this integrated lens, the chapter aims to unlock new insights and avenues for advancing the state-of-the-art (SOTA) in image dehazing research and practice [4].

Visual information is the cornerstone of many applications that shape our world. From the autonomous vehicles navigating our streets to the robotic arms assembling intricate machinery in factories, clear and accurate vision is fundamental for successful operation. Surveillance systems rely on it to monitor

public spaces, while medical imaging allows doctors to diagnose and treat diseases. In the realm of remote sensing, clear visuals are essential for monitoring environmental changes and managing natural resources [5].

However, adverse weather conditions like haze, fog, and smoke can significantly disrupt this visual clarity. Haze, a widespread phenomenon, arises from tiny particles suspended in the atmosphere. These particles scatter light, reducing visibility and obscuring crucial scene details within captured images. This not only hinders the performance of the aforementioned applications but can also lead to safety hazards and inaccurate decision-making [6].

Imagine an autonomous car struggling to navigate through a hazy landscape, its sensors failing to distinguish between road markings and blurred surroundings. Or picture a medical professional unable to discern subtle details in a hazy X-ray, potentially delaying a critical diagnosis [7]. These scenarios highlight the urgency of developing robust methods to counteract the effects of haze and restore clarity to images shown in Fig. (1).



Fig. (1). Hazy image and ground truth image.

This chapter delves into the fascinating realm of image dehazing, exploring how image processing techniques and deep learning models together are shaping the future of this field. We will begin by unravelling the scientific principles behind haze formation and the challenges it presents. We will then embark on a journey through traditional image processing methods for dehazing, understanding their strengths and limitations. Subsequently, we will witness the rise of deep learning as a game-changer in this domain, exploring the potential of convolutional neural networks (CNNs) to achieve superior dehazing performance. We will unveil how deep learning leverages the wisdom of image processing to extract meaningful features from hazy images and recover the hidden scene with exceptional clarity. Finally, we will cast our gaze towards the horizon, discussing the exciting

Deep Learning-based Approaches for Addressing Imbalance in Breast Cancer Image Datasets: Challenges, Opportunities, and Open Issues

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Abstract: Breast cancer detection is a critical area in healthcare where deep learning has shown remarkable promise in assisting medical professionals with early diagnosis. However, the effectiveness of these models is often limited by the imbalance present in medical datasets, where negative (non-cancerous) cases vastly outnumber positive (cancerous) cases. This disproportionate distribution leads to biased learning, as deep learning models tend to prioritize the majority class while neglecting the minority class, which is clinically most important. Consequently, false negatives—cases where cancer goes undetected—pose significant risks to patient outcomes. Addressing this imbalance is therefore essential to ensure accurate and trustworthy predictions in breast cancer detection systems. In this chapter, we propose a comprehensive framework that directly tackles the imbalance problem through a combination of innovative data-level and model-level strategies. At the data level, our approach employs advanced augmentation techniques and synthetic image generation methods designed specifically for medical data, ensuring that positive class samples are enriched without compromising clinical authenticity. At the model level, we integrate cost-sensitive learning and adaptive weighting mechanisms within deep neural networks, encouraging the model to focus more on minority cases. Furthermore, we enhance robustness by employing ensemble strategies that reduce bias and improve generalization. Unlike existing solutions that address imbalance in isolation, our framework emphasizes a holistic integration of sampling, augmentation, and model optimization to create a balanced learning environment. This proposed approach not only mitigates dataset imbalance but also improves sensitivity and specificity, providing a more reliable decision-support tool for healthcare professionals.

Keywords: Breast cancer, Data analysis, Deep learning, Imbalanced dataset, Machine learning.

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INTRODUCTION

In the contemporary era, the significance of data has attained a paramount status, as the prosperity and advancement of a company or organization are predominantly contingent upon the adept comprehension and effective utilization of the amassed data. Every organization and corporation nowadays produces vast amounts of data across several industries, including commercial, finance, banking, and the health sector . Medical data collection can be sourced from various entities within the healthcare ecosystem, including hospitals, healthcare professionals, care providers, and insurance agencies. Upon acquiring the necessary medical datasets, the next step would be to meticulously examine and develop appropriate modeling techniques. These techniques are employed to extract valuable insights that can facilitate accurate predictions.

When a dataset exhibits an unbalanced distribution, a significant percentage of cases are associated with a single class referred to as the dominant class, and comparatively fewer belong to another class known as the dormant class, it is commonly referred to as data imbalance. Within the domain of machine learning, data imbalance emerges as a noteworthy concern. It is observed that the distribution of classes within a dataset could be more equitable, with a majority of datasets exhibiting a long-tail distribution [1]. The challenge associated with high-imbalance datasets arises from the disproportionate distribution of instances across different classes. Consider a scenario where there are 90 cases from the dominant class and only 10 cases from the minority class. In this case, a classification model that assigns all 100 inputs to the majority class would achieve an accuracy of 90%, completely disregarding the dormant class. This observation highlights a common trend: the classification performance of machine learning models decreases with imbalanced datasets [2]. In various domains, including the medical field, the minority class is often considered more significant. Nevertheless, it often faces the challenge of being overshadowed by the majority class, leading to overfitting. To address the curse of data imbalance, preprocessing techniques, including “random oversampling” and “undersampling,” have been employed [3]. It is imperative to employ these techniques to develop precise classifiers [4].

The exponential growth of data has been observed in various industries, with the healthcare sector experiencing a significant surge due to digitalization. The available data exhibits a significant imbalance, necessitating the implementation of various methodologies to address this concern. The healthcare sector exhibits a notable disparity in data distribution, with a substantial preponderance of data about individuals with normal or healthy conditions compared to those afflicted

with an illness. Consequently, the classifier exhibits a bias favoring the dominant class, thereby diminishing the accuracy of predictions about the minority class [5].

IMBALANCED MEDICAL DATASETS: AN OVERVIEW

Data imbalance is a common phenomenon in datasets used for various machine learning and mining tasks [6]. Imbalanced datasets can manifest in different ways and for various reasons. Binary Class Imbalance is the simplest form of data imbalance, with only two classes. One class is significantly more prevalent than the other. For example, detecting a rare disease in medical diagnosis might lead to a binary class imbalance if the disease cases are a small fraction of the total instances. In multi-class datasets, there are more than two classes. An imbalance occurs when some classes are heavily overrepresented while others are underrepresented. Specific labels might be assigned to only a few instances in datasets with multiple labels, leading to multi-label imbalance. An example is document categorization, where some topics are less common than others [7]. Various types of data imbalance and factors causing data imbalance are shown in Fig. (1) and 2, respectively.

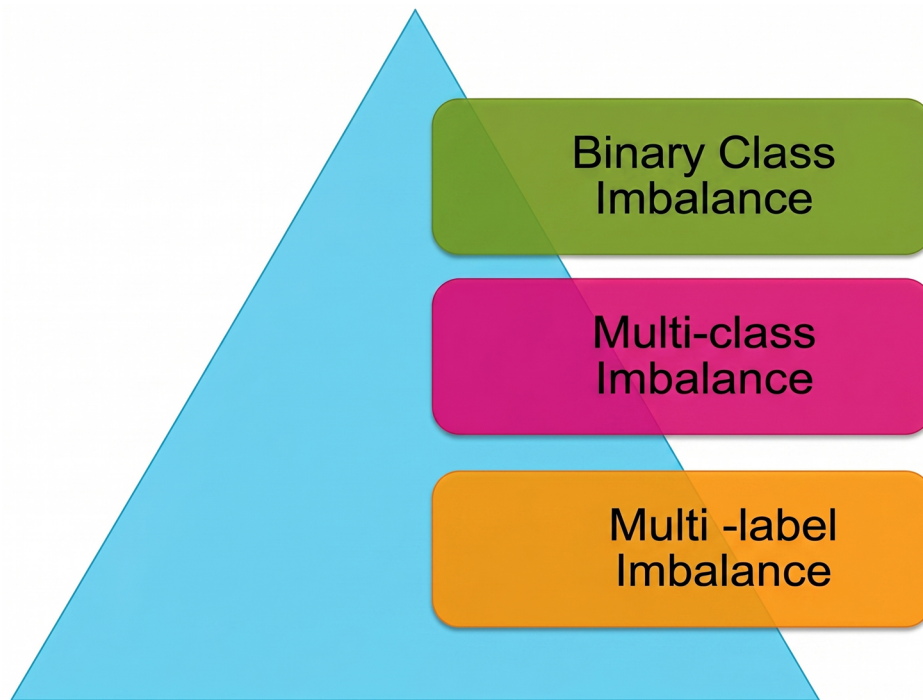


Fig. (1). Types of data imbalance.

Ancient Indian Scripts Identification: A Machine Learning and NLP Approach

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Abstract: Understanding of ancient script is linked to the discovery of our past heritage and cultural evolution. The task of deciphering such texts, often eroded by time, presents significant challenges. Recent advancements in Machine Learning (ML) and Natural Language Processing (NLP) offer transformative tools to automate and enhance the interpretation of these historical artifacts. This chapter introduces the application of ML and NLP techniques in identifying and analyzing ancient Indian scripts, throwing light on their complexities, cultural context, and linguistic variations. The chapter provides a comprehensive review of existing methodologies and the obstacles inherent in deciphering historical documents. Challenges associated with scripts like Brahmi, Devanagari, and others are explored, which highlight their linguistic intricacies and historical depth, and also their cultural specificity. Traditionally, transcription by experts has been the primary approach. This method is time-intensive and prone to errors. By contrast, recent advancements in ML and NLP have enabled automated processes, achieving notable improvements in accuracy and efficiency. The key techniques, which include image preprocessing, feature extraction, and classification algorithms, are assessed to determine their suitability in addressing the complexities of ancient scripts. Additionally, the chapter investigates the integration of domain-specific knowledge, such as epigraphy and palaeography, with ML and NLP frameworks. This interdisciplinary approach utilizes historical corpora, linguistic resources, and computational algorithms to enhance accuracy and contextual understanding. The chapter emphasizes the need for collaboration among historians, linguists, and computer scientists to develop robust systems for deciphering ancient texts. Case studies and a literature review demonstrate the potential of ML and NLP in revolutionizing the study of Indian scripts. The chapter concludes with a discussion on future research directions, underscoring the importance of innovation and interdisciplinary collaboration in unravelling the secrets encoded in these invaluable relics of the past.

Keywords: Ancient scripts, Brahmi, Epigraphy, Historical documents, Indian texts, Machine learning, Natural language processing, Text identification.

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INTRODUCTION

We need to know about our ancient scripts. The identification and interpretation of ancient texts have long been a cornerstone of historical and linguistic research. They are a window to our understanding of our ancient history. The lack of knowledge and understanding of Pali, Maratha, and even the ancient scripts used by the Moghuls will hinder the accurate comprehension of historians to arrive at conclusions regarding the history associated with those earlier periods. Understanding ancient scripts is critical for estimating the history and societal structures, as well as the languages in prevalence, the cultures of past civilizations, and their origins [1, 2]. Numerous scripts have been used over the centuries, *viz.*, Brahmi, Tamil-Brahmi, and Devanagari, each contributing to the richness of our cultural heritage. The ancient Indian scripts threw light on the socio-political and religious practices in vogue, and conditions of the economy of these times. Inscriptions and manuscripts, artifacts, and currency of those times contain revelatory information. The comprehension of these texts helps historians and linguists reconstruct historical narratives and understand linguistic tradition. This is crucial in the preservation of administrative records and ancient literature [3, 4].

The manual deciphering of these scripts is time-consuming and contains errors. This study looks into the application of modern Machine Learning and Natural Language Processing techniques in the identification and interpretation of ancient scripts. Through probing the methods and challenges involved, contributions to digital humanities and computational linguistics can be made. The comprehension and digitalization of ancient texts ensure that invaluable cultural information is not lost forever. This enables easy access for those seeking information, including researchers as well as the general public. The identification and assessment of these texts are labour-intensive when done manually and prone to errors. This necessitates the development of automated solutions.

Some of the major Ancient Indian Scripts include Brahmi, Tamil-Brahmi, Kharosthi, Devanagari, and others. Brahmi is considered one of the earliest antiquated writing systems prevalent in ancient India, and a few such inscriptions date back to the 3rd century BCE. It is widely accepted that several South and Southeast Asian scripts originated from Brahmi. Languages like Sanskrit and Hindi are derived from the Brahmi script and are recognized by the horizontal line at the top of the letters. Tamil-Brahmi uses the features of the Brahmi script adapted for the Tamil language. It was used in inscriptions from the early centuries CE. These scripts, in addition to documenting historical events, also reflect the linguistic diversity and cultural richness of ancient India. They are

crucial for our understanding of pre-modern historical literature and for assessing administrative records and religious texts that were prevalent several centuries ago.

Deciphering ancient scripts involves challenges such as the availability of complete data, fading of inscriptions, and the need for expert knowledge in historical linguistics and paleography. Ancient scripts often exhibit variations and evolutions over time and across regions [5].

Some of the important tasks in the analysis would include aspects of image preprocessing and feature extraction, as well as the use of classification algorithms to address the complexities of understanding ancient documents, besides the utilization of resources that contain linguistic and historical collections, and techniques of inferencing contextuality to improve the accuracy of text identification [6].

To improve the readability of ancient texts, a combination of domain knowledge and modern technologies can go a long way. Domain knowledge in fields such as epigraphy and paleography, coupled with knowledge of technology related to ML and NLP, can help the process of decipherment. In fact, a team consisting of linguists, computer scientists, and historians working together, sharing their expertise, can enable the building of effective systems for text identification [7].

The evolution of languages dates back several centuries, bringing with it changes and complexities of its own. Literature [8] provides a detailed review that examines the application of machine learning in the study of ancient texts, covering a wide range of languages, scripts, and media across more than three and a half millennia of global civilizations. In the case of Indian scripts like Brahmi and Devanagari, the challenges of unravelling their meanings are immense [9]. An attempt is being made in this write-up to summarize the existing literature and the possibilities of using modern technologies – NLP and ML – in the identification and transcription of historical documents, and to posit future research directions.

HISTORICAL BACKGROUND OF ANCIENT INDIAN SCRIPTS

Brahmi Script

Brahmi script has been traced back to the 3rd century BCE. Several modern Indian scripts like Tamil and Devanagari have inherited some of their characteristics. The discovery of Inscriptions written using the Brahmi script on rock edicts, coins, and other artifacts reveals its wide usage in ancient times. Text identification of Brahmi script and its variability pose enormous challenges in

A Deep Learning Approach for Geopolitical Entities Extraction from Indian Election Data

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Abstract: Named Entity Recognition (NER) is an essential task in Natural Language Processing (NLP) that enables the identification and classification of significant entities from unstructured text. In the context of Indian elections, extracting geopolitical entities such as states, districts, and parliamentary constituencies is particularly important for effective data analysis, interpretation, and decision-making. This chapter proposes a deep learning-based framework for geopolitical entity recognition in election-related textual data, combining Embeddings from Language Models (ELMo) with Bi-directional Long Short-Term Memory (BiLSTM) networks to capture both contextual semantics and sequential dependencies. To further enhance accuracy, a custom gazetteer of Indian geopolitical entities was integrated into the model, enabling it to leverage domain-specific knowledge and resolve ambiguities often encountered in election data. The framework was evaluated using a corpus of over 50,000 words derived from official documents published by the Election Commission of India. Experimental results demonstrate that incorporating deep contextual embeddings alongside gazetteer-based features significantly improves the model's ability to identify and classify entities compared to baseline approaches. This study not only highlights the importance of combining neural architectures with curated domain knowledge but also lays the foundation for more accurate text mining and information retrieval systems in the electoral domain. The proposed methodology can serve as a reliable tool for political analysts, researchers, and policymakers who seek to derive insights from large-scale electoral data. Future directions include extending the approach to recognize other domain-specific entities and refining gazetteer integration techniques to further boost generalizability and robustness across varied datasets.

Keywords: BiLSTM for NER, Deep learning for NER, ELMo word representation, Gazetteer, Geopolitical entities (GPEs), Indian Election domain text, Information retrieval, Named entity recognition, Natural language processing, NLP, Text mining.

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INTRODUCTION

The standards of Indian elections are considered to be among the highest across the world. The Indian constitution elaborates Indian democracy as a federal structure, with Parliament as the central government and assemblies as provincial governments, known as State Governments in the Indian context. Some named entities that appear frequently in texts related to Indian elections include voters, candidates contesting elections, constituencies, etc. At times, NEs are not single words but chunks of words containing stop words like “Andaman and Nicobar Islands.” The context of named entities in a sentence plays an important role in their appropriate understanding. It is important, since the motto of the Election Commission of India – an autonomous body responsible for the conduct and administration of elections in India – is to ensure free, fair, transparent, and inclusive elections. Therefore, besides names, the extraction of GPEs is also significant.

NER is a part of NLP that can extract named entities from a text for categorization into different types. These entities can be anything ranging from the names of people, organizations, and locations to temporal entities such as dates and times, to numerical entities like quantities and monetary values, and many more. It helps many businesses and organizations to find insights from large unstructured datasets [1]. It is one of the important steps for extracting information to facilitate the conversion of information present as unstructured text into structured data, for example, data in a relational database. NER has applications in many NLP tasks such as information retrieval [2], machine translation [2], question answering [3], and sentiment analysis [4, 5]. An NER system takes text data as input and finds and tags each entity in the text as the appropriate type of named entity, depending on the text data domain. For example, while classes such as diagnosis, disease, medicine, etc. may be appropriate for text in the medical domain [6], company names or mutual funds may be more suitable for financial documents [7]. Similarly, in the Indian context, ‘New Delhi’ and ‘Sikkim’ should be correctly recognized as GPEs. Over the past few years, advancements in deep learning have revolutionized NER systems, allowing for greater accuracy and flexibility across a range of domains.

Early NER models mostly relied on rule- and dictionary-based approaches, which required domain specialists and qualified linguists to create and maintain rule sets. However, the rules do not cover all language events, the creation process is too long, and this technique is less likely to be portable. NER, although being a fundamental NLP function, is hampered by the complexities that come with every natural language. Some of these challenges include ambiguity and abbreviations,

the number of words or phrases written in different forms, and terms that are not often used these days or are domain-specific.

In the context of Indian elections, the need for accurate extraction of geopolitical entities (GPEs)—such as states, districts, and parliamentary constituencies—has become increasingly significant. Elections in India involve a complex interplay of geographical and political boundaries, making it essential to identify these entities correctly to facilitate data analysis. GPE extraction enables better insights into election trends, voter demographics, and constituency-level dynamics, providing valuable tools for researchers, policymakers, and election officials. However, the diversity and multilingual nature of Indian election data pose significant challenges for traditional NER systems. This chapter presents a deep learning-based approach to extract and classify geopolitical entities from Indian election-related texts. By leveraging Embeddings from Language Models (ELMo) for contextual word representations and Bi-directional Long Short-Term Memory (BiLSTM) networks for sequence encoding, the proposed model can accurately identify GPEs in election documents. Furthermore, to improve accuracy, a custom gazetteer of geopolitical entities was integrated into the model, enriching word embeddings with domain-specific knowledge about Indian locations and constituencies.

This chapter highlights useful methods for demonstrating the efficacy of combining deep learning techniques with gazetteer features to enhance NER performance in the Indian election domain. The model was evaluated on a corpus of over 50,000 words from the Election Commission of India's dataset, yielding encouraging results. By refining the NER process, this work opens new possibilities for automated text mining and information retrieval within the domain of Indian elections.

APPROACHES FOR NER

Rule-Based Approaches

Historically, NER systems were developed using rule-based approaches, where experts manually crafted grammars and dictionaries to recognize entities. While effective for specific tasks, these systems struggled with scalability and adaptability, especially in complex domains like elections, where named entities may include not just single words but phrases containing stop words and contextually significant terms. In a rule-based system, the programmer defines the rules based on the grammar of the language to detect named entities [8, 9]. For example, "Election Commission of India" is an organizational entity that consists of a noun phrase preposition

An Efficient Remote Patient Monitoring: The Convergence of Blockchain and Artificial Intelligence

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Abstract: With a notable trend towards remote patient monitoring (RPM), propelled by technological progress and the increasing demand for accessible, efficient healthcare solutions, the medical care landscape has undergone substantial changes. Blockchain and artificial intelligence (AI) are the core of this transformation, which collectively redefine RPM systems. This study investigated the combination of blockchain and AI, offering an innovative approach to improve patient care, data protection, and operational effectiveness. Blockchain technology ensures data integrity and privacy through a decentralized, immutable ledger, fostering transparency, secure information transfer, and seamless interoperability among health care platforms. AI algorithms deliver sophisticated analytics and predictive capabilities, enabling the real-time detection of health irregularities and tailored interventions. AI-powered RPM systems promote proactive healthcare, decrease hospital readmissions, and enhance patient outcomes by continuously tracking vital signs, medication compliance, and behavioral patterns. The merging of blockchain and AI has established a robust ecosystem that optimizes healthcare processes, diminishes administrative tasks, and reduces operational expenses. This integration encourages data-driven decision-making and preventive healthcare, laying the groundwork for a sustainable, patient-focused healthcare system. In summary, the integration of blockchain and AI into RPM represents a revolutionary advancement, addressing the evolving healthcare needs of the digital era and heralding a new era of innovation and accessibility in care provision.

Keywords: Blockchain technology, Healthcare evolution, Interoperability, Remote patient monitoring.

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INTRODUCTION

Background and Literature Survey

From General-Purpose Blockchains to Decentralized Applications (DApps), the development of blockchain technology has opened the door to innovative and safe digital ecosystems. A blockchain functions as a distributed digital ledger that keeps track of transactions across several computers, guaranteeing the data's immutability.

This concept was first introduced in 2008 by an individual or group known as Satoshi Nakamoto, with its initial implementation in 2009 as a key part and requirement of Bitcoin transactions [1]. The following image (Fig. 1) depicts the process of executing a transaction within a blockchain.

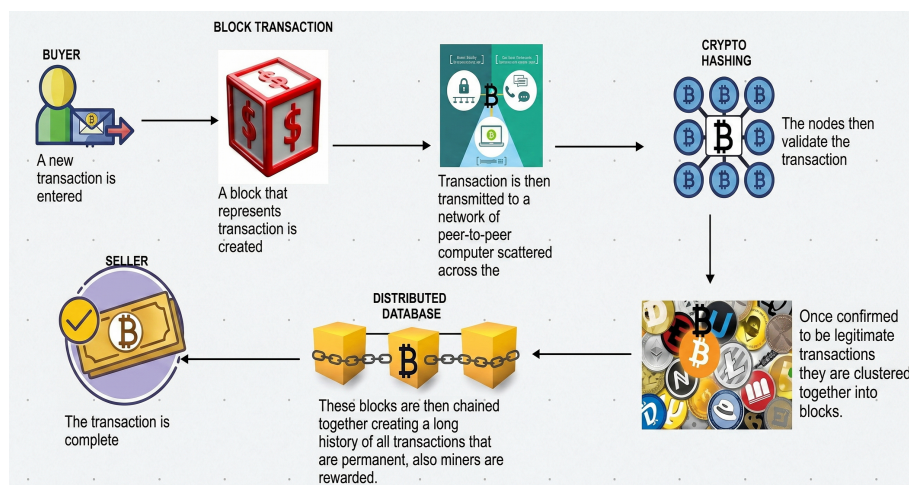


Fig. (1). Blockchain execution.

The healthcare industry has been transformed by blockchain technology, which offers a secure, decentralized, and transparent method for managing medical information. The following is an elaborate explanation of how blockchain functions in healthcare. (Fig. 2) shows the flowchart for Blockchain in Healthcare, which illustrates the steps employed in the RPM. Protecting health information presents significant challenges.

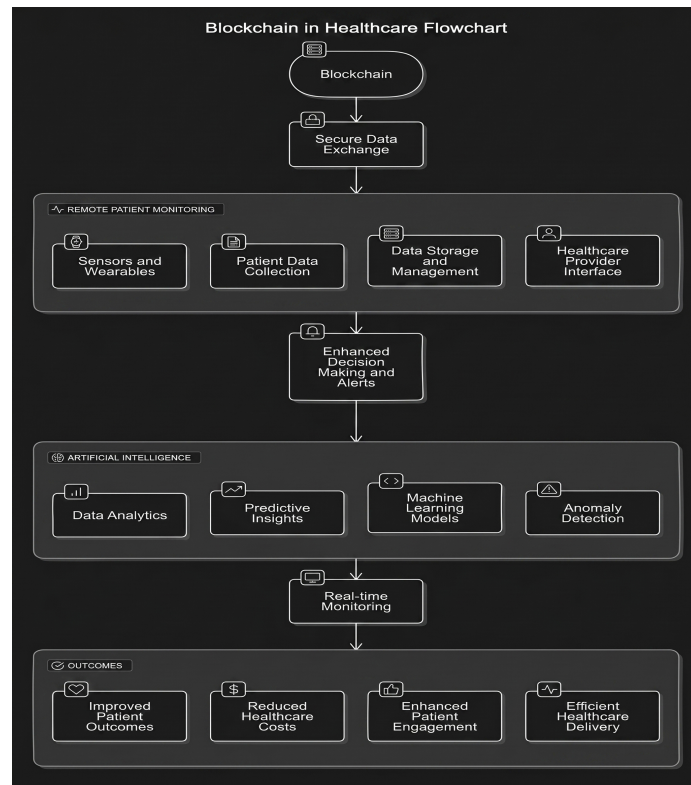


Fig. (2). Flowchart for Blockchain in healthcare.

In a study [2], the author has examined the incorporation of Blockchain and AI in telemedicine, highlighting their advantages and implementation hurdles. In a study [3], Taherdoost explored the fusion of blockchain and artificial intelligence technologies, concentrating on their joint applications. This Applied Sciences publication investigated the potential benefits and obstacles of combining these technologies. The research [4] offers valuable perspectives on automated systems that could be applicable for understanding AI and automation implementation in various fields, including healthcare. The authors [5] proposed a three-layered framework designed to enhance Medicare interoperability through intelligent, thoughtful, and strategic API-driven integration. In a study [6], the author delved into the convergence of big data and machine learning in healthcare, providing a comprehensive analysis of how these technologies are revolutionizing healthcare practices and decision-making processes. Another study [7] authors examined the effect of big data on organizational decision quality, stressing the significance of data quality and diagnosticity. Their research investigated whether high-quality data can enhance firm decision-making. In a study [8], the authors propose a secure electronic health record (EHR) system based on an attribute-based

Handwritten English Character and Digit Recognition using Deep Learning Techniques (CNN and SVM)

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Abstract: Recognizing patterns in handwritten characters is challenging because each individual has a unique writing style. Nonetheless, this recognition field holds great promise across applications such as historical document digitization and accessibility enhancements for individuals with low vision. As a result, researchers highly prefer the Handwritten Character Recognition (HCR) field. Recently, using deep learning algorithms, the overall performance of HCR models has greatly improved. Our chapter proposes a CNN-SVM hybrid model for handwritten English character and digit recognition on the MNIST dataset. The major features of both classifiers are combined in this model. In our model, handwritten characters and numbers are automatically processed by the CNN's receptive fields to extract the most identifiable features. After extracting the feature, the data is classified using Support Vector Machines (SVMs) to determine the recognized alphabet or number.

Keywords: Convolutional neural networks, Handwritten character recognition, Hybrid model, MNIST dataset, Optical character recognition, Support vector machine.

INTRODUCTION

HCR converts handwriting into data that can be studied further. HCR is one of the key machine learning topics being researched today. However, it remains one of the most difficult problems because each person's handwriting varies greatly and is inconsistent, making it extremely challenging to identify handwritten characters. Moreover, there may be a lot of noise in the scanned handwritten character image input. Despite these difficulties, identifying handwriting patterns can be helpful in many fields, such as historical document digitization, signature

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verification, and processing blank cheques. Therefore, researchers highly prefer the HCR field, which has been the subject of extensive research over the past few years. However, conventional methods had some drawbacks that prevented them from being more dependable. Common problems in scanned handwritten character recognition include similarity in handwriting, distorted shapes, or varying thicknesses. These problems increase

the uncertainty in the input data. Recent research has shown that deep learning algorithms work very accurately for the OCR process. By using deep learning methods, we can overcome these shortcomings, and extracting features becomes easier and more efficient [1].

There are two steps involved in identifying the characters. The handwritten characters are first scanned, and then the key elements of the supplied data are extracted using feature extraction. Subsequently, the characters are categorized according to the way the attributes extracted in Step 1 are categorized. A branch of machine learning called neural networks (NNs) is modeled after how the human brain functions. Neurons lay the foundation of the neural network by processing information and using cues from the biological neural network. Weights for inputs, biases, and connections make up the main components of a neural network. In a neural network (NN), every node is referred to as a perceptron [2]

In 1980, CNNs were first implemented, inspired by the architecture of the human brain. Because we have seen so many images of things as humans, we can identify stuff we have seen before, even as young children. Similar to one another, CNNs use the MLP architecture to analyze visual pictures as a kind of deep neural network. This suggests that every neuron within the layer is interconnected. The present study employs Convolutional Neural Networks (CNNs) to extract features from scanned handwriting inputs, achieving high character recognition accuracy. CNNs' ability to recognize patterns in photos makes them popular in the field of image categorization. CNNs, or feed-forward neural networks, operate on multiple layers. CNNs are more accurate at feature extraction and classification than other algorithms because they are composed of artificial neurons with the same capacity for optimization and learning as real neurons.

It requires very little preprocessing of input data and treats every pixel in an image as a feature during image classification. However, advancements in GPU and computational technology have made these tasks far more efficient [3, 4]. Fig. (1) represents the basic working principle of a Convolutional Neural Network.

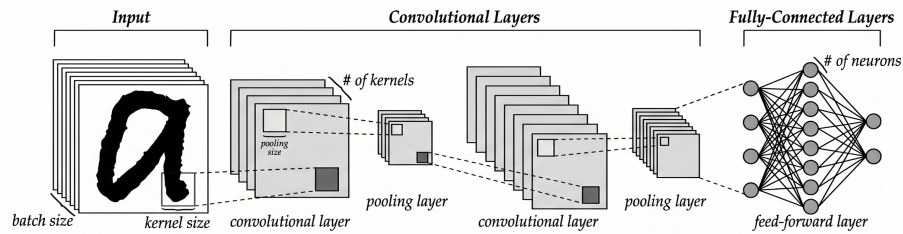


Fig. (1). Basic working principle of convolutional neural network [5].

Having the biggest margin makes a hyperplane optimal. Comparing kernel SVM and training time, linear SVM uses less memory and is more efficient. In order to classify data, linear SVM operates in the original spatial dimension. But sometimes linear SVM works better than kernel SVM, for example, when classifying documents or handling big datasets. We reduced computing time in our investigation by using a linear SVM as the final classifier. The handwritten character recognition (HCR) system was built using the suggested approach in our study. OCR research in computer science includes the recognition of handwritten characters.

RELATED WORK

Many studies are being conducted in response to the widespread use of HCR in the present day. So, the model could be both far more dependable and efficient. S. Khan *et al.* [6] applied symbol identification to handwritten digits for machine learning classification. The character recognition system uses features such as temporal, statistical, and structural. A fuzzy model was used to implement the recognition system. Y. Boulid *et al.* [7] developed a model where, in the process, the character images are pre-processed, and the image components are categorized using different classification methods. N. Ahmad *et al.* [8] suggested OCR to extract specific highlights from an input image, which arranges its content to classify defined characters, such as letters and numbers. A recognition model that can identify both uppercase and lowercase letters, as well as handwritten characters in English, was presented there.

M. Askari *et al.* [9] represented the method for an image character that was a special implementation of Arabic character recognition. Here, comparisons were conducted using the Random Forest Classifier, K-Nearest Neighbors, and SVM. F. Sarvaramini *et al.* [10] implemented Convolutional Neural Networks to achieve promising results. High accuracy was obtained in the feature extraction and classification. M. A.A. Bhuiyan *et al.* [11] used a multi-resolution approach with their model. R. Tavoli *et al.* [12] addressed the recognition of handwritten Arabic

Artificial Neural Network Applications for Intelligent Transportation Systems

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Abstract: This chapter examines the revolutionary impact of Artificial Neural Networks (ANNs) on Intelligent Transportation Systems (ITS), emphasizing the role of advanced image processing techniques in enabling intelligent, data-driven solutions for urban transportation. As urban areas progress towards linked smart cities, the use of artificial neural networks (ANNs) has become essential for establishing efficient, responsive, and adaptable transportation systems. ITS applications, such as Intelligent Transportation Management and autonomous driving, depend on ANNs to analyze intricate, real-time data, facilitating dynamic traffic management, congestion forecasting, and enhanced routing capabilities. Advanced artificial neural network designs, including Convolutional Neural Networks (CNN), You Only Look Once (YOLO), Single Shot Multibox Detector (SSD), Recurrent Neural Networks (RNN), Generative Adversarial Networks (GAN), and Long Short-Term Memory (LSTM) networks, are essential for processing high-resolution image data, object detection, and traffic flow prediction, among other applications. This chapter showcases case studies that illustrate the effective integration of Artificial Neural Networks inside Intelligent Transportation Systems in several worldwide smart cities, emphasizing real applications and results. These examples demonstrate how advanced image processing enhances urban travel by facilitating proactive, safe, and sustainable mobility solutions that align with the objectives of contemporary smart cities.

Keywords: ANNs, Autonomous driving, CNN, ITS, IIP, LSTM, RNN, SSD, Smart City, YOLO.

INTRODUCTION

Traffic congestion has emerged as a pervasive issue in metropolitan areas globally, attributable to population growth, deteriorating infrastructure, accele-

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rated urbanization, and the consequent increase in vehicle numbers. Current solutions are inadequate for managing the complexities of substantial traffic demand. Thus, there is an immediate need for sophisticated, adaptable systems that can manage traffic in real time, thereby improving efficiency and reducing congestion. Numerous nations have previously adopted and developed smart cities with existing technologies [1, 2]. Recent advancements in artificial intelligence (AI) have created new opportunities to enhance transportation systems. Intelligence in image processing is essential in several significant application domains, including image and video processing, Natural Language Processing (NLP), healthcare, finance, transportation, robotics, gaming, entertainment, and education. Intelligence in transportation systems is among several that employ image processing at multiple levels to augment the system's intelligence [3, 4].

This chapter offers a comprehensive introduction to Intelligent Transportation Systems (ITS) that utilize the capabilities of Artificial Neural Networks (ANNs) specifically for advanced image processing. Furthermore, it encompasses its design, potential uses, and future prospects within the transportation system, as shown below [5, 6].

- Intelligent Transportation Systems
- Artificial Neural Networks
- Intelligent Transportation System with Artificial Neural Networks
- Smart City
- Traffic management
- Autonomous Driving
- Case Studies

INTELLIGENT TRANSPORTATION SYSTEMS

ITS is a multifaceted system including numerous architectural components, navigation assistance equipment with communication protocols, traffic control units, and regulatory software [7 - 11]. A fundamental Intelligent Transportation System is illustrated in Fig. (1) with various components. The aim of an ITS is to improve traffic flow efficiency, safety, and environmental sustainability. The current methods are insufficient, and ITS enhances traffic management through the monitoring, management, and optimization of road transport by integrating modern communication networks, data analytics, and computing technologies [12, 13]. And ITS also alleviates traffic congestion, forecasts traffic patterns, and facilitates a smooth flow of pedestrians and vehicles throughout the entire road network by utilizing sensors, real-time data, and AI-driven technology [14, 15].

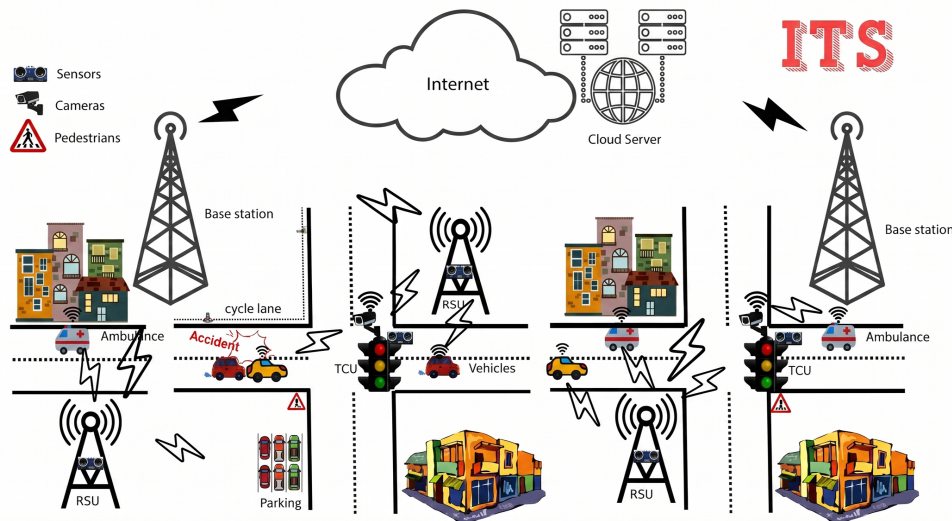


Fig. (1). List of supporting components that is constantly expanding.

Components

A range of essential elements inside an ITS work together to manage traffic effectively. For infrastructural support, the architectural elements include different sensors, cameras, roadside units (RSU), base stations (BS), cloud servers, and regulatory protocols. Cameras and other sensing devices are meticulously placed at significant locations, such as highway intersections and high-traffic zones, to gather data on traffic, vehicle speeds, and incidents. Additionally, intelligent cars are outfitted with various sensors on the onboard unit (OBU), including global positioning systems (GPS), allowing real-time location and movement tracking. Other elements include radio frequency identification (RFID) and Bluetooth devices at several critical points to collect toll and location data from cars in real time [16, 17]. Fig. (1) shows the long list of these supporting components that are constantly expanding, and there is insufficient space to cover them all here.

Communication

The many infrastructure components mentioned are essential for real-time interaction and use standardized protocols (such as the Internet of Vehicles (IoV) and Infrastructure-to-Everything (I2X)) for effective communication. These links establish a unified network that facilitates interaction among vehicles, infrastructure, and traffic management centers. Moreover, data analysis and processing involve aggregating information from various traffic collection units to

Advanced Image Analysis Techniques Using Machine Learning and Transformers

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Abstract: Computer vision has witnessed remarkable progress in recent years, particularly in the domain of image analysis, which forms the foundation for numerous real-world applications. Traditional methods for image understanding often rely on handcrafted features and shallow models, which struggle to handle the complexity, high dimensionality, and unstructured nature of modern visual data. This limitation reduces their effectiveness in tasks such as medical imaging, remote sensing, and scene understanding, where accurate interpretation of intricate patterns is critical. The emergence of deep learning has fundamentally transformed this landscape, enabling models to automatically learn hierarchical representations directly from raw data and to capture complex spatial and semantic relationships. Convolutional neural networks (CNNs) have long dominated image analysis, offering strong performance in classification, detection, and segmentation tasks. However, recent advances highlight the limitations of CNNs in modeling global dependencies, motivating the exploration of alternative architectures. Transformers, originally developed for natural language processing, have demonstrated exceptional capability in capturing long-range correlations and contextual dependencies. Their application to computer vision tasks has opened new avenues for achieving state-of-the-art results across diverse benchmarks. This research investigates advanced methods for image analysis that integrate transformer architectures with machine learning, seeking to enhance model

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accuracy, robustness, and interpretability. By leveraging the strengths of both CNNs and transformers, this study aims to address existing challenges in picture analysis and contribute to the development of more generalizable and efficient vision systems. The findings offer promising directions for future applications where precise and scalable image analysis is indispensable.

Keywords: Advanced image analysis techniques, Convolutional neural Network (CNNs), Machine learning, Transformers, Vision transformers (ViTs).

INTRODUCTION

The field of image analysis has significantly evolved with the advent of machine learning (ML) and deep learning (DL) techniques [1, 2]. Traditional image processing methods have been largely replaced or augmented by sophisticated models that can learn complex patterns from vast datasets. Recently, transformers—originally developed for natural language processing—have demonstrated remarkable potential in vision tasks, pushing the boundaries of image recognition, segmentation, and enhancement. This review examines advancements in image analysis enabled by machine learning and transformers, highlighting their impact across various applications. Earlier image processing techniques relied on feature extraction and rule-based approaches. Methods such as edge detection, histogram equalization, and morphological operations were generally used for object recognition and classification. Traditional machine learning (ML) models were employed to improve classification accuracy by learning from handcrafted features. However, these approaches were often limited by their inability to generalize well across diverse datasets and complex visual patterns [3, 4].

MACHINE LEARNING AND DEEP LEARNING APPROACHES

The introduction of deep learning (DL) revolutionized image analysis, enabling models to learn hierarchical features directly from data. CNNs became the foundation of modern image analysis, excelling in tasks such as image classification, segmentation, and object detection. Architectures like AlexNet, VGG, ResNet, and EfficientNet significantly improved performance by leveraging deep hierarchical structures. These models employ layers of convolutional filters to extract spatial features, allowing for robust feature representation. Further advancements included (GANs) and autoencoders [5], which enhanced image synthesis, super-resolution, and de-noising. GANs, in particular, facilitated high-quality image generation through adversarial training, in which a generator and a discriminator compete to improve image authenticity. Meanwhile, RNNs and LSTM networks contributed to video analysis and sequen-

tial image processing, but their limitations in handling long-range dependencies prompted the need for more advanced architectures [6, 7].

THE RISE OF TRANSFORMERS IN IMAGE ANALYSIS

Transformers, initially designed for natural language processing (NLP), have gained major traction in computer vision due to the ability to model long-range dependencies without relying on spatial locality. Vision Transformers (ViTs) have emerged as powerful alternatives to CNNs, demonstrating competitive performance in image classification and segmentation [8]. ViTs divide images into patches and process them using self-attention mechanisms, capturing global contextual relationships more effectively than traditional CNNs. Hybrid models, such as the Convolutional Vision Transformer (CvT) and the Swin Transformer [9], combine convolutional layers with transformer-based attention mechanisms to balance computational efficiency with performance. These architectures have proven effective in various image analysis applications, including medical imaging, autonomous driving, and remote sensing. Throughout this chapter, we will investigate how convolutional neural networks (CNNs) have emerged as the cornerstone of modern image processing. When it comes to image segmentation, object recognition, and classification, computer networks (CNNs) have been shown to be quite effective [10]. In the next section, we will investigate the role that transformers play in image analysis, with a particular emphasis on their ability to capture global dependencies in images and their potential to either replace or enhance CNNs in certain applications. Additionally, we investigate new developments that combine CNNs with transformers, such as vision transformers (ViTs) and transformer-based object identification models. These developments are still being investigated. These methods take advantage of the merging of CNNs and transformers in image processing to provide better efficiency and performance. We examine the issues currently being faced in this area, as well as the future directions being pursued. These challenges include the need for more interpretable and explainable models that are resistant to adversarial attacks and scalable to large-scale image datasets. The purpose of this article is to present a complete review of sophisticated image analysis approaches that make use of machine learning and transformers, demonstrating the revolutionary influence that these techniques have had on the area of computer vision. Fig. (1) shows the advanced Image Analysis Techniques using machine learning and transformers, and Table 1 shows the image analysis using machine learning.

CHAPTER 9

Intelligent Agricultural Monitoring Framework Based on Machine Learning Techniques

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Abstract: The term smart agriculture refers to a relatively new academic discipline that makes use of technology to enhance agricultural methods in order to maximize crop output, quality, and sustainability. Using monitoring systems that apply machine learning (ML) algorithms to analyze data from field sensors, is an essential component of smart agriculture. With the data these technologies may provide, farmers would be able to make more informed decisions about watering, fertilising, and insect control, among other crucial farming tasks. This study aims to thoroughly examine smart agriculture monitoring systems that utilise machine learning applications. Data collection, pre-processing, feature selection, model construction, model deployment, and feedback loops are among the key components of such systems. Furthermore, we examine the most popular machine learning algorithms used in smart agriculture, including neural networks, decision trees, random forests, and support vector machines. We also discuss how these algorithms are applied to forecast crop production, identify diseases, and schedule irrigation.

Keywords: Crop production prediction, Disease detection, Farming techniques, Irrigation scheduling, Monitoring systems, Machine Learning (ML), Smart agriculture, Support vector machines.

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INTRODUCTION

Precision agriculture, or smart agriculture, is a new kind of farming that uses technology to improve farming techniques and boost output. Utilizing monitoring systems that employ machine learning (ML) algorithms to analyze data from various field sensors is an essential part of smart agriculture. To help farmers make better choices and increase productivity, these tools provide them with helpful information and suggestions. The use of ML in agricultural monitoring systems may completely alter how farmers oversee their harvests and use available resources. Machine learning algorithms may aid farmers in real-time optimization of agricultural techniques by analysing massive volumes of data to identify trends, forecast results, and make predictions. Greater sustainability, less resource usage, and higher agricultural yields are all possible outcomes of this [1].

This chapter discusses the various parts of a machine learning (ML)- based smart agricultural monitoring system. Everything from the sensors used to the data they gather will be covered in our discussion of the information-gathering process. Fig. (1) illustrates data-preprocessing techniques, such as cleaning and standardisation, used to prepare data for machine learning algorithms. Furthermore, we will thoroughly examine the various machine learning models used in smart agriculture, including decision trees, artificial neural networks, random forests, and support vector machines. We will go over the process of training these models using historical data and then deploying them to the monitoring system so that farmers may get real-time insights and suggestions [2]. Considering all factors, machine learning-driven smart agricultural monitoring systems have the potential to transform farming by enhancing its efficiency, cost-effectiveness, and environmental sustainability. Increased agricultural yields, reduced environmental impact, and food security for decades to come are all possible outcomes of farmers embracing this technology, as shown in Table 1.

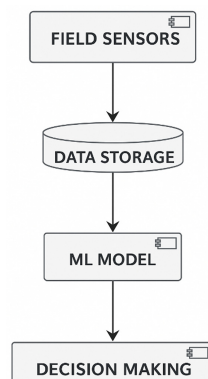


Fig. (1). ML in agricultural monitoring systems.

Table 1. A smart agricultural system that makes use of machine learning might keep tabs on and analyse the data and metrics shown in this table.

<i>Metric</i>	<i>Description</i>	<i>Example Value</i>
Temperature	Measure of the temperature in the agricultural environment.	25.6°C
Humidity	Measure of the humidity level in the agricultural environment.	65%
Soil Moisture	Measure of the moisture content in the soil.	35%
Light Intensity	Measure of the intensity of light in the agricultural environment.	1200 lux
Crop Growth Stage	Classification of the current growth stage of the crops using machine learning algorithms.	Vegetative
Pest Infestation	Detection of pest infestation using machine learning algorithms.	Low
Disease Detection	Detection of diseases in crops using machine learning algorithms.	None
Irrigation Scheduling	Scheduling of irrigation based on soil moisture levels and weather forecasts using machine learning algorithms.	Next irrigation in 2 days
Crop Yield Prediction	Estimation of agricultural productivity using machine learning techniques.	5000 kg/ha

ARTIFICIAL INTELLIGENCE APPLICATION IN AGRICULTURAL MONITORING TOOLS

Empirical evidence has demonstrated that the integration of machine learning (ML) into agricultural monitoring systems has yielded significant enhancements in the efficiency, output, and environmental performance of farming practices (2023). The assessment of extensive data collected from sensors and other sources by machine learning algorithms has the potential to provide farmers with valuable insights and recommendations. The following is a list of important parts of agricultural monitoring systems that make use of machine learning:

- **Crop Yield Prediction:** Agricultural yield prediction is the capacity of machine learning algorithms to analyse past data on weather conditions, soil quality, and crop characteristics to estimate future crop yields. Farmers can make more informed choices about planting, harvesting, and resource allocation with this information [3].
- **Detection of illness:** Machine learning algorithms are able to examine photographs of crops in order to identify indications of illness or pest infestation. The practice of early detection enables farmers to take prompt action, such as the application of pesticides or the implementation of quarantine measures, in order to avoid the spread of disease and reduce the damage to their crops.

Artificial Intelligence for Image-based Weed Identification in Agriculture

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Abstract: Weeds are undesired plants that grow in places where they are not intentionally planted, competing with crops for vital resources like water, nutrients, and sunlight. The competition can significantly reduce agricultural productivity. Moreover, conventional weed control methods often have detrimental environmental effects. As a result, effective weed management strategies are crucial for mitigating infestations and preserving the productivity and sustainability of agricultural systems. These strategies encompass a range of approaches, including cultural practices, mechanical methods, chemical treatments, and biological controls. In response to the growing demand for sustainable solutions, new technologies aimed at reducing herbicide use have gained attention. One such solution is automated weed control, which offers a more precise and efficient way of targeting weeds, ultimately reducing the need for herbicides. Recent advancements in computing power, particularly the use of GPUs, have accelerated the adoption of artificial intelligence (AI) and deep learning (DL) technologies in agriculture. These AI-driven techniques have demonstrated significant promise in accurately identifying and classifying weeds from field image data. By automating weed detection, AI-based algorithms not only minimize herbicide use but also help boost crop productivity and promote sustainable agricultural practices.

Keywords: Artificial Intelligence, Image classification, Machine learning, Precision agriculture, Weeds identification.

INTRODUCTION

In agriculture, effective weed control plays a role in maintaining the health of crops, ensuring sustainability, conserving natural resources, and ultimately enhancing global food security on a larger scale. Weeds in fields compete with

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crops for resources like water, nutrients, and sunlight, resulting in significant reductions in crop yields and quality. This detrimental impact on crops not only leads to losses for farmers but also poses a threat to food production worldwide. Furthermore, the economic effects of weeds go beyond just yield losses; they also include expenses related to labor, herbicides, machinery, as well as effects on crop quality and market value [1]. Additionally, ecosystem health and biodiversity can be maintained through effective weed management practices, as traditional weed control methods like herbicide use can have consequences such as soil erosion, water pollution, and deterioration of biodiversity [2]. Moreover, the rise of herbicide-resistant weed populations has highlighted the need for integrated weed management strategies to prevent resistance development and ensure the efficacy of herbicides. As a result, these challenges can be tackled through automated weed control methods to improve productivity**, meet the growing demand for food supplies,** while reducing the risks associated with food shortages and famines.

Some authors [3] and [4] highlight the use of both traditional machine learning (ML) and deep learning (DL) techniques for this application. These approaches generally reduce the reliance on manual labor and improve crop management, especially in weed detection [5]. The key distinction between these methods lies in their complexity [6, 7]. Machine learning relies on manually designed algorithms and statistical models that allow systems to analyze data, make predictions, and recognize patterns or make decisions accordingly [8, 9]. In contrast, deep learning mimics the structure of the human brain by using multiple interconnected layers of neurons to learn autonomously. These models extract features in a hierarchical manner, with increasing complexity as the network depth grows [10, 11]. While machine learning is suitable for simpler tasks with fewer variables and lower computational demands, it is particularly suitable for applications like Internet of Things (IoT) devices [12, 13]. Our chapter aims to achieve two main objectives:

- To demonstrate how AI-based weed identification can revolutionize integrated weed management.
- To discuss the challenges, opportunities, and future directions in this area. We will explore the integration of AI with weed management to motivate experts and researchers to embrace technologies for enhanced weed control.

The steps involved in automated image-based weed identification, the challenges and limitations of AI in weed management, and development pathways will be discussed in subsequent sections. Furthermore, a few existing case studies in the

literature for weed identification are also highlighted to showcase real-world applications for sustainable agriculture.

THE NEED FOR AUTOMATED WEED IDENTIFICATION

Automated weed identification has become an invaluable asset to modern agriculture for several key reasons. First and foremost, automated methods offer greater efficiency and precision compared to manual solutions, providing faster and more accurate management strategies of unwanted vegetation. Automated weed identification contributes to cost reductions by decreasing labor hours and herbicide costs, and to environmental sustainability by enabling targeted herbicide application that minimizes chemical use while simultaneously mitigating environmental impact. Remarkably, it enables prompt intervention by providing real-time data on weed presence and distribution; farmers can then take swift action to manage infestations. Automated systems' scalability makes them ideal for efficiently covering large agricultural areas efficiently particularly useful in large-scale farming operations. Overall, using AI and computer vision technologies for weed identification increases crop yields while simultaneously decreasing environmental impacts and improving economic sustainability of agriculture operations [14]

Successful weed management maximizes crop yields by decreasing competition for essential resources, increasing economic viability of farming operations by minimizing losses and production costs, protecting ecosystems from disruption by controlling weed growth that disrupt ecosystems, leading to pollution; diversifying control tactics helps manage herbicide resistance for greater effectiveness; sustainable agriculture practices prioritize efficient resource usage while increasing ecological resilience - thus making weed control integral for long-term productivity and environmental wellbeing.

Challenges with traditional methods

- **Labour-intensive:** Traditional methods for weed identification rely heavily on manual labor that requires significant manpower, taking significant time and manpower resources to complete.
- **Subjectivity:** Identification by human observers may result in subjective judgment and inaccurate identifications, causing inconsistent outcomes.
- **Expertise Requirement:** Identifying weeds accurately often requires specific botanical knowledge and training; this restricts who can effectively perform this task.

CHAPTER 11

A Machine Learning-based Approach for Smart Agriculture Monitoring and Decision Support

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Abstract: The field of machine learning is expanding and has a wide range of potential uses in agriculture. Machine learning is used to forecast pests and illnesses, decrease water usage, and increase crop yields, which is a topic of investigation for farmers and agricultural experts. Machine learning is capable of improving resource efficacy along with food production sustainability for farmers in the future. Numerous factors either directly or indirectly affect crop growth. Among these are the climate parameters. We can boost productivity by employing machine learning to monitor and regulate these parameters. In addition, there is a need for technological solutions to address a number of issues, including fire alerts, maintaining humidity levels and appropriate temperatures, and meeting the needs of sophisticated plants while monitoring unauthorized entry into agricultural areas. The significance of an appropriate and satisfactory supply of power cannot be understated. By using a NodeMCU Wi-Fi module, the technology offers a practical and effective solution to the issues identified in the Indian farming system. Various sensors such as those for temperature, fire, light, PIR, humidity, and soil moisture, have been utilized to monitor and regulate a variety of technological issues. Using IOT and machine learning, the projected system uses a Wi-Fi module to display real-time data that can be watched online from any location in the world. The farmer is automatically notified by this module about the need for water, site temperature, moisture and humidity, light, fire warning, and unwelcome occupancy or encroachment. Using the machine learning principle, an experiment was conducted with varying soil and plant levels. It was established that the sensor exhibited sufficient sensitivity to yield consistent results under varying water level situations for diverse combinations of plants and soil.

Keywords: Automatic farming, Blynk server, Humidity sensor, Machine learning, Node MCU, PIR sensor, Soil moisture sensor.

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INTRODUCTION

In many regions of Southern India, the agricultural legacy of India extends even further, dating back to the Indus Valley Civilization [1]. India is currently the second-largest producer of agricultural products worldwide. Despite the country's overall economic growth, the contribution of agriculture to India's GDP continues to decline. However, in terms of population, agriculture is India's largest economic segment and plays a major role in the nation's overall socioeconomic structure. With \$38 billion in agricultural exports in 2013, India ranked seventh globally and sixth globally in terms of net exports [2]. Most agricultural exports are sent to emerging or developing countries. India exports agricultural, horticultural, and processed food items to about 120 countries; the majority of these destinations include the SAARC countries, the Middle East, Southeast Asia, the European Union, and the United States [3, 4].

Some important industries in our country still haven't fully embraced or utilized automation, even though everything in our society can be controlled and operated automatically. These include the agricultural sector. The process of automated farming involves monitoring and modifying the climate variables that have an impact on plant growth and the final result, either directly or indirectly.

India's problems with groundwater overexploitation would unavoidably get worse and spread if corrective action is not taken before the problem is intractable or not worth solving. Technology is needed to address other farming problems, such as monitoring unauthorized entry into agricultural fields and maintaining proper temperature, humidity, and light levels for sophisticated plants. However, the most important element for agriculture is a regular and sufficient electricity supply. Farmers, who ensure the availability of power because their task cannot begin without it, have also faced challenges due to a very erratic power source that frequently experiences power disruptions, in addition to decreased efficiency. Using IOT technology, this system can display real-time data that is accessible or viewed online from any location in the world. The internet was accessed with the Node MCU WiFi module. Applications in agriculture are made much simpler and more efficient by machine learning.

Complex problems are usually solved by machine learning algorithms, while human skill becomes inadequate. In agriculture, one can employ machine learning to predict soil properties like moisture content and organic carbon content, as well as to identify weeds and diseases in crops, detect species, and estimate crop production [5]. By employing several functions on the input and increasing the model's complexity, deep learning improves on traditional machine learning. Using network architecture, this allows for hierarchical data representation

through several layers of abstraction. The ability of the Deep Learning model to identify novel objects, such as anomalies, instead of only a predetermined collection of objects, is a crucial component. The program finds items that are unknown, far away, and poorly obscured by taking advantage of the homogeneous characteristics of an agricultural field [6].

This hardware effectively and efficiently addresses the highlighted issue with the Indian farming system. The solution that is being given is inexpensive, safe for the environment, and electronically operated, which will improve farmer satisfaction with the Indian agricultural system.

RELATED WORK

In the modern era, innovation and the adoption of new technology are often used to satisfy human needs. This has led to the development of the Internet of Things (IoT) [7, 8]. A network of machines, sensors, software, devices, and people connected via the Internet to exchange data, communicate, and interact is referred to as the “Internet of Things” (IoT) [9]. The goal of IoT is to create a seamless connection between the digital and physical realms. Smart homes [10, 11], smart cities [12, 13], smart energy [14, 15], autonomous automobiles [16, 17], smart agriculture [18, 19], campus management [20, 21], healthcare [22, 23], and logistics [24, 25] are just a few of the areas in which IoT has been applied recently. The number of IoT applications has been illustrated by Shafique *et al.* [26]. Information about automatic water supply to fields is detailed by Satya Prasanth Yalla *et al.* [27]. Modules and soil moisture sensors are included in the automation of the system, and sunlight is used as the preferred renewable energy source for power generation. E. Pradeep *et al.* developed a PV-powered farmer pump [28], considering components such as the power source, AC, DC, GSM technology, inverter frequency, well, waterline in the well, and submersible pump. Researchers demonstrate a state-of-the-art technique utilizing a GSM module. Jia Uddin *et al.* proposed a variable-rate autonomous microcontroller-based irrigation system [29].

All power needed to run the system comes from solar energy. Sensors are placed on the paddy field. The farmer receives continual readings of the water level from these sensors. The solar tracking system design maximizes solar energy capture and subsequently converts it into electrical energy for the irrigation system. The power was investigated by Binoy Seal *et al.* in [30]. Ishwar Kumar *et al.* proposed a solar-powered vehicle trailer in conjunction with an autonomous water flow management system based on moisture sensors in [31]. It is a recommended solution to the energy issues that Indian farmers are currently facing. Nilesh R. Patel *et al.* [32] list several monitoring and regulating methods developed to

CHAPTER 12

The Indispensable Contribution of Satellite Imagery to Disaster Management: Insights and Perspectives

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Abstract: Natural disasters happen often and are becoming stronger. It is important to react quickly and effectively. Remote sensing technologies help officials quickly assess the damage, detect changes in the area, find important areas that need help, and plan for rescue. Also, the early detection of natural disasters plays a vital role in predicting future disasters so that the communities and officials are ready to act ahead of time. This research work explores the indispensable role of remote sensing satellite images in the areas of disaster management. The study covers a range of disasters, including earthquakes, floods, forest fires, volcanic eruptions, tsunamis, tornadoes, and cloud bursts. A significant number of relevant scholarly articles published in 2023 were identified for each disaster, and more than 1000 research papers were found by combining all the disasters' keyword searches. Of which, more than 125 papers were found to be more relevant and have been studied. The study conducts a thorough literature review to identify the importance and contributions of remote sensing imagery. The work discussed some of the popular algorithms which are predominantly used across these studies, including Convolution Neural Networks (CNN), Random Forest, Support Vector Machine (SVM), U-Net-based methodologies, and many more. The study also highlights the challenges that still persist in these areas. The work is useful for future researchers to understand the importance of satellite imagery during disasters and the key challenges persisting in this area.

Keywords: Challenges, Disaster, Remote sensing, Satellite images, Survey.

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INTRODUCTION

Remote Sensing

Remote sensing is a technology that is used to gather information about features (objects) like buildings, water bodies, land, vegetation, *etc.*, from space with the help of satellites. It collects the data through the sensors, which can have multiple spectral bands. These inputs from the sensors are typically analyzed well by experts to know about the surface of Earth and its features without direct physical contact. There are mainly two types of remote sensing, active and passive [1]. Active remote sensing has its own radiance that sends signals and measures what reflects back to the sensor. In contrast, passive remote sensing measures reflected sunlight. There are different ways of remote sensing. One of the most popular is capturing images.

There are different types of remote sensing images which are used for extracting unique features of the Earth. One example has been shown in Fig. (1). Optical remote sensing uses sensors for visible, near-infrared, and short-wave infrared to create images of the Earth's surface by capturing sunlight reflected from objects on the ground. Different materials absorb and reflect light in different ways and at different wavelengths. Infrared remote sensing uses special sensors to detect infrared light reflected from the Earth. The middle-wave infrared (MWIR) and long-wave infrared (LWIR) fall under the thermal infrared region. These radiations come from warm objects like the Earth's surface. The temperature of land and water bodies can also be measured by this method. Thermal infrared remote sensing is useful for detecting forest fires. Multispectral remote sensing entails taking pictures in more than one spectral band at multiple wavelengths throughout the electromagnetic spectrum. These wavelengths may be separated through filters or detected using devices that might be sensitive to precise wavelengths, including light beyond what the human eye can see, such as infrared and ultraviolet. This method aids in gathering additional data that the human eye's red, green, and blue receptors are unable to detect. LiDAR (Light Detection and Ranging) is a remote sensing technology that examines the Earth's surface by emitting brief bursts of laser energy and collects information about nearby surroundings, as well as the distances. Then, 3D models and maps of the objects and the surrounding areas are made using this.

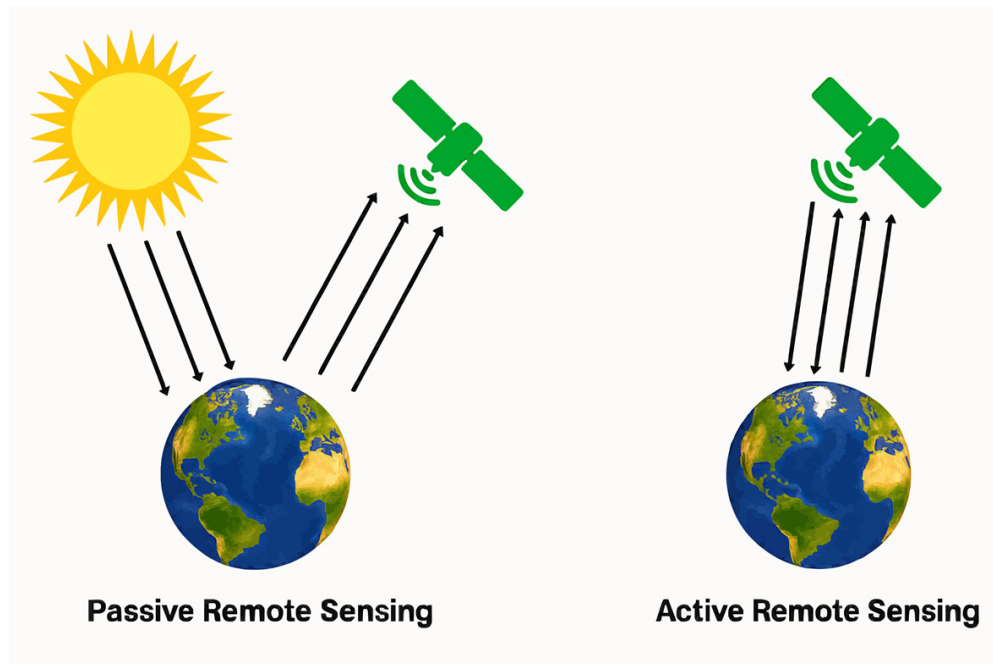


Fig. (1). Types of remote sensing [1].

Remote sensing images are characterized by:

1. The ability to discriminate among electromagnetic spectrum wavelengths is known as spectral resolution. The increased spectral resolution provides more precise information regarding surface properties.
2. Temporal resolution is the rate at which pictures are taken in a certain spot. It enables the monitoring of changes over time, including dynamic events and seasonal variations.
3. The ability to discriminate between minute variations in radiation intensity is known as radiometric resolution. Sufficient radiometric resolution improves the capacity to distinguish minute changes in surface characteristics.
4. Radiometric Resolution: The capacity to discriminate between minute variations in radiation dose. Sufficient radiometric resolution improves the capacity to distinguish minute changes in surface characteristics.
5. Geometric resolution is the degree of accuracy with which the spatial connections between objects in a picture are portrayed. Essential for precise mapping, geo-referencing, and spatial analysis.

These characteristics describe the properties of data obtained through remote sensing, regardless of whether it's active or passive. The data collected through

CHAPTER 13

PyroVisor D3ML-based Intelligent De-Hazing Algorithm**Aryan Vashisth¹, Akshansh Mishra¹ and Meena Kumari^{2,*}**¹ *Department of Computer Science and Engineering (Artificial Intelligence), ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India*² *Department of Computer Science and Engineering (Internet of Things), ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India*

Abstract: PyroVisor D3ML is a hybrid AI-based algorithm aimed at improving real-time video reproduction during indoor fire hazards. This innovation addresses the challenges faced by rescue teams using Python and its packages, such as PyTorch, NumPy, and OpenCV. Dark Channel Prior, depth estimation, and pre-trained machine learning models are the three main components that PyroVisor D3ML utilizes to facilitate rescue operations. The Dark Channel Prior estimates haze in each video frame, which helps remove unwanted smoke and haze, while depth estimation improves the accuracy of the de-hazing process by incorporating depth information. In combination, these components enable instant de-hazing of videos in real-time, allowing navigation and rescue teams to have clear visibility. It is therefore evident that PyroVisor D3ML is a useful tool for rescue operations under fire conditions, as it significantly enhances visibility and helps rescuers move through obstacle-laden areas more easily.

Keywords: D3ML, Image quality, NumPy, OpenCV, Pytorch.

INTRODUCTION

Environmental factors like haze and fog can significantly degrade image quality. A major challenge in its removal is the optimised calculation of atmospheric light as well as transmission depth. With the rapid progress in Artificial Intelligence (AI) and Machine Learning (ML) technologies, there have been substantial breakthroughs in fields like image processing and other applications. Computer Vision, in particular, is becoming a ubiquitous technology with numerous applications in modern technology. Image de-hazing, which addresses the issue of images degraded by haze, is a key problem in this field. This issue has widespread

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applications, not only in computer vision but also in daily life. One of the major challenges in computer vision is handling images degraded by haze and smoke. These degrade scene visibility and clarity, hindering the performance of vision-based systems such as surveillance, autonomous driving, and remote sensing.

The primary aim of image de-hazing algorithms is to restore clear images from hazy or smoky inputs. These algorithms leverage deep learning, statistical modeling, and optimization techniques to improve the quality of images and their usability in various applications. The research objective is to present an approach that will increase the visibility of a hazed atmospheric/underwater image through appropriate image enhancement and image restoration techniques and Algorithms.

To evaluate the de-hazed image, various performance evaluation methods, such as qualitative evaluation and quantitative evaluation, are used. Qualitative Evaluation is based on naturalness, color, and visibility of the de-hazed image. Quantitative evaluation is based on PSNR, MSE, SSIM, entropy, *etc.*

Image de-hazing is a crucial image processing technique aimed at enhancing the quality of images that have been degraded by haze or fog. Haze, often caused by atmospheric conditions or underwater environments, reduces visibility and clarity in images. The primary objective of de-hazing is to restore the original visibility by removing the haze effect, thus improving the overall quality of the image. There are two major models based on the environment: the Atmospheric Model, which addresses haze and fog in outdoor environments, and the Underwater Model, which focuses on haze caused by water bodies. De-hazing is important for several reasons. Firstly, it significantly increases visibility, especially in environments where fog or haze is prevalent, thereby enhancing the performance of applications that rely on clear and sharp images, such as remote sensing, surveillance, and autonomous driving. Additionally, de-hazing improves human visual perception by making images clearer, more accessible, and easier to interpret, which is critical for tasks involving image analysis and decision-making. Through de-hazing, both machine-based systems and human users benefit from better image quality and improved interpretability.

Dehazing is an essential image processing technique that improves image quality, particularly for images captured by visible-light cameras. Environmental factors such as humidity, temperature, and pressure can degrade image clarity, but de-hazing addresses these issues, resulting in sharper, clearer images. One of the primary objectives of de-hazing models is to remove haze and smoke, which often obscure important details in images. This process not only makes the images visually more pleasing but also enhances the effectiveness of vision-related tasks. Clear, haze-free images are crucial for accurate analysis and decision-making, particularly in fields such as surveillance, autonomous driving, and

remote sensing, where precise visual information is essential to successful outcomes. Fig. (1) provides an overview of the Image De-Hazing Atmospheric Model.

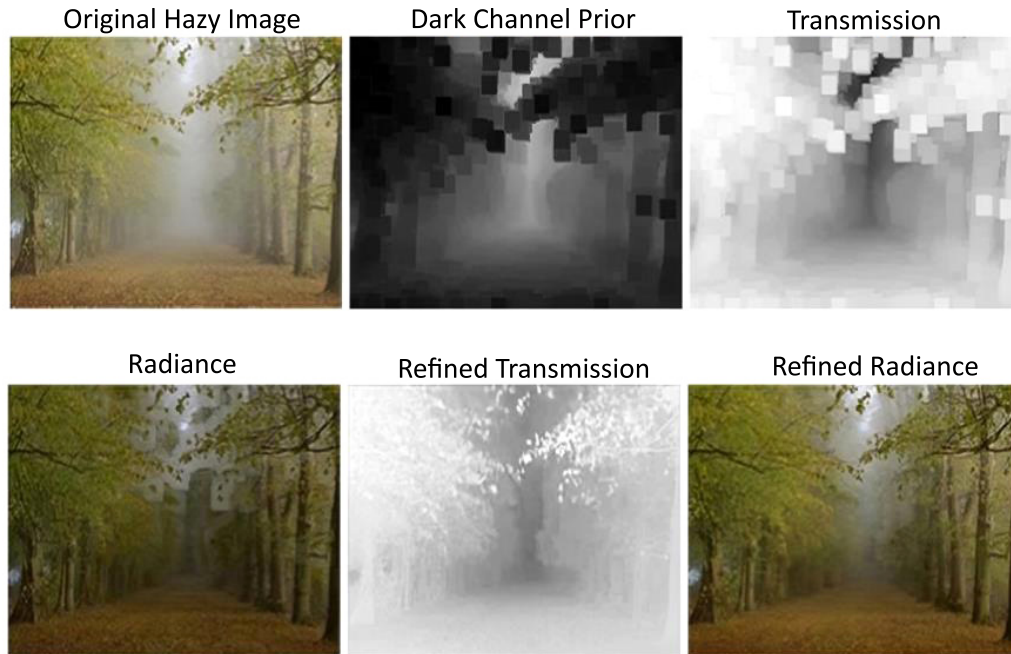


Fig. (1). Overview of image de-hazing atmospheric model.

HAZE IMAGING FORMATION MODEL

A widely used haze imaging formation model is present in the given Equation 1:

$$I(y) = J(y)t(y) + A(1 - t(y)) \quad (1)$$

Where:

$I(y)$ is the observed image, which is hazy.

$J(y)$ is the haze-free Image(the ideal image you want to recover)

A is the Atmospheric Light

$t(y)$ is the Transmission map, which represents the degree of visibility at each pixel,

Here, β is the coefficient of attenuation, and dy is the depth of the image at each pixel.

CHAPTER 14**Integration of Computer Vision Systems in Robotics and Assembly Lines****M. Babu^{1,*}, Dler Salih Hasan², Aneesh Kumar Mishra³, L. Karthick^{4,*}, T. Prabhu⁵ and Surrya Prakash DilliBabu⁶**¹ *Department of Mechanical Engineering, SRM Easwari Engineering College, Chennai, Tamil Nadu, India*² *Department of Computer Science and Information Technology, Salahaddin University - College of Science, Erbil, Iraq*³ *Department of Computer Science and Engineering, JECRC University, Jaipur, Rajasthan, India*⁴ *Department of Mechanical Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu, India*⁵ *Department of Mechatronics Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu, India*⁶ *Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India*

Abstract: The integration of Computer Vision Systems (CVS) into robotic platforms has revolutionized assembly line operations, delivering substantial improvements in efficiency, accuracy, and flexibility. As manufacturing industries continue to evolve toward intelligent and adaptive automation, the need for advanced systems capable of handling complex and dynamic production tasks has become increasingly critical. CVS empowers robots with the ability to perceive and interpret visual information in real time, enabling them to recognize, locate, and manipulate objects with high precision even in environments characterized by variability and unpredictability. This capability extends automation beyond rigid, repetitive tasks and enables adaptive responses, such as identifying part variations, detecting defects, and supporting collaborative interactions with human workers. However, integrating CVS into robotic assembly lines also presents notable challenges, including high computational demands, sensitivity to variable lighting conditions, object occlusions, and the need for reliable real-time data processing. Additional concerns include ensuring robustness, affordability, and scalability across diverse industrial contexts. Despite these obstacles, continuous advancements in deep learning, sensor technologies, and edge computing offer promising pathways to address existing limitations. These innovations pave the way for greater resilience and adaptability of CVS-enabled robots, ultimately

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expanding their potential applications in modern manufacturing. This presentation provides a comprehensive overview of the incorporation of CVS into robotic assembly lines, emphasizing its transformative relevance, the technical and practical challenges encountered, and the opportunities for future development. The discussion highlights how this integration contributes to the vision of smart factories, where intelligent automation enhances productivity, quality assurance, and sustainable manufacturing practices.

Keywords: Algorithms, Assembly line operations, Computer Vision Systems (CVS), Machine learning, Product design and positioning, Robots.

INTRODUCTION

Advanced cameras, algorithms for image processing, and approaches for machine learning are some of the key components that make up this integration [1]. The visual information that is captured by high-resolution cameras is then analysed by computer algorithms in order to extract important characteristics and make judgments based on that information [2]. The use of machine learning algorithms is of utmost importance in the process of teaching robots to detect objects, patterns, and anomalies [3], which in turn enables them to adapt to a wide variety of assembly line procedures. The integration of CVS into robots for assembly lines often results in an increase in both productivity and quality, which is one of the most significant advantages. It is possible for robots that are outfitted with vision systems to carry out activities with increased speed and precision, which ultimately results in increased throughput and decreased mistake rates. In addition, CVS makes it possible for robots to manage changes in product design and positioning, which increases the flexibility of operations on assembly lines [4].

Although there are several benefits associated with the use of CVS in robotics, there are also a number of hurdles involved. Among them is the need for robust algorithms that can handle a wide range of lighting conditions, occlusions, and object transformations [5]. Furthermore, there is still a significant issue regarding the safety of human operators working alongside vision-enabled robots [6, 7]. A look into the future reveals that the integration of CVS with robots for manufacturing lines has a tremendous amount of potential. It is anticipated that developments in camera technology, artificial intelligence, and robotics will provide additional enhancements to the capabilities of systems that are equipped with vision. Furthermore, integrating CVS with emerging technologies such as the Internet of Things (IoT) and augmented reality (AR) will enable human operators and robotic systems to communicate and collaborate seamlessly, as shown in Table 1.

Table 1. A table to summarize the integration of computer vision systems in robotics for assembly lines can help organize the key components, benefits, challenges, and future prospects. Here's a basic example.

Component	Description
<i>Robot</i>	An automated machine capable of carrying out tasks.
<i>Computer Vision System (CVS)</i>	A system that enables robots to perceive and interpret visual data.
<i>Machine Learning Algorithms</i>	Algorithms that train robots to recognize objects, patterns, and anomalies in visual data.
<i>Visual Data</i>	Information captured by cameras and processed by CVS.
<i>Assembly Line</i>	Manufacturing line where products are assembled.
<i>Benefits</i>	<ul style="list-style-type: none"> ● Improved productivity and quality. Greater speed and accuracy in tasks ● Enhanced flexibility in handling variations in product design and placement
<i>Challenges</i>	<ul style="list-style-type: none"> ● Handling diverse lighting conditions, occlusions, and object variations. ● Ensuring the safety of human operators working alongside robots.
<i>Future Prospect</i>	<ul style="list-style-type: none"> ● Advancements in camera technology, AI, and robotics. ● Integration with IoT and AR for seamless communication and collaboration.

ENHANCING PRODUCTIVITY AND QUALITY: INTEGRATING COMPUTER VISION SYSTEMS (CVS) IN ROBOTICS FOR ASSEMBLY LINES

The incorporation of computer vision systems (CVS) into robots that are used in assembly lines does, in fact, give a considerable benefit in terms of enhancing both productivity and quality, as shown in Fig. (1) [9 - 11]. The following is a more in-depth explanation of how these advantages are achieved *via* the integration:

- **Increased Productivity** Robots that are equipped with CVS are able to carry out duties in a more efficient and precise manner than their counterparts that do not have vision [12]. They have the ability to work more quickly, which decreases cycle times and increases throughput. As an additional benefit, they can perform tasks that would be difficult or even impossible for robots without vision, such as selecting components from a bin that are randomly oriented [13].
- **Enhanced Quality** The capacity of CVS-equipped robots to precisely detect and identify parts and components guarantees that assembly procedures are carried out in the right manner. Because of this, the possibility of mistakes and flaws in the completed goods is decreased, which ultimately results in outputs of a better quality [14].

CHAPTER 15

Smart Farming with Deep Learning: Enhancing Crop Management through Advanced Image Analysis

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Abstract: A type of advanced image processing and data technologies for analysis with promising outcomes is called deep learning, or DL. In addition to being used in many other industries, DL is also being used in agriculture. Because deep learning algorithms provide precise predictions and sophisticated image processing, they have completely changed several industries, particularly agriculture. This study provides a comprehensive overview of study results and publications on deep learning methods for agricultural image processing and prediction and their variations, emphasizing the uses of these networks in weed proof of identity, irrigation administration, disease identification, and crop yield prediction. This work focuses on specific agricultural issues, the model and architecture that were employed, the resources from which the data were gathered, the data preparation process, and the overall operation carried out in compliance with the methodology applied to each investigation project. Additionally, we examine numerous deep learning approaches used in other fields and also contrast them with current methodologies. When it comes to regression and classification performance, deep machine learning performs differently from more traditional methods. Our results show that deep machine learning yields results with excellent accuracy. Compared to conventional photographic processing techniques, these outcomes are far more accurate. In addition to classification tasks, deep learning can be used for yield manufacturing, detection, and disease division.

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Keywords: Convolutional neural networks, Crop production, Deep learning application in farming, Disease prediction, Remote sensing.

INTRODUCTION

India's food consumption is rising quickly, yet the nation's arable land and resource availability are constrained. As a result, it is imperative to address the requirement for agricultural output in a more clever and effective way [1, 2]. Crop yield has emerged as a major worry in the agricultural industry. Deep learning algorithms are being applied to agricultural applications for image processing and prediction, driven by the increased demand for environmentally friendly and efficient farming methods. India's food consumption is rising quickly, yet the nation's arable land and resource availability are constrained. As a result, it is imperative to handle the requirement for producing food in an increasingly clever and effective way [3].

Agriculture is the use of the natural environment to produce food, and it has been done for hundreds of thousands of years. In the majority of nations, it is regarded as the main source of employment [4]. But historically, farmers did not know much about crop yields, different kinds of soil, weather patterns, or how to utilize inputs correctly. This led to issues including poor irrigation, failed crops, and haphazard modifications to farming methods. Due to resource constraints and smaller parcels of land, these problems were easier to handle in the past. But as farms grew larger and were split into larger hectares, it quickly became clear that efficient management and the observation of agricultural data were required [5].

Failing to do so may lead to additional issues and higher manufacturing expenses. This is one area where the most recent digital technologies' enormous potential is useful. Agriculture is moving closer to industrialization thanks in large part to the benefits that these developments offer [6]. Well-informed farmers can practice crop choosing based on the condition of the soil, best irrigation practices, and general management of farms by utilizing the strength of data analytics. They can increase output, cut down on resource waste, and lessen their influence on the natural world as a result. Artificial intelligence also provides farmers with up-to-date data on the weather, enabling them to modify their plans as necessary. Additionally, it enables them to remotely monitor crop development and health, quickly detecting and addressing problems such as pests or illnesses [7, 8]. All things considered, artificial intelligence is a paradigm change for the farming sector. It makes it possible to use data, technology, and knowledge to maximize agricultural output on a larger scale. Agriculture can keep developing, satisfy the needs of an expanding population, and help ensure an adequate supply of food in the decades to come by accepting these digital breakthroughs [9]. Out of 755

papers published in various journals, the major focus was on Disease Detection (449 papers), 231 papers on Yield Prediction, 41 papers on Weed Detection Techniques, 24 papers on Crop Rotation Techniques, and 10 papers on Species or Plant type Detection. Through this, we can learn that the major focus is on disease detection, which is very important as this will increase the volume of crop production effectively via utilizing the least amount of resources.

LEARNING MODELS

Warren McCulloch and Walter Pitts established DL in 1943. Many DL models have now been produced. Knowledge about the models produced throughout 2017 and 2021 is compiled here. During that particular period, researchers produced a large number of models. We'll review the most popular models. CapsuleNet, IRCNN, RefineNet, and Mask-RCNN are among the models that the authors published in 2017 [11]. The DL model is still being developed. DeepLab and DCRN are some of them. Google AI created EfficientNet, which is again a well-defined model.

This concept has since piqued the curiosity of other scholars. A United Model constructed around the CNN was planned in 2020 [12]. Later, ConvXGB—which depends on CNN and XGBoost proposed by Chen *et al.* —was also released. The aforementioned paperwork is summarized in Figs. (1, and 2) give a broader overview of the advancement of various DL models from 2017 to 2021.

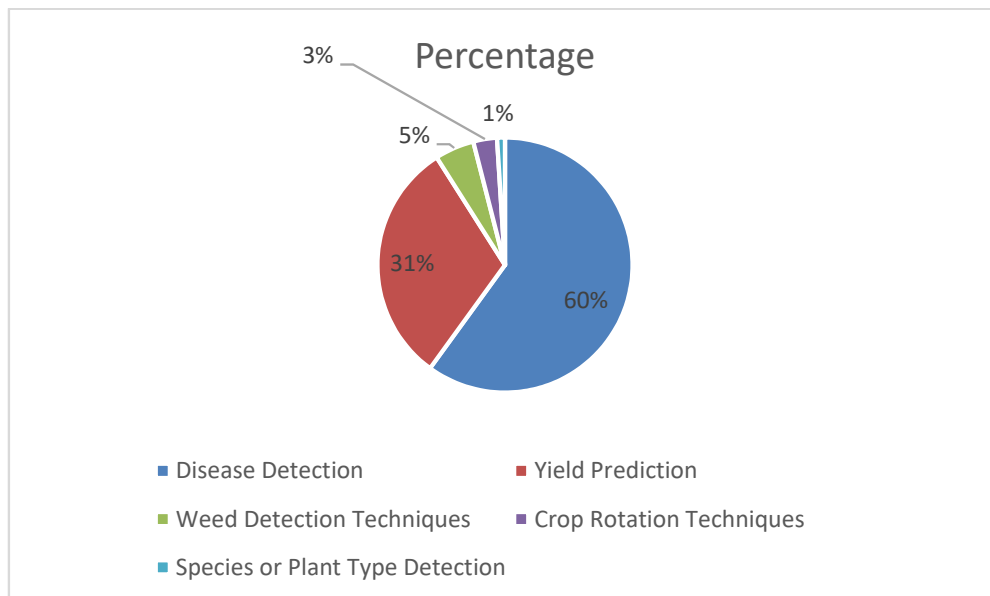


Fig. (1). A pie chart shows how the articles are distributed based on the preference [10].

SUBJECT INDEX

A

Academic research paths, new 61
 Accelerators 266
 Accident detection 142
 real-time 148
 Accuracy rate 33, 36, 261, 298, 299, 300
 Accuracy-speed balance 265
 ACS (assembly constituencies) 79, 80, 82, 83
 Activation function 15, 40, 236
 convolutional layer 40
 non-linear 71
 Activation layers 15
 Adaboost classifiers 35
 Adaptability cvs 275
 Adaptability robots 273
 Adaptive performance 264
 Adaptive transmissio 13
 Adaptive weighted undersampling method 39
 Adversarial training 153, 255
 AGLCM classifier 35
 Agricultural area 199, 292, 293, 308
 Agricultural crop evaluation model 304
 Agricultural IOT 204
 Agricultural monitoring tools 169
 Agro-economics 306
 AI-based weed identification 183, 185
 AI-driven remote diagnostics 102
 AI-powered rpm systems 90
 AI4bharat initiative 60
 Air light estimation 255
 Alexnet 32, 38, 42, 43, 189, 190, 289, 296,
 298, 299, 300, 303, 308
 Algorithm complexity 278, 280
 Ancient indian scripts 48
 ANNS (artificial neural networks) 35, 71, 128,
 129, 131, 132, 133, 146, 148, 149
 Anomaly detection 105
 AOD-Net 276, 278, 280
 Api integration 99
 AR (augmented reality) 162, 163, 270, 271,
 275, 276, 277

ASM (atmospheric scattering model) 2
 Atmospheric light intensity 12
 Attention mechanisms 9, 124, 132, 193, 195,
 254, 256
 AUC evaluation indexes 38
 Autoencoders 52, 132, 136, 153
 Automated irrigation systems 172
 Autonomous driving 128, 129, 133, 134, 135,
 144, 146, 147, 148, 154, 157, 250
 Average path length similarity 228

B

Bacterial leaf blight 299
 Batch normalisation 32, 33
 Bayesian inference 301
 Bbi model 295
 Bi-directional lstm 73
 Bilateral filtering method 255
 BILSTM (bi-directional long short-term
 memory) 66, 68, 81
 Binarization 53, 54, 115, 116, 117, 118
 Blockchain architecture 99
 Blockchain-based health platforms 101
 Brahmi script 48, 49, 50, 51
 Breast cancer detection 26, 37

C

Capsule networks 124, 135, 136
 CDM (common data model) 99
 CGAN (conditional generative adversarial
 network) 15, 21, 33, 38
 CLAHE (contrast limited adaptive histogram
 equalization) 35
 Class imbalance problem 37
 Cloud burst 225, 241, 242
 Clustering algorithms 52, 54
 CNN (convolutional neural networks) 55, 225,
 235, 240, 241, 242, 253, 254, 255
 Defogging network 255
 Feature extraction 244

Fruit recognition 306
 Contrastive learning 13
 ConvXGB 287
 CRF (conditional random fields) 69, 70, 71
 Crop health score 172
 Crop yield prediction 169, 219, 294
 Cross-covariance image transformer 155
 CVT (convolutional vision transformer) 154
 CycleGan 12, 239

D

Dark channel prior (DCP) 2, 6, 15, 16, 18, 19, 20, 21, 249, 252, 253, 255, 256, 261, 264
 Data augmentation 38, 43, 58
 DBN (deep belief network) 34, 35
 DCNN (deep convolutional neural network) 114, 187, 188, 289, 290, 298, 300, 303, 304, 306
 DeepEvap model 308
 Deep residual haze network 11
 De-hazenet 261, 263
 DEMS (digital elevation models) 234
 DenseNet 32, 36, 37, 189, 190, 194, 296
 Depth estimation 146, 249, 256, 264
 Devanagari script 50
 Dht11 temperature sensor 207, 208
 Dimensionality reduction 52, 54, 55, 116, 117, 132
 Disaster management strategies 232
 DNN (deep neural network) 11, 26, 71, 111, 123, 288, 295, 304, 305, 308
 Domain adaptation 162, 163, 294
 Dropout regularization 32, 240
 Drqn 294

E

Early warning systems (EWS) 102, 228, 231
 Earthquake disaster assessment (EDA) 232
 ECI Manuals 81
 Efficientnet 153
 EHRS (electronic health record) 92, 97, 98, 99, 100, 101, 103, 106
 ELMO (embeddings from language models) 66, 68, 73
 ELU (exponential linear unit) 114
 Entity recognition 69
 Extreme gradient boosting (XGBoost) 35

F

F-score / f1-score 38, 85, 229
 Fast/faster R-CNN 290
 FD-GAN 15, 16, 18, 19, 20, 21
 FDSI (flood detection in satellite images) 229
 Feature extraction (FE) 33, 35, 36, 47, 49, 52, 53, 54, 111, 112, 115, 117, 119, 124, 153
 Feature fusion attention network (FFA-Net) 12
 Federated learning 114
 FHIR resources 99
 FNN (feedforward neural networks) 132, 135
 Food production 183, 190, 194, 195, 294
 stable 195
 sustainable 190
 Fully convolutional networks (FCNS) 146, 157

G

GANS (generative adversarial network) 14, 15, 32, 38, 39, 43, 128, 132, 146, 153, 155, 239, 255, 256
 Gaussian function 34
 Gazetteer features 68, 73, 80, 81, 84, 85
 GDPR 99, 102, 105
 Generalization error 38, 43, 124
 reduced 38
 Geopolitical entities 66, 68, 72, 77, 78, 85
 classifying 72, 85
 extracting 66, 72
 identified 77
 tagging 78
 Geospatial imagery 228, 229
 Googlenet 38, 189, 290, 298, 300
 GPS-guided tractors 192
 Gray scaling 115, 116, 117, 118
 Griddehazenet 261
 GSM technology 201

H

Handwritten character recognition (HCR) 38, 110, 111, 112, 113, 114, 115, 117, 124
 Haralick texture features 35
 Haze imaging formation model 251
 HIPAA 99, 100, 102, 105
 Histogram of oriented gradients (hog) 54, 113
 H17 standards 98

Human-robot interaction 281
Hyper-parameter tuning 240
Hyperledger fabric 99

I

IFC (information fidelity criterion) 260
Image quality assessment (IQA) 260, 261
Image segmentation 146, 154, 155, 157, 164, 238
Imagenet 156, 157, 289, 290
Inception-v3 39, 298, 303
Intelligent image processing (iip) 128, 131, 133, 137, 139, 140, 141, 144, 145, 146
Internet of vehicles (IOV) 130
Intersection over union (IOU) 228, 229, 230

K

K-NN (k-nearest neighbors) 35, 36, 112, 113, 136, 178, 241
Kharosthi script 50
Knowledge graphs 59, 79

L

Land cover mapping 293
LDA (linear discriminant analysis) 116, 117, 119
Lenet5 291
Local response normalization (LRN) 32
LSTM (long short-term memory) 50, 123, 128, 132, 136, 147, 148, 291, 293, 295, 296

M

Mango-YOLO 296
MAPE (mean absolute percentage error) 295
Mask-RCNN 287
Max-pooling layers (MPL) 32, 42
Mias datasets 34, 35, 36
Micro-calcifications 35
Mnist dataset 110, 117, 118
MobileNetV2 39, 189, 190
MSBDN 15, 16, 19, 20, 21
MSE (mean squared error) 11, 16, 250, 260, 263, 308
Multi-scale deep neural network 11

N

Named entity recognition (ner) 56, 57, 66, 67, 68, 69, 70, 71, 72, 83, 84, 85
NASNetLarge 39
Natural language processing (nlp) 47, 48, 49, 52, 54, 57, 59, 60, 61, 66, 73, 114, 129, 132, 154
NODE MCU ESP8266 199, 207
Nyu Depth V2 11, 12

O

OCR (optical character recognition) 53, 56, 57, 61, 62, 110, 114, 115
OMOP 99

P

Palaeography 47, 51, 59
PCA (principal component analysis) 34, 52, 155
PIR sensor 199, 207, 208
Plantvillage dataset 302
Precision agriculture 168, 182, 193, 304, 306
PSNR (peak signal-to-noise ratio) 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 260, 261, 263, 264

R

R-FCN 290, 306
Radial basis function (RBF) 119
Random forest (RF) 35, 36, 37, 167, 168, 174, 177, 178, 187, 219, 234, 236, 237, 241, 242
Rapid damage assessment (RDA) 228, 230, 231
RELU activation 15, 32, 43, 119
Reside dataset 10, 17, 261
RMSE 295
RNN (recurrent neural networks) 50, 52, 54, 55, 57, 62, 71, 128, 132, 134, 136, 148, 288, 289, 302
RPM (remote patient monitoring) 90, 91, 94, 95, 96, 98, 99, 100, 101, 103, 106, 107
RSU (roadside units) 130, 138

S

SAR (synthetic aperture radar) 232, 233
Scale-invariant feature transform (sift) 35, 54, 113
Semantic segmentation 143, 157, 229
Sentinel-2A 234, 235
Smart contracts 99, 101, 105
Softmax function 71, 114
Spectral resolution 227
SSIM (structural similarity index) 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 260, 261
Support vector machines (SVM) 35, 36, 54, 69, 110, 113, 119, 123, 124, 167, 178, 187, 203, 237, 238
Swin transformer 154

T

Telemedicine platforms 102
TensorFlow 15, 301
Tokenization 52, 53, 56, 106
Transfer learning (TL) 34, 36, 38, 52, 54, 55, 155, 187, 188, 240, 245, 246, 300, 301, 303
Transmission map 6, 7, 8, 9, 10, 12, 251, 256, 258

U

U-net 7, 9, 146, 157, 238, 239, 241
UAVS (unmanned aerial vehicles) 219, 229, 294, 305
Undersampling 27, 30, 38, 39

V

Variable rate technology (vrt) 175
VGG (visual geometry group) 32, 43, 153, 290, 300, 303
Vision transformer (VIT) 37, 39, 153, 154, 155, 160

W

WBCD (wisconsin breast cancer diagnostic) 37
Weed detection systems 186, 305

X

XceptionNet 190, 193, 194
XCIT 155

Y

YOLO 128, 134, 135, 136, 141, 145, 148, 240



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