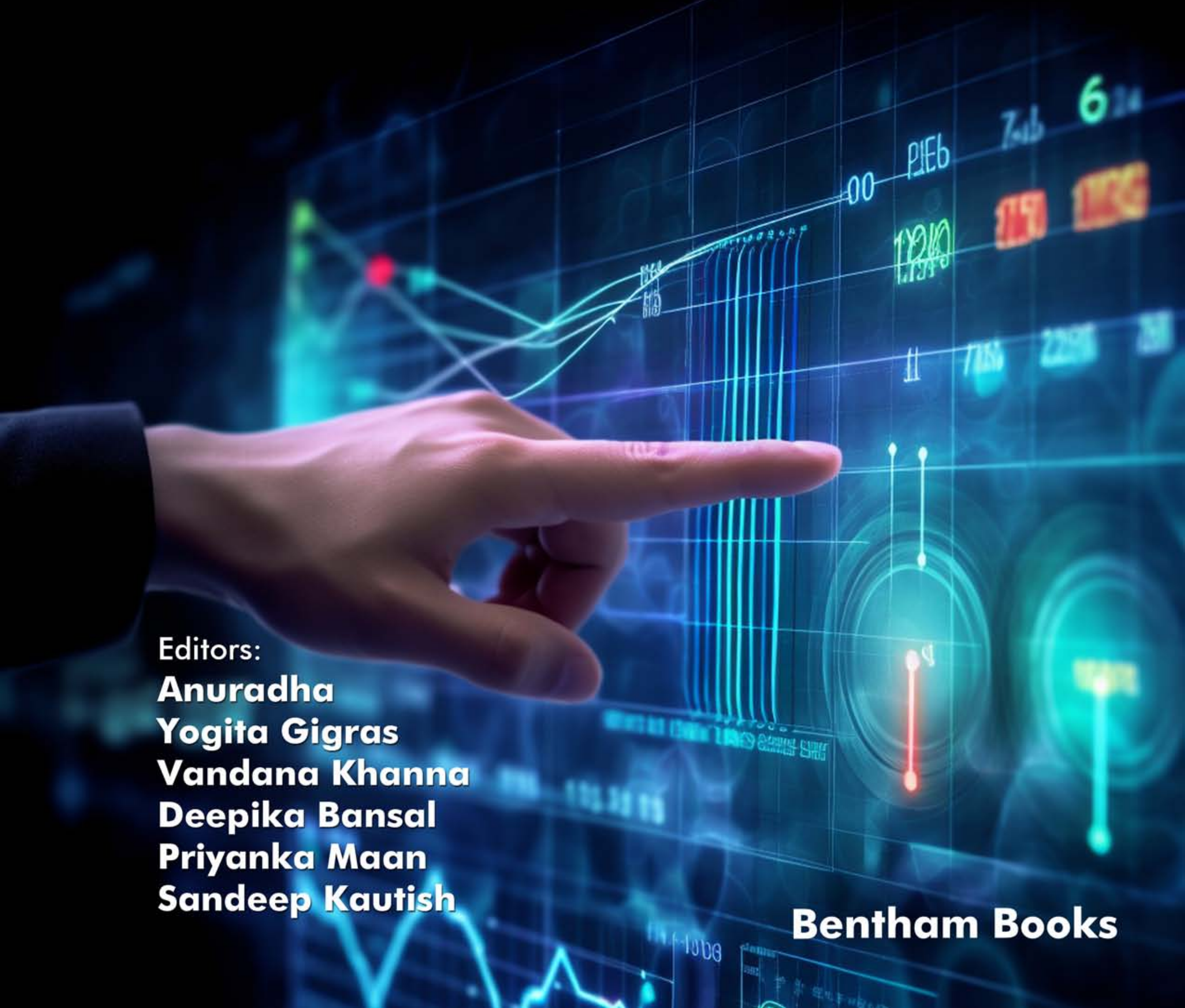
DATA ANALYTICS FOR IOT APPLICATIONS



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Bentham Books

Data Analytics for IoT Applications

(*Volume 1*)

Digitization and Automation for the 21st Century

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Data Analytics for IoT Applications

(Volume 1)

Digitization and Automation for the 21st Century

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ISBN (Online): 979-8-89881-270-6

ISBN (Print): 979-8-89881-271-3

ISBN (Paperback): 979-8-89881-272-0

Published by Bentham Science Publishers Pte. Ltd. Singapore, in collaboration with
Eureka Conferences, USA.

First published in 2025.

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BENTHAM SCIENCE

CONTENTS

PREFACE

The Digital Pillbox: Integrating AI, IoT, and Pharma Solutions (Part-II) explores the convergence of cutting-edge technologies shaping the future of healthcare and medication management. Building upon the foundation laid in Part I, this volume dives deeper into advanced topics such as robotic automation, smart pillboxes, ethical frameworks, and the integration of IoT across various pharmaceutical and healthcare platforms. It highlights futuristic trends, the societal impact of digital tools, and strategic approaches for building connected patient-centric systems. The chapters are authored by interdisciplinary experts who examine not only the technological benefits but also the ethical, regulatory, and operational challenges faced in real-world implementation. This book aims to serve as a comprehensive guide for healthcare professionals, technologists, researchers, and policymakers, providing insights into the potential of digital innovation to enhance patient outcomes, streamline care delivery, and transform global health systems. We hope this volume inspires thoughtful dialogue, practical integration, and sustained innovation in digital healthcare.

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CHAPTER 1

Optimizing Feed-Forward Neural Networks with Hybrid Particle Swarm and Salp Swarm Algorithm

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Abstract: The extraction of optimal parameters of Artificial Neural Networks (ANN) is a tedious task, as it requires continuous efforts. This process also leads to high cost and low efficiency. To overcome these problems, we have proposed a hybrid model of the Particle Swarm Optimization Algorithm (PSO) and Salp Swarm Algorithm (SSA), namely PSO-SSA, which combines three strategies, namely the Weighted Position Strategy, Adaptive Velocity, and Locality Pruning Strategy. To study the effectiveness of the proposed model, the model is applied to seven classification problems varying from low-dimensional to high-dimensional, namely, 3-digit XOR, Iris, Balloon, Breast Cancer, Heart, MicroMass, and Health News on Twitter. The extensive comparative study shows that our model performed best among other state-of-the-art techniques. The performance metrics used are convergence rate, classification accuracy, general performance, and Mean Square Error (MSE).

Keywords: Classification, Nature-inspired algorithm, Neural networks, Particle swarm optimization, Salp swarm algorithm, Training.

INTRODUCTION

Artificial Neural Networks (ANN), bioinspired by the neurons in the human brain, are conventional computational intelligence tools. They can perform tremendous parallel computations; therefore, their application domain ranges from solving classification and clustering to approximating function problems [1]. The classification problem involves two phases, training and testing. During ANN training, the data sets are randomly divided into training data sets and test data sets [2 - 4]. The training data sets build the classification model, which is then

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applied to the test data sets to predict the class label [5]. Training the ANN is an optimization problem in which we find the weights and biases to minimize the Minimum Square Error (MSE) [6]. Since the search space of ANN is complex, multimodal, and high-dimensional, therefore, training the ANN requires an effective optimization technique.

According to the state-of-the-art literature techniques, training of the ANN can be of two types, Deterministic and Stochastic. Deterministic training uses mathematical optimization techniques to train the ANN. If the test samples are compatible, the classification accuracy achieved by deterministic training remains the same consistently, *e.g.*, gradient-based [7] and back propagation [8]. These trainers demonstrate effective convergence; however, if the initial solution is near the local optima, it gets stuck and affects the quality. On the other hand, the stochastic techniques use metaheuristics to improve the solution quality by avoiding the local optima trap. They are also known as metaheuristic optimization algorithms. They are, nevertheless, slower than deterministic methods. These techniques sample multiple regions of the search space and have a high capability of achieving exploration and exploitation, *e.g.*, Particle Swarm Optimization (PSO) [9], Firefly Algorithm (FA) [10], Chameleon Swarm Algorithm (CSA) [11], Red Fox Algorithm (RFA) [12], Horse Optimization Algorithm [13], Bat Algorithm [14], Differential Evolution (DE) [15], Bacterial Foraging Algorithm [16], and many more.

Metaheuristic algorithms can successfully train ANNs due to the following characteristics: 1) They are global optimizers, 2) they have the ability to balance exploration and exploitation, 3) they can solve the nonlinear and multimodal problems due to their gradient-free behavior, and 4) they avoid local minima to a large extent due to their stochastic behavior [17, 18]. Each metaheuristic optimization algorithm has its advantages and disadvantages for training the ANN. FA helps optimize the weights of the ANN, though its convergence time is relatively higher [19]. CSA has been used for feature selection, which is an important step in the subsequent classification task using ANN [20]. It gives good convergence speed and accuracy and performs parallel search effectively, but it sometimes offers random solutions and is complicated. PSO is a simple- to-implement algorithm and takes less time in computations, but it has poor exploration ability [21]. Artificial Bee Colony Algorithm (ABC) and bacterial foraging algorithm have good global convergence against other optimization algorithms, but have a limited search space for initial solutions [22]. RFA and SSA are used to solve high-dimensional problems, but they have weak searchability. We can conclude that no optimization technique is capable of solving real-world problems (no-free lunch theorem) [23]. Many global optimizers were capable of optimizing neural networks by finding the weights and biases, though the convergence was not fast. Hence, there was a need to find the best optimal parameter values and ensure faster convergence in addition to exploration-exploitation balance. Some optimization algorithms from the literature got stuck in the local optima trap and led to premature convergence and higher computational costs. Also, there is no mention of the overfitting problem, which is the phenomenon where the algorithm gives the best performance on training data but poor performance on generalization [24]. It is the biggest challenge in the ANN optimization that hampers the quality of solutions. Metaheuristic algorithms can impact the performance of ANNs by addressing the overfitting problem.

The literature shows that there have been a lot of surveys using metaheuristic optimization algorithms to solve classification using neural networks. The various optimization algorithms have been applied and tested on feed-forward neural networks to prove their efficiency and reduce MSE [25]. The Arithmetic Optimization Algorithm has been used to optimize the weights in ANN by the authors [26]. The authors simulated the proposed algorithm by replacing healthy generation with improved indicators. This paper highlights the use of nature-inspired algorithms in improving the accuracy and performance of ANNs. The multi-objective grey wolf optimizer was used to train the network by selecting the optimal values as weights and biases between the layers [27]. The paper showed an integration of optimization algorithms and ANNs for complex systems and highlights the importance of optimization algorithms for achieving the right predictions. A thorough analysis of results showed good performance over other conventional algorithms. The biological neurons are imitated by training the artificial neural networks using cuckoo search with Levy flight behavior [28]. The algorithm demonstrated good convergence compared to other state-of-the-art algorithms and successfully classified the patterns. The neural network model was processed using the genetic algorithm [29] and used to predict accurate air temperature. The authors determined the optimal duration and resolution of the weather variable using the proposed model. The results were good, though the parameter settings were fixed and could not be changed.

In the same context, many variants of PSO have come up over the years to optimize artificial neural networks since PSO works on the current best and the global best solution, which results in a quality solution. It is relatively simple and efficiently solves real-world problems [30]. The hybrid of PSO and Gravitational Search Algorithm (GSA) was proposed by Mirjalili *et al*. [31]. The use of PSO bridled the slow searching speed of GSA, and the resultant hybrid trained the ANN model. The analysis proved that the PSO-GSA hybrid could solve the neural networks without getting trapped in local optima and with good convergence speed. Also, this paper showed the ability of nature-inspired algorithms to

CHAPTER 2

Interpretability *vs.* Efficiency in Application-Specific Analytics

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Abstract: Interpretability in machine learning models is explored in this systematic literature review. This review covers a wide range of topics, including healthcare, social media analysis, fake news detection, self-driving vehicles, *etc*. It examines the importance of interpretability in these domains and highlights the ethical implications associated with black box models. Moreover, the review discusses efforts made to understand and explain complex models using techniques and tools.

Through an analysis of selected research articles from the past decade, the review reveals the impact of interpretability on model performance and decision-making. It identifies highly interpretable models, moderately interpretable models, and black box models, along with their respective applications and outcomes. The review emphasizes the need for ongoing research to maintain a balance between accuracy and interpretability. This systematic literature review demonstrates that interpretability plays a crucial role in domains where accountability, trust, and transparency are paramount. Providing insights for future research, the review describes the benefits and challenges associated with interpretability in machine learning models.

Keywords: Artificial intelligence, Interpretable machine learning, Machine learning.

INTRODUCTION

The explainability of AI/ML models is gaining importance in the present-day scenario of high AI utilization. The majority of the time, the predicted output would be enough; however, sometimes, we need to know how the model reached

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the conclusion. This is where Explainable Artificial Intelligence models come in. They provide a means to understand how the model reached the outcome and a way to identify any bias or errors in the model.

Research Questions Tackled

The two research questions that are tackled in this review are:

- *RQ1: To what extent is research exploring the trade-off between model accuracy and interpretability in machine learning?*
- *RQ2: How does explainability affect accuracy?*

Contributions

A comprehensive overview of interpretable machine learning is presented in this literature review, which covers articles published between 2013 and 2023. A systematic analysis of various models, methodologies, and applications is provided, making it a valuable reference for researchers.

This review identifies and highlights key trends, such as the rise of highly interpretable models. It also highlights the significance of domain-specific interpretability and the growing emphasis on ethical considerations when developing and deploying models.

This review provides valuable insights to researchers by identifying limitations in existing studies and suggesting areas for further study. This will help them address challenges and increase the interpretability and applicability of ML models in real-world settings.

Here's how the rest of the paper unfolds:

Based on 141 selected articles, the systematic literature review analyzes interpretable machine learning models from 2013 to 2023 (May). The review begins with an insightful introduction, underlining the importance of transparency and justifying the decisions made by these models. Section 2 details the PRISMA methodology used for article selection, ensuring a rigorous search process.

Section 3 of the review explores highly interpretable, moderately interpretable, and black box models, providing insights into their characteristics and practical applications. Various scenarios are analyzed, guiding decision makers when accuracy outweighs interpretability.

In section 4, we identify limitations of some articles, including inconsistent evaluation metrics and possible biases. The future work will include standardized metrics and the development of techniques that cater to scenarios when accuracy is the primary concern, interpretability is the main priority, or when both are equally important.

The conclusion synthesizes key findings, highlighting the importance of addressing ethical and societal concerns related to interpretability. The review reinforces the potential of interpretable models, even outperforming black box models in some cases. It is a valuable resource for academicians, advancing the adoption of interpretable machine learning in the real world. By bridging the gap between transparency and high accuracy, this review contributes to the understanding and implementation of interpretable machine learning.

METHODOLOGY

The Elsevier, ACM, and IEEE Xplore databases were chosen for their high-quality and relevant papers. On the above-mentioned databases, the following keywords were searched: *"Interpretable Artificial Intelligence" or "Explainable Artificial Intelligence"*. In addition, the papers were filtered out using the time range of 2013-2023, but all of them were published during this timeframe, so the number of papers remained 1579. When the search was refined to include papers that contained Machine Learning Models, the number was reduced to 391. The number dropped further to 148 when accuracy was added to the advanced search option.

The selected articles from 2013 to 2023 indicate a noticeable increase in research attention towards the balance between accuracy and explainability. No articles were identified between 2013 and 2017. However, the number of articles steadily grew in subsequent years, with one article in 2018, four articles in 2019, and a significant increase in 2020, with 16 articles. The trend continued to rise in 2021, when 24 articles were included. The selection of articles for this review was guided by a PRISMA flowchart (Fig. **1**)

Notably, a substantial majority of the selected articles were published in the most recent years, with 65 articles in 2022 and 38 articles in 2023 (Fig. **2**).

CHAPTER 3

App-Based Digital Audiometer: Dhvanimitra

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Abstract: The growing number of children with hearing impairment underscores the urgent need for efficient and accessible screening and diagnosis methods for hearing impairment. Traditional audiometry, while being effective, relies on cumbersome equipment and lengthy testing procedures, hindering early detection and intervention. This paper introduces DhvaniMitra, a novel mobile application-based audiometer designed to simplify hearing health assessment.

Keywords: Audiogram, Audiometry, Digital equipment, Hearing loss, Machine Learning.

INTRODUCTION

The modern world is defined by the widespread use of these electronic devices since a significant portion of the global population depends on them for entertainment, work, or communication. Mobile technology has made life easier, but there are also health risks associated with it, especially when it comes to high-energy Electromagnetic Fields (EMFs) that these gadgets create. The growing prevalence of mobile phone use has made it more critical than ever to comprehend how exposure to electromagnetic fields affects hearing function. In 2023, India's rate of smartphone penetration stood at 71%, with projections indicating a rise to 96% by the year 2040. Mobile phones operate using radio frequency waves, which are transmitted and received within a frequency range of 800 to 2000 MHz, thereby potentially inducing both thermal and non-thermal effects on the human

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body [1]. A study conducted by Velayutham, involving 100 participants (53 men and 47 women), was aimed at determining if there is more loss of hearing in the dominant ear than the non-dominant ear. It was found that out of these 100 individuals, twenty-eight presented with an operational threshold greater than 20 dB at high frequencies due to radiofrequency radiation from mobile devices [2].

Kerekhanjanarong has conducted another study that involves a hundred students aged from 18 to 22 years. In this study, 9% of them experienced tinnitus, 7% said they felt like their ears were full, 6% complained of earache, while 5% had dizziness. The result from the study depicted that there was a positive relationship between the number of hours that these students use their mobile phones and the prevalence rate of hearing impairment among them [3]. A study conducted in 2021 in Indonesia showed that children between the ages of 15 and 18 years old experienced mild to moderate Noise-induced Hearing Loss (NIHL) if they used earphones often. The extent to which one's hearing was damaged depended on how much noise was generated by the earphones when they were being played, as well as exposure time and the time of usage [4]. A later study revealed in-ear headphones as the most potent of any kind in terms of causing hearing loss; they specifically caused an increase in hearing threshold by nine decibels leading to a permanent ear loss [5]. DhvaniMitra created in this research, offers a way for users to check their hearing patterns. It therefore uses high-frequency audiometry to scan one's sense of sound, hence revealing hidden symptoms about high-frequency hearing. Furthermore, the inclusion of machine learning algorithms makes it possible for the app to predict hearing outcomes and help individuals adequately decide on their hearing health.

LITERATURE REVIEW

Mustafa *et al.* (2023) [6] conducted a study where EEG signals were used to conduct audiometry. They used the Hughson-Westlake method to expose participants to random sounds that ranged from 10 dB to 110 dB in intensity and from 125 Hz to 12000 Hz in frequency. The electrical signals captured the human brain's response to these sounds, thus generating the initial EEG data for eliciting brain responses. Based on individual ear, a MATLAB graphical user interface was developed based on individual ear responses to the sound stimuli . The brain's response to these auditory stimuli was captured as electrical signals, forming the raw EEG data to elicit brain responses. The raw EEG data underwent preprocessing before being used to train machine learning models. To utilize the gathered real-world data, it was initially transformed into vectors and matrices employing the Count Vectorizer and TFIDF method. The study employed various classification algorithms, including Support Vector Machine, Light Gradient Boosting Machine, Decision Tree Classification, K-Nearest Neighbor, Naïve

Bayes, and Logistic Regression. The dataset was split into 67% for training and 33% for testing to achieve maximum accuracy during model evaluation.

As a result, audiograms were made separately for each ear, with ears identified by different colors on the graph – red for the right ear and blue for the left one. At the same time, sound stimuli evoked potentials were recorded with a 16-channel EEG system, supplemented with ROC curves built from different classifiers. Below are the performance outcomes of these classification algorithms.

Table 1. Performance results of machine learning classification algorithms with 16-channel EEG signals.

Algorithm	FP	TP	TN	FN	Recall (%)	Accuracy (%)	MSE	Precision (%)
LGBM	25	134	125	28	82.7	83.0	17.0	84.3
SVM	0	0	150	162	69.1	48.1	51.9	-
N. Bayes	8	10	142	152	6.2	48.7	51.3	55.6
k-NN	59	92	91	70	56.8	58.7	41.3	60.9
LR	25	53	125	109	32.7	57.1	42.9	67.9
RFC	17	81	133	81	50.0	68.6	31.4	82.7
DTC	20	112	130	50	0	77.6	22.4	84.8

According to the analysis of performance accuracy, LGBM (Light Gradient Boosting Machine) achieved the highest success rate at 83% as measured by the Area Under the Curve and Receiver Operating Characteristic (ROC) curves, as shown in Table **1**.

The study in 2019 by Zhao Yanxia *et al.* is one more instance where machine learning strategies have been applied to foreseeing listening loss [7]. The threshold shift in the hearing capability was assessed among 1,113 factory workers in China who were exposed to noise from the factory. To conduct this experiment, some Machine Learning Algorithms were employed including Neural Network Multilayer Perceptron, Support Vector Machine (SVM), Random Forest, and Adaptive Boosting. The author classified these models according to two important metrics: accuracy in the area under the ROC curve (AUC) and prediction accuracy. This means that the prediction accuracy fell within the range of 78.6% and 80.1% indicating that sound could be minimized for hearing evaluations and forecasts using these four methods. Tzong-Hann Yang *et al.* (2023) carried out an investigation that considered, with the consideration of a total of 1526 older-aged people, what might constitute an effective intervention: differing among 6 different types LGBM (Light Gradient Boosting Machine), LR (Logistic Regression); GBC (Gradient Boosting Classifier), SDTC (Snap Decision

CHAPTER 4

IoT-Based Approach for Chronic Obstructive Pulmonary Disease Detection

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Abstract: This research paper presents developments regarding Chronic Obstructive Pulmonary Disease (COPD), a lung condition characterized by symptoms that rapidly affect breathing capacity. Patients also suffer from restricted airflow. COPD is a challenge that humankind has faced on a global level. Various measures and studies have been undertaken to combat this respiratory condition. We leveraged studies on the integration of remote healthcare in managing lung diseases to draw insights while constructing our device. We aim to promote the use of the Internet of Things (IoT) to manage COPD effectively and concisely at home. Our device utilizes various sensors, such as a spirometer, to integrate technology for a beneficial purpose. It takes real-time lung capacity measurements, processes the information collected through sensors, and provides appropriate steps for management. Our goal is to implement remote monitoring for Chronic Obstructive Pulmonary Disease.

Keywords: Artificial intelligence, Chronic obstructive pulmonary disease, Cloud Computing, Internet of things, Remote monitoring, Respiratory disease, Sensor integration.

INTRODUCTION

The treatment and management of Chronic Obstructive Pulmonary Disease (COPD) have undergone improvements over time. IoT development has enabled data-driven approaches and techniques, leading to remote monitoring [1]. Today's healthcare advancements are largely due to the efficiency of remote monitoring healthcare systems. Due to airflow obstruction, COPD is the third leading cause of mortality worldwide. The number of people admitted for treatment places a significant burden on hospitals.

Regular checkups and therapies for the management of COPD have always been the main ways through which the patients were catered. Unfortunately, these

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techniques had a severe failure rate, and they lacked the personalized effects that are a crucial component for managing this particular lung condition, simply because the severity and the divergence of symptom ranges in patients differed [2].

By real-time monitoring systems and analysis of the data, a more comprehensive treatment can be built that caters to the needs of the individuals. This device takes into account various factors like FEV1, FVC, age, gender, smoking history, and much more. Based on the ongoing inputs, real-time analysis is done, which prompts the users for apt interventions if needed. This also helps in reducing the number of days spent in the hospital, thereby providing more relief and efficiency with the management of COPD in the comfort of home.

The real-time data that is generated by the Internet of Things (IoT) can be monitored by machine learning algorithms or artificial intelligence. These handy tools help in making the right analysis even when a massive amount of data has already been produced. There can be customized recommendations based on the data submitted by the patient. These recommendations can include changing the course of treatment and suggesting different sets of therapies and lifestyle changes to reduce risks and improve the overall health of the patient.

The studies done on COPD, including the diverse set of research papers, were thoroughly read to use the Internet of Things to its highest potential. The approach that drastically reduced hospital admissions and ER visits was a remote monitoring system called tele-monitoring, which was especially built for chronic illnesses. Further advancements led to the integration of IoT, machine learning, and artificial intelligence, which improved accuracy and made tailored treatment programs possible for patients [3]. The usefulness and clinical implications can be understood by the work in this research paper.

RELATED WORK

A lot of research has been carried out on the application of IoT tools in healthcare, particularly for dealing with chronic conditions such as COPD. This is proved by many clinical trials, which indicate that IoT could be applied to diagnosis and management as well as monitoring patients.

Telemonitoring technology and its relationship to COPD management were the subject of a landmark analysis. Emergency room visits were reduced by 15% and hospitalization rates fell by more than 25% in this group ($p < 0.05$). Also, they discovered improvement in their subjective quality of life, with a mean difference of 4.3 with a 95% CI of 2.1-6.5, indicating that telemonitoring may have an impact on the use of healthcare while preserving or enhancing patient care [4].

Research on wearable technology in telehealth healthcare indicates increasing utilization of Wearable Internet of Things, and IoT devices, in containing the spread of chronic diseases. It is also a fact that due consideration was given to patient compliance, data accuracy, and integration into the existing healthcare system in this study; the focus being mainly on technology developments. Seventy percent of users in a survey reported that the technology improved the ease and accuracy of health monitoring [5]. This thus manifests how these gadgets have immense potential to dramatically revolutionize the whole paradigm of treating chronic diseases.

Another project aimed to design a proof-of-concept IoT-based health monitoring system using Arduino that recorded the heart rate and body temperature of the user. The data is retrieved remotely *via* a cloud server from the wearable device, thus showing one of the applications of IoT in in-home medical care facilities. It would enable the medical professionals to determine remotely the type of problems the patients would be facing, hence increasing the efficacy and caliber of care provided [6]. The research into tele-home healthcare wearable technology indicates that wearable IoT devices are increasingly utilized in managing ailments. The research addressed issues such as data accuracy, patient adherence, and integration with existing healthcare systems, all from a technological improvement perspective. As shown by 70% of users who reported enhanced convenience and precision of health monitoring, wearable technology has the potential to completely transform the way chronic health conditions are managed.

According to a comprehensive review of medication adherence in COPD patients, those who adhered to their treatment programs had a reduction in severe exacerbations by 50%. Adherence reduced both the frequency and severity of COPD exacerbations. Conversely, each nonadherent COPD patient led to an increase of $1000 in annual healthcare utilization costs and associated expenses. This shows the substantial cost and health benefits of ensuring that patients use their medicine correctly [7]. Yet another investigation was dedicated to IoT and machine learning, which are of concern in the field of pulmonology and critical care medicine. This research has proved that custom treatment planning is possible, with a 30% improvement in diagnostic accuracy for diseases such as COPD when machine learning algorithms are integrated into IoT devices. Thus, using IoT combined with AI will enable more precise and personalized healthcare interventions and thus better patient outcomes.

With research concerning machine learning-based diagnostic biomarkers for COPD, there has been a new approach to the diagnosis and management of the disease. Such biomarkers, being peculiar to COPD only, can be easily recognized through Internet-of-Things-enabled gadgets. The use of this novel method

CHAPTER 5

IoT-based Facial Recognition Door Lock System

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Abstract: This research paper talks about the development of an innovative IoT-based smart door lock that also uses facial recognition, Internet of Things (IoT) integration, and the ESP32-CAM microcontroller to increase home security. As locks continue to evolve with more new features, the use of IoT is increasing and enhancing the security and usability. ESP32-CAM was selected for this project because of its built-in Wi-Fi connectivity and camera, which render it exceptionally suited for creating a smart lock system that is able to not only recognize the saved faces but also alert the user if there is an intruder. When compared to other microcontrollers like Raspberry Pi, the ESP32-CAM offers many more advantages, including enhanced security features, a user-friendly interface, and a lower cost, and much more in initial price. This paper also compares and talks about already existing facial recognition-based door locks, providing a detailed analysis of their plus points and limitations to understand the current state of the technology. The research also provides a detailed breakdown including the system's development process, selection of components for the device, and compilation of hardware components for the implementation of the model, The paper also includes the algorithms and user interface design. In this paper, you'll see how each component works, its usage, and how each component works together to ensure reliable and accurate facial recognition. Also, model testing was done to get the device's performance in a number of different conditions and usage areas. The results of these tests show that ESP32-CAM based smart door lock is a good and powerful solution and it is also cost-effective, offering good amount of savings compared to other smart lock systems in the market. This paper highlights how the project talks about some of the common security problems associated with the old locking system. By offering a more accessible and reliable alternative, this smart lock system has the potential to revolutionize home security. The integration of advanced facial recognition technology with IoT makes the home door lock system a more secure and user-friendly approach to home access control.

Keywords: Affordable solution, AI (Artificial Intelligence), Cost-effective, ESP32-CAM microcontroller, Facial recognition technology, Home security, Intelligent door lock, IoT (Internet of Things), Reliable alternative, Smart door lock system, Smart home systems, Traditional locks, User-friendly, Wi-Fi.

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INTRODUCTION

Home security is evolving every day with the introduction of the Internet of Things (IoT), leading to more demand for smart door systems that can recognize faces. In the past, locks were only based on physical keys, cards, fingerprints, and PIN codes. However, with advanced technology offering devices such as the ESP32-CAM microcontroller, it has now made it possible to make more affordable smart doors. These systems now also provide features such as mask detection, enhancing their ability to keep homes secure. Smart lock provides features like unlocking the lock with your smartphone with the help of IoT. These IoT-based models are connected to the local network and provide access to the device remotely, ensuring efficient battery usage and good connectivity. While earlier versions of smart locks had some security challenges, recent advancements have made them much more dependable and secure. ESP32-CAM is a much better option for these because it combines strong security features with a small amount, offering a more cost-effective alternative to options like the Raspberry Pi [1] [2]. This study is centred on developing a smart door system that uses ESP32-CAM for facial recognition with a built-in camera, trying to increase home security such that it is both affordable and user-friendly. We have also compared ESP32-CAM with the Raspberry Pi and a few other models; the purpose of the research is to compare and understand the best option for smart door locks to make a more affordable and friendly model [3]. The literature review in this paper is divided into three main sections: Methodology, which explains the research approach; System Design, which explains in detail the construction and integration of the system's components; and User Data Collection, which discusses how user data is gathered and stored to use the device for further usage. After exploring all these areas, the paper discusses the implementation of the ESP32-CAM-based smart door system, present the results obtained by testing the facial recognition models, a conclusion, and future plans about the project, and also the potential impact of this project on home security.

LITERATURE REVIEW

There have been studies on understanding how facial recognition door lock systems are developed. Ikponmwosa (2023) and Yatmono (2022) used the Raspberry Pi module and a camera to capture and recognize faces [2] [3]. Ikponmwosa's asystem performed well, with a 100% success rate when conditions were just right [2]. Then, Irjanto (2020) and Nurindini (2023), who focused on security, came up with another model. They achieved a 97.5% accuracy rate using the CNNnet method, and then 96% after Nurindini added mask detection for COVID-19 safety [4]. Table **1** presents the literature review in a tabular format.

Various advanced technologies, including the Internet of Things (IoT), machine learning, and computer vision, are utilized to enhance security and improve the overall user experience. Techniques such as Haar Cascades, Local Binary Patterns (LBP), and Eigenfaces are widely employed for face detection and recognition tasks. Haar Cascades is favored for its ability to quickly detect faces, offering fast processing times. LBP is effective in capturing texture information, which, when combined with other methods, enhances the system's accuracy. Eigenfaces, which relies on Principal Component Analysis (PCA), extracts critical features from facial images, facilitating accurate identification and recognition of individuals.

Table 1. Summary of literature review.

Reference	Face Detection Algorithm	Methodology	Limitation
Ikponmwosa (2023) [2]	Local Binary Patterns (LBP) algorithm	Raspberry Pi module & camera module	100% success rate
Yatmono (2022) [3]	Local Binary Patterns (LBP) combined with a Stacked Autoencoder (SAE)	ESP32-CAM Microcontroller & Camera Module	99.05% success rate
Irjanto (2020) [4]	CNN Alexnet	Raspberry Pi module & camera module	97.5% accuracy
Nurindini (2023) [4]	Viola-Jones Algorithm	Integrated Mask detection along with facial recognition	98% accuracy

The ESP32-CAM is a low-cost microcontroller with a camera, perfect for IoT projects. One common application is facial recognition connected with an electric door lock in IoT systems. The system captures pictures with the ESP32-CAM and saves them to an SD card, comparing the images with a list of authorized faces to accept or reject the person. OpenCV is also used for this task. Some apps even connect wirelessly to a mobile device to remotely unlock the house. However, challenges come up with these systems sometimes, like when intruders try to trick them using photos or videos (spoofing). To tackle this, more advanced techniques like 3D face recognition and liveness detection are being developed. Issues like lighting and facial changes can affect the system's accuracy, but infrared cameras and advanced algorithms can help smooth these problems out. Combining facial recognition with other biometric methods or IoT devices increases both safety and convenience.

METHODOLOGY

The high-resolution camera captures clear and detailed images of individuals' faces, serving as the input device for the facial recognition system [1]. The microcontroller, acting as the processing unit, receives input from the camera,

CHAPTER 6

The Privacy Paradox in the Age of Information: Issues and Challenges of Data Protection

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Abstract: With the proliferation of the digital era, concerns relating to data privacy have emerged with complex implications impacting not just individuals but society at large. In this chapter, the composite aspects and difficulties related to data privacy in India have been analysed. The chapter has been further categorized into parts for a better understanding of the subject. Firstly, it deals with data in general and "Data Protection", and secondly, the data is divided into two types, namely, "Personal Data" (PD), *i.e.*, data with personally identifiable information (PII), and "Non-Personal Data" (NPD), *i.e.*, data without PII. A framework for the governance of NPD is also suggested by the author, considering that there is no mention of it in the DPDP Act, 2023. Lastly, conclusions and suggestions are presented at the end.

Keywords: Data Breaches, Data Fiduciary, Data Principal, Data Privacy, Digital economy, Governance, Legal framework, Legislation, Non-Personal Data (NPD), Personal Data (PD), Policy, Regulatory framework.

DATA – IN GENERAL: AN INTRODUCTION

'The Data can serve as the stones that enable one to cross the river.'- Deng Xiaoping.

The buzzword for various industrialists, governments, academicians, researchers, policymakers, enterprises, and others in the 21st century can be said to be 'data', an intangible object that is acting as fuel for driving the wagons of the 4th Industrial Revolution. Some refer to data as the 'new oil' [1], while others describe the flow of data across the world as 'the lifeblood of the digital economy' [2]. But in its simplest form, data can be understood to mean 'transmissible and storable computer information' [3]. Also, in the Indian legal context, the "Information Technology Act, 2000" defines data as,

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"*A representation of information, knowledge, facts, concepts or instruction, which are being prepared or have been prepared in a formalized manner, and is intended to be processed, is being processed or has been processed in a computer system or computer network, and may be in any form (including computer printouts magnetic or optical storage media, punched cards, punched tapes) or stored internally in the memory of the computer*" [3].

Data is gaining so much of the limelight due to the benefits it offers to those who want to utilize it. For example, companies collect and analyze data of an individual's online habits to target advertisements to those individuals and, in turn, gain economic benefits. As a person's online habits may directly or indirectly reveal a lot about that person's likes, dislikes, ideology, food habits, and more. Now, governments and political parties are also showing interest in these datasets for policy-making and election strategies. Hence, a new 'data arms race' [4] has already begun. So, governments of various countries are coming up with regulations to protect their national interest by securing the data of their citizens by enacting privacy laws and regulating the cross-border flow of data. Some even consider data as a national asset and are hence facilitating the social and economic benefits that might accrue from its overall economic growth. Huge amounts of data are being generated every day, as is evident from an estimate that has predicted that the size of the digital universe is expected to reach around 181 zettabytes by the end of 2025 [5]. To bring this into perspective, this number can be thought of as 40 times more bytes than the observable stars [5]. Some of the statistics that highlight the amount of data generated are given below:

1. 294 billion emails and 500 million tweets are sent out every day.
2. Daily data created on Facebook amounts to around 4 petabytes, and the number of searches done every day is around 5 billion.

Based on these figures, it was estimated that by 2025, 463 exabytes of data would be created every day. This is being made easy with better technologies available on smartphones themselves. According to the article published on Statista, "*the number of smartphone users in the world nearly amounted to 2.7 billion in 2019, which is expected to exceed 3.8 billion in 2021. In a similar vein, it was predicted that 748 million people in India would own smartphones by 2020, and 1.5 billion by 2040"*.

This massive data generation leads to various social and economic benefits. Primarily, value creation out of data is illustrated in the Fig. **(1)** below:

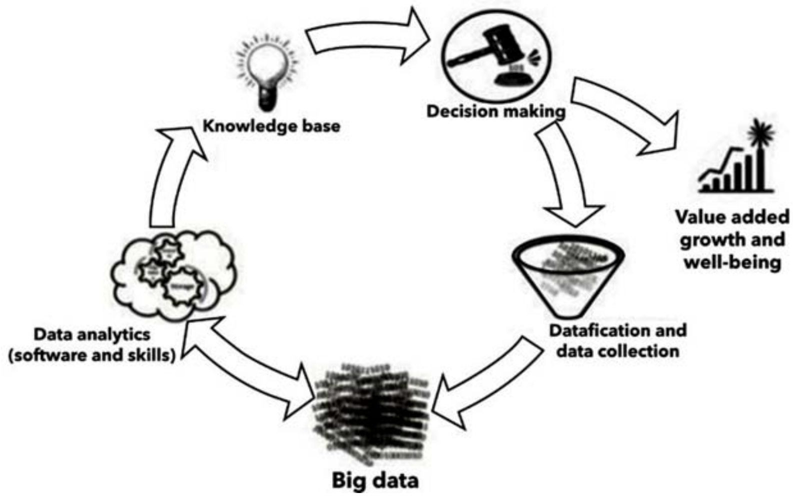

Fig. (1). Data value creation.

It is evident from the figure that this process of value creation out of data is not linear and involves, at different phases, feedback loops. The OECD (Organisation for Economic Co-operation and Development) report for "the G20 Digital Economy Taskforce" describes the 2 stages by which social and economic value of data is extracted:

1. Through analysis, the transformation of data to information can be used for gaining insights.
2. The crucial element of any business is decision-making; hence, insights from data can help in taking action and making decisions.

In the digital economy, understanding the distinctions between the PD and NPD, along with the regulations governing them, is vital due to the pivotal role played by data. India's legal system is evolving to demonstrate the nation's commitment to balancing privacy protection with fostering novelty and economic development. The country's "Data Protection policies", whether through enacted laws or proposed frameworks, aim to safeguard individual privacy while enabling responsible utilisation of data for societal advancement.

"Data Protection" in India is undergoing significant development, mostly due to the growing digitalization of personal and sensitive information. Ensuring data security has become a paramount concern given the pervasive use of the internet, mobile connectivity, and the economy in the digital era. The Indian government has taken significant steps to address these challenges by enforcing stringent "Data Protection regulations".

CHAPTER 7

Configuration of an IoT-based Drone in Precision Agriculture

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Abstract: Agriculture is regarded as the principal source of livelihood. Many essential agricultural operations, such as monitoring crops, irrigation systems, applicatio of pesticides, and many others, are carried out using techniques that are labour intensive. A decrease in the Return on Investment (ROI) in this sector may be attributed to a number of factors, including the fact that resources are insufficient, that they are not distributed in accordance with the weather conditions, or that they have not been used to their fullest capacity. There has been an increase in demand for drone technology that is equipped with Artificial Intelligence (AI) and remote sensing capabilities. This is due to the benefits that drone technology offers. To fulfill a wide range of needs at different stages of the crop cycle, drones may be equipped with technologies such as sophisticated cameras, automation, and highly precise GPS navigation systems. The information obtained is useful for regulating crop health, treatment, scouting, and irrigation, as well as for conducting field soil analysis and crop damage assessments at the same time. In addition to reducing the amount of time and money spent, the drone survey helps to increase agricultural yields. These research works present the complete overview of the configuration and implementation of the AI based drones that are used in precision agriculture. An extensive review of the drone technology prerequisites for implementing agricultural drones, including applications as well as hardware factors such as different categories of drones, sensors, and computing units, is also included.

Keywords: Artificial Intelligence, Crop monitoring, Drones, Drone configuration, IoT, Precision farming, Pesticide Spraying.

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INTRODUCTION

In general, a drone is an aircraft that does not have a pilot on board and operates *via* remote control or software. The majority of people who use this language are civilians. In general, the phrase "Unmanned Aerial Vehicles" (UAV) refers to any aircraft that is flown without the presence of a pilot and has the capability of being reused [1, 2]. This term is used more often by the armed forces. When conducting this study, we referred to it as "drones" for agricultural purposes. Over the course of many years, the concept of drones has been applied in various ways. Unmanned air balloons were used by Austria in their assault on Venice in the year 1849. The majority of the balloons, with the exception of one, were unable to reach the region that was intended to be targeted because of a sudden shift in the wind. Austria released over 200 balloons that contained explosives weighing between 11 and 14 kilograms. A French scientist named Professor Charles Richet was instrumental in the development of the quadcopter design, which was first introduced in 1907 by brothers Jacques and Louis Bréguet. Despite the fact that they used a pilot to elevate the ship vertically by 0.6 meters, it is not considered a free flight. To maintain control, four men were required. On the other hand, the quadcopter's design is cutting-edge in comparison to many of the commercial drones of today. Following the conclusion of World War I, the Ruston Proctor Aerial Target, which was the beginning of the first unmanned aircraft, was built in 1916. Archibald Low, a British engineer, was the one who came up with this idea, and it was first used in the radio guidance system. The first wireless rocket was also constructed by Low and his crew in the year 1917 [3, 4].

Errors, efforts, and time spent by humans are all reduced by automation technologies. Numerous advancements have been made in the field of automation across various industries, including manufacturing, defense, and transportation, utilities, and information technology. The beginning of the realization of industrial automation occurred in the 1990s and early 2000s, and it has now reached the level of Industry 4.0 status. Industrial 4.0 is characterized by the use of information and communication technologies that enable sophisticated intelligent machine networking and industrial processing [5].

Unbelievably rapid and accurate data collection in high resolution regarding crop health, soil conditions, and environmental factors is possible with the assistance of these drones. At its inception, the drone was designed and constructed for military purposes in mind. It was known by various designations, such as UAV, Miniature Pilotless Aircraft, and Flying Mini Robots[6[[7]. Presently, there are numerous sectors in which it is being implemented, including agriculture, business, infrastructure, security, insurance claims, mining, entertainment, communications, and transportation. Because of the extensive utilization of drones, a tremendously accelerated progression in drone technology has occurred, culminating in the technology becoming increasingly user-friendly on a daily basis. The utilization of small UAVs is increasing in prevalence within the agricultural sector. It is anticipated that this trend will persist for the foreseeable future. At present, drones are classified as semi-automated devices; however, there is a gradual shift towards fully autonomous configurations. When considering agricultural planning and the associated gathering of geographical data, these devices present an immense capacity for advancement. Notwithstanding its specific inherent constraints, this methodology possesses the capacity to be leveraged for efficient data analysis. Upon their initial inception, UAVs were remotely piloted, radio-controlled apparatus. In contrast, modern drones are autonomous aerial vehicles controlled by GPS. The usage pattern of a drone dictates the selection of cameras, sensors, and control devices that are implemented [8].

According to their weight, the government of India divided drones into a number of different categories. The drone will be referred to as a Nano drone if its weight is equal to or less than 250 grams. The drone is referred to as a micro drone if it weighs between 250 grams and 2 kilograms, which is somewhat more than the Nano. If the drone weighs between 2 kilograms and 25 kilograms, then it is considered to be a small drone. In the event that the drone weighs between 25 and 150 kilograms, it will be referred to as a medium drone. In the event that the drone weighs more than 150 kilograms, it will be referred to as a huge drone [9].

LITERATURE REVIEW

Haitao Xiang and Lei Tian [10] used a light helicopter that was fitted with a multispectral sensor for the agricultural remote sensing system. According to the authors, the overall weight of the equipment is less than 14 kilograms.

Tisdale *et al.* [11] used receding-horizon route planning and provided an explanation on the capabilities of UAVs to carry out autonomous tasks. They employed a technique called regressing-horizon route planning for the purpose of conducting autonomous search and localization throughout this work. This was introduced for unmanned aerial vehicles with fixed wings.

Vu NA *et al.* [12] provided an explanation of the approach that can be used to minimize the size of the propulsion system in order to optimize the design and manufacture of a drone that is capable of meeting the requirements of the mission.

Faical *et al.* [13] used a computer-based system that is capable of autonomously adapting to the laws of UAV control, accurately spraying pesticides on the fields. They recommended that the sole method of pesticide application would be to spray it in a specific region.

CHAPTER 8

Design and Development of a Machine Learning-Based System for Fresh Fish Sorting through Image Processing

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Abstract: The work aims at designing a Machine learning based highly efficient fresh fish sorting machine that is highly efficient and has high accuracy. The work also claims to follow all ethical practices pertaining to the use of this system for fresh fish sorting. A machine learning algorithm is implemented to categorize fish based on their species and size. This system ensures a higher accuracy when compared with manual sorting and is also less time-consuming. The system is designed using a Machine learning model for Raspberry Pi and ESP32 for real-time communication. The other components used are infrared sensors and servo motors. A Graphic User Interface was designed to enhance the user-friendliness of the sorting mechanism.

Keywords: ESP32, Infrared sensors, Real-time communication, Servo motors, YOLOv8.

INTRODUCTION

The food industry is rapidly advancing, and this works has the potential to decrease the human effort spent on sorting fishes manually. This innovative work incorporates a real-time hardware implementation, along with a Machine Learning (ML) model, and image processing technique.

The main aim of the work is to revolutionize the fish sorting industry by building an intelligent system that will automate the process of fish sorting. The sorting is performed based on the species and size of the fish. There are several constraints such as the identification of the species that is made easy with the help of a machine learning model using YOLO algorithm. The hardware component

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consists of Raspberry Pi, sensors, servo motors, and a setup with a conveyor belt system for efficient working of the system. This concept will help take one step closer to a new era of fish sorting.

RELATED WORKS

The work of Dennis M. Barrios, Ramil G. Lumauag, and Jolitte A. Villaruz [1] uses machine vision for sorting and has a hardware setup with a camera and sorting mechanism, and software development. The photos are system-processed using a size identifier and a classification algorithm. Furthermore, the future scope is to improve automation capabilities. M. Yousef Ibrahim and J Wang [2] created a novel system with workile-inspired flaps. This demonstrates a potential approach for increasing efficiency by reducing manual labor in the fishing business. In the article by Yuanhong Wu, Rui Zhuang, and Zhendong Cui [3], the size of the fish "Yellow croakers" was determined with the help of an area-weight prediction model. Yunhan Yang *et al*., [4] managed to develop a system to identify the size of fish. To train the model, there were 529 images used, and the images were preprocessed before training. ResNet-18, VGG-11, and DenseNet-121 were the CNN architectures used, which were then trained in PyTorch. This chapter discusses the advancements in various noninvasive techniques for the fish biomass estimation, such as machine vision, environmental DNA, acoustics, and resistivity counters [5]. CNN regressors are developed to examine various fish weights [6]. To visualize and understand the decision-making process of convolutional neural networks, the Gradient-weighted Class Activation Mapping technique is used [7]. Fast Fourier Transform is used to find the absolute scale of the captured fish images [8]. The CA-YOLO model enables the identification of elements in a complex spatial image [9]. Multi-objective techniques are incorporated in Genetic Programming for image segmentation [10].

METHODOLOGY

The block Diagram of Hardware Design is shown in Fig. (**1**). To ensure accurate detection and identification, a diverse dataset encompassing various fish species and sizes is included. This work considers 10 common fish species found in the waters of South India. Notably, a fundamental element of CNN principles is the implementation of YOLOv8.

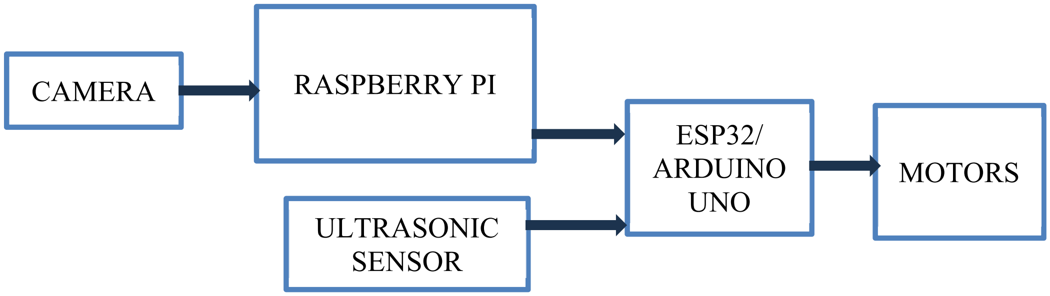

Fig. (1). Block diagram of hardware design.

Real-time communication is ensured by Arduino UNO and Raspberry Pi platforms, which also enables intelligent decision-making during sorting. Fish are precisely positioned on the conveyor belt and then sorted based on the decision made.

User communication is essential. Users can enter specific fish species through the GUI created. Tools such as TensorFlow, OpenCV, and Python are selected to control the process.

Data Collection and Preparation

The flow of work begins with data collection, where 10 common fish species found in the waters of South India have been considered. These include Catla, Croaker, Horse Mackerel, Mackerel, Milkfish, Rohu, Sardine, Sea Bass, Threadfin, and Tilapia. Images were captured using a smartphone camera with a resolution of 2600x4624 pixels, and were later resized. For the preparation of data, images were augmented and resized to a size of 640x640. This was done with the help of Kernel Bulk Image Resizer Software. Image labelling was performed using Roboflow. Each image in the dataset was manually labelled, which guaranteed accuracy for training the data. Augmentation helps the model generalize between different images that are present and provides a much diverse dataset in the real-world scenario. This ensures accurate detection during the actual process of identification.

Model Architecture and Training

To ensure accurate and high-speed detection and classification of fish, YOLOv8n has been utilized. In this model, the whole image is processed in a single pass and is relatively easy to use in comparison with other models.

On Kaggle, the model training using the dataset is complete. Kaggle offers GPUs with high computational power, which accelerates the training process of

CHAPTER 9

Significance of the Power Saving Mode feature of Narrow Band-IoT Technology.

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Abstract: Narrowband IoT (NB-IoT) is a Low Power Wide Area Network (LPWAN) wireless technology standardized by the 3rd Generation Partnership Project (3GPP), widely adopted especially by Communication Service Providers (CSPs) in China. It is used in many Internet of Things (IoT) applications for long battery life. Its earmarked Power Saving Mode (PSM) feature enables adjusting the packet 'detach-attach' interval as per the requirement of the IoT application. Similarly, PSM feature results are demonstrated through a field trial on the 1800 MHz frequency band using 180 KHz 'in-band' mode of operations, and results are obtained for a 4 min (240 Sec) 'detach-attach' cycle interval. Obviously, the 'wake-up-cycle' could be set to every eight hours, once a day, or once a month, *etc.*, thus conserving the battery for a long time. Various applications that are in dire need of such a feature are also listed in this paper, highlighting their demand for long battery life.

Keywords: Battery life, IoT (Internet of Things), NB-IoT (Narrowband IoT), PSM (Power Saving Mode).

INTRODUCTION

NB-IoT is an LPWAN technology that uses 180 KHz bandwidth on the LTE bearer to support data-light applications with an adjustable battery life feature, *i.e.*, PSM [1, 2]. There is a detailed report titled 'NBIoT Deployment Guide to Basic Feature set Requirements', published by GSMA [1], which clearly identifies a few features earmarked for NB-IoT technology, PSM being one. This chapter higlights the field trial results of the PSM mode of NB-IoT technology and shows that the packet 'detach and attach' cycle on network can be set with 4 min (240 Sec) interval, we can set it up as per the requirement of the application,

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thus saving the battery power for its long life. The entire trial setup is also mentioned in detail. The field trial results can be very useful for the research fraternity to adopt and proliferate NB-IoT technology all over the world. Even the device's ecosystem is now very mature for NB-IoT technology after its adoption by leading chipsets.

NB-IOT TELECOMMUNICATION TECHNOLOGY

NB-IoT is an LPWAN technology standardized by 3GPP in Rel-13 that forms part of cellular IoT. It allows access to network services *via* Evolved Universal Terrestrial Radio Access (E-UTRA) [3] with a channel bandwidth limited to 180 kHz [1] on Long Term Evolution (LTE) bearer. Because of PSM and Extended Discontinuous Reception (eDRX) [1, 2] features, NB-IoT has gained importance in several IoT applications, owing to long battery life support and extended coverage, respectively.

BENEFITS OF NB-IOT COMMUNICATION TECHNOLOGY

Technology Benefits

- Long range
- Low power
- Long battery life
- Less packet loss
- Underground coverage owing to eDRX [1, 2]
- Spectrum efficient, only 180 KHz in 5 MHz LTE spectrum
- High density of devices/ Sq. km

Business Benefits

- Low-cost devices
- Small size of the communication module
- Data-light applications, and lower data cost
- Long battery life and low operational cost

FIELD TRIAL OF POWER SAVING MODE (PSM) FEATURE OF NB-IOT

Trial Objective

To demonstrate through PSM [1, 2] feature, in a field trial of NB-IoT technology using 'inband mode' on 1800 MHz, (4 min) 240 sec intervals could be set for packet 'detach-attach cycle'.

Trial Setup

Trial Procedure

NB-IoT-related Radio Access Network (RAN) software and Home Subscriber Server (HSS) /Packet Core (PC) features must be activated on the telecom operator's network. A User Equipment (UE) supporting NB-IoT, Band 3/ 1800 MHz with 'in-band' mode ought to be used for the trial. 'Detach-Attach' time interval as per the PSM feature configuration is measured at UE level. The Operations Support System (OSS) framework is used to capture packet 'detach-attach' interval logs [4]; thus, results obtained are captured after setting device wakeup configuration to 240 Sec (4 min) [4].

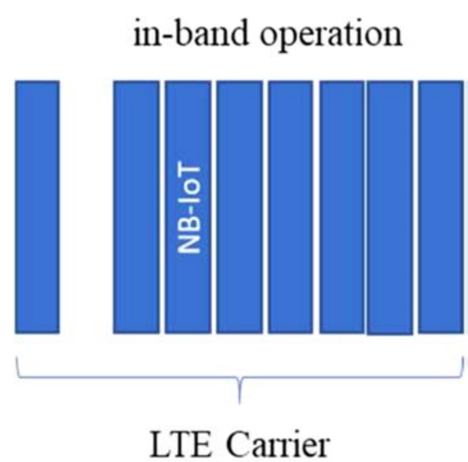

Fig. (1). In-band mode depiction.

Radio Access Network (RAN) Configuration

NB-IoT technology occupies a frequency band of 180 kHz bandwidth, which corresponds to one resource block in LTE transmission. With this selection, the following operation modes are possible:

- Stand-alone operation
- Guard band operation
- In-band operation utilizing resource blocks within an LTE carrier

Used 'in-band' mode as visualized in Fig. **(1)**, as it is supported widely by UEs and networks across the world. Thereupon, a radio base package of software corresponding to the NB-IoT feature set is activated for

CHAPTER 10

AI and Data Analytics: A New Frontier in Fraud Detection

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Abstract: Instances of fraud affect numerous industries, leading to the widespread adoption of Artificial Intelligence (AI) for analyzing fraudulent activities. AI can help detect fraud at early stages. Mastercard and Visa have saved billions of dollars using AI. This chapter discusses current trends in how organisations use AI for fraud detection. Data has been collected from the Anti-Fraud Technology Benchmarking Report 2024. The data contains insights from 1187 respondents, mostly accounting professionals, banks, and fraud examiners from public and private sector organizations. Data analysis has revealed that government and private organisations have started using AI in fraud data analytics. This study will help understand the current use of AI in the anti-fraud programs run by various organisations.

Keywords: Anti-fraud programmes, Artificial Intelligence, Asset misappropriation, Banking fraud, Data analytics, Financial statement fraud, Forensic accounting, Fraud examiners, Fraud prevention techniques, Identity theft, Manipulation risk analyzer, Predictive analysis, Vulnerability risks, White collar crime.

INTRODUCTION

Financial fraud poses a significant threat to the global economy, eroding trust and empowering criminals [1]. Traditional detection methods struggle to keep up with scams as they become increasingly sophisticated. This demands a paradigm shift towards advanced technologies. Artificial Intelligence (AI) and data analytics offer a powerful new frontier in fraud detection. This research explores the

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synergistic relationship between these technologies and examines their combined potential to revolutionize fraud prevention strategies. This study explores the application of Artificial Intelligence (AI) techniques, including machine learning and deep learning algorithms, to detect fraudulent patterns and anomalies within vast datasets. It analyses the integration of AI with data analytics tools to enhance accuracy, efficiency, and flexibility in fraud detection across various organizational sectors [2]. Additionally, the research investigates challenges associated with legacy system integration and explores strategies for overcoming compatibility barriers. The impact of Generative AI, a recent advancement, is also examined. It also highlights its potential benefits and potential misuse within fraud detection frameworks. Also, organisations like the Association of Certified Fraud Examiners (ACFE) & Statistical Analysis System (SAS), through their strategic partnership, tried to study and find out how organisations use their anti-fraud programs to detect significant risk areas that can have potential or may contribute towards positioning fraudulent cases in the future to come back. Thus, it is vital to spot risk areas to stay in check on the flow of labour in an organisation.

Major Risk Areas where Organisations use Data Analytics Tools to Detect Fraud

Mastercard Fraud

Data analytics significantly contributes to detecting and preventing Mastercard fraud. Machine learning algorithms can identify anomalies and potentially fraudulent activities by analysing transaction data, patterns, and user behaviour.

Insurance Fraud

Within the insurance industry, data analytics aids in tackling fraud. Data analytics tools can identify irregularities and patterns that indicate fraudulent claims by analysing historical claims data.

Identity Theft

Data analytics plays a pivotal role in identifying fraud. Through anomaly detection and behavioural analysis, systems analyse login patterns, geographic locations, and device usage to detect unusual activities indicating unauthorized access.

Related-Party Relationships

Organizations use data analytics to assess risks associated with related-party relationships. By identifying common patterns and mapping them to internal controls, risks related to fraudulent activities will be mitigated.

Payroll Schemes

Data analytics tools help organizations detect payroll-related fraud. By analysing payroll data, discrepancies, and patterns, irregularities can be noted like ghost employees or unauthorized payments.

Vendor Fraud

Organizations use data analytics to spot fraudulent vendors. By analysing vendor transactions, payment patterns, and deviations from norms, they can detect suspicious activities and stop vendor-related fraud.

Loopholes in creative accounting practices

Ethical considerations on using the best accounting methods and techniques to avoid world-related financial frauds and scandals are considered very important after deeply analysing cases like the Enron scandal, WorldCom, Satyam, *etc.* However, with technological advancements, fraud detection in creative accounting practices will use AI-generated algorithms. One in 10 public companies is thought to commit securities fraud annually, and virtually all manipulate their financial statements to some extent. Most do so to create the appearance that the organization is more valuable than it truly is [3]. Some copulate to govern their stock price. Whatever the reason, if we extrapolate the estimated cost of accounting fraud within the US to the entire world, the annual cost of accounting fraud to the world economy is a minimum of US$1 trillion [4]. It is a variety that we have often quoted elsewhere. Considering that number, the planet consumes about US$3 trillion of petroleum annually. So, accounting fraud matters, and we have not even considered the indirect costs because of the misallocation of resources. Some researchers have even found that a build-up of misreporting can cause a recession or lower economic growth through its actual effects.

AI Manipulation Risk Analyzer (MRA) is trained to look for patterns related to accounting manipulation and various fraud styles. It identifies these patterns in known historical cases of significant accounting manipulation, fraud, and resulting corporate failure. The MRA allows the user to analyse hundreds or

CHAPTER 11

Leveraging Nature-Inspired Algorithms for Iot-Enhanced Healthcare Solutions

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Abstract: Natural processes have been known to produce optimal results, which is the very basic reason that these natural processes have inspired many algorithms for solving complex problems. This class of meta-heuristic algorithms derived from natural processes is called Nature-Inspired Algorithms (NIA). Many such algorithms have been used in different processes associated with healthcare, from medical image processing to its analysis for disease prediction. Early detection of diseases is very important, as medical treatment at an early stage may not cure a critical disease fully, but can control and limit its aggressive growth. This chapter focuses on the study of different NIA for various diseases' prediction while comparing their suitability. A variety of evolutionary algorithms and swarm intelligence algorithms have been used for other important tasks in the healthcare industry. This chapter surveys the use of various nature-inspired algorithms for medical signal and image processing, followed by their application in disease prediction using medical images and other medical data. A wide range of diseases are covered, including heart disease, diabetes, *etc.* The latest trends to improve the efficiency and accuracy of these algorithms with machine learning techniques, with faster computations, are emphasized for each task. Lastly, the use of these algorithms is studied for various medical devices and systems for optimal data collection. The chapter is expected to help the readers understand the choice of algorithm for each of the required targeted tasks in healthcare.

Keywords: Alzheimer's disease, Artificial intelligence, Biomedical, Convolutional Neural Network, Cuckoo search, Discrete Wavelet Transform, Disease prediction, Firefly Algorithm, Genetic Algorithm, Healthcare, Image processing, IoT, Medical sensor, Nature inspired algorithms, Network classifier.

INTRODUCTION

Scientists and researchers have developed many algorithms inspired by different natural processes. Such a class of algorithms is called Nature-inspired Algorithms

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(NIA). These algorithms are generally metaheuristic and can optimally solve multi-dimensional problems involving a large number of variables in a reasonable time with less computational effort. These algorithms are generally suitable for global optimization with certain trade-offs between the local search and randomization, with no guarantee of obtaining the optimized result every time for every problem. The metaheuristic algorithms work with a diversification and intensification approach, that is, the solution search is diversified by exploring the global space to find multiple solutions, followed by working intensely for the best obtained solution over the local space. The selection of the best solution ensures optimal convergence of the solution, but to avoid being trapped at local optima, randomization is essential while providing solution diversity.

These NIAs are generally classified into three categories [1, 2]: evolutionary algorithms, swarm intelligence, and bacterial foraging algorithm. The evolutionary algorithms are inspired by the process of biological evolution based on Darwinian theory and natural selection. The possible solutions to the problem at hand are treated as a population, and each solution is measured for its suitability with the help of a fitness function. The weaker population is discarded during evolution, and the best is selected for mutation to evolve over time. Another class of algorithms is inspired by the behaviour of a group of living organisms and hence called Swarm Intelligence (SI) algorithms. These algorithms work with a number of agents interacting among themselves and with the local environment on the principles of proximity, diverse response, stability, and adaptability. The third class of nature-inspired algorithms is bacterial foraging, which is inspired by the behaviour of Escherichia coli during the search for nutrients.

A book [3] presented the details about the development of these NIAs over time with more details of some of the important and early NIAs in individual chapters. The 1960s witnessed the development of evolutionary algorithms with the Genetic Algorithm (GA), which follows the process of recombination or crossover, mutation, fitness, and selection of the fittest based on the Darwinian theory of evolution. It explores the solution space over multiple iterations to converge towards optimal solutions. Fig. (**1**) shows the outline of GA, which is modified by other NIAs based on inputs, parameters, and processes involved in some other natural phenomenon considered. An important limitation of this early NIA is that it offers no guarantee of finding global optima while taking a long time to converge. A large population size is expected with a large number of generations for good results.

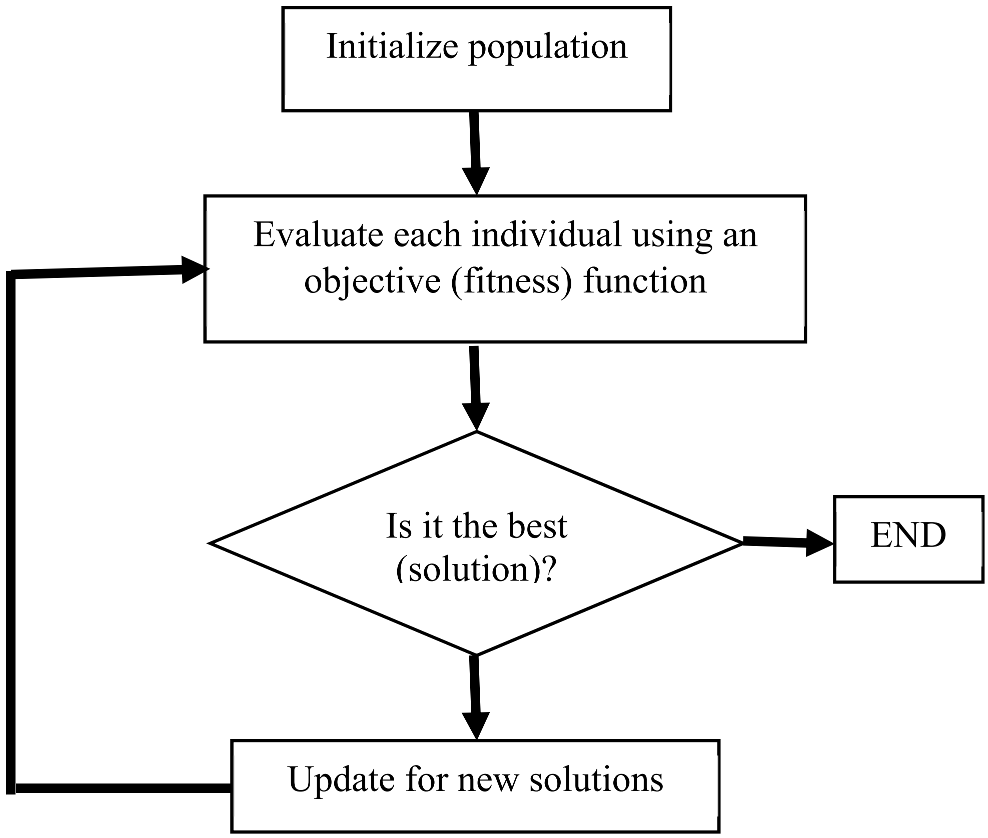

Fig. (1). Genetic Algorithm.

Another algorithm was developed in the 1980s called Simulated Annealing (SA), which was inspired by the process of metal annealing. Particle Swarm Optimization (PSO) was introduced in 1995, inspired by the intelligence of groups of fish, birds, and even humans. Differential Evolution (DE) algorithms closely follow the evolution of GA. Then came many other bio-inspired algorithms like Artificial Bee Colony (ABC) in 2005 inspired by honey collecting strategy of the honey bees, Firefly Algorithm (FA) in early 2008 inspired by flashing behaviour of fireflies and assigning brightness based on the performance of objective function, Cuckoo Search (CS) algorithm in 2009 inspired by brooding parasitism of cuckoo bird which lays one egg and dumps it into a randomly chosen host nest, bat algorithm in 2009 inspired by echolocation behaviour of bats, flower pollination algorithm in 2012 inspired by the process of pollination of flowers, and whale optimization method that emerged in 2016 inspired by the killing nature of humpback whales. Since then, new algorithms

CHAPTER 12

Artificial Intelligence and Robotics in Forensic Science

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Abstract: Integration of Artificial Intelligence and Robotics has revolutionised the field of Forensic Science. AI can process data swiftly and accurately from various databases like DNA, fingerprint, palm print, voice and pattern recognition in surveillance footage, *etc.* AI-led tools could be beneficial in the reconstruction of a crime scene by using the available information for creating 3-dimensional models of the location. By automating a number of forensic tasks, AI saves time for the investigators along with a reduction in errors on his / her part, thereby increasing the overall amount of work done manually.

Robots offer a physical hand in doing forensic specimen tests better and without bothering about any errors. They can be used to gather evidence in dangerous environments where forensic scientists struggle to reach physically. It can also reduce the chances of evidence contamination at a crime scene by being present only during collection, hence ensuring accurate results. Additionally, robots are suitable for forensic labs as well, where they perform elaborate tasks like DNA fingerprinting with more precision than any human being.

Although AI and Robotics play a vital role in reducing human efforts and making the entire process of investigation error-free, they face certain barriers regarding privacy and admissibility in the court of law. Hence, the legal system must address these challenges in order to adhere to the concept of fairness and dependability of the evidence.

Keywords: AI, Artificial Intelligence, Cyber, Digital forensic, Forensic science, Robotics, Virtual autopsy.

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INTRODUCTION

Forensic Science

Forensic science can be defined as the application of scientific methods and logic to solve criminal cases. It associates people, places, and things involved in the criminal activity and assists in the investigation and resolution of the crime [1]. ‘Forensic Science’ is derived from a combination of two Latin words, ‘Forensics’, which means Forum and refers to a public open court, and ‘Science’, which means knowledge [2]. Forensic scientists assist the investigating officers in collecting the evidence from the crime scene and preserving it in an appropriate way. Forensic scientists then analyse it in the laboratory using high-end specialized tools and techniques and draw conclusions based on the results obtained, thereby finding the culprit and solving the crime. They are then called to the court to testify as expert witnesses.

Branches of Forensic Science

Crime Scene Investigation

It involves collecting, preserving and analysing the evidence found at the crime scene. At the crime scene, the crime scene officers first trace the evidence and secure the entire crime scene by sending all the unwanted persons out and barricading the scene, and then document it by taking photographs of the scene and the evidence. A sketch of the crime scene is made, which helps the investigating officers during the reconstruction of the crime scene. The crime scene officers then collect the evidence using appropriate tools, preserve it carefully, and send it to the laboratory for further analysis [3]. Crime scene officers play a vital role in upholding the integrity of the evidence during the investigation process, making it admissible in the court. The results are shown in Fig. (**1**).

Criminology & Victimology

Criminology deals with the cause, consequences, and prevention of crime, whereas victimology deals with how the crime has affected the victim and their relations. Criminologists aim to determine the factors that lead to criminal behaviour and work on taking effective measures to prevent crimes from taking place. Victimologists, on the other hand, examine the psychological effects on the victim and their close ones after experiencing crime and work to improve their treatment for them to resume their normal life [4].

Cyber and Digital Forensics

Digital forensics can be defined as the collection, retrieval, preservation, and analysis of electronic data or evidence from electronic devices like smartphones, computers, storage devices, *etc.*, after a crime has taken place. Digital forensic experts retrieve and analyse the digital evidence and identify the identity of the perpetrator and the motive of the crime [5]. Crimes that come under digital forensics include intellectual property theft, fraud, embezzlement, *etc.*

Cyber forensics, on the other hand, specifically deals with crimes that take place in the cyberspace, such as hacking, phishing, data breaches, *etc.* Cyber forensic professionals analyse the digital trails left by the criminals, identify the vulnerabilities that were exploited, and try to trace the origin of the cyber-attack. Basically, digital forensics deals with digital data investigations, whereas cyber forensics deals with online or network-based crimes.

Fig. (1). Crime Scene Investigation.

DNA Fingerprinting

DNA fingerprinting can be defined as a laboratory technique that is used to determine the identity of an individual based on their genetic makeup [6]. It is based on the fact that every individual has a unique DNA, except in cases of identical twins. It is used in cases where there is a need to prove or disprove a person's link to the crime, or in paternity testing, or to identify a victim, *etc.* Restriction Fragment Length Polymorphism (RFLP) and Polymerase Chain Reaction are two main techniques used for DNA fingerprinting. DNA is extracted and isolated from the sample, processed and analysed, and then compared with

CHAPTER 13

LPG Gas Leakage Detection and Alerting System Using Arduino Nano Controller

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Abstract: LPG gas leakage symbolizes a foremost threat in both residential and industrial environments. There is a huge shortcoming in the current system's ability to detect LPG leakages. Whenever a 1% of gas leakage happens, it takes an average of one hour to be detected. This emphasizes the need for robust detection and prevention mechanisms. The essential component for this detection mechanism is a load cell that meticulously monitors gas consumption, promptly alerts users to reducing levels, thus helping them to avoid unexpected disruptions. Moreover, there is a GSM module within a system that sends real-time text messages about a gas leak or a low level of gas detected by sensors. This feature enables quick responses and interventions, ensuring safety risks are managed proactively. By integrating these components, this not only enhances safety but also promotes peace of mind for homeowners and businesses alike. Through continuous monitoring and timely alerts, it aims to mitigate the risks associated with gas leaks, thereby safeguarding lives and property. As it strives to create a safer environment, it recognizes the importance of preventive measures in minimizing the impact of potential hazards. Hence, this chapter offers a comprehensive solution tailored to detect and prevent gas leaks from LPG cylinders, prioritizing household safety.

Keywords: AC supply, Arduino nano controller, Buzzer, Gas concentration, Gas cylinder, Gas sensor, GSM module, LCD display, Leakage, Load cell, LPG, Message alert, Micro-controller, MQ6 Sensor, Servo-motor.

INTRODUCTION

The large-scale deployment of gas cylinders presents significant challenges in both domestic and commercial settings. Liquefied Petroleum Gas (LPG), an inflammable gas, which is widely used in our houses and workplaces, may leak [1]. LPG is highly explosive and poses significant risks during transportation, which can result in damage to storage tanks or cause fires and explosions.

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Accidents involving LPG tanker trucks can compromise tank integrity, often leading to significant gas leakage and subsequent explosions. LPG tank leakage greatly impacts the severity level of these incidents. Due to the serious consequences associated with LPG tank explosions, many researchers globally have investigated the explosion processes of LPG tanks. For instance, Yang and coworkers analyzed historical data from over 130 LPG transportation incidents [2] and utilized scenario simulations to study their development. Some researchers also developed fire detection techniques, which allowed them to determine the theoretical probability of LPG accidents [3 - 5].

There is a significant deficiency in the current system's ability to detect LPG leakage. When even a 1% gas leakage happens, it takes an average of 60 minutes to identify it. In order to solve this problem, an efficient monitoring and detection system for LPG gas leakage needs to be developed [6, 7]. Flammable gas mixtures, commonly known as Liquefied Petroleum Gas (LPG), serve as a major fuel source in various applications, such as heating, cooking, and vehicle propulsion. Despite being odorless, a safety measure includes Ethyl Mercaptan to transmit a detectable smell in case of leaks. Originating mostly from fossil fuel sources, LPG presents significant hazards due to its combustible nature under pressure, necessitating efficient detection methods. Various approaches, including optical sensors [8], cable sensors [9], and wireless sensor networks [10], have been employed and distinguished into software and hardware methods, with ongoing research attempting to enhance technical capabilities. Leak detection methodologies encompass three primary classifications: automated, manual, and semi-automated. Automated detection operates independently without operator intervention, enabling swift response mechanisms such as SCADA (Supervisory Control and Data Acquisition) [11]. Manual methods rely on human operation, which makes use of devices like thermal imagers or LiDAR (Light Detection and Ranging). Semi-automated solutions involve partial human input, leveraging statistical or digital signal processing techniques. Technological approaches to leak detection fall into two main categories: direct and indirect methods. Direct methods involve handheld detectors or aerial imaging for large-scale pipelines, while indirect methods employ remote monitoring or centralized systems for detection [12].

The longer response time and inaccurate detection by traditional methods result in the introduction of an Android-based automatic gas detection system. A study [13] discovers a basic FPGA-based system using MQ6 sensors to detect LPG leaks. As soon as detection occurs, the system notifies response teams *via* GSM for quick action. However, it lacks remote monitoring capabilities or mechanisms for leak mitigation. In residential areas, embedded real-time systems deploy sensor nodes communicating with a central unit to detect gas leaks, triggering alarms for immediate response. However, people are alerted *via* text messages using a unique identifier [14]. Although such systems reduce risks, they do not eliminate them, as they primarily focus on detection rather than repression. Efforts have been made to increase gas safety in homes through wireless modularization of safety devices. Integrating intelligent gas meters with microcontrollers and cutoff valves, the system focuses on fire detection and suppression. However, dependency on existing meter infrastructure restricts its standalone applicability [15].

Additionally, wireless sensor networks have been employed to detect gas leaks in industrial settings, point out data collection for accurate localization, and reduce response times. Innovations such as automatic safety gas stoves use IR sensors to detect utensil presence and hence, control gas supply accordingly. However, these systems may face gas leaks above the stove burner, and thus require additional sensing units for comprehensive detection. Similarly, cost-effective solutions merge weight and MQ series sensors, offering automated gas booking and leakage monitoring, incorporating safety measures like exhaust fans and solenoid valves for containment [16]. This chapter uses the MQ6 sensor, which is widely used for detecting flammable gases, like LPG, butane, and propane. It works on the fact that gas is absorbed onto a sensing material, providing an affordable and reliable solution for detecting flammable gases.

VARIOUS APPROACHES

Authors have proposed a gas leakage detector to meet the professional and health standards of the UK, addressing major concerns in residential, urban premises, and gas-initiated transportation vehicles. Kamweru and coworkers suggested an embedded system for the maintenance of gas cylinders, which includes four main units: a GSM module, a PIC (Peripheral Interface Controller), a leakage detection unit, and protection circuitry. The detection unit identifies gas leakage in the surroundings and sends SMS alerts to the consumer using GSM. Additionally, the system can automatically book a refill cylinder *via* SMS [17].

Jolhe and coworkers designed a microcontroller-based system using an MQ6 gas sensor for LPG leakage detection. This unit integrates an alarm to provide auditory or visual leakage indications. The sensor, known for its high sensitivity, quick response time, and being inexpensive, sends an automatic message to the user or family members *via* GSM when leakage is detected. It also measures the LPG cylinder's weight, displaying it on an LCD [18]. If the gas weighs less than or equal to 10kg, the system sends a text message to a distributor to request a new cylinder. When the gas quantity is less than or equal to 0.5 kg, it informs the consumer to refill the cylinder *via* a message. In this chapter, an embedded system

CHAPTER 14

IoT-based Livestock Management System

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Abstract: This method is an automated, low-cost, simple, stress-free, and non-intrusive solution to fulfil the needs of animal behaviour monitoring. Additionally, uncommon in rural locations is the availability of veterinary physicians. Farmers in remote locations must make frequent, expensive trips with their animals to veterinary hospitals. Cattle that are in poor health are given medical attention. It is also a complete waste of the money paid for both the trip and the therapy if the cattle's condition does not improve after the treatment. An Internet of Things (IoT) system can be used to track a cow's health, identify the primary diseases that affect dairy cows, and determine the types of wearable, non-invasive sensors required for disease monitoring. The Internet of Things (IoT) based system will continuously monitor the health of the cattle to ensure high-quality milk, boost productivity, detect anomalous health issues early to stop them from spreading throughout the herd, and significantly impact farm profitability.

Keywords: Accelerometer, Bio sensor, Cattle monitoring, Disease detection, Estrous detection, Health monitoring, Heat detection, Heat stress, Ketosis, Lameness, Livestock monitoring, RFID, Rumination, Sensor.

INTRODUCTION

To increase yield, support sustainable farming practices, and improve farming operations and livestock management, smart agriculture solutions integrate IoT and automation technology. These technologies can ensure environmental sustainability, optimize agricultural operations, and maximize profitability. Livestock management systems using IoT eliminate uncertainty regarding herd health. Battery-operated sensors track the position, temperature, blood pressure, and heart rate of animals *via* a wearable collar or tag, and they transfer the information to farmers' devices almost instantly through the air.This enables farmers to monitor the whereabouts and health of every individual animal in their herd from anywhere, and toreceive notifications when something deviates from

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the expected range. Instead of having to examine each animal's vital signs to see whether a disease has spread, they can quickly determine which livestock is afflicted and which is not. Historical data is analyzed to identify trends in cattle health or to monitor the spread of diseases. Conventional diagnostic techniques are usually labour-intensive, time-consuming, and sophisticated; they require the knowledge and skills of qualified professionals working with specialized tools. In order to surmount these challenges and develop bio-sensing devices that are extremely dependable, affordable, and have a fast response time, novel technologies are being utilized [1]. Issues related to the body and body weight can be identified by tracking physiological parameters of the cattle remotely. Fusing and analyzing data from microphones, still and video cameras, and other sources using AI algorithms can yield precise information necessary for cattle management [2]. Detecting disease conditions very early can preventthe spread of the disease and prevent huge losses incurred by farmers. For cattle owners in India, a smart wearable device that identifies cattle ailments at an early stage is very useful. A wearable device can track vital physiological parameters, like rectal temperature, cardiac rate, respiration rate, degree of movement, and different activity patterns. Applying this data to a prediction algorithm, animals that are going to be affected by illness are identified and separated at an early stage, which will protect farmers from huge losses incurred due to the spread of diseases by providing proper veterinary care for the diseased cattle. Foot and Mouth Disease (FMD) will affect the economy of farmers to a great extent. Abnormal variations in an animal's physiological condition, activity level, feeding and drinking habits, and normal health can be estimated using a variety of sensors, which include accelerometers, strain gauges, Radio Frequency Identification (RFID) Tag, and digital cameras [3]. Smart wearable Tags based on bio-chemical sensors measure an animal's physiological, immunological, and behavioral reactions, including cattle [4]. The peculiar characteristics of biosensors like very small size with minimal weight, high accuracy, and minimal likelihood of false positives make them ideal for detecting variations in temperature, electrical potential, color, pH, ion concentrations, enzymatic reaction, and functional loss. Innovative biosensors offer several benefits and applications in livestock management, such as disease isolation and detection, reproductive cycle detection, health monitoring, and physiological wellness monitoring of an animal by observing its environment. The use of wearable technology and biosensors in the management of animal health is becoming more and more significant. These tools can aid in the early identification of animal illnesses, reducing monetary losses. A variety of sensors for animal health management are in various stages of commercialization across the world. Some approaches for accurately detecting health status and diagnosing illnesses are primarily relevant to humans, with only minor modifications or testing in animal models [5]. The current state of medical technology makes early illness detection difficult and laboratory testing for animals expensive [6]. There is a need for detection technologies that can anticipate when and in what group an incident is likely to occur, inform diagnosis and treatment options, and forecast potential repercussions on a specific community. In addition to being sensitive and accurate for the parameters being studied, these tools can also be dependable and easy to use, which can expedite the monitoring process. Using portable devices in place of more traditional methods, including taking notes, maintaining a farm journal, or using basic equipment without data-sharing features, may make general farm monitoring simpler and more dependable. For portable devices, numerous methods have been created to lessen the labor-intensive nature of manually recording data [7]. New diseases posing a threat to animal health emerge on a yearly basis in the contemporary world. As of right now, there are no practical, affordable diagnostic methods for identifying diseases in livestock that are farmed early on. By offering innovative diagnostic instruments for the early identification of significant health risks in the agri-food animal sector, bio-sensing technologies have the potential to address these problems [8]. A crucial aspect of animal husbandry is breeding. To determine the appropriate time range for artificial insemination, cow ovulation cycles need to be observed. Using a variety of technologies, it is now possible to diagnose mastitis (both clinical and subclinical), metabolic diseases such as acidosis and ketosis, the animal's reproductive status, and the anticipated time of calving. Automated Milking Systems (AMSs) present both challenges and opportunities for dairy farmers. AMSs enable the monitoring of production and milk quality at the quarter-level, as well as milking frequency at the cow level, all of which can aid in the development of disease detection.

PRECISION LIVE - STOCK FARMING

The amount of progress that agriculture and animal farming have made in the last century is astounding. Although it was unthinkable a few decades ago, complete automation of crop harvest and environmental condition monitoring is now commonplace. With the aid of sophisticated machinery and technology, we have found ways to maximize productivity in these sectors, both for profit and to fulfill the needs of the growing global populace. However, there are drawbacks to this progress. The development of large-scale farming has resulted in some conditions growing worse. As the demand for animal products has increased, farming facilities have been expanding while occupying less area in order to maintain cost effectiveness. To put it mildly that has little bearing on the health of farm animals. Recently, there has been a serious threat to quality control due to increasing demand [9]. Providing a complete, safe, and secure environment for the farm animals is becoming very tedious due to mass production. Also, due to pollution, soil fatigue, and, above all, carbon footprint, the farm environment makes it

SUBJECT INDEX

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Dr. Anuradha is an Associate Professor at The NorthCap University with over 15 years of academic and research experience in Computer Vision, Big Data Analytics, Remote Sensing, and Machine Learning. She has supervised PhD scholars, published research papers, book chapters, and patents, and co-edited books with leading international publishers. Her research has received over 300 citations and she actively collaborates with institutions like HARSAC and CSIR-NPL. She also serves as a reviewer for reputed journals and has secured national research grants, mentored award-winning student projects, and contributed to internships and placement coordination.

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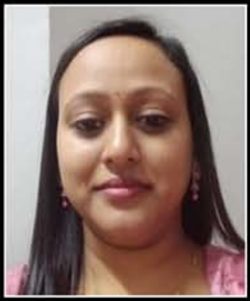
Dr. Yogita Gigras is an Associate Professor at The NorthCap University with over 16 years of teaching experience and a Ph.D. in Soft Computing. She has guided numerous research projects, published over 42 papers, and co-authored a book with Wiley. A Certified Ethical Hacker and Data Science professional, she helped establish the Tinkering Lab and has mentored students in several award-winning innovation projects.

Vandana Khanna

Dr. Vandana Khanna is an Associate Professor and Deputy Dean (PhD Program) at The NorthCap University, with a PhD in Photovoltaic Modeling and over 22 years of experience in industry, teaching, and research. She began her career in the VLSI industry with Motorola and Freescale and has since supervised PhD scholars, published over 50 papers, and secured several patents, including a German patent. Founder of the Tinkering Lab, IEI Students' Chapter, and Chetna Club, she actively promotes research, innovation, and social responsibility. Her achievements include multiple national and institutional awards for teaching, research, and academic excellence.



Deepika Bansal

Dr. Deepika Bansal is an Assistant Professor at Maharaja Agrasen Institute of Technology with 10 years of teaching and research experience. She earned her Ph.D. from The NorthCap University on dementia detection using machine learning and holds a B.Tech (Distinction) and M.Tech in CSE. She has published research in reputed international journals, serves as a reviewer for journals like Hindawi and IGI Global, and specializes in Data Mining, Machine Learning, Image Processing, AI, and Deep Learning.

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Dr. Priyanka Maan is an Assistant Professor in Computer Science and Engineering at SRM University with over 9 years of teaching and research experience. She holds a Ph.D. in Optical Image Encryption and specializes in Cryptography, IoT, AI, and Machine Learning. She has published extensively, holds a patent for an AI-driven battery management system, and actively participates in conferences and academic review activities, contributing significantly to research and education in computer science.

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