RESEARCH TRENDS IN ARTIFICIAL INTELLIGENCE: INTERNET OF THINGS

Editors:

Sonali Mahendra Kothari Vijayshri Nitin Khedkar Ujwala Kshirsagar Gitanjali Rahul Shinde

Bentham Books

Research Trends in Artificial Intelligence: Internet of Things

Edited by

Sonali Mahendra Kothari

Department of Computer Science and Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115, India

Vijayshri Nitin Khedkar

Department of Computer Science and Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115, India

Ujwala Kshirsagar

Department of Electronics and Telecommunication Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115 India

&

Gitanjali Rahul Shinde

Department of Computer Science & Engineering (Artificial Intelligence & Machine Learning) Vishwakarma Institute of Information Technology Kondhwa (Budruk) Pune – 411048 Maharashtra, India

Research Trends in Artificial Intelligence: Internet of Things

Editors: Sonali Mahendra Kothari, Vijayshri Nitin Khedkar, Ujwala Kshirsagar and Gitanjali Rahul Shinde

ISBN (Online): 978-981-5136-44-9

ISBN (Print): 978-981-5136-45-6

ISBN (Paperback): 978-981-5136-46-3

© 2023, Bentham Books imprint.

Published by Bentham Science Publishers Pte. Ltd. Singapore. All Rights Reserved.

First published in 2023.

BENTHAM SCIENCE PUBLISHERS LTD.

End User License Agreement (for non-institutional, personal use)

This is an agreement between you and Bentham Science Publishers Ltd. Please read this License Agreement carefully before using the book/echapter/ejournal (**"Work"**). Your use of the Work constitutes your agreement to the terms and conditions set forth in this License Agreement. If you do not agree to these terms and conditions then you should not use the Work.

Bentham Science Publishers agrees to grant you a non-exclusive, non-transferable limited license to use the Work subject to and in accordance with the following terms and conditions. This License Agreement is for non-library, personal use only. For a library / institutional / multi user license in respect of the Work, please contact: permission@benthamscience.net.

Usage Rules:

- 1. All rights reserved: The Work is the subject of copyright and Bentham Science Publishers either owns the Work (and the copyright in it) or is licensed to distribute the Work. You shall not copy, reproduce, modify, remove, delete, augment, add to, publish, transmit, sell, resell, create derivative works from, or in any way exploit the Work or make the Work available for others to do any of the same, in any form or by any means, in whole or in part, in each case without the prior written permission of Bentham Science Publishers, unless stated otherwise in this License Agreement.
- 2. You may download a copy of the Work on one occasion to one personal computer (including tablet, laptop, desktop, or other such devices). You may make one back-up copy of the Work to avoid losing it.
- 3. The unauthorised use or distribution of copyrighted or other proprietary content is illegal and could subject you to liability for substantial money damages. You will be liable for any damage resulting from your misuse of the Work or any violation of this License Agreement, including any infringement by you of copyrights or proprietary rights.

Disclaimer:

Bentham Science Publishers does not guarantee that the information in the Work is error-free, or warrant that it will meet your requirements or that access to the Work will be uninterrupted or error-free. The Work is provided "as is" without warranty of any kind, either express or implied or statutory, including, without limitation, implied warranties of merchantability and fitness for a particular purpose. The entire risk as to the results and performance of the Work is assumed by you. No responsibility is assumed by Bentham Science Publishers, its staff, editors and/or authors for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products instruction, advertisements or ideas contained in the Work.

Limitation of Liability:

In no event will Bentham Science Publishers, its staff, editors and/or authors, be liable for any damages, including, without limitation, special, incidental and/or consequential damages and/or damages for lost data and/or profits arising out of (whether directly or indirectly) the use or inability to use the Work. The entire liability of Bentham Science Publishers shall be limited to the amount actually paid by you for the Work.

General:

2. Your rights under this License Agreement will automatically terminate without notice and without the

^{1.} Any dispute or claim arising out of or in connection with this License Agreement or the Work (including non-contractual disputes or claims) will be governed by and construed in accordance with the laws of Singapore. Each party agrees that the courts of the state of Singapore shall have exclusive jurisdiction to settle any dispute or claim arising out of or in connection with this License Agreement or the Work (including non-contractual disputes or claims).

need for a court order if at any point you breach any terms of this License Agreement. In no event will any delay or failure by Bentham Science Publishers in enforcing your compliance with this License Agreement constitute a waiver of any of its rights.

3. You acknowledge that you have read this License Agreement, and agree to be bound by its terms and conditions. To the extent that any other terms and conditions presented on any website of Bentham Science Publishers conflict with, or are inconsistent with, the terms and conditions set out in this License Agreement, you acknowledge that the terms and conditions set out in this License Agreement shall prevail.

Bentham Science Publishers Pte. Ltd. 80 Robinson Road #02-00 Singapore 068898 Singapore Email: subscriptions@benthamscience.net



CONTENTS

PREWORD	i
EFACE	ii
ST OF CONTRIBUTORS	ii
HAPTER 1 IOT AND AI-BASED SMART FARM: OPTIMIZING CROP YIELD AND	
STAINABILITY	1
Namrata Nishant Wasatkar, Pranali Gajanan Chavhan and Vikas Kanifnath Kolekar	
INTRODUCTION	1
CHALLENGES AND ISSUES	3
PROCESS OF SMART FARMING	3
Predictive Analytics	4
Precision Farming	5
Autonomous Equipment	5
Image Processing	5
Blockchain Technology	5
Decision Support Systems	5
AUTONOMOUS EQUIPMENT FOR SMART FARMING	
Autonomous Tractors	6
Drones	6
Robotic Harvesters	6
Autonomous Seeders	6
Autonomous Weeders	7
SENSORS IN SMART FARMS	7
Soil Sensors	
Weather Sensors	
Plant Sensors	9
Nutrient Sensors	1
GPS Sensors	1
BENEFITS OF SMART FARMING	1
Improved Efficiency	1
Increased Yields	1
Reduced Environmental Impact	1
Improved Quality and Safety	1
Increased Profitability	1
THE IMPACT OF CLIMATE ON SMART FARMING	1
CASE STUDY OF SMART FARMING USING IOT	1
HOW TO USE AI FOR OPTIMIZING AND PREDICTING YIELD	1
Data Collection and Analysis	1
Predictive Modeling	1
Machine Learning	1
Crop Monitoring	1
Precision Agriculture	1
Automated Irrigation Systems	1
Crop Monitoring	1
Livestock Monitoring	1
Automated Machinery	1
CASE STUDY -AUTOMATED IRRIGATION SYSTEMS	1
Water Conservation	1
Increased Crop Yield	1

F	Reduced Labor Costs
l	Improved Accuracy
ł	Flexibility
CONC	
REFE	RENCES
CHAPTER LEARNING	2 IMPACT OF AUTOMATION, ARTIFICIAL INTELLIGENCE AND DEEP G ON AGRICULTURE CROP YIELD
Prabha	akar Laxmanrao Ramteke
INTRO	ODUCTION
AI TE	CHNIQUES FOR PROBLEM SOLVING IN AGRICULTURE SECTOR
I	Fuzzy Logic
I	Artificial Neural Networks
1	Neuro- Fuzzy Logic
I	Expert System
OBST	ACLES IN THE FIELD OF AGRICULTURE AND IN AI ADAPTATION
(Consumer Inclinations
Ι	Lack of Labour
I	Environmental Accountability
7	Tiny and Dispersed Landholdings
S	Seeds
I	Land Mechanization
F	Farm Automation or Smart Farming
REQU	JIREMENT OF ARTIFICIAL INTELLIGENCE IN THE AGRICULTURE SEC
1	Numerous Applications of AI & other Technologies that can Boost Agriculture Yield
Ι	Development Driven by the IoT
Ι	Ingenious Agriculture
I	Advantages of Intelligent Farming
AGRI	CULTURE APPLICATIONS AND USE CASES
(Climate Conditions Monitoring
(Greenhouse Automation
(Cattle Management and Monitoring
I	Precision Agriculture
5	Smart Farming Predictive Analytics
A SMA	ART FARMING SOLUTION
Ι	IoT Hardware
(Connectivity
Ι	Data Gathering Intervals
3	The Farming Sector's Data Integrity
Ι	Disease Detection
AUTO ABILI	OMATION TECHNIQUES FOR IRRIGATION AND RE-ASSISTING FARMEF
Ţ	Using Drones and Robots to Automate Agriculture
	Robots and Autonomous Machines
	Robotic Weeding and Seeding
	Automatic Irrigation
	Automation of Harvest
AGRI	CULTURE AUTOMATION BENEFITS
Ţ	The Agricultural Sector Satisfies Consumer Demand
۔ ۲	The Industry's Labour Deficit is Becoming Better
	,

MODERN AI-BASED PREDICTION MODE	L APPLICATIONS IN AGRICULTURE
RELATING TO SOIL, CROP, DISEASES, AN	ND PEST MANAGEMENT 34
Soil Administration	
Crop and Yield Management	
Plant Disease Control	
Weed Management	
Pest Management	
Monitoring and Storage Control Manageme	ent for Agricultural Products
Manage Yield Prediction	
SOLUTIONS FOR MONITORING SMART H	FARMING
Monitoring the State of Soil	
Agriculture Weather Monitoring	
Systems for Automating Greenhouses	
System for Monitoring Crops	
CONCLUDING REMARKS	
ACKNOWLEDGEMENTS	
REFERENCES	
CHAPTER 3 AIOT. DOI E OF ALIN IOT ADDI I	CATIONS AND FUTURE TRENDS 42
Rooma Thabur Prashant Pansa Parul Rhanarkar	and Pradmya Borkar
INTRODUCTION	and Fraanya Borkar
VOICE ASSISTANTS	
POROTS	44
SMADT DEVICES	44
SWART DEVICES	
ADDI ICATIONS	
Impact of A IoT on Society	40
CONCLUSION	51
DEFEDENCES	51
CHAPTER 4 THE ROLE OF MACHINE INTELL	IGENCE IN AGRICULTURE: A CASE
STUDY	
Prabhakar Laxmanrao Ramteke and Ujwala Kshi	rsagar
INTRODUCTION	
Understanding Essential Agriculture Stages	55
Agriculture's Stages	
CASE STUDIES	
An IOT-based System for Crop Irrigation .	
Applications of Machine Learning Al	gorithms in High Precision Agriculture 57
Soil Characteristics and Weather For	recasting 59
MODELLING SOIL WATER BALANCE	
DESIGN AND IMPLEMENTATION OF A SH	ENSOR NETWORK-BASED SMART NODE 61
Smart-node Hardware	
Acquisition Programme, Connectivity Arch	itecture and Software 62
IN IRRIGATION MANAGEMENT DECISIO	N SUPPORT SYSTEM: ANALYSIS AND
APPLICATION	
MACHINE LEARNING RECOMMENDED I	RRIGATION METHODS 63
Cotton Centre Pivot Irrigation is Efficiently	Scheduled and Controlled by a Mechanism
based on Canopy Temperature	
Intelligent Irrigation Monitoring with Therr	nal Imaging in Smart Agriculture with the
Internet of Things	

FREDUCTION MODEL FOR RICE PLANT DISEASE DETECTION THAT IS OPTIMAL Multi-Rotor Drone Fixed-Wing Drone Single-Rotor Helicopter Drone FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forceasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector	IRRIGATION SENSOR COUPLED TO AUTOMATIC WATERING SYSTEM	6
CLASSIFICATION MODEL FOR RECEIPANT DISEASE DETECTION THAT IS OPTIMAL Multi-Rotor Drone Fixed-Wing Drone Single-Rotor Helicopter Drone FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determine the Crop's Readiness Field Administration Determing the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA - LASSO TECINIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handing Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS Releiff Boruta Loren	CLASSIEICATION MODEL EOD DICE DI ANT DISEASE DETECTION THAT IS	0
Multi-Rotor Drone Fixed-Wing Drone Single-Rotor Helicopter Drone FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Intermet of Things (1oT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview </th <th>CLASSIFICATION MODEL FOR RICE PLANT DISEASE DETECTION THAT IS OPTIMAL</th> <th>6</th>	CLASSIFICATION MODEL FOR RICE PLANT DISEASE DETECTION THAT IS OPTIMAL	6
Fixed-Wing Drone Single-Rotor Helicopter Drone FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING	Multi-Rotor Drone	0
Single-Rotor Helicopter Drone FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL	Fixed Wing Drone	0
FARMING USING ARTIFICIAL INTELLIGENCE THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using al that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING <td>Single Datar Heliconter Drone</td> <td> 0</td>	Single Datar Heliconter Drone	0
THE USE OF THE INTERNET OF THINGS AND CLOUD COMPUTING TO CREATE A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lence	Single-Rotor Hencopter Dione	0
A CUSTOM AGRICULTURAL DRONE Autonomous Quadcopter On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming Precision Farming ApticATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES PATISET USED Handling Class Imbalance IVijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe <td>THE USE OF THE INTERNET OF THINGS AND CLOUD COMPLETING TO CDEA</td> <td> 0 TE</td>	THE USE OF THE INTERNET OF THINGS AND CLOUD COMPLETING TO CDEA	0 TE
A CONTONING OF LOARD DIVERSING ALCONTROLOGY OF A CONTONING OF LOARD DIVERSING SUSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lerge	A CUSTOM ACRICIII TURAL DRONF	11L 6
Automotol Quadopticity On-Ground Sensor Nodes Image Processing Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA-LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Ma	Autonomous Quadconter	0
Image Processing	On-Ground Sensor Nodes	C
Cloud Analytics and Data Storage Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Legen	Image Processing	······ 7
Frontend INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA-LASSO TECHNIQUES Vigayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta L acc	Cloud Analytics and Data Storage	
INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta L areo	Frontend	
 Use of Weather Forecasting Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES 	INTERACTIVE CULTIVATION SENSING SYSTEM POWERED BY IOT	······ / 7
Using Drones to Assess Crop Health Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Loreo	Use of Weather Forecasting	······ 7
Predictive Analytics and Precision Agriculture A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Loreo	Using Drones to Assess Cron Health	
A System Using AI that can Identify Pests IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta L acoo	Predictive Analytics and Precision Agriculture	
IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP YIELD The Internet of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lacoo	A System Using AI that can Identify Pests	
The Interior of Things (IoT) Driven Development The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Loreo	IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURAL CROP VIELD	
The Development of Understanding via Images Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta L area	The Internet of Things (IoT) Driven Development	
Identifying Diseases Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	The Development of Understanding via Images	
Determine the Crop's Readiness Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Losso	Identifying Diseases	
Field Administration Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Largo	Determine the Cron's Readiness	
Determining the Best Combination of Agronomic Goods Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lagoo	Field Administration	
Crop Health Surveillance Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Logoo	Determining the Best Combination of Agronomic Goods	, 7
Irrigation Automation Methods that Help Farmers Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	Cron Health Surveillance	
Precision Farming Precision Farming APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	Irrigation Automation Methods that Help Farmers	
APPLICATIONS OF AI TO AGRICULTURE PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Laggo	Precision Farming	
PRODUCT RECOMMENDATIONS USING AI: CASE STUDY Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	APPLICATIONS OF AI TO AGRICULTURE	-
Solution Overview Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	PRODUCT RECOMMENDATIONS USING AI: CASE STUDY	
Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	Solution Overview	
CONCLUDING REMARKS ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology	,
ACKNOWLEDGEMENTS REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	CONCLUDING REMARKS	····· ,
REFERENCES APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	ACKNOWLEDGEMENTS	<i>,</i>
APTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES	REFERENCES	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
APTERS OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES USING RUTA- LASSO TECHNIQUES		
Vijayshri Nitin Khedkar, Sonali Mahendra Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta	IAPTER 5 OPTIMAL FEATURE SELECTION AND PREDICTION OF DIABETES UN DUTA - LASSO TECHNIQUES	JING
Vijayshri Nitin Kheakar, Sonali Mahenara Kothari, Sina Patel and Saurabh Sathe INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso		8
INTRODUCTION RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	Vijayshri Nitin Kheakar, Sonali Manenara Kothari, Sina Patel and Saurabh Sathe	5
RELATED WORKS DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	INTRODUCTION	7
DATASET USED Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	KELATED WORKS	8
Handling Class Imbalance RESEARCH APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	DATASET USED	8
Research APPROACH FEATURE SELECTION METHODS ReliefF Boruta Lasso	Handling Class Impalance	ð
ReliefF		8
Boruta	PEATUKE SELECTION METHODS	ð
Borua	Kener	č
	D01ula	ð
LASSU	Lassu	ð

Feature Selection Results	,
Evaluation Metrics 87	,
Cross-Validation 88	
Classification Method Results 89	,
Evaluation of Receiver Operating Characteristics (ROC))
DISCUSSION 91	
CONCLUSION 93	,
FUTURE SCOPE 93	,
REFERENCES 93	,
CHAPTER 6 EMPOWERED INTERNET OF THINGS FOR SUSTAINABLE	
DEVELOPMENT USING ARTIFICIAL INTELLIGENCE	'
Pranali Gajanan Chavhan, Namrata Nishant Wasatkar and Gitanjali Rahul Shinde	-
INTRODUCTION 96	1
Artificial Intelligence	
Significance of Artificial Intelligence	1
Benefits of AI 10	0
Improving Sustainability in AI 10	1
IOT AND ITS SIGNIFICANCE 10	2
ROLE OF AI IN IOT	2
SUSTAINABLE SECURITY FOR THE IOT USING AI 10	4
A General Pseudo-code for a Sustainable Security Solution for IoT using AI 10	4
Process	4
DDoS (Distributed Denial of Service) Attacks	6
Types of Attack	6
Methods of Attack	7
Source of Attack	7
ENERGY MANAGEMENT USING AI 10	7
THE IMPACT OF THE IOT ON SUSTAINABLE WATER MANAGEMENT 10	8
When and Where to Irrigate with the Right Amount of Water Using IoT 10	8
Smart Irrigation	9
Leak Detection	9
CLIMATE CONTROL SYSTEMS WITH AI 11	0
General Circulation Models (GCMs) 11	1
Earth System Models (ESMs) 11	2
AI-IOT USE CASES	3
Smart Home Automation	3
Intelligent Transportation Systems 11	4
Smart and Sustainable Transportation 11	4
Intelligent Traffic Management 11	4
Intelligent Transportation Systems (ITS) 11	5
Autonomous Vehicles	5
Predictive Maintenance 11	5
Ride-sharing and Carpooling 11	5
Smart Parking 11	5
Predictive Maintenance	6
Agricultural Monitoring 11	6
Healthcare Monitoring	6
Energy Management 11	7
FUTURE OF IOT IN SUPPORT OF SUSTAINABILITY 11	7
Smart Energy Management 11	7

Resource Conservation	117
Smart Transportation	
Sustainable Agriculture	
CONCLUSIONS	
FUTURE SCOPE	118
REFERENCES	118
CHAPTER 7 DICITAL TWIN AND ITS APPLICATIONS	120
Kiran Wani Nitin Khedekar Varad Vishwarupe and N Pushvanth	
INPODICTION	120
DICITAL TWINS	
AUCMENTED REALITY	
Hardware for Augmented Reality	127
VISUAL IZATION OF THE DIGITAL TWIN DATA	120
REAL-TIME MONITORING	120
DICITAL TWINS USAGE & APPLICATIONS	130
CONCLUSION	131
REFERENCES	133
CHAPTER 8 ONTOLOGY BASED INFORMATION RETRIEVAL BY USING	SEMANTIC
	135
Rupali R. Deshmukh and Anjali B. Raut	105
Historical Background	
Growth of Information Retrieval	
Ontology	
LITERATURE REVIEW	
ISSUES IN INFORMATION RETRIEVAL	
AIM	
PROPOSED RESEARCH METHODOLOGY	
REFERENCES	
CHAPTER 9 PARADIGM SHIFT OF ONLINE EDUCATION SYSTEM DUE	ГО COVID-19
PANDEMIC: A SENTIMENT ANALYSIS USING MACHINE LEARNING	150
Prajkta P. Chapke and Anjali B. Raut	
INTRODUCTION	
HISTORICAL BACKGROUND	
Social Network Analysis	152
Impact of Social Networks	152
Positive Impact	153
Negative Impact	153
Characteristics of Social Networks	153
User-based	
Interactive	
Community-driven	154
Relationships	
Emotion Over Content	155
Growth and Development in Sentiment Analysis	155
CONTRIBUTION IN THE AREA OF RESEARCH	156
Institution Involves in Area & Research	156

Trends in the Area of Development	157
Changing Prospective	157
Industrial Trends and International Trends	157
MOTIVATION	158
LITERATURE REVIEW	159
RESEARCH ISSUES	
GAP IN RESEARCH	
PROBLEM STATEMENT	
Aim and Objectives	
Aim	
Objectives	
IMPLICATIONS	
EXPECTED RESULT	
CONCLUSION	
REFERENCES	
CHAPTER 10 IMAGE PROCESSING FOR AUTONOMOUS VEHICLE BASED C LEARNING)N DEEP 167
Tanvi Raut, Ishan Sarode, Riddhi Mirajkar and Ruchi Doshi INTRODUCTION	167
Levels of Autonomous Driving	
Camera vs LiDAR: The Better Hardware for the Detection of Vehicles	
CHALLENGES FACED BY AUTONOMOUS VEHICLES	170
LITERATURE SURVEY	170
IMAGE RECOGNITION BASED ON DEEP LEARNING	172
Advantages of CNN Over Traditional Algorithms	174
SYSTEM ARCHITECTURE	174
Proposed Algorithm	175
Object Detection	
You Only Look Once (YOLO)	177
Lane Detection	179
CONCLUSION	
REFERENCES	
CHAPTER 11 APPLICATIONS OF ALAND IOT FOR SMART CITIES	186
A Kannammal and S Chandia	100
INTRODUCTION	187
Internet of Things	187
AI-Enabled IoT	188
POTENTIAL USE CASES OF ALAND IOT IN SMART CITIES	188
Smart Home	188
Smart Management of Equipment	189
Human Activity Recognition	189
Smart Healthcare	190
Role of AI Algorithms in Smart Healthcare	190
Fitness-Tracking System	
Glucose-Level Monitoring System	
Body-Temperature Monitoring System	
Stress Detection System	
Oxygen-Saturation Monitoring System	
Other Healthcare Applications	
Smart Transport	
*	

Connected-Vehicle Infrastructure Pedestrian (VIP)	
Smart Parking System (SPS)	
Automated Incident Detection System (AID)	
Smart Infrastructure	
Smart Grid and Energy	
Energy Consumption Forecasting	
Smart Grid Monitoring and Management	
Structural Health Monitoring	
Smart Water	
Leakage Detection and Isolation	
Efficient Distribution and Consumption	
Real Estate Investment	
CONCLUSION	
REFERENCES	
CHAPTER 12 ANALYSIS OF RGB DEPTH SENSORS ON FASHION DATASET FOR	
VIRTUAL TRIAL ROOM IMPLEMENTATION	
Sonali Mahendra Kothari. Vijavshri Nitin Khedkar. Rahul Jadhav and Madhumita	
Bawiskar	
INTRODUCTION	
Internet of Things (IoT)	
Components of IoT	
AUGMENTED REALITY (AR)	
VIRTUAL REALITY	
FASHION ANALYSIS AND RECOMMENDATION	
RGB-DEPTH SENSOR	
VIRTUAL TRIAL ROOM TECHNIQUES AND FASHION DATASETS	
12.6.1. Virtual Trial Room Techniques	
Fashion Datasets	
DISCUSSION AND FUTURE DIRECTIONS	
SUMMARY	
CHALLENGES IN SENSOR SELECTION AND TRIAL ROOM SETUP	
FUTURE DIRECTION	
CONCLUSION	
REFERENCES	
SUBJECT INDEX	

FOREWORD

Artificial Intelligence (AI) in healthcare and biomedical applications is taking good shape nowadays. The convergence of AI, the Internet of Things, Blockchain and healthcare aims at delivering features such as scalability, security and privacy to high-level intellectual functions that are beneficial to the new era of digital information. In recent times, AI has touched major milestones by overcoming the challenges faced in realizing the full potential of projects in various fields such as smart homes, agriculture, smart cities, healthcare and medical, *etc.* Due to these transformations, the data is increasing at a faster rate in terms of size, complexity, variety, and heterogeneity, and in the sequel, computational intelligence, and machine learning the key contributors to improve business intelligence.

The book outline and contents show that the major coverage of the book includes a brief introduction to the domain, research challenges, literature review and state-of-the-art, different algorithms/techniques / deployment methods, data acquisition techniques including types of sensors used in IoT and communication, preprocessing and data cleaning, if required, application development and design issues, mathematical modeling of the engineering problems for ai based solution, different resources like datasets, APIs, software tools and packages evaluated or proposed, results, discussion and performance measures and future research directions. This will help readers to get detailed insights into the application of computational intelligence in the healthcare domain.

In addition to this, the communication and computing systems encompass every stage of professional and personal life, including education, healthcare, re- identification, transportation and social security. Data Science is used to analyze data from wearable trackers to ensure their patients' well-being, assist in hospital administration by reducing the waiting time and enhance public care. Cloud Security helps in the ease of scaling, increased reliability and availability, disaster recovery, and managing remote work. These key enablers for the healthcare and biomedical domain and more focus on IoT, big data and cloud will help readers to empower their research and learning in these areas.

Buyers, who belong to the category of researchers, will benefit from the state-of-art and future research directions provided in the book. Practicing engineers will benefit from the knowledge of the current challenges in technology, deployment methods and solutions. Post-graduate students will be introduced to new domains, and recent advancements in them. They will also be made aware of the rapid growth in technology and obsolesce.

Parikshit N. Mahalle

Department of Artificial Intelligence and Data Science Bansilal Ramnath Agarwal Charitable Trust's Vishwakarma Institute of Information Technology Pune, India

PREFACE

Artificial intelligence (AI) has grown in popularity in today's world. It refers to the simulation of natural intelligence in machines that have been programmed to learn and emulate human actions. AI is being used by huge companies all over the world to make the lives of end-users easier. The smart sensors and actuators are two key components of the Internet of Things (IoT). The IoT enables seamless connection to devices irrespective of time and location and hence it is an important component of what is known as the Industrial Revolution 4.0. One of the most significant advantages of the IoT is the reduction of human errors and manual labor, as well as the increase in overall efficiency and cost-effectiveness, both in terms of time and cost. This book offers recent research work going on in different domains where AI and IoT can be used. This book is a one-stop-shop for real-time work to solve engineering problems in various domains. The first few chapters are focused on the importance and amalgamation of IoT and AI for smart farming. It gives details about the basics of AI and IoT, and different algorithms available in AI and IoT for solving problems in agriculture. Healthcare is an important domain where early prediction of disease can save valuable human lives. In view of this, the second section of the book includes chapters focusing on research in the health care domain.

In today's era where enormous data are generated every day, it is very important to analyze the data and find solutions to various problems, and predict future trends. The next section of the book is dedicated to such recent trends and research in different fields where IoT and AI can help in making better analyses, and predictions. In the real world, data comes for various use cases and there is a need for source-specific data science models. The book includes chapters highlighting research work done by various authors in multidisciplinary domains considering the needs of today and tomorrow.

Sonali Mahendra Kothari

Department of Computer Science and Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115, India

Vijayshri Nitin Khedkar

Department of Computer Science and Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115, India

Ujwala Kshirsagar

Department of Electronics and Telecommunication Engineering Symbiosis Institute of Technology Symbiosis International (Deemed University) Pune – 412115 India

&

Gitanjali Rahul Shinde

Department of Computer Science & Engineering (Artificial Intelligence & Machine Learning) Vishwakarma Institute of Information Technology Kondhwa (Budruk) Pune – 411048 Maharashtra, India

List of Contributors

A. Kannammal	Department of Computing (Decision and Computing Sciences), Coimbatore Institute of Technology, Coimbatore, Tamil Nadu-641014, India
Anjali B. Raut	Department of Computer Science & Engineering, H.V.P.M's, C.O. E.T., Amravati, Maharashtra, India
Gitanjali Rahul Shinde	Department of Computer Science & Engineering (Artificial Intelligence & Machine Learning), Vishwakarma Institute of Information Technology Kondhwa (Budruk), Pune – 411048, Maharashtra, India
Ishan Sarode	BTech-Information Technology, Vishwakarma Institute of Information Technology, Pune, India
Kiran Wani	Department of Mechanical Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India
Madhumita Bawiskar	Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India
N. Pushyanth	Department of Computer Science, University of Oxford, Oxford, United Kingdom
Namrata Nishant Wasatkar	Vishwakarma Institute of information and Technology, Pune, (Maharashtra State), India
Prabhakar Laxmanrao Ramteke	H.V.P. M's College of Engineering and Technology, Amravati (Maharashtra State) Affiliated to Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
Prashant Panse	Department of Information Technology, Medi-Caps University, Indore, India
Parul Bhanarkar	Department of Computer Science & Engineering, Jhulelal Institute of Technology, Nagpur, India
Pradnya Borkar	Department of Computer Science & Engineering, Symbiosis Institute of Technology, Nagpur, India
Pranali Gajanan Chavhan	Vishwakarma Institute of information and Technology, Pune, (Maharashtra State), India
Prajkta P. Chapke	Department of Computer Science & Engineering, H.V.P.M's, C.O. E.T., Amravati, India
Reena Thakur	Department of Computer Science & Engineering, Jhulelal Institute of Technology, Nagpur, India
Rupali R. Deshmukh	Department of Computer Science & Engineering, H.V.P. M's COET, Amravati, Maharashtra, India
Riddhi Mirajkar	Faculty, Vishwakarma Institute of Information Technology, Pune, India
Ruchi Doshi	University of Azteca, Chalco de Díaz Covarrubias, Mexico
Rahul Jadhav	Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India

S. Chandia	Department of Computing (Decision and Computing Sciences), Coimbatore Institute of Technology, Coimbatore, Tamil Nadu-641014, India
Saurabh Sathe	San Jose State University, California, USA
Sonali Mahendra Kothari	Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Pune – 412115, India
Sina Patel	Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India
Tanvi Raut	BTech-Information Technology, Vishwakarma Institute of Information Technology, Pune, India
Ujwala Kshirsagar	Department of Electronics and Telecommunication Engineering, Symbiosis Institute of Technology Symbiosis International (Deemed University), Pune – 412115, India
Vikas Kanifnath Kolekar	Vishwakarma Institute of information and Technology, Pune, Maharashtra State, India
Vijayshri Nitin Khedkar	Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Pune – 412115, India
Varad Vishwarupe	Department of Mechanical Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India

iv

1

IoT and AI-based Smart Farm: Optimizing Crop Yield and Sustainability

Namrata Nishant Wasatkar^{1,*}, Pranali Gajanan Chavhan¹ and Vikas Kanifnath Kolekar¹

¹ Vishwakarma Institute of information and Technology, Pune, Maharashtra State, India

Abstract: The "Smart Farm" project is an IoT-based agriculture project aimed at optimizing crop yield and promoting sustainability in farming practices. By integrating various IoT devices and sensors, the project aims to improve the efficiency of farming operations, reduce waste, and enhance the quality and quantity of crop yields. The project focuses on using IoT technology to monitor and control various aspects of farming, including soil moisture, temperature, humidity, crop health, and livestock behaviour. By leveraging data from these sensors and devices, farmers can make more informed decisions about irrigation, pest control, and crop management, leading to increased productivity and sustainability. Overall, the Smart Farm project seeks to transform traditional farming practices into a more efficient, data-driven, and sustainable model that benefits both farmers and the environment.

Keywords: Agricultural robotics, Agricultural applications, Computer vision, Crop and soil management, Machine intelligence, Satellite drone.

INTRODUCTION

Agriculture is a critical industry that plays a significant role in global food security, economic development, and environmental sustainability. However, traditional farming practices often rely on manual labor, intuition, and guesswork, which can lead to inefficiencies, waste, and environmental degradation. In recent years, there has been a growing interest in using Internet of Things (IoT) technology to improve the efficiency and sustainability of farming operations. The "SmartFarm" project is an IoT-based agriculture project that aims to optimize crop yield and promote sustainability by integrating various sensors and devices into farming practices. By collecting and analyzing data from these devices, farm-

^{*} Corresponding author Namrata Nishant Wasatkar: Vishwakarma Institute of information and Technology, Pune, Maharashtra State, India; E-mail: namrata.kharate@viit.ac.in

2 Research Trends in Artificial Intelligence: Internet of Things

Wasatkar et al.

ers can make more informed decisions about irrigation, pest control, and crop management, leading to increased productivity and sustainability. This project represents a significant shift towards data-driven, efficient, and sustainable farming practices that benefit both farmers and the environment. In this paper, we will explore the various components of the SmartFarm project, including the sensors and devices used, the data analysis techniques employed, and the expected outcomes and benefits of the project.

Agriculture involves five steps are as follows:

- Preparing the soil.
- Planting.
- Spraying applications, fertilizer or chemicals.
- Harvesting.
- Managing: Determining what you did well and what you'll do next year by collecting data for all of these steps.

Smart farming, also known as precision agriculture or digital farming, is an advanced agricultural system that uses technology to optimize crop production and maximize yields while reducing waste, energy consumption, and environmental impact. It involves the use of various technologies, such as sensors, drones, machine learning, and data analytics, to monitor and control every aspect of the farming process [1].

The main goal of smart farming is to increase the efficiency and productivity of agriculture by making data-driven decisions based on real-time information [2]. For example, farmers can use sensors to measure soil moisture, temperature, and nutrient levels to determine the optimal time to plant, irrigate, or apply fertilizers. Drones equipped with cameras and sensors can help farmers monitor crop growth, detect pests and diseases, and identify areas that need attention.

Smart farming also involves the use of precision machinery and robotics, such as automated tractors and harvesters, to reduce labor costs and improve accuracy. In addition, data analytics and machine learning algorithms can help farmers analyze large amounts of data to identify patterns and optimize farming practices for better yields.

Overall, smart farming is a promising approach to modern agriculture, as it has the potential to increase yields, reduce costs, and minimize environmental impact.

CHALLENGES AND ISSUES

Farming faces several challenges and issues that can impact crop yield, profitability, and sustainability [2]. Here are some of the most significant issues in farming:

- Climate Change: Climate change is causing extreme weather events, such as droughts, floods, and heat waves, which can impact crop yields and soil health.
- Water Management: Access to water and efficient water management is critical for farming, especially in arid and semi-arid regions. Water scarcity and inefficient irrigation methods can lead to crop failure and reduced yields.
- Soil Health: Soil health is essential for crop growth, but soil degradation from erosion, overuse, and chemical use can lead to reduced yields and nutrient-poor crops.
- Pests and Diseases: Crop pests and diseases can devastate crops, reducing yield and quality, and increasing the need for pesticides and herbicides.
- Labor Shortage: Farm labor shortages can lead to increased costs and reduced efficiency, especially during peak seasons.
- Access to Markets: Farmers may face challenges in accessing markets to sell their products, especially small-scale and subsistence farmers.
- Food Security: Despite advancements in farming practices, many regions still face food insecurity due to poverty, conflict, and lack of access to resources.
- Sustainable Farming: Ensuring that farming practices are sustainable and do not harm the environment is becoming increasingly important to consumers and policymakers.

Addressing these issues will require a combination of technological advancements, policy changes, and changes in farming practices to ensure that farming remains a sustainable and profitable industry.

PROCESS OF SMART FARMING

The "SmartFarm" project involves several processes that are aimed at optimizing crop yield and sustainability through the use of IoT technology [3]. Agriculture, which provides a country with the necessary fuel, food, fibre, and feed, is its foundation. Due to the significant advancements in bioinformatics, which permeate many areas of our lives, the important industry has grown more adaptable and sophisticated. A significant chapter in the history of global agriculture is that of "smart agriculture," which began with the use of several cutting-edge technologies during various agricultural practises, including precultivation, cultivation, seedling, fertilisation, weed detection, irrigation, pesticide

CHAPTER 2

Impact of Automation, Artificial Intelligence and Deep Learning on Agriculture Crop Yield

Prabhakar Laxmanrao Ramteke^{1,*}

¹ H.V.P. M's College of Engineering and Technology, Amravati (Maharashtra State) Affiliated to Sant Gadge Baba Amravati, University, Amravati, Maharashtra, India

Abstract: Every nation is concerned about the growing problem of agriculture automation. It is challenging to supply the food needs of the existing population due to rising numbers, frequent climate change, and scarce resources. Farmers are forced to wreak havoc on the land by applying dangerous pesticides more often since their old techniques cannot keep up with the growing demand. As a result, agricultural practices are significantly impacted, and the land gradually loses its fertility and becomes unproductive. The agriculture sector can benefit from technology like Artificial Intelligence (AI), deep learning, the Internet of Things (IoT), embedded systems, and automation. Artificial neural networks, the Internet of Things, fuzzy logic, machine learning, and other technologies may all be used to automate agricultural systems. Artificial intelligence technology is advancing quickly, and as a result, its employment is in a wide range of fields. Utilizing clever technologies, the agricultural industry has become able to regulate the field environment that is essential to the care of every plant. A suitable atmosphere and appropriate irrigation are provided by the plant's identification and suitable circumstances. In order to increase agriculture yields, it has become important to manage crops in controlled settings like greenhouses that can enhance the output. This chapter focuses on the use of artificial intelligence and IoT technology to improve the productivity of agricultural enterprises. AI technologies might help farmers overcome problems like weeds, pests, and climatic variability that lower output. Numerous uses of AI are now being deployed, such as automatic machine changes for weather forecasting and pest detection. The goal of implementing AI and IoT is to increase the possibility of producing healthy crops by recognizing damaged crops and crop yield growth.

Keywords: Agriculture crop yield, Artificial intelligence, Artificial neural networks, Automation, Drone, Deep learning, Fuzzy logic, Internet of things.

^{*} **Corresponding author Prabhakar Laxmanrao Ramteke:** H.V.P. M's College of Engineering and Technology, Amravati (Maharashtra State) Affiliated to Sant Gadge Baba Amravati University, Amravati, Maharashtra, India; Email: pl_ramteke@rediffmail.com

INTRODUCTION

In this digital age, as technology advances, people are attempting to combine the functions of their natural and artificial brains. A whole new branch of artificial intelligence has emerged as a result of this continuous study. This is the method that allows people to build intelligent devices. The field of computer science, which includes AI, has the ability to be aware of its surroundings and should thrive to increase success rates. Based on prior experience, AI ought to be able to work. Machine learning, deep learning, CNN, ANN, IoT, and machine learning are some of the specialized fields that advance machine work and support the creation of more cutting-edge technology. The world's population has increased gradually and has already surpassed 7.7 billion people. By the year 2030, India's population is projected to exceed 1.5 billion, while the globe's population will increase from 7.7 billion in 2019 to over 8.5 billion. In the coming years, there will be a 70% rise in global food consumption and a major decrease in agricultural supply due to growing urbanization. By 2050, India will be the most populous nation on earth, and its domestic food production is already falling behind. The lack of planning, unexpected weather, incorrect harvest, irrigation technologies, and animals are the main causes of the decreased food output. Because of current global warming, nature has undergone a significant transformation. Because of the increase in the earth's average temperature, climatic conditions are unclear. The largest problem for farmers is persistent drought, not significant rain. Poor weather conditions cause farmers to earn 20-25 percent less money, according to India's yearly economic report.

One thought that comes to me is: What are all of these people going to eat? This inquiry is primarily directed at the agricultural sector. The population is not the only issue that modern farmers must deal with. What about the lack of workers and the need for eco-friendly food among consumers? Smart farming provides the solution to all of these issues. Software designed specifically for a certain site can save greenhouse gas emissions while also lowering the quantity of herbicides and fertilizers utilized (Impact of automation). Every nation's primary issue and the developing topic is agriculture automation. Given how quickly the world's population is expanding, there is an urgent demand for food. Farmers must apply toxic pesticides more often since their traditional methods are insufficient to meet the growing demand. This damages the soil and has a significant impact on agricultural operations, as the soil ultimately stays unfertilized. This chapter discusses several automation approaches and best practices, including the Internet of Things, wireless technology, artificial intelligence, machine learning, and deep learning. Crop diseases, improper storage management, misuse of pesticides, weed control, inadequate irrigation, and improper water management are a few issues affecting the agriculture sector. Machines were used to augment or replace

20 Research Trends in Artificial Intelligence: Internet of Things

Prabhakar Laxmanrao Ramteke

human work throughout the industrial revolution. However, with the development of information technology in the twenty-first century, the idea of artificially intelligent machines was unavoidably born with the invention of the computer. The sustainability of any economy rests on the implementation of this technology in agriculture [1]. "Thing-to-thing" communication is what the word "IoT" refers to. System communication, automation, and cost-cutting are the three key objectives. AI is widely used in a variety of fields, including security, agriculture, economics, education, and many more. The machine learning process plays a role in the application of AI [2]. Agriculture used to be only concerned with growing crops and food [3]. But during the past 20 years, much has changed in terms of how crops and animal products are processed, produced, marketed, and distributed. Currently, agricultural operations provide the primary means of subsistence while increasing GDP [4, 5], contributing to national commerce, lowering unemployment, supplying raw materials for other sectors to produce goods from, and generally developing the economy [6 - 8]. It is essential that agricultural methods be examined with the goal of expanding creative techniques to sustain and enhance agricultural operations as the world's population grows geometrically. The use of technology in agriculture will be made possible by other developments like big data analysis, Internet of Things technologies, and artificial intelligence [9, 10]. Understanding concerns like the use of toxic pesticides, regulated irrigation, pollution management, and environmental repercussions in agricultural operations is urgently needed. It has been demonstrated that automating farming procedures increases soil productivity and improves soil fertility. Farm automation techniques can increase agriculture's profitability while simultaneously minimizing its environmental impact [11 - 13].

The use of computers in agriculture was first mentioned in a paper in 1983 [14]. The current issues in agriculture have been addressed using a variety of strategies, from databases to decision support systems [15, 16]. Agriculture is a dynamic industry, making it impossible to generalize problems and offer a universal fix. It can now accurately capture the intricate intricacies of each circumstance and offer the most appropriate answer using AI approaches. With the advancement of various AI approaches, extremely complicated issues are being handled gradually [17].

AI TECHNIQUES FOR PROBLEM SOLVING IN AGRICULTURE SECTOR

Following are some important AI approaches that may be utilized as targeted areas for issue-solving in the agricultural field:

CHAPTER 3

AIoT: Role of AI in IoT, Applications and Future Trends

Reena Thakur^{1,*}, Prashant Panse², Parul Bhanarkar¹ and Pradnya Borkar³

¹ Department of Computer Science & Engineering, Jhulelal Institute of Technology, Nagpur, India

² Department of Information Technology, Medi-Caps University, Indore, India

³ Department of Computer Science & Engineering, Symbiosis Institute of Technology, Nagpur, India

Abstract: Technology such as the Internet of Things (IoT), big data, cloud computing, fog computing, edge computing, and blockchain can be a perilous factor when it comes to encouraging the integration of new technologies. Artificial Intelligence (AI) is an integral part of agricultural and industrial development. This chapter describes the extensive evolution of AI and IoT. Researchers and practitioners will find this chapter essential for understanding AI and IoT, along with models, current status, future trends, and industrial development. There are a number of issues with AI, but overall, it is considered to be an advanced and revolutionary assistant in a wide range of fields. The purpose of this chapter is to present a comprehensive study on AIoT that explains the convergence of AI and IoT. Herein, we summarize some innovative AIoT applications that are likely too intense for our world.

Keywords: Artificial intelligence, Agriculture, Green development, Internet of Things.

INTRODUCTION

Researchers spent more than 50 years creating the autonomous learning capabilities of computers, starting with the development of computers that needed human manipulation in the 1950s. This development is a turning point for computer science, business, and society. In a way, computers have developed to the point where they are capable of finishing new tasks on their own. Future AI will communicate with humans using their native language, gestures, and emotions to adapt to them and learn from them. People will live in real physical space and remain in the digitally virtualized network as a result of the widespread

^{*} Corresponding author Reena Thakur: Department of Computer Science & Engineering, Jhulelal Institute of Technology, Nagpur, India; E-mail: en19cs601002@medicaps.ac.in,

AIoT: Role of AI

use and interconnection of various intelligent terminals. The distinctions between humans and machines will already be blurred in this cyberspace [1 - 3].

• Artificial Intelligence (AI) is an intelligent machine that can simulate the intellect of a human by using this branch of computer science. AI seeks to replicate human qualities like perception, reasoning, comprehension, *etc.* in machines. In order to improve productivity and create new goods and services, intelligent systems in many different industries are built on extremely disruptive AI capabilities as shown in Table 1.

Table 1. Key definitions.

Artificial Intelligence	Machines, devices, or systems that learn and perform new tasks.
The Internet of Things	It involves collecting, sending, and processing data from devices connected to the internet.
Artificial Intelligence of Things	Collects data and intelligence. After analyzing the information, AIoT will perform tasks without any human intervention.

• The Internet of Things (IoT), on the other hand, is a network of interconnected things or gadgets that, through software or sensors built into them, can gather and transmit data in real time. The use of IoT enables significant levels of automation across a variety of functions and sectors. IoT devices produce a ton of data from sensors and human input.

ROLE OF AI IN IOT

The IoT is transforming how we connect devices in our surroundings and throughout the cities, including long-distance communications. This type of network generates vast information about online activities happening every moment. The daily data generated by these networks are 5 quintillion bytes/1 Billion Gigabytes/ 5 Exabytes. The technologies, including Artificial Intelligence, 5G networks, and Bigdata, are the key to creating and managing these networks. IoT and AI are combined to form AIoT that a smart network of connected devices with AI, unleashing data's power better and faster than ever.

Artificial Intelligence and Machine Learning models set over connected devices like edge domains, cloud centers, *etc.*, allow AIOT to collect real-time information through various sensors. This data can then be utilized for positioning, comparison, prediction, scheduling, and many more tasks. IoT provides AI with the data to feed the training algorithms, whereas AI provides IoT with perception and recognition capabilities. The two combined provide a

platform for upgrading the economy sector, improving the industry, and optimizing the experience. In urban areas, AIoT businesses were implemented in mass around 2019. Several research articles and references present AI and Machine learning models being utilized in the domain of IoT [1].

In an IoT-enabled device, the environment is sensed, the data is captured, processed, and actions are taken. The action performed determines the intelligence of the device [1]. The goal of IoT devices powered by AI technology involves automation and adaptation. A few of the developments in current AIOT applications are described in this section.

VOICE ASSISTANTS

A voice service agent works as a personal assistant for users using cloud-based services. Smart devices within their proximity are controlled by them. They can also perform query replying like calling cabs, making restaurant reservations, *etc.* A few well-known assistants include Alexa from Amazon and Siri from Apple Inc [4].

ROBOTS

The development of robots that mimic humans and can communicate with them through the understanding, reciprocation, and expression of specific human emotions is one of the results of recent advances in this field of robotics [5]. An example is SoftBank's Pepper, which can understand human emotions such as anger, sadness, and joy. Hanson Robotics' Sophia can express emotions with over 50 facial expressions.

SMART DEVICES

Robots and voice assistants aren't the only IoT SO/devices that can help people with their tasks. Deep neural networks, transfer learning, computer vision, object identification, face and speech recognition, speech and expression recognition, and speech are all used by AI-enabled SOs. Using Honeywell's HD Wi-Fi doorbell, SkyBell, consumers may use their smartphone or voice assistant to open the door. The video camera on the doorbell alerts the homeowner when someone is at the door and streams a live view to their phone.

INDUSTRIAL IOT

In addition to being used in smart homes, IoT has a wide range of applications in various industrial sectors. In addition to identifying potential problems early, it can assist operators in making any necessary changes, from a small sensor to an entire facility. IoT-based industrial solutions such as Plutoshift are also available.

The Role of Machine Intelligence in Agriculture: A Case Study

Prabhakar Laxmanrao Ramteke^{1,*} and Ujwala Kshirsagar^{2,*}

¹ H.V.P.M's College of Engineering & Technology, Amravati (Maharashtra State) Affiliated to Sant Gadge Baba Amravati University, Amravati, Maharashtra, India

² Department of Electronics and Telecommunication Engineering, Symbiosis Institute of Technology Symbiosis International (Deemed University), Pune – 412115, India

Abstract: India's GDP is heavily reliant on agricultural products and business management. Therefore, it is crucial for the agriculture industry to comprehend the most common uses of artificial intelligence (AI) through case studies. To increase its production, this industry must overcome a number of obstacles, such as soil treatment, plant disease and pest effects, crop management, farmers' innovative methods, and the use of technology. The major ideas behind AI in agriculture are its adaptability, excellence, accuracy, and economy. It is critical to examine AI applications for managing soil, crops, and the environment, and plant or leaf diseases. Food security continues to be seriously threatened by deforestation and poor soil conditions, both of which harm the economy. The application's advantages, constraints, and methods for employing expert systems to increase productivity are all given particular attention. Businesses are utilizing robots and automation to assist farmers in developing more effective weed control strategies for their crops. See & Spray, a robot created by Blue River Technology, is said to use computer vision to monitor and accurately spray weeds on cotton plants. Crop and Soil Monitoring - Businesses are using deep learning and computer vision algorithms to interpret data taken by drones and/or software-based technologies to monitor the health of crops and soil. Crop sustainability and weather forecasting are accomplished *via* satellite systems. A Colorado-based startup employs satellites and machine learning algorithms to examine agricultural sustainability, forecast weather, and assess farms for the presence of diseases and pests. Utilizing predictive analytics, machine learning models are being created to monitor and forecast various environmental factors, such as weather variations. Drones and computer vision are used for crop analysis, while machine learning is used for identifying soil flaws.

Keywords: Agricultural robotics, Agricultural applications, Computer vision, Crop and soil management, Machine intelligence, Satellite drone.

^{*} Corresponding authors Prabhakar Laxmanrao Ramteke and Ujwala Kshirsagar: H.V.P.M's College of Engineering & Technology, Amravati (Maharashtra State) Affiliated to Sant Gadge Baba Amravati University, Amravati, Maharashtra, India; & Department of Electronics and Telecommunication Engineering, Symbiosis Institute of Technology Symbiosis International (Deemed University), Pune – 412115, India; E-mails: kshirsagarujwala9@gmail.com; pl_ramteke@rediffmail.com

INTRODUCTION

The foundation of India's economy is agriculture. For more than 58 percent of rural households, it serves as their primary living area. The development and application of machine learning have improved agricultural benefits. Because artificial intelligence (AI) can be applied broadly to a variety of issues, particularly those that humans find difficult to handle effectively, it is gaining relevance extremely quickly. Therefore, farming solutions driven by AI help farmers produce more with less while improving quality and offering speedy go-to-market strategies for their crops.

In order to increase efficiency, agriculture is powered by AI, which examined its services in acquiring, comprehending, and responding to various situations. In order to increase production and efficiency, artificial intelligence technology is helping several agricultural industries.

The management of irrigation systems and soils is extremely important in agriculture. Crop loss and poor crop quality are caused by improper irrigation and soil management. To increase production, a smart management system is therefore required. The Internet of Things based smart irrigation system may automate the watering process by assessing the soil moisture and weather conditions. Because artificial intelligence is aware of previous weather conditions and patterns, soil, and its contents' quality, and the varieties of crops or yields to be cultivated, it may skip irrigation, one of the labor-intensive farming operations. The goal of automated irrigation systems is to boost average yields by utilizing real-time machines that can continuously maintain the correct soil conditions, considerably lessen the farmers' laborious tasks, and also has the ability to lower production costs. The awareness of AI would have a significant influence on reducing water loss for agriculture, which uses around 70% of the nation's freshwater.

Understanding Essential Agriculture Stages

Lack of information at each level of agriculture can cause new issues to appear or exacerbate existing ones, raising the cost of farming. The demand for the agricultural industry is exacerbated by the daily population expansion. From crop selection to harvest and product sale, agribusiness suffers from extremely high overall losses. Since knowledge is power, farmers may be able to make better decisions and lessen issues linked to agriculture by following the information regarding crops, the changing environment, and the targeted market. Information may be collected and processed using technologies including blockchain, IoT, edge computing, machine learning, deep machine learning, and cloud computing.

56 Research Trends in Artificial Intelligence: Internet of Things

Ramteke and Kshirsagar

Applications of machine learning, computer vision, and IoT will assist to enhance the quality, raise production, and eventually increase the productivity and economy of farmers and related industries. The various stages required in Agriculture production are shown in Fig. (1).

Agriculture's Stages



Fig. (1). Stages in Agriculture. Source: V. Meshram, K. Patil *et al*. Artificial Intelligence in the Life Sciences 1 (2021), Elsevier.

CASE STUDIES

An IOT-based System for Crop Irrigation

In smart irrigation systems using IoT, Gursimran Singh suggested machine learning technologies to improve irrigation water use by forecasting the future soil moisture of a field. To anticipate futuristic soil moisture, field real-time data from different sensors such as temperature, humidity, moisture of soil, and UV radiation are combined with weather forecasts through the internet. The analysis of several machine learning methods for forecasting future soil moisture shows the outcomes of several machine learning techniques. The system architecture of an IOT-based crop irrigation system is shown in Fig. (2).

Optimal Feature Selection and Prediction of Diabetes using Boruta- LASSO Techniques

Vijayshri Nitin Khedkar^{1,*}, Sonali Mahendra Kothari¹, Sina Patel¹ and Saurabh Sathe²

¹ Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India

² San Jose State University, California, USA

Abstract: Diabetes prediction is an ongoing research problem. The sooner diabetes is detected in a human, the sooner lives and medical resources can be saved. Predicting diabetes as early as possible with easy to measures parameters with optimal accuracy is an ongoing problem. When dealing with large data, feature selection plays an important role. It not only reduces the computational cost but also increases the performance of a model. This study ensemble three different types of feature selection techniques: filter, wrapper and embedded. Ensembling Boruta and LASSO features give optimal results. Also, effectively handling class imbalance leads to better results.

Keywords: Diabetes Prediction, Ensembling features, Feature selection, SMOTE.

INTRODUCTION

Diabetes is a metabolic disease identified by the high insulin levels in the blood [1, 2]. Also known as diabetes mellitus, it often leads to complicated diseases like heart attack, kidney failure, stroke and nerves. Diabetes is grouped into mainly three types: diabetes type 1, diabetes type 2, and gestational diabetes. Type 1 Diabetes occurs when there is a lack of insulin in the body which permanently damages cells that produce the pancreas. The second type of diabetes is when the body cannot effectively use the insulin produced by it, and gestational diabetes is usually seen in pregnant women.

Identifying diabetes at an early stage is a strenuous task since most medical data are correlated, structured, nonlinear and intricate in nature. The use of machine le-

^{*} **Corresponding author Vijayshri Nitin Khedkar:** Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India; E-mail: vijayshri.khedkar@sitpune.edu.in

Optimal Feature Selection

Research Trends in Artificial Intelligence: Internet of Things 81

arning-based systems has emerged in the field of healthcare [3, 4], not only for diabetes but for other diseases like coronary arteries, heart disease, and cancer. Machine learning-based systems can be used for feature selection and classification. A very important pre-processing step while training any data is variable selection. The main aim of this step is to filter out non-contributing features from the training dataset. Performing feature selection comes with many benefits: it deals with the problems related to dimensionality, avoids overfitting problems and reduces the total time cost for training the model.

Majorly, methods for features selection are categorised into filter methods, wrapper methods, and embedded methods [5 - 8]. Previously, authors have aimed at comparing various feature selection methods for varied domains. However, many studies have been developed based on one type of feature selection technique. There are different advantages and disadvantages of using a particular type of technique, and using a single type of algorithm has its own drawbacks. To overcome this drawback, the ensemble feature selection method is being explored recently. Ensemble-based feature selection techniques generate different subsets and get a final output. However, these studies are mainly limited to a single algorithm; not all three categories are considered in an ensemble feature selection. Also, many methods are being used for predicting or diagnosing diabetes. Mainly, these methods use advanced lab test results for prediction, which is time and cost-consuming. It is necessary to predict diabetes as early as possible using easy to measure features that can save time, money and health for health professionals and patients.

In this study, we focus on inspecting how different machine learning models behave and perform with different feature selection techniques along with various combinations of filter, wrapper and embedded feature selection methods. Also, identifying easy to measure features that do not require advanced lab tests for predicting diabetes as early as possible. This paper demonstrates that aggregation of Boruta and LASSO for feature selection and combining it with random forest gives better results for the data.

RELATED WORKS

A study [9] used decision trees, Naive Bayesian, Random forest, Support Vector Machine, and K nearest neighbour for predicting diabetes in an early stage based on data collected from UCI called PIDD dataset. The main aim was to select the correct attribute by iteratively checking the correlation between attributes. Different metrics were used for evaluating the models. RF and DT outperformed in terms of specificity. However, NB gave better accuracy. Various machine learning algorithms such as Logistic regression, gradient boost, and random forest

82 Research Trends in Artificial Intelligence: Internet of Things

Khedkar et al.

were compared [10]. The main finding of this study was that logistic regression gave the highest accuracy of 96% with the private dataset used, which has features like insulin, BMI, Blood pressure, age, job type, and glucose. In comparison, gradient boost and AdaBoost classifiers gave 77% accuracy with the PIMA dataset.

Another study [11] proposed its own dataset for predicting type 2 diabetes. The class imbalance was treated by SMOTE technique, and for feature selection, Chisquare, and logistic regression were used. By comparing various ML algorithms, out of which the decision tree outperformed the proposed dataset. It was found out that smoking, healthy diet, blood pressure, BMI, gender and region were significant factors contributing to prediction accuracy. A study [12] used the NHANES dataset for predicting diabetes by extracting features like age, ethnicity, body mass index, fitness, drinking habits, smoking habits, nutrition intake, cholesterol, and calorie consumption. Moreover, linear SVM and bagged trees were compared, giving 88.5% and 87% accuracy. However, after removing outliers and missing values, the dataset was very small, which cannot be validated in real-time situations.

DATASET USED

A publicly available dataset from National Health and Nutrition Examination Survey (NHANES), which is cross-sectional ongoing survey data, was utilised for experiments. The survey collects health, nutrition, and lab examinations which consist of different measurements such as cholesterol, blood pressure and other specimens for lab testing. Survey participants were recognized as positive diabetic patients if any one of the following conditions were met:

- i. Plasma fasting glucose >=126 mg/dL
- ii. Glycohemoglobin >=6.5%
- iii. Serum glucose $\geq 2000 \text{ mg/dL}$
- iv. Responding 'Yes' when asked, "Did a doctor tell you that you have diabetes?"

Feature Selection Techniques	AGE	RAC	EDU	GEN	WAI	MAR	HEI	LEG	WEI	BMI	СНО	НҮР	DYS	SYS	HEA	EXE	ALC
ReliefF	<	\checkmark	\checkmark	\checkmark	-	>	-	-	-	-	-	\checkmark	-	-	\checkmark	-	\checkmark
Boruta	\checkmark	-	-	-	\checkmark	-	<	\checkmark	\checkmark	>	<	-	-	<	-	-	-
LASSO	<	-	\checkmark	\checkmark	\checkmark	>	-	\checkmark	\checkmark	>	<	-	-	<	\checkmark	\checkmark	-

CHAPTER 6

Empowered Internet of Things for Sustainable Development Using Artificial Intelligence

Pranali Gajanan Chavhan^{1,*}, Namrata Nishant Wasatkar¹ and Gitanjali Rahul Shinde²

¹ Vishwakarma Institute of information and Technology, Pune. (Maharashtra State), India

² Department of Computer Science & Engineering (Artificial Intelligence & Machine Learning), Vishwakarma Institute of Information Technology Kondhwa (Budruk), Pune – 411048, Maharashtra, India

Abstract: Everyone has been utilizing the Internet of Things in current years (IoT). Therefore, as the IoT has grown enormously, so too have concerns about Artificial Intelligence. Artificial intelligence (AI) is at the forefront of ubiquitous computing and is utilized to create intricate algorithms to safeguard networks and systems, including IoT devices. But to carry out cyber security assaults, hackers have learned how to make use of AI, and they have even started to deploy antagonistic AI. The goal of this research work is to comprehensively present and summarize the pertinent literature in these fields. It does this by compiling data from a few other surveys and research papers regarding sustainable development using AI, IoT, and attacks with and against AI. It also shows the relationship between IoT and AI.

Keywords: Artificial intelligence (AI), Cyber security Attacks, Energy management, Internet of things (IoT), Intelligent transportation systems (ITS), Smart irrigation, Water management using AI.

INTRODUCTION

The Internet of Things (IoT) has revolutionized the way we live and work by connecting everyday devices and facilitating communication between them. As the number of connected devices continues to grow, it is essential to ensure the security, efficiency, and reliability of IoT systems. Artificial Intelligence (AI) offers a wealth of opportunities for improving IoT, from enhancing security measures to optimizing performance. This study aims to explore various methods for securing, enhancing, and ensuring the reliability of IoT in the context of AI.

^{*} **Corresponding author Pranali Gajanan Chavhan:** Vishwakarma Institute of information and Technology, Pune. (Maharashtra State), India; E-mail: pranali.chavhan@viit.ac.in

Empowered Internet

This will include an examination of current techniques and technologies, as well as an evaluation of their effectiveness and limitations. The goal of this research is to identify the most promising approaches for improving IoT with AI and provide insights for future work in this area.

The field of computer science known as AI is concerned with developing intelligent machines that can carry out tasks that ordinarily require human intelligence, such as visual awareness, speech recognition, decision-making, and language translation. Large datasets can be used to teach AI systems to recognize patterns, predict consequences, and then be programmed to respond accordingly. The goal of AI is to create systems that can perform tasks that would normally require human intellect and make decisions and perform actions that are not explicitly programmed. Some common examples of AI include virtual personal assistants like Siri and Alexa, recommendation systems used by streaming services, and self-driving cars.

AI offers several opportunities for improving the IoT in the following ways:

- Security: AI can be used to improve security in IoT systems by detecting and preventing cyber-attacks. For example, AI algorithms can identify anomalies in network traffic and take action to prevent potential security breaches [1].
- Performance Optimization: AI can be used to optimize the performance of IoT systems by analysing data and making predictions to improve efficiency. For example, AI algorithms can be used to predict which devices will consume the most power and adjust their usage accordingly [2].
- Predictive Maintenance: AI can be used to predict when IoT devices will fail and schedule maintenance accordingly. This can help reduce downtime and improve the overall reliability of IoT systems [1].
- Automation: AI can be used to automate many tasks in IoT systems, freeing up time for human operators and improving overall efficiency [3].
- Decision-Making: AI can be used to make decisions in IoT systems, for example, deciding which devices to turn on and off based on usage patterns.

In Fig. (1), AI offers a wealth of opportunities for improving IoT by providing new ways to enhance security, optimize performance, improve reliability, automate tasks, and make informed decisions.



Fig. (1). Sustainable Security for the IoT Using Artificial Intelligence Architectures.

Artificial Intelligence

The ability of computers and other devices to carry out tasks that would ordinarily need human intelligence is known as AI, such as recognizing speech, understanding natural language, and making decisions [4].

An example of AI is a virtual personal assistant, such as Apple's Siri or Amazon's Alexa. These devices use Natural Language Processing (NLP) and machine learning algorithms to understand and respond to user requests for information, music, or other services. The more a user interacts with the virtual assistant, the more it learns about the user's preferences and behaviours, allowing it to provide a more personalized experience over time.

In Fig. (2), AI is used everywhere for example in self-driving cars, which use a combination of computer vision, machine learning, and sensor technology to understand and respond to their environment. These cars can detect obstacles, make decisions about the best route to take, and adjust their speed and trajectory accordingly, all without human intervention. As Artificial Intelligence is a broad field, the code will vary depending on the specific problem or task you want to solve with AI [3]. However, here in below Fig. (3) is a simple example in Python that uses a machine learning algorithm called a decision tree for classification:

CHAPTER 7

Digital Twin and Its Applications

Kiran Wani^{1,*}, Nitin Khedekar¹, Varad Vishwarupe¹ and N. Pushyanth²

¹ Department of Mechanical Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India

² Department of Computer Science, University of Oxford, Oxford, United Kingdom

Abstract: Digital twin technology is an important part of the industry 4.0 revolution. Digital twins is a concept of integrating different smart technologies including integration of data and digitization. The vision of the digital twin technology is based on the philosophy that any component, assembly, system, process, product, or even environment can be replicated in terms of form, functionality and several other parameters in a digital way throughout different phases of its lifecycle. The Digital Twin concept is based on the highly growing information and communication technologies alongside conventional methods for getting better interconnection and integration amongst all the entities involved in a particular phase of the product lifecycle. The Internet of things (IOT) and artificial intelligence (AI) are crucial parts of the Industry 4.0 revolution. IOT proposes to embed electronics, sensors, network connectivity and different software platforms with products. Better integration between the physical and digital world is achieved by a strong network infrastructure that facilitates remote sensing, monitoring and even controlling of connected systems. This technology provides users with many benefits such as increased efficiency, reduced downtime, improvement in precision and accuracy along with cost saving.

This chapter includes an overview of digital twin-enabling technologies and their applications. The applications range from Artificial Intelligence, Internet of Things (IoT) to manufacturing.

Keywords: Artificial intelligence, Digital twins, Internet of things (IoT), Machine learning.

INRODUCTION

As the world is moving towards building smarter products, the technological advancements required to achieve this have taken strides in recent days. Among them, in industry, the concept of digital twin has attracted a lot of attention world-

^{*} **Corresponding author Kiran Wani:** Department of Mechanical Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India; E-mail: kiranwani2010@gmail.com

Digital Twin

Research Trends in Artificial Intelligence: Internet of Things 121

wide. It provides many advantages in the field of manufacturing like production and design, remote diagnostics, condition monitoring and operation in extreme conditions and services. It affects the design, structure and operation of the product. Digital twin majorly depends on accumulating data from sensing systems and presenting the data collected in real-time along with the modification and update with its physical model. With time, evolution is happening at a rapid pace, as is technology. The next generation technologies like advanced cloud computing, smart manufacturing, big data and AI are coming to the limelight, making life easier. As per several national manufacturing development strategies put forward like Industry 4.0, manufacturing based on cyber physical system (CPS) and industrial robotics is new. In order to bring such advancements to the industry, effective methods for maintenance, operation and monitoring are required. Also, to simulate plans or build what-if scenarios for the products, facilities, and processes we wanted to change before we actually put real-world resources behind, real-world implementation can be done with the promise of digital twins (DT).

From a temporal view point, there is a growing interest in DT and its evolution as shown in Fig. (1). As computing technology is developing day by day, CAD, CAM and CAE models are able to simulate the real-time changes in the virtual space. This prevents the spending of valuable resources and time by visualizing the data acquired from the models. After iterations, a final outcome can be decided based on the application and we may proceed with manufacturing.



Fig. (1). Digital twin technology evolution with time [1].

The DT acts as a bridge between two spaces, that is the virtual space and physical space. By doing so, it eradicates the boundaries between them. The physical space is a real-life environment which involves several factors such as people, infrastructures and hardware with measurable properties such as mass, shape, size, *etc.* Each entity has its own positioning and follows physical laws and deals with

uncertainty. The factors have their own physical functions and with proper organization, the tasks can be completed by considering the constraints on resources like time, cost quality, *etc*.

Augmented Reality (AR) and Virtual Reality (VR) are some of the technologies that can benefit from the implementation of a Digital Twin, due to the fact that it provides a virtual and realistic view of the environment in which the historical and real-time data flow is integrated with the human presence. However, considering the large amount of data and information in real-time that come from the Digital Twin model, it is difficult to provide users and operators with this information in an easy and intuitive way. In particular, AR does not replace the physical world but allows the user to see the physical world with overlapping virtual objects. Moreover, it gives users the opportunity to interact with the physical world to perform specific tasks or be alerted to possible dangers. The inclusion of these enabling technologies within Industry 4.0 implies their importance for modern factories. In general, an architecture that integrates the Digital Twin and AR/VR is composed of the following three main blocks:

- A. Calibration: In order to obtain a clear and intuitive data visualization using AR devices, all the processing of historical data is as important as the data. In order to better manage the AR device, the 3D or 2D models must be perfectly aligned with the physical part. This process is called calibration.
- B. Control process: The control process is a very important aspect for AR systems as it allows the user to interact with both the physical and the virtual part of the Digital Twin. After viewing the data in the increased process, users can use this information to support decision-making and directly control the physical part through the AR device.
- C. Augmented process: The augmented process, through the AR devices, must provide users with an intuitive and clear AR view of the information coming from the Digital Twin. In practice, the AR device receives data from the virtual part, and after the calibration phase, it correctly presents this to the user.

Making use of the current technology, some challenges arise in using AR in the manufacturing sector. They can be summarized in four types:

- 1. Real-time data: There is a huge amount of real-time data exchanged between the manufacturing process, cloud and VR devices, and these have to be managed in order to support the users and operators in the correct way.
- 2. 3D and 2D modelling: Recognizing, tracking and following the target object(s) are extremely important for the quality of AR utilization.

Ontology Based Information Retrieval By Using Semantic Query

Rupali R. Deshmukh^{1,*} and Anjali B. Raut²

¹ Department of Computer Science & Engineering, H.V.P. M's COET, Amravati, Maharashtra, India

² Computer Science & Engineering, H.V.P. M's COET, Amravati, Maharashtra, India

Abstract: The volume of data is increasing quickly in the modern day. Effective information retrieval techniques are needed to extract important facts from such a large collection of information. As a result, retrieval of information is the process of gathering valid data from a variety of sources. The majority of the time, information is retrieved from the internet using search queries. The aim of this research is to explore various issues existing in information retrieval techniques and to propose new techniques to overcome existing challenges in the field of Information retrieval.

Modern information retrieval methods have been examined, and it was discovered that they do not take semantic keyword knowledge into account when returning results. The semantic web is a development of the internet that enables computers to comprehend human inquiries in terms of their intent and produce pertinent responses.

This research mainly focuses on Ontology-Based Information Retrieval which can support semantic similarity and retain the view of an approximate search in a document repository using machine learning techniques. Further, this research works explores an adaptive update model for retrieving the information and proposes a semantic search model for the given user query. The objective of ontology-based semantic web information search is to increase the accuracy, precision and recall of user queries.

Keywords: Information retrieval, Machine learning, Ontology, Semantic web, Semantic query expansion.

INTRODUCTION

Huge data is generated in an integrated environment from multiple sources. The generated data is housed in a repository. The need to retrieve context-specific rel-

^{*} Corresponding author Rupali R. Deshmukh: Department of Computer Science & Engineering, H.V.P. M's COET, Amravati, Maharashtra, India; Tel: 8275389793; E-mail: drupali1604@gmail.com

Deshmukh and Raut

evant data is a challenging need of the time. Information Retrieval (IR) is becoming a more popular technique due to the tremendous growth of data resources on the internet in many forms. The main motive of the IR system is to discover the relevant information and documents that fulfill the requirements of the user. As searching the documents through the internet has become an imperative part of people's life, there is a great demand for obtaining such documents from a huge source of information which are appropriate to the information referred. Searching for information and documents from Web repositories through search engines gives many times irrelevant pages. This is because of the fact that search engines solve queries based on text pattern matching. This may sometimes output relevant as well as matched but irrelevant information.

Semantic web technology plays a significant role in retrieving relevant information. The semantic search tries to understand the user intention and improves the search accuracy and in turn appears in the searchable data space. Ontology plays a vital role in Semantic Web Technology. The component of the Semantic Web referred to as Ontology provides a common understanding of a particular term along with its relationship with the other terms in the query, where, the adaptive ontologies represent both the search domain and the user domain. This will reflect the search domain's ability to adjust to domain evolution semi-automatically. The obtained data in ontologies were used to strengthen the semantics of submitted queries as well as online data.

Likewise, the system automatically uses the chosen ontologies to enrich the produced query in accordance with the query enrichment criteria. Based on web data found in the graphs that validate the enriched query, the domain ontology is modified. The vision of the semantic Web proposes a situation where the information and administrations on the Web can be semantically translated and handled by machines to encourage human utilization. The semantic Web depends vigorously on the formal ontologies that structure basic information with the end goal of far reaching and transportable machine understanding. Semantic Web innovation depends on metaphysics as an instrument for displaying a conceptual perspective of the genuine and relevant semantic examination of documents.

Accordingly, the accomplishment of the semantic Web will be subject to the expansion of ontologies, which requires quick and simple designing of philosophy and evasion of a learning procurement bottleneck. However, there are certain challenges to which knowledge can or should be formalized.

The main purpose of this study is to propose an ontology-based information retrieval model that can retain the perception of an estimated search in a document

Ontology Based Information

repository and permit semantic query expansion similarity. In addition, this research investigates the creation of rank-based simultaneous history and knowledge update models and offers an adaptive update model for gathering information as well as a semantic query expansion model for the specified user query. Accuracy, precision, and recall are to be strengthened by ontology-based semantic query expansion and web information search.

Historical Background

Information Retrieval (IR) is the science and technology of efficiently allowing interested parties to obtain data from a repository of information. In information retrieval (IR), the task is to select information resources in vast repositories and satisfy customers' queries that reflect information needs. As things like text, image, audio, or a combination of all these, information resources are represented.

The basic aspects of the IR process are shown in Fig. (1). The user represents required information using query syntax during the conceptualization phase of IR. Only a minimal presentation of information complexity is required in the query. In practice, the user approximates the requirement for the inquiry by expressing numerous instances of the standout demand qualities, resulting in a set of terms that are tied to some coordinating terms. This frequently results in retrieval ambiguities, making it the major supply for the revision process.



Fig. (1). Basic Information Retrieval Process.

CHAPTER 9

Paradigm Shift of Online Education System Due to COVID-19 Pandemic: A Sentiment Analysis Using Machine Learning

Prajkta P. Chapke^{1,*} and Anjali B. Raut¹

¹ Department of Computer Science & Engineering, H.V.P.M's, C.O. E.T., Amravati, India

Abstract: The COVID-19 epidemic has completely altered the environment and every aspect of every individual. The most affected part is the education system and the stakeholders associated with it. Organizations are currently being forced to adapt and alter their strategies in response to the new situation created by the COVID-19 epidemic. The proposed study gathers tweets on online schooling from social media sites like Twitter and Facebook comments in order to conduct a thorough sentiment analysis (SA) during the epidemic. The current study utilizes techniques for natural language processing (NLP) and machine learning (ML) to extract subjective data, establish polarity, and identify how people felt about the educational system prior to and following the COVID-19 crisis. The first step in the proposed study is to retrieve tweets using Twitter APIs before they are ready for rigorous preprocessing. One filtering method is Information Gain (IG). We will identify and examine the latent causes of the unpleasant feelings. We'll look at the machine-learning classification algorithm at the end. The proposed model will analyse the perceptions of people about the online educational system during COVID-19.

Keywords: COVID-19, Machine learning, Natural language processing, Online educational system (OES), Pandemics, Sentiment analysis.

INTRODUCTION

The Internet has developed over the past 20 years from being almost non-existent to being the biggest, most accessible database of knowledge ever made. It has changed the way people communicate, transact business, shop, socialize, and approach information and education. Education is becoming more accessible than ever because of online learning, which is revolutionizing the way traditional

^{*} Corresponding author Prajkta P. Chapke: Department of Computer Science & Engineering, H.V.P.M's, C.O. E.T., Amravati, India; E-mail: prajkta.chapke@rediffmail.com

Paradigm Shift

classes are administered. It is much more than just a fresh method of distance education.

Online education is a style of instruction where students use their personal computers to access the internet. Over the past 10 years, many unconventional students, such as those who choose to continue working full-time or raising families, have become more and more interested in online graduation and courses. The host university's online learning portal frequently provides online academic and graduation programs, some of which use digital technologies.

Schools, training facilities, and institutions of higher education have been forced to close in the majority of countries as a result of the COVID-19 lockdown and social isolation tactics. There has been a paradigm shift in how educators deliver high-quality education using a range of online channels. Online learning, distance learning, and continuing education have emerged as the panaceas for this unprecedented global epidemic, notwithstanding the challenges that both teachers and students must overcome. Both learners and teachers may experience a completely different learning, yet they are forced to adjust because there are few or no other options. Through a variety of online channels, the educational system and instructors have accepted "Education in Emergency," forcing them to use a system for which they are not ready.

E-learning resources have been essential in facilitating student learning while universities and schools have been closed due to the pandemic. Staff and student preparation must be assessed during the transition to the new changes and supported appropriately. Learners who have a fixed mindset find it difficult to adapt and alter to a new learning environment, in contrast to students who have a growth mentality.

The survey by the Chicago Community Networks Study included not only a series of questions on organizational characteristics but also a roster of organizations identified by the research team and by locals as contributing to community development work in each organization's neighbourhood [1]. India is not an exception to the difficulty of online learning for both students and teachers worldwide. Online courses have had a greater detrimental effect on a small percentage of students. Most teachers who taught English were unpaid during the shut-down of the school; embassies rejected offering student visas; and new teachers were not appointed by the school [3]. People are now using social media to express their emotions as a result. In order to examine the emotional current of Indian instructors and learners in light of these issues, this study will employ machine learning (ML) on Twitter tweets.

Technology will have a significant impact on education in the upcoming years. The Internet of Things (IoT) is reaffirming its critical role in the context of information and communication technologies and societal advancement. Institutions may improve learning outcomes with the use of IoT by offering more open learning opportunities, increasing operational effectiveness, and collecting real-time, actionable insight into student performance.

To our knowledge, this is the initial research to look at how COVID-19 has affected India's educational system using data from social media. Research will commonly use the social media sample approach. This study provides a helpful data analysis of the feelings at this point by assessing the emotions and the shift in positive and negative polarity throughout time.

HISTORICAL BACKGROUND

Social Network Analysis

Social Network Analysis (SNA) is a demonstrative strategy to reveal the connections inside an informal community that are likely to lead to further associations. It incorporates an arrangement of strategies and instruments to give a visual picture of the interpersonal organization and acts like an" authoritative X-beam" into the casual workings of a gathering of individuals. The essential spotlight is on the connections between individuals as opposed to the characteristics of the people [2].

Impact of Social Networks

Just one click away, the thoughts are shared with other people, paving the way to start a new journey in a new world. This technology is used for many other purposes, but communication is the main one and still persists. A new bond is created with common friends and similar people. It seems to be the perfect tool for those who admire each other, but some are worried about the impact of these social networking sites. There are two types of attitudes and impacts —positive and negative —that are realized by the users [3]. The impacts are mainly classified as follows:

- Positive Impact
- Negative Impact

Image Processing for Autonomous Vehicle Based on Deep Learning

Tanvi Raut¹, Ishan Sarode¹, Riddhi Mirajkar^{2,*} and Ruchi Doshi³

¹ BTech-Information Technology, Vishwakarma Institute of Information Technology, Pune, India

² Faculty, Vishwakarma Institute of Information Technology, Pune, India

³ University of Azteca, Chalco de Díaz Covarrubias, Mexico

Abstract: The automation industry is rapidly growing and coming up with new and improved techniques for reducing time and efforts. One such example is the autonomous cars which are said to be the future of the automobile industry since they would be driver less, very efficient and relieve the stress of daily commuting [1]. Advances in technology using the AI and deep learning techniques help in improving the safety of the passengers and also in minimizing the efforts of the driver. For the study of autonomous vehicles, a lot of data needs to be collected, some of which include warning signals, speed limits, obstacles, collision avoidance, *etc.* This paper shows how IoT devices *i.e.* cameras and LiDAR sensors help in data collection, how deep learning is a solution, and how image recognition methods that use deep learning can help in object or any obstacle detection. An image processing algorithm based on deep learning is proposed in which the image perception can be made by an optical camera communication technique that can be used for collecting the data. Hence it will highlight how deep learning is used in the field of image processing or image recognition.

Keywords: Autonomous driving, Camera, CCD, LiDAR, Convolution neural network(CNN), Deep learning, Image processing, Lane detection, LED area detection, Machine learning, Object detection, Vehicles, YOLO.

INTRODUCTION

Modern day cars are equipped with technology that assist drivers to avoid drifting into adjacent lanes, making unsafe lane changes, brake automatically if a vehicle stops ahead, and warn drivers of vehicles behind them and various other things. All of these features use a combined effort of software and hardware to help iden-

^{*} **Corresponding author Riddhi Mirajkar:** Faculty, Vishwakarma Institute of Information Technology, Pune, India; E-mail: riddhi.mirajkar@viit.ac.in

tify certain safety risks. Autonomous cars are vehicles capable of driving without human input by sensing the environment and making decisions based on the conditions. The car can travel to any place a traditional car can go and drive with experience [2].

Levels of Autonomous Driving

Autonomous driving is classified into 6 different levels. This classification is done based on the amount of control that the computer or the AI has over the car or the amount of input that is required from the driver. Fig. (1) shows a representation of the different levels of autonomous driving based on the input required by the users.

Level 0 - The work is done by humans and there is no role of the computer.

Level 1 – The work is mostly done by a human and only the acceleration is done by the computer.

Level 2 – The ADAS (Advanced Driver Assistance System) can handle tasks like steering and acceleration, but human monitoring is required at all times.

Level 3 – The ADAS can perform driving tasks in limited areas, but human input is required in cases where the computer fails and asks the driver to regain control.

Level 4 – The ADS (Advanced Driving System) can perform all driving tasks independently in which human attention is not required.

Level 5 – Involves complete automation in which all the work is done by the vehicle in all conditions and requires no human attention or input.

Camera vs LiDAR: The Better Hardware for the Detection of Vehicles

LiDAR technology utilizes light pulses to detect and gauge the distance and range of objects, similar to how radar uses radio waves. This information is then used to inform the actions of self-driving vehicles, such as applying the brakes to avoid collisions. Additionally, LiDAR systems can generate 3D maps of the surrounding environment by emitting thousands of pulses per second and using on-board software to process the resulting data. These maps provide a comprehensive, 360 degree view that enables self-driving cars to navigate various road conditions.



LEVELS OF DRIVING AUTOMATION

Fig (1). The 6 distinctive levels of autonomous driving.

Cameras on self-driving vehicles utilize visual data captured by the optics in the lens to inform the on-board software about the surrounding environment. With advances in computer vision algorithms and neural networks, these cameras are capable of identifying various objects and utilizing this information to guide the actions of the vehicle, such as avoiding collisions, slowing down in the presence of traffic, and safely changing lanes. Additionally, cameras may utilize OCR (Optical Character Recognition) technology to interpret and read text from road signs and other written materials. Table **1** gives a detailed difference between the two systems.

Table 1. Distinction between	Camera and LiDAR System.
------------------------------	--------------------------

Camera	LiDAR
The camera has better advantages at visual recognition and working with AI to identify objects on the road.	LiDAR plots a virtual map in real time which gives it more precision while determining distance between objects.
The camera also has the capability to utilize OCR and read road signs.	Since LiDAR uses radio waves, it cannot read road signs.
Cameras are more reliable when used as visioning systems as they are good at imaging.	LiDAR's reliability is affected by wavelength stability and detector sensibility.
Cameras lack range to detect objects and weather conditions like fog can hamper this range further.	LiDAR systems have a better range since it relies on radio waves and harsh weather conditions like fog do not affect its capabilities.
Cameras are less expensive and compact to fit.	LiDAR is on the expensive side and looks bulky on the vehicle.

CHAPTER 11

Applications of AI and IoT for Smart Cities

A. Kannammal^{1,*} and S. Chandia¹

¹ Department of Computing (Decision and Computing Sciences), Coimbatore Institute of Technology, Coimbatore, Tamil Nadu-641014, India

Abstract: Due to the rapid increase in urban population, the today's life of every citizen undergoes drastic changes. For the betterment of human life, Government of India had decided and announced the development of smart cities *i.e* the cities to be developed with all modern facilities in which people can use the internet for their daily activities. Smart city development would heavily depend on the Internet of Things (IOT) which combines three important aspects of Internet such as people-people interaction, people-objects interaction, and objects-objects interaction. Artificial Intelligence (AI) is another technology that provides the city equipped with efficient systems for security, safety, parking, *etc.*

The applications of AI enable IoT in smart cities that are discussed in this chapter such as Smart Home, Smart Healthcare, Smart Water, Smart Grid and Energy, Smart Transport, and Real Estate investment. Section 12.1 gives an introduction about the chapter that includes an introduction to Smart City, IoT and integration of AI and IoT. Section 12.2 discusses the potential use cases of AI and IoT in smart cities. Smart Home use case that includes smart management of equipment and human activity recognition is discussed. It also discusses Smart Healthcare which includes the fitnesstracking system, glucose-level monitoring system, body-temperature monitoring system, stress detection system, and oxygen-saturation monitoring system. Smart Infrastructure is also discussed which includes Smart Water, Smart Grid and Energy, and structural health monitoring. Smart Transport is also discussed in this chapter which includes the Vehicle Infrastructure Pedestrian (VIP), Smart Parking System (SPS) and Automated Incident Detection system (AID). The final section concludes the chapter by discussing the challenges in the smart city environment and future enhancements.

Keywords: Artificial intelligence, Internet of things, Smart city, Smart healthcare, Smart infrastructure, Smart home, Smart transport, Smart water.

* **Corresponding author A. Kannammal:** Department of Computing (Decision and Computing Sciences), Coimbatore Institute of Technology, Coimbatore, Tamil Nadu-641014, India; E-mail: kannammal@cit.edu.in

INTRODUCTION

Due to the complexity of the ecosystem such as increased population, climatic variations, pollution, scarcity of resources, heavy traffic, poor infrastructure *etc.*, cities have become unorganized. So, there is a need for using technology as a solution to all these issues. This paved the path for the development of smart cities [1]. By utilizing all the city resources, the quality of life should be improved and operational cost should be reduced. A smart city can be defined by various characteristics as shown in Table 1. Each characteristic is defined based on the key aspects of the city.

	Characteristics	Factors				
		Smart Energy				
	Smart Environment(Natural Resources)	Smart Air, Water, Land, and waste Managemer				
		Environmental Protection				
		Smart Health and Education				
	Streat Society (Ouslity of Life)	Smart Safety and Security				
	Smart Society(Quality of Life)	Smart Housing				
Sr		Smart Cultural Facilities				
		Smart Public and Social Services				
	Smart Government(Governance)	Smart Participation in decision-making				
		Smart Industry and Business				
	Smart Economy(Infrastructure, Technology and Environment)	Smart Tourism				
	Environnenty	Smart Payment and Banking				
		Local accessibility				
	Smart Mobility(Transport and ICT)	Innovative and Safe Transport Systems				
		Availability of ICT-infrastructure				

Table 1. Characteristics of a Smart City	Table 1.	Characteristics	of a	Smart	City.
--	----------	------------------------	------	-------	-------

Internet of Things

The Internet of Things (IoT) is an interconnected system of physical items that are distinctively addressable and has various degrees of sensing and processing capabilities. Its main feature is to make the devices communicate through the internet as their common platform. The broad areas which are covered by IoT are the industrial sector, health sector, smart cities, security, agriculture, and emergencies among many others.

AI-Enabled IoT

AI is considered the science of agent design. By associating intelligence with the agent's behavior, a human-like mind without a human-like brain is acknowledged [2]. When the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) is implied for a city, then the city is considered to be smart. Many practical innovations have been produced in such cities in almost all sectors [3]. By utilizing all the city resources, the quality of life is improved and operational cost is reduced. The major role of IoT is connecting the various digital and analog devices through the Internet with its unique identifier while the role of AI is to focus on devices making decisions through learning from their data and experience [4].

POTENTIAL USE CASES OF AI AND IOT IN SMART CITIES

Smart Home

The smart home is one of the inevitable components of a smart city. Gartner defines a smart home as "Smart Homes consist of a set of devices and services that are connected to each other and to the internet and can automatically respond to pre-set rules, be remotely accessed and managed by mobile apps or a browser, and send alerts or messages to the user(s) [5]."

IoT facilitates the interaction between connected household equipment and people, and integrating AI with it makes this interaction intelligent and smart. Industry giants like Amazon, Samsung, Apple, Google, *etc.* have leveraged this to offer smart home platforms that integrate well with third-party applications. Fig. (1) illustrates how IoT can be set up from the rooftop to the garage, which facilitates reduced carbon emission, energy consumption, and cost benefits along with other benefits. IoT environment is set up using a variety of sensors like motion, hydraulic, chemical, ambient, electric, identification, biosensors, and presence used for detecting motion, measuring liquid level and flow, physical quantities, electrical power, near field communication, health parameters, and presence of objects, respectively.

AI and IoT are combined together to provide effective solutions to daily household routines by collecting and analysing data through sensors and interactions [6]; for example, water leakage prevention, temperature control in rooms and water tanks, water usage monitoring, air quality control, automatic on/off of fans, lights, and air conditioners, recording of TV programs of user's taste, detection of trespassers, people behaviour monitoring, *etc.* As a smartphone is an essential component of a smart home, the user can easily monitor from a

Analysis of RGB Depth Sensors on Fashion Dataset for Virtual Trial Room Implementation

Sonali Mahendra Kothari^{1,*}, Vijayshri Nitin Khedkar¹, Rahul Jadhav¹ and Madhumita Bawiskar¹

¹ Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India

Abstract: This paper presents a Virtual Trial Room software using Augmented Reality which allows the user to wear clothes virtually by superimposing 3d clothes over the user. These sensors are valued particularly for robotics or computer vision applications because of their low cost and their ability to measure distances at a high frame rate. In November 2010, the Kinect v1 (Microsoft) release encouraged the use of Red Green Blue (RGB)-D cameras, and in July 2014, a second version of the sensor was launched. Because high-frequency point nuclei can be obtained from an observed picture, users can imagine employing these sensors to fulfill 3D acquisition requirements. However, certain issues such as the adequacy and accuracy of RGB-D cameras in close-range 3D modeling have to be addressed owing to the technology involved. The quality of the data obtained therefore constitutes an important dimension. In this study, the usage of the current sensor Kinect v2 is explored in the three-dimensional reconstruction of tiny objects. The advantages and problems of Kinect v2 are addressed in the first section and then photogrammetry versions are presented after an accurate evaluation of the generated models.

Keywords: Augmented reality, Depth Sensor, Fashion Recommendation, IOT, Virtual reality, Virtual trial room.

INTRODUCTION

As Vivienne Westwood has said, "fashion is very essential. It is enhanced life and worth doing well, like everything that brings joy". In the 14th century, there were the first changes in fashion in European culture; subsequently, the number of fashion designers across the globe grew because of the industrial revolution [1]. In the 21st century, every year fashion trends change. Trends in fashion influence

^{*} **Corresponding author Sonali Mahendra Kothari:** Department of Computer Science and Engineering, Symbiosis Institute of Technology, Symbiosis International [Deemed University], Maharashtra, India; E-mail: sonali.kothari@sitpune.edu.in

local culture and climate change; yet these trend communities tend to be the world's leading fashion industry [2]. Unattended future popularity in fashion pictures must be predicted by a training prediction model to represent their trends throughout time [3].

The number of shopping malls owing to fast urbanisation is rapidly increasing and apparels is one of the best-known categories in shopping malls. The experience of cloth buying in shopping centres is mostly based on the availability of clothing that fit trends and hassle-free cloth testing. At the present time, in shopping centres or clothes stores, the trial of clothes is time-consuming because clients need to be in long queues and wait for their turn while they wear all the selected clothing and if they're not satisfied with the testing of selected clothes, they need to wait again in a queue with new clothes. The virtual test room is an Android application, which enables clients to choose clothing from the catalogue and try out to chosen garments on the virtual 2D/3D model [4]. The goal of the virtual test room is to maximise the accurate depiction and adjustment of the look and the customer preferences on the screen by overlaying the modelled clothes with the figure of the customer [5]. Two factors are thus necessary: information on the client's body size ("height, neck, breast, waist, hips, and arm measurement"), and the size of the chosen item of clothing, which should be taken into consideration. However, varying on whether it deals with 2D or 3D modelling, the method for adapting the garment to customer's body figure is different [6].

Due to the development in digitization and online platforms, Retail has undergone seismic changes over recent years [7]. A study claimed that the pace of change made possible *via* new technologies is accelerating [8]. One such technology, which "provides the shopping experience with the potential to revolutionise". By overlaying virtual components directly in the real-time environment, Augmented Reality (AR) may improve sensory impressions for customers [9].

Internet of Things (IoT)

IoT is a system of internet-based linked gadgets. It includes a desktop, a mobile, a laptop, mechanical equipment, sensors, household appliances, and automobiles. These gadgets are intended to exchange data *via* the internet with other devices. Many of the things around us are on the network in one way or another under the Internet of Things (IoT) concept. The new problem in which information and communication systems are invisibly integrated into the environment around would be tackled through Radio Frequency Identification (RFID) and sensor network technology. This leads to huge quantities of data being kept in a seamless, efficient, and easy-to-understand manner, processed and displayed. This model consists of goods and services that are supplied in a way such as

Analysis of RGB

Research Trends in Artificial Intelligence: Internet of Things 205

conventional goods. With monitoring, storage, analytical tools, visualisation platforms and customer delivery, cloud computing may offer a virtual infrastructure for such utilities. Cloud computing's cost-based approach allows end-to-end service delivery, enabling companies and consumers to access apps from anywhere. It is an essential component of smart connectivity and context-friendly computing using network resources. The increasing availability of wireless internet connectivity such as Wi-Fi and 4G-LTE already demonstrates a development toward ubiquitous communication and information networks [10].

Components of IoT

However, all complete IoT systems are the same in that they represent the integration of six distinct components: sensors/devices, gateway, connectivity, data processing, analytics, and a user interface. Some of the major elements are required. The components are shown in Fig. (1) [10].



Fig. (1). Components of IOT.

• Sensor

The sensor is linked to the Internet of Things device to the outside world or a person. As the name implies, it detects changes and transmits data to the cloud for processing, as the name implies. Pressure sensors, temperature sensors, and light intensity detectors are examples of sensors that constantly gather data from the environment and send it to the next layer.

SUBJECT INDEX

A

Active stereo vision (ASV) 208, 209 Activities, plant photosynthetic 10 Adaptive neuro-fuzzy inference system 21 Agricultural 1, 12, 18, 21, 54, 61, 116 applications 1, 54 machinery 12 monitoring 116 systems 18, 21, 61 Agriculture 13, 16, 18, 19, 21, 22, 27, 28, 54 applications 27, 28 automation 18, 19 industry 13, 16, 21, 22, 54 system 28 AI-based 39, 194, 195 parking 195 smart parking system 194 systems 39 AI-based sentiment analysis 156 systems 156 technologies 156 AI-powered 13, 104, 113, 115 autonomous vehicles 115 cameras and drones 13 IoT devices 113 IoT systems 104 AI-trained devices 30, 74 AIoT 44, 47 businesses 44 in smart healthcare 47 AIoT applications 42, 46, 47 innovative 42 limitless 47 Air quality sensors 9 Algorithms 109, 150, 190, 191, 192, 194, 198 artificial intelligence 109 genetic 192, 194 in smart healthcare 191 machine-learning classification 150 neural network 190, 198 Amazon shoe datasets 208

Amazon's Alexa 98, 114 Apollo program 125 Apple's SIRI 98 Application programming interface (API) 214 Artificial 18, 19, 21, 43, 194, 197 immune systems (AIS) 194 intelligence machines 43 neural networks (ANN) 18, 19, 21, 194, 197 Aspect-based sentiment analysis (ABSA) 155 Atmospheric pressure sensors 9 Attacks, cyber security 96 Automated 14, 47 machinery 14 vehicles 47 Automatic 15, 18, 29, 64 crop protection 29 irrigation systems 15 machine changes 18 watering system 64 Automation 26, 27, 37, 38, 45, 167, 189 for green houses 38 greenhouse 27, 37 industrial 45 industry 26, 167 intelligent 189 Autonomous driving 167, 168, 169, 170, 172, 183, 184 systems 170 vehicles 183 Autonomous harvesting systems 60

С

Cameras, sensing 208 Cardiovascular risk prediction 192 Cloud 45, 66, 193 database system 193 server 66 storage system 45 Cognitive psychology 157 Communication 120, 124, 152, 159, 204

222 Research Trends in Artificial Intelligence: Internet of Things

systems 204 technologies 120, 124, 152, 159 Community 143, 151 development work 151 evolution analysis 143 Computer vision 44, 54, 56, 57, 58, 73, 169, 172, 175, 181, 195, 200, 203, 207 algorithms 54, 169 applications 203 technologies 73 Conditions 7, 11, 19, 22, 27, 30, 59, 64, 74, 76, 82, 102, 116, 145, 162, 168, 192, 214 cardiac 192 chronic 116 climatic 19 environmental 7, 11, 102 meteorological 59 Connectivity 125, 205 cloud-based 125 wireless internet 205 Convolution neural network (CNN) 19, 60, 167, 172, 173, 174, 176, 177, 184, 194, 197 COVID-19 150, 151, 152, 156, 158, 161, 163, 164, 193 crisis 150, 156, 164 infection 193 lockdown 151 situation 193 Crop(s) 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 24, 27, 28, 34, 37, 38, 50, 54, 55, 56, 59, 60, 63, 64, 65, 66, 70, 71, 72, 73, 74, 75, 77, 108, 109 and soil monitoring 54 consumable 34 cultivation 37 damaged 18 devastate 3 diseases 5, 19, 75 forecast 4, 13 health monitoring systems 72 irrigation 56, 60 maize 64 management systems 34 mapping 6 monitoring 13, 14, 27, 38, 63, 73 nutrition enhancements 24 oil 50 plant 6

producing healthy 18 protecting 28 rice 66 rotation 72, 75 Cyber 50, 96, 199 -security applications 50 security assaults 96 terrorism 199

D

Deep neural networks 44, 155 Deficit irrigation methods 62 Devices 1, 2, 4, 7, 19, 25, 43, 45, 49, 50, 97, 106, 107, 109, 114, 139, 171, 188, 190, 193, 195, 206 consumer-linked 25 digital 49 infected 107 intelligent 19 mass storage 139 potable monitoring 190 visual sensing 171 Diabetes 80, 93 gestational 80 mellitus 80, 93 Diseases 2, 3, 9, 14, 29, 30, 34, 60, 61, 71, 75, 77, 80, 81, 93, 192 cardiovascular 192 heart 81 life-threatening 93 metabolic 80 rheumatic 192

E

Energy 2, 31, 62, 101, 107, 117, 186, 188, 189, 193, 196, 198 conserve 117 conserving 107 conservation 198 consumption 2, 107, 188, 196 demand 107 renewable 62 solar 31 Ensemble-based feature selection techniques 81

Kothari et al.

Subject Index

Fabric luminance 210

F

soil surface 59

Ι

Facets 64, 77, 155 semantic relevance 155 Facial expression analysis 157 Farm 20, 209 automation techniques 20 phenotyping 209 Farmers 1, 2, 4, 5, 7, 11, 12, 13, 14, 16, 19, 21, 22, 23, 28, 35, 38, 54, 55, 71, 72 aids 71, 72 contemporary 21 marginal 22 Farming 1, 2, 3, 4, 5, 9, 10, 11, 21, 22, 23, 24, 33, 35, 37, 70, 74, 75, 77 digital 2 greenhouse 37 industry 22, 23, 24 machine-learning 70 practices, labor-intensive 74 Farming operations 1, 7, 12, 25, 55 labor-intensive 55 Food supply chain 35 Forecast 57, 65 production 65 soil moisture 57 Forecasting energy consumption 196 Fuel 3, 9, 115 conserving 9 consumption 115

G

Gaussian 180, 197 blur method 180 radial basis function 197 GPS 5, 6, 10, 115 devices 115 sensors 10 technology 5, 6 Growth 5, 18, 26, 39, 70, 136, 139 intelligent agricultural 39

H

Herbicides, field spraying 31 Home security system 190 Humidity 4, 9, 59 sensors 4, 9 Image 5, 60, 69, 70, 124, 167, 172, 176, 179, 181 processing 5, 60, 69, 70, 124, 167, 172, 176, 179, 181 recognition methods 167 sensor 176 Image processing algorithms 5, 167, 171 deep learning-based 171 Industries 9, 11, 13, 18, 20, 31, 43, 44, 45, 46, 54, 55, 56, 77, 102, 104, 118, 120, 121, 122, 124, 125, 167 agricultural 11, 13, 18, 55, 77 automobile 167 dynamic 20 marine 9 Infrared thermography 10 Intelligence 25, 43, 44, 188 computational 25 Intelligent 20, 26, 32, 43, 58, 64, 96, 114, 115 agricultural automation 32 farming 26 irrigation 58 irrigation monitoring smart system 64 machines 20, 43 traffic management 114 transportation systems 96, 114, 115 Interactive cultivation 70 sensor system 70 IoT 1, 4, 7, 16, 18, 25, 44, 93, 108, 113, 196 industrial 25, 44, 196 -powered irrigation systems 108 smart agricultural 25 technologies 1, 4, 7, 16, 18, 93, 108, 113 IoT-based 25, 46, 56, 110, 192 crop irrigation system 56 leak detection systems 110 network 192 products 46 sensors technology 25 system for crop irrigation 56 IoT devices 12, 43, 44, 46, 93, 96, 97, 102, 103, 104, 105, 106, 110, 116, 199 connected 46 IoT in smart 193, 194, 195 healthcare 193 transport 194, 195

224 Research Trends in Artificial Intelligence: Internet of Things

IoT sensors 10, 93, 116, 117, 170 in smart farming 10 Irrigation 1, 2, 3, 4, 5, 8, 9, 15, 16, 26, 30, 64, 65, 74, 77, 108, 109 agricultural 77 automate 30, 74 automation methods 74 sensor 64, 65 Irrigation systems 15, 55, 60, 62, 108 autonomous 15, 62 intelligent 60

L

LiDAR technology 168

Μ

Machine intelligence in agriculture 54 Machine learning 2, 4, 5, 6, 7, 20, 54, 55, 56, 57, 58, 81, 85, 98, 135, 146, 147, 148, 156, 163, 164, 179, 208 algorithms 2, 4, 5, 6, 7, 54, 57, 81, 85, 98, 156, 163, 164 applications 57, 58 deep 55 methods 56 process 20 techniques 56, 135, 146, 147, 148, 179, 208 Mining, social media sentiment 159 Multi 9, 66 -rotor drone 66 -weather sensors 9

Ν

Natural language processing (NLP) 51, 98, 147, 150, 156, 160, 162, 190 Network traffic 97 Neural networks 104, 111, 155, 169, 170, 171, 173, 174, 177, 192, 195, 196 attention-based 155 Neuro-fuzzy systems 21 Neutron probe method 8 NLP 155, 161 algorithms 161 processes 155 Noise distortion 180 Non-imaging sensor systems 10 Nutrition management 72

0

Ontology 138, 140, 141, 142
-based automatic semantic Web service synthesis technique 141
construction 142
language (OWL) 138, 141, 142
learning 140
Ontology-based annotation 140
techniques 140
OpenCV 210, 214
and TensorFlow lite technologies 210
Optical camera communication technique 167

P

Pest and disease sensors 10 Pest infestations 4, 14, 35, 38, 74 insect 35 Plant disease sensors 9

R

Radial basis function (RBF) 197 Real-time 47, 126 health systems (RTHS) 47 monitoring 126 Reducing water waste 109

S

Sensors 1, 2, 4, 7, 8, 9, 10, 12, 14, 27, 28, 36, 43, 57, 58, 61, 110, 130, 189, 197, 203, 205, 208, 209, 213, 215 accelerometer 189 agricultural 27, 36 camera 215 crop health monitoring 4 electrochemical 10 motion 28 networks 61 robotic 197 SkySqurrel technologies 72 Smart agriculture 3, 14, 25, 26, 37, 50, 64 monitoring system 25 sensors 26 technologies 37 Smart building applications 49 Smart city 186, 198, 199

Subject Index

applications 198

Research Trends in Artificial Intelligence: Internet of Things 225

V

Vehicle optical camera communication (VOCC) 175 Video management systems (VMS) 48 Virtual reality (VR) 122, 123, 203, 207

W

Waste 1, 4, 5, 7, 10, 11, 12, 13, 22, 100, 101, 109, 117 management systems 101 resource 4, 5 Water 3, 5, 8, 9, 10, 11, 12, 15, 28, 31, 34, 36, 74, 77, 96, 108, 109, 110, 188, 197, 198 conservation 15 consumption of 198 issues 31 leakage prevention 188 leaks 198 management 3, 96, 108, 110, 197 saving 31, 74 tanks 188 wastage 198 waste 77, 109, 197 Water flow 198 sensors 198 Wearable(s) 50, 93, 116, 193, 194 devices 50, 93 stress-monitoring 193 Weather 8, 12, 13, 36, 37, 55, 56, 61, 108, 109, 169, 170, 195 conditions 12, 13, 36, 55, 61, 108, 109, 169, 170, 195 forecasts 56 monitoring system 37 sensors 8 Web service composition 141 Wrapper techniques 86

construction 199 development 186 SMOTE 82, 83, 84, 91 data 84 method 83 technique 82, 91 Social 152, 157, 159 network analysis (SNA) 152 networking programs 157 networking services 159 Soil 3, 7, 8, 10, 20, 30, 34, 54, 60, 63, 68, 108, 109 degradation 3 environment 30 fertility 20, 68 nutrients 10 productivity 20 sensors 7, 8, 63 survey technique 34 treatment 54 type 34, 108, 109 water balance (SWB) 60 Soil moisture 1, 4, 8, 13, 36, 55, 56, 57, 58, 61, 65, 70, 108 data 108 futuristic 56 measuring 8 Subsurface drip irrigation (SDI) 31 Support vector machines (SVM) 81, 90, 91, 160, 191, 196, 197, 198

Т

Technologies 5, 18, 21, 35, 49, 55, 68, 98 artificial intelligence 18, 35, 55 blockchain 5 cloud computing 68 contemporary deep learning 49 sensor 98 soft computing 21 Temporal convolution network (TCN) 64

U

Ultrasonic and water flow sensors 198



Sonali Mahendra Kothari

Prof. Sonali Mahendra Kothari obtained her Ph.D. in computer engineering specialization from Sant Gadge Baba Amravati University, Amravati, India. Currently, she is working as associate professor in the Department of Computer Science and Engineering at Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, India. She has more than 20 years of teaching and research experience. She is a senior member of IEEE, and a life member of ISTE. She has worked as reviewer for various international conferences and guest reviewer for Elsevier and IGI-Global journals. She has received the best paper award in the international conference twice for her research work in the field of malware analysis. She has published a number of research articles in various international/national conferences and journals. She has authored 2 books, filed a patent and 2 copyrights. She has guided more than 100 undergraduate students and 8 postgraduate students for their research work. Her recent research interests include cyber security, precision agriculture using IoT and machine learning. She has delivered many talks in various educational institutes at national level.



Vijayshri Nitin Khedkar

Prof. Vijayshri Nitin Khedkar is a member of various professional bodies. She is a senior member of IEEE and a member of IEEE Women in Engineering Society. Her research interests are in the field of artificial intelligence, machine learning and internet of things. She did Ph.D. in computer science & engineering from Symbiosis International University, Pune, India. She is currently working as an assistant professor in the Department of Computer Science and Engineering at Symbiosis International University, Pune, India. She has published a number of papers in the international journals and conference proceedings, published two patents and served as reviewer for few Scopus indexed journals. She has one major research project ongoing & funded by Symbiosis International University, India. Besides, she has completed three consultancy projects. She has played a vital role at organizing various international conferences, industry led hackathons, faculty development programs, etc. and mentored many national and international students by collaborating with various international researchers on different research projects.



Ujwala Kshirsagar

Prof. Ujwala Kshirsagar is serving as an associate professor in the Department of Electronics and TeleCommunication at Symbiosis International University, India since 2020. Before that, she was the professor and dean at H.V.P. M's College of Engineering and Technology, Amaravati, India since 2003. She completed her Ph.D. in VLSI Technology from Sant Gadge Baba Amravati University, Amravati, India. She is a distinguished academician skilled in VLSI and Embedded System Design and nano electronics manufacturing. She has completed 9 funding projects in the field of VLSI and nano electronics manufacturing sponsored by Govt. of India and Meity. She is the recipient of three national awards for outstanding research in advanced electronics manufacturing. She has published in a number of international journals including Scopus, Web of Science and UGC refereed journal with three best paper awards. She has also published six patents and one book with the international publisher. She has served as a resource person in many workshops, STTPs and conferences at national and international level. She also delivered many talks on Future Trends in Technology", "VLSI Technology and its Applications" and "Futuristic technology for Industry 4.0" to various engineering colleges throughout India



Gitanjali Rahul Shinde

Prof. Gitanjali Rahul Shinde is presently working as head & associate professor in the Department of Computer Science & Engineering (AI & ML), Vishwakarma Institute of Information Technology, Pune, India. She did Ph.D. in wireless communication from CMI, Aalborg University, Copenhagen, Denmark on Research Problem Statement "Cluster Framework for Internet of People, Things and Services" – Ph. D awarded on 8th May 2018. She received the research funding for the project "Lightweight group authentication for IoT" by SPPU, Pune. She has presented a research article in the World Wireless Research Forum (WWRF) meeting, Beijing China. She has published a number of papers in national, international conferences and journals. She is the author of books with publishers Springer and CRC Taylor & Francis Group and she is also the editor of the books. Her book "Data Analytics for Pandemics A COVID 19 Case Study" has been awarded as the outstanding book of the year 2020.