Detecting Counterfeit Medicines Utilizing Artificial Intelligence Technique

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Abstract: Counterfeit medicine poses a significant threat to public health, with the potential to cause harm and undermine trust in healthcare systems. Traditional methods of detecting counterfeit drugs often fall short due to the increasing sophistication of counterfeiters. This research paper is an approach to tackle the issue by employing deep learning algorithms for image classification. It leverages the power of Deep Learning (DL) algorithms to automatically learn relevant features from images of pharmaceutical products and accurately distinguish between genuine and counterfeit drugs. The experimental results demonstrate the effectiveness of the DL model in achieving high accuracy and robustness in identifying counterfeit drugs. It not only advances pharmaceutical security measures but also showcases the potential of DL functions in image classification for safeguarding public health and safety. By comparing with the DL algorithms, it specifies the accuracy of the counterfeit drugs.

Keywords- Counterfeit Medicine, Deep Learning (DL), Image Classification, Pharmaceutical Security.

I. INTRODUCTION

Counterfeit medicines, characterized by unauthorized or fraudulent production and distribution, pose a pervasive and formidable threat to global public health. Infusing fake pharmaceuticals into legitimate supply chains undermines patient safety, compromises the efficacy of medical treatments, and erodes public trust in healthcare systems. According to World Health Organization (WHO) estimates, around 10% of medicines in the global pharmaceutical market are counterfeit drugs, contributing to millions of deaths annually. Traditional methods of detecting counterfeit medicines, such as holographic features, packaging analysis, and chemical testing, are proving insufficient in addressing the escalating sophistication of counterfeiters [1].

The escalating sophistication of counterfeiters demands innovative and technologically advanced solutions for effective detection and prevention. Deep Learning (DL) has emerged as a potent force in image processing and classification tasks in recent years. Its features capture the complicated problems in image classification without prior information about the image. Conventional Machine Learning (ML) approaches work with

feature extraction manually and classification algorithms that classify the objects separately. Although the DL techniques that work with the network itself

Traditional Machine Learning approaches do the feature extraction manually and the classification algorithm classifies the objects separately. But, In Deep Learning approaches the network itself extracts the features without user interpretation and also categorizes the objects [2].

This research endeavors to the gaps in counterfeit medicine detection by the approaches based on DL algorithms. Unlike traditional methods, which often rely on manual inspection or chemical analysis, our proposed methodology harnesses the power of Artificial Intelligence (AI) to learn and discern patterns indicative of counterfeit pharmaceutical products autonomously. By training an ANN on a diverse dataset containing images of both genuine and counterfeit medicines. The main aim is to develop a robust and scalable solution that is capable of accurately classifying the products. This provides an advanced defense against the proliferation of counterfeit medicines.

DL which could be demonstrated by Artificial Neural Networks (ANN), has unparalleled capabilities in automatically extracting intricate features from images. Leveraging this technology to identify counterfeit medicine can potentially revolutionize the current landscape of pharmaceutical security. Delving into the complexities of a methodology encompassing dataset preparation, preprocessing, model architecture, training, and evaluation promises a breakthrough in counterfeit medicine detection. By amalgamating the strengths of DL with the pressing need for heightened pharmaceutical security, it contributes to the ongoing efforts to safeguard public health, restore trust in medicinal supply chains, and mitigate the detrimental impact of counterfeit medicines on a global scale. The subsequent sections of this paper will provide an in-depth exploration of our proposed methodology, experimental results, and conclusions drawn from our endeavors.

This research paper evaluates Counterfeit Medicines' impact on public health and provides a data-driven analysis of their wide prevalence. It compares counterfeit medicines using traditional and state-of-the-art techniques. It will conduct a comparative study to evaluate the viability, effectiveness, and robustness of these techniques.

II. LITERATURE SURVEY

Iyolita Islam et. al. (2022) [3] analyze the existing study of counterfeit medicines by preventing and reducing them using digital interventions. Blockchain, IoT, RFID, Image Processing, and Pattern Recognition are the primary technologies to encounter counterfeit medicines. In addition, it focuses on the research gaps and proposes a future research direction, including emerging technologies, to improve the medicine supply chain traceability and develop incident reporting systems for counterfeit medicines.

B. Krakowska et al. (2016) [4] discuss the chemometric methods used to demonstrate the authenticity of medicines. The study discusses several analytical techniques, including chromatographic and spectroscopic methods, which help to identify genuine and counterfeit medicines. It presents the case studies that demonstrate to identify by using pattern recognition and classification models, to assist drug authentication. The main aim of the review is to highlight the importance of multivariate data analysis in detecting counterfeit medicines and suggest the best practices for selecting analytical approaches and chemometric techniques.

Sumit Kumar et al. (2025) [5], study gives the application of blockchain in preventing counterfeit medicine in the supply of medicines. Its main feature is to identify the need for transparency, traceability, and security in the distribution of medicines. Earlier studies explored blockchain solutions for drug traceability, supply chain transparency, and security by leveraging smart contracts, distributed ledgers, and cryptographic approaches. To explore and analyze the drug movement patterns to predict counterfeit risks, it has integrated Artificial Intelligence (AI) for fraud detection. From the existing research a Hyperledger Fabric-based Cryptic Mediledger Fabric (CMLF) framework, to enhance real-time drug tracking, data integrity, and stakeholder collaboration within the limitations of the previous models.

Kirti Motwani et al. (2022) [6], explore DL-based methods for the detection of counterfeit medicines to emphasize the role of AI and image-processing techniques in pharmaceutical validation. Traditional anti-counterfeiting methods, like holograms, covert markers, and track-and-trace systems, have been used but within limitations of terms of cost, accessibility, and usage of the medicines. From the studies, the object detection models, such as Single Shot MultiBox Detector (SSD), can able to classify and verify medicine packages based on logo recognition and text extraction. The cloud-based AI services like Azure OCR are integrated with Optical Character Recognition (OCR) techniques, to allow for automated text verification on drug packaging, enhancing counterfeit detection accuracy. This paper builds upon the existing research by proposing a deep learning framework which combines with the object detection, text recognition and database verification to deliver the accurate and flexible approach for counterfeit medicine detection.

Aakansha Soy et al. (2025) [7], discuss the several technologies in combining the counterfeit medicines in pharmaceutical industry, which focus on AI, blockchain and image-based validation and verification techniques. Various research has highlighted the role of blockchain technology in ensuring assured and transparent drug supply chain management, in reducing the risk of counterfeit medicines entering in the global network of distribution. The AI technology-based image processing in Convolutional Neural Network (CNNs) verify in detecting minute packing variations, including barcode discrepancies and tamper-evident features. In addition to this, Generative Adversarial Networks (GANs) model is used to detect the counterfeit medicine by generating synthetic datasets which improve the model training and classification accuracy. This study proposes a multi-layered validation framework integrated with CNNs, GANs, and blockchain technology to enhance the detection of counterfeit medicine by ensuring high accuracy, traceability and security in the pharmaceutical validation and verification.

III. METHODOLOGY

3.1 Proposed Methodology:

The proposed deep-learning based approach employs an ANN technique for counterfeit medicine detection by analysing medicines, image processing, and feature extraction by learning complicated patterns from the data.

Artificial Neural Network (ANN)

ANN is a DL model which mimics human brain's neuron network and have the ability to recognize patterns, of the computational model suitable for detecting counterfeit medicine images. ANN is trained based on the counterfeit and genuine medicine images by learning from the large datasets of the labelled images of medicines [8].

The flow structure of the multi-layered framework is given in Fig.1, it demonstrates the methodology for counterfeit medicine detection using the DL technique.
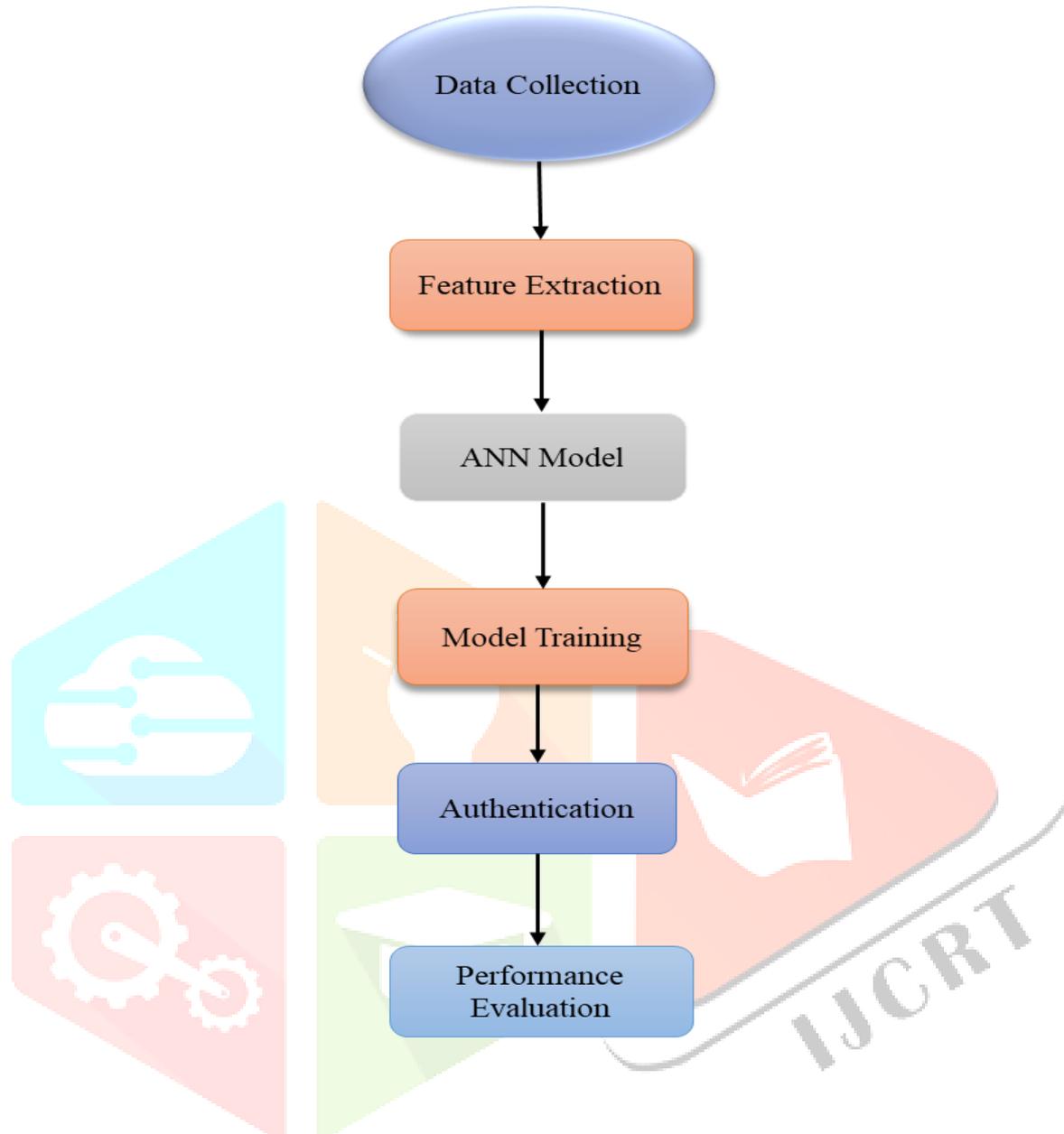

Figure 1. Represents the Methodology of Counterfeit Medicine Detection Using DL Model

The neuron structure contains three inputs, one output, and computing functions, the input layer has three neurons and the output layer has two neurons, then, Eq 1 has follows,

$$Z = \sum i = 1^3 x_i * w_i \quad y = f(z) \qquad (1)$$

Where x denotes input, w denotes weight, f denotes activation function.

The output function is denoted in Eq 2 & 3,

$$y_1 = f(\sum i = 1^3 x_{1,i}{}^{.w}1, i) \qquad (2)$$

$$y_2 = f(\sum i = 1^3 x_{2,i}{}^{.w}2, i) \qquad (3)$$

The size of signal will be denoted as x·w [9,10]

Algorithm for ANN-based counterfeit medicine image detection

Step:1 Medicine image data is collected and processed according to the labelled images.

Step:2 Feature Extraction is the next step to process the visual features which differentiate the counterfeit and genuine medicines images. Fig 2 represents the feature extraction of genuine medicine.
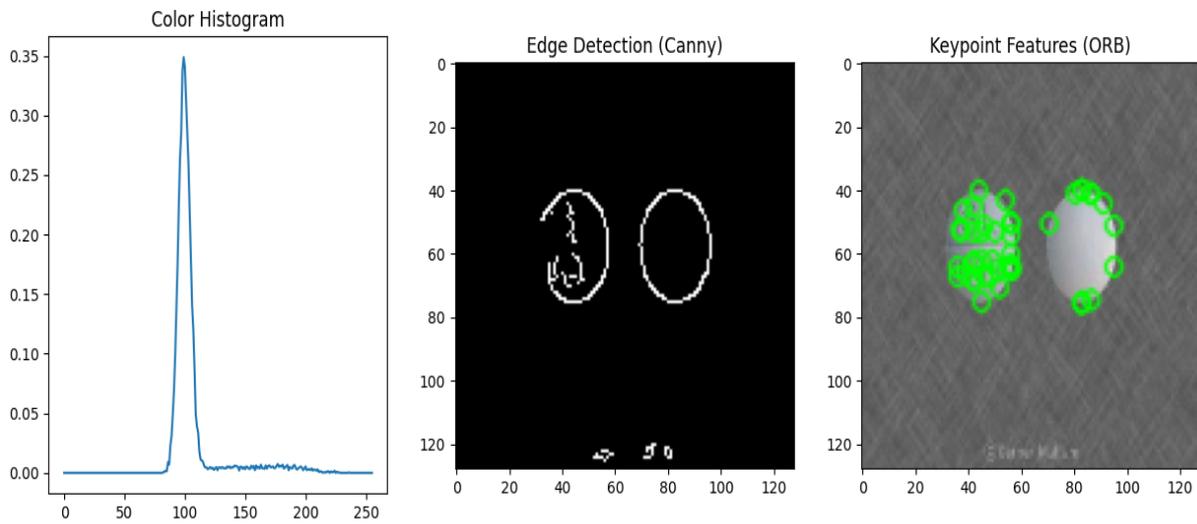

Figure 2. Show the Feature Extraction of Genuine Medicine

Step: 3 To initialize the ANN model the feedforward neural network is connected with the input layer, hidden layers, and output layers.

Step:4 The ANN model is trained by setting the hyperparameters such as, learning rate, batch size, epochs. The training set from the ANN model is used with backpropagation and gradient descent.

Step:5 The model evaluation is evaluated using accuracy and the prediction is processed by loading new medicine images, and preprocess the image by feeding the trained with ANN model. The output classification with the probability score is genuine or counterfeit.

From the ANN model the detection of counterfeit medicine is classified which it could perform well by comparing with the existing methods. Thus, it is evaluated by using the ANN model to obtain the difference between counterfeit or genuine medicine.

IV. RESULTS AND DISCUSSION

The proposed ANN model, the dataset is used from [11], the dataset is trained and tested and validated. The pre-processed images are labelled, to differentiate counterfeit or genuine medicine by extracting its features of color histogram, edge detection, and key point features of the genuine medicines. From the datasets 80% of images are trained, 10% are tested and 10% are validated and accurate performance evaluation is obtained. To attain the expected result it is compared with the original image Fig 3 & 4 Classification of Genuine and Counterfeit medicine images. Fig 5 represents the Accuracy and loss function of the counterfeit medicine. In table 1 it represents the performance evaluation metrics of Counterfeit Medicine, using ANN model.
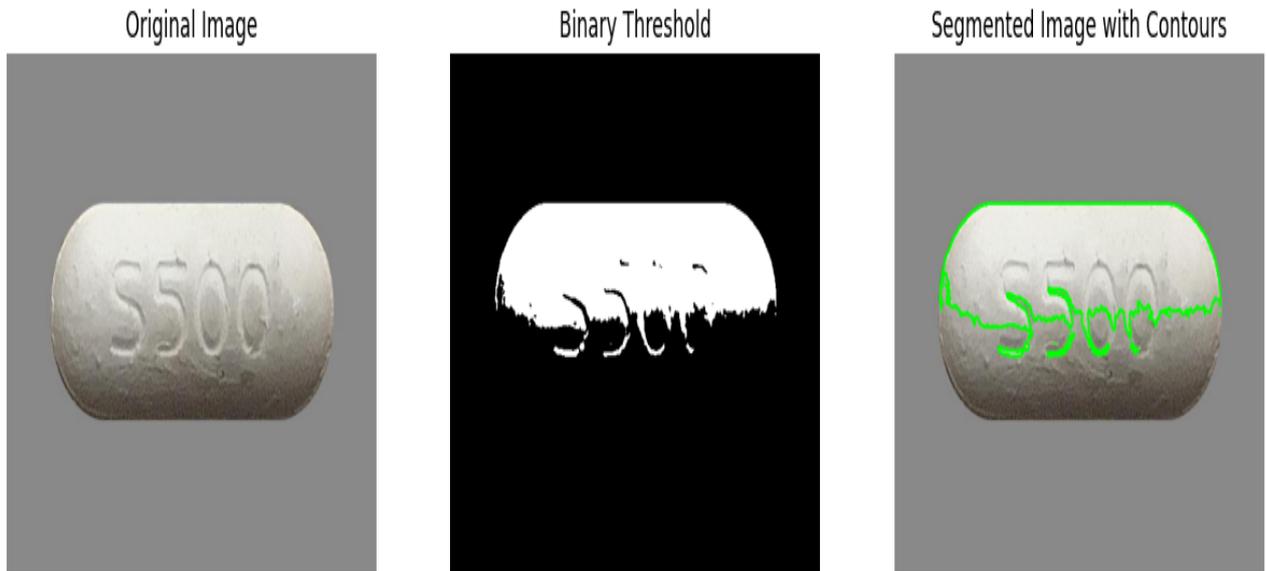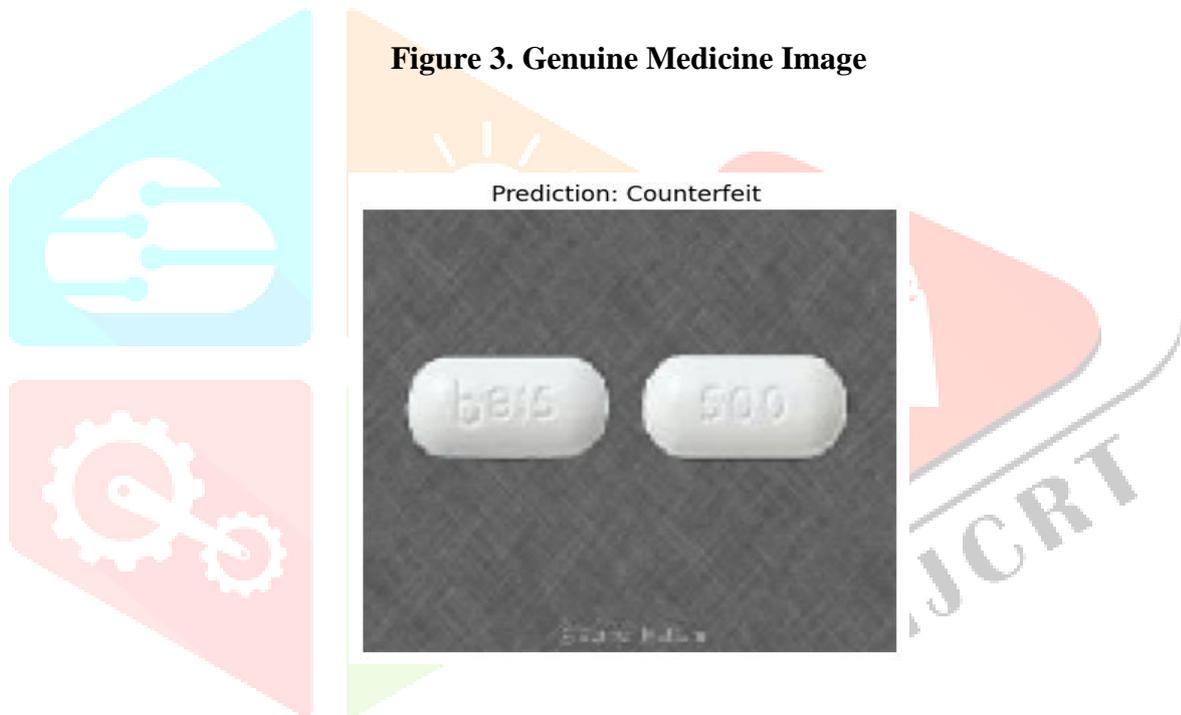
Figure 3. Genuine Medicine Image
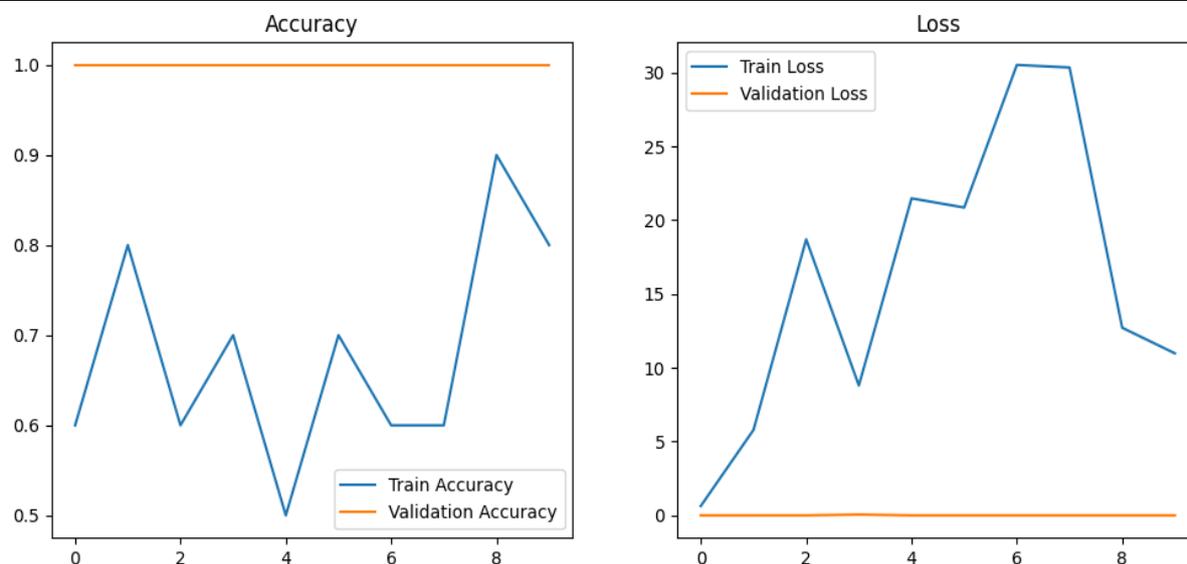

Figure 4. Prediction of Counterfeit Medicine

Figure 5. Represents the Accuracy & Loss Function of Counterfeit Medicine

Table 1. Performance Metric of Counterfeit Medicine

Metrics	%
Accuracy	92
Precision	87
Recall	90

V. CONCLUSION

By implementing ANN for counterfeit medicine detection gives a reliable and efficient method for analysing genuine and counterfeit medicine based on the image features. The model effectively learns the patterns to distinguish between counterfeit and genuine medicine from the images. From the comparison the DL techniques' accuracy is calculated, indicating that the ANN model performs better in identifying the counterfeit medicines. The ANN model is integrated with image processing techniques and feature extraction to identify the difference between counterfeit and genuine medicines. The model is trained and tested using the well-prepared dataset and validated with the performance metrics for the classification of the medicines.

FUTURE ENHANCEMENT

The ANN model gives a differentiate result for counterfeit and genuine medicine images, to improve the systems performance and real-world applicability the several enhancements are made. To expand the dataset with different and high-resolution images of medicines from various sources will improve the model's generalization. This model, combined with blockchain-based traceability or QR code verification systems, creates a more secure and transparent supply chain management in the pharmaceutical industry.

References

[1]. Singh S, Gupta P. A Comprehensive Study on Counterfeit Medicine and its prevention in India through its Regulatory Approach. Int J Drug Reg Affairs [Internet]. 2022 Jun 15 [cited 2022 Jun 15]; 10(2):9-13. Available from: http://ijdra.com/index.php/journal/article/view/515

[2]. Fábio do Prado Puglia, Juliana de Abreu Fontes Kristiane Mariotti, Michel José Anzanello, Jacob Scharcanski , João Batista Gonçalves de Brito, Rafael Scorsatto Ortiz, "Identifying the most relevant tablet regions in the image detection of counterfeit medicines", Journal of Pharmaceutical and Biomedical Analysis 205 114336, (2021).

[3]. Iyolita Islam, Muhammad Nazrul Islam, Digital Intervention to Reduce Counterfeit and Falsified Medicines: A Systematic Review and Future Research Agenda, Journal of King Saud University Computer and Information Sciences, https://doi.org/10.1016/j.jksuci.2022.02.022 (2022)

[4]. B. Krakowska, D. Custers, E. Deconinck, M. Daszykowski, "Chemometrics and the identification of counterfeit medicines—A review", Journal of Pharmaceutical and Biomedical Analysis 127, 112–122, (2016).

[5]. Kumar, S., Mehra, R., Sivaraman, H., Garg, U.: "A research and enhancement strategy for detecting counterfeit medications utilizing blockchain technology", IET Blockchain 5, e70003 (2025). https://doi.org/10.1049/blc2.70003.

[6]. Kirti Motwani, Rachael Dsouza, Rhea Dsouza, Janice Jose, "Counterfeit Medicine Detection using Deep Learning", International Journal of Innovative Research in Technology (IJIRT), Volume 9 Issue 3, August 2022.

[7]. Aakansha Soy, Sutar Manisha Balkrishna, "AI Predictive Analytics for Verifying Pharmaceutical Authenticity and Combating Drug Counterfeiting", Communications on Applied Nonlinear Analysis, Vol 32 No. 2s (2025).

[8]. Neocleous, C., Schizas, C., "Artificial neural network learning: a comparative review", In: Hellenic Conference on Artificial Intelligence. vol. 2308. Springer, Berlin Heidelberg, pp. 300–313, 2002.

[9]. Daniel, G.G, "Artificial Neural Network". Springer, Netherlands, (2013).

[10]. Jie Wu, Yiqiang Zhao, "Machine learning technology in the application of genome analysis: A systematic review", Gene 149-156, (2019).

[11]. https://www.drugs.com/alpha/d.html