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DETECTION AND IFENTIFICATION OF PILLS USING MACHINE LEARNING

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Abstract: In the medical field, precise pill identification and detection are essential for avoiding prescription mistakes and guaranteeing patient safety. Machine learning must be used to automate the process because traditional manual approaches are tedious and susceptible to human mistake. Due to changes in illumination, background noise, and picture quality, conventional rule-based image processing methods—which depend on texture, colour, and shape—frequently have accuracy and robustness issues. Using Convolutional neural networks, more commonly trained on a dataset of pill pictures with data augmentation for improved generalisation, this study suggests a deep learning-based method to overcome these drawbacks. Multiple convolutional, maximal pooling, and layer dropouts are included into the model to improve feature extraction and lessen overfitting. Accuracy under various circumstances is ensured by validating performance on a distinct dataset.

I. INTRODUCTION

Ensuring proper drug administration is essential for patient safety and successful treatment in the contemporary healthcare industry. Pill identification and detection are important in lowering prescription mistakes, which, if ignored, can result in serious health issues. Healthcare workers, especially chemists, must accurately identify tablets in order to avoid giving out the wrong drug. However, manual pill identification techniques are time-consuming and ineffective since they frequently involve a lot of human labour and are prone to mistakes.

The availability of many kinds of tablets and the growing complexity of pharmaceutical goods have made identification even more difficult. Health care providers categorise pills according to their size, shape, and colour using manual observation, which is a major component of traditional pill identification systems. When working with tablets that have

comparable physical properties, these techniques may become unreliable. Environmental elements like background noise, camera quality, and illumination can also make identification more challenging and make correct recognition more challenging.

Automated pill detection devices have drawn a lot of interest recently in an effort to get around these restrictions. Without the need for human assistance, these systems effectively recognise and categorise tablets by utilising cutting-edge technology. The identification process is made faster, more reliable, and more scalable by employing image-based detection techniques. By increasing patient safety, decreasing human error, and boosting accuracy in prescriptions, automated technologies have the potential to completely transform the healthcare industry.

The goal of this study is to develop an automated pill detection and identification system that improves pill categorisation accuracy and dependability by utilising machine learning techniques. By offering a more effective, scalable, and interpretable way of pill recognition, the suggested system overcomes the drawbacks of conventional techniques. Incorporating cutting-edge technology not only increases system accuracy but also aids in the creation of clever healthcare apps, which eventually improve patient safety and healthcare delivery.

Moreover, more complex and dependable pill recognition algorithms may now be created because to developments in deep learning and computer vision. Convolutional Neural Networks (CNNs) have been used extensively in medical imaging and have demonstrated remarkable efficacy in image identification tasks. Even when pills have identical visual qualities, automated pill detection systems can accurately identify them by using CNNs to learn intricate patterns and features from pill photos. The system is more resilient in real-world situations because to data augmentation approaches, which also improve the model's generalisation across various lighting conditions, backdrops, and picture quality.

The capacity of a pill identification system to produce findings that are clear and easy to understand is another essential component.

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Our method addresses this by utilising SHAP (SHapley Additive exPlanations), which highlights the most significant elements in a picture and aids in explaining the model's decision-making process. In healthcare settings, where responsibility and trust are critical, this interpretability is essential. Healthcare workers may utilise the automated system as a dependable tool in their workflow with confidence if they understand how it makes its predictions.

The complement to its immediate use at pharmacies and hospitals, a sophisticated pill recognition system may be included into mobile health apps, enabling patients to check their prescriptions at home. People who are managing several medicines, older patients, or those with visual problems can all benefit from such a system. Furthermore, using cloud-based databases can help with real-time updates and guarantee that the system stays current with newly approved drugs. This novel method of pill identification might completely change how drugs are administered and drastically lower the number of medication-related mistakes made in medical settings.

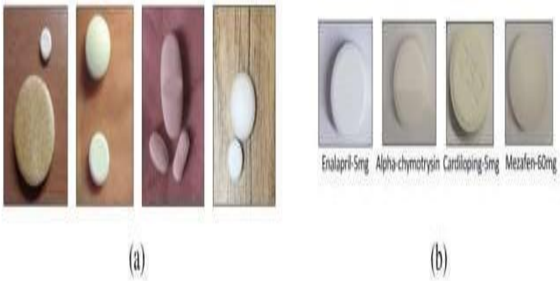

Fig 1. Hard samples with high similarity in terms of shape, color and size (examples taken from our handcrafted dataset). (a) Pills with similar shapes, colors, and different sizes. (b) Pills with similar shapes, sizes and colors.

1.1. MOTIVATION OF DEEP LEARNING

Due to the serious health dangers associated with improper prescriptions, the rapid improvements in healthcare necessitate more effective and dependable systems for pill identification. It takes a lot of time and is prone to mistakes for chemists and medical personnel to visually analyse pills using traditional manual methods based on their colour, shape, and texture. There is an urgent need for a controlled automatically intelligent system that can precisely categorise and identify pills due to the growing complexity of pharmaceutical goods and the existence of visually identical tablets. The shortcomings of traditional pill identification techniques can be addressed using deep learning, especially neural networks using convolution (CNNs), which have become an effective tool for picture recognition applications.

Deep learning models have the ability to automatically extract complex patterns and representations from pictures, in contrast to rule-based image processing methods that depend on manually created attributes like form, texture, and colour. This feature enables CNNs to accurately identify pills even in difficult situations including uneven illumination, shifting backdrops, and distorted images. The model's capacity to generalise is further improved by data augmentation, which guarantees that the system functions effectively with unknown data. The identification process may be greatly enhanced in terms of precision, resilience, and scalability by utilising deep learning, which would eventually lower the hazards related to improper drug delivery.

The potential to increase interpretability and confidence in automated systems is a key driver behind the integration of deep learning techniques into pill recognition. By emphasising the primary visual characteristics that impact categorisation, SHAP (SHapley Additive exPlanations) is included into the model to produce clear predictions. This makes the model a more reliable tool for healthcare applications by guaranteeing that medical practitioners can comprehend and assess the model's decision-making process. In the medical industry, where patient safety is directly impacted by decision accuracy, improving interpretability is essential.

Additionally, deep learning is being used for medication identification outside of pharmacies and hospitals. Patients can independently confirm their prescriptions by integrating it into mobile health applications. Elderly patients, people with visual impairments, and people who manage several medicines can particularly benefit from this. Furthermore, real-time updates may be made possible by cloud-based integration, guaranteeing that the system stays correct even when new drugs are released. Healthcare systems may greatly improve efficiency, accuracy, and patient safety while lowering human error in prescription management by using deep learning to automate pill recognition.

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1.2.THE AIM OF THE THESIS

The principal objective of this thesis is to create a sophisticated, automated pill detection and recognition system that uses deep learning methods to improve precision, effectiveness, and dependability in the medical domain. In order to protect patients, it is essential to administer medications correctly because prescription mistakes might result in serious health issues. Largescale healthcare applications cannot benefit from the labour-intensive and human error-prone nature of traditional automated pill identification techniques. Convolutional neural network algorithms (CNNs), a type of machine learning methodology, will be used in this study to automate the process and decrease reliance on manual methods while improving accuracy and dependability in pill categorisation.

The limits of traditional rule-based image processing methods, which mostly use texture, shape, and colour for identification, are the focus of this study. These conventional methods frequently produce inconsistent findings due to their inability to handle changes in background noise, lighting conditions, and image quality. The goal of this study is to increase the generalisation and robustness of pill recognition by using CNN-based deep-learning algorithms that have been trained on a large dataset of pill pictures using data augmentation approaches. Multiple convolutional layering max pooling layers of data, and dropout layers are included into the model architecture to maximise feature extraction and reduce overfitting, guaranteeing good accuracy under a variety of testing scenarios.

Improving the deep learning model's interpretability through the use of SHAP (SHapley Additive exPlanations) is another important goal of this research. Healthcare practitioners may find it challenging to trust the predictions made by deep learning-based models due to their black-box character. The system helps users comprehend which picture attributes contribute to a given categorisation by using SHAP to provide visual representations of its conclusions. This interpretability guarantees increased openness, which boosts trust in the system's dependability and usefulness in actual healthcare applications.

The ultimate goal of this project is to develop an intelligent and scalable healthcare system that enhances pill recognition accuracy while supporting more general uses like real-time medication validation and mobile health monitoring. The suggested approach can improve overall patient safety, expedite pharmaceutical operations, and drastically decrease drug mistakes by automating the identification procedure. The results of this study will help develop AI-powered healthcare solutions and open the door for more advancements in intelligent medication administration and recognition systems.

1.3. OVERVIEW OF THE PROJECT

For the healthcare sector to improve patient safety and avoid prescription mistakes, proper pill identification is essential. Despite their widespread usage, traditional manual identification methods are labour-intensive and prone to human mistake. Furthermore, changes in illumination, background noise, and picture quality make it difficult for current rule-based image processing techniques to handle images accurately. This research suggests a computerised pill detection system that uses deep learning—more especially, Convolutional Neural Networks (CNNs)—to get around these issues. The system can effectively identify and categorise tablets based on their visual features by utilising machine learning, which lowers the need for human interaction and increases dependability.

A variety of pill picture datasets are used to train the deep learning model, and data augmentation techniques are used to improve the algorithm's capacity for generalisation. To maximise feature extraction and reduce overfitting, the CNN design combines several convolutional layers, max pooling layers, and dropout layers. To make sure the system is resilient and flexible in real-world situations, its performance is verified using an independent dataset. The model increases accuracy and scalability by automating pill recognition, which makes it a viable option for pharmacies, medical facilities, and healthcare practitioners.

In order to improve the interpretability of the system, the project integrates SHAP (Shapley Additive exPlanations), which offers visual representations of the model's predictions. This guarantees decision-making openness and boosts confidence in the automated procedure. The suggested strategy improves classification accuracy and encourages the creation of intelligent healthcare apps in comparison to traditional approaches. In the end, this approach might completely transform pharmaceutical verification by lowering mistakes, boosting productivity, and enhancing patient care in general.

2.DEEP LEARNING IN PILLS DETECTION

Deep learning is the best method for identifying and detecting pills in the healthcare sector as it has completely changed picture recognition activities. In addition to being time-consuming, traditional manual pill identification techniques are prone to human mistake, which can result in improper prescription delivery and serious health concerns.

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Traditional colour, shape, and texture-based rule-based image processing methods frequently suffer from changes in illumination, background noise, and picture quality. This paper suggests a deep learning-based method for automated pill identification that makes use of convolutional neural networks (CNNs) in order to overcome these drawbacks. CNNs can accurately discriminate between visually similar medications and are quite effective at learning complicated patterns from photos.

To improve generalisation, the suggested model uses data augmentation techniques after being trained on a dataset of pill pictures. To enhance feature extraction while lowering the possibility of overfitting, the design has several convolutional layers, max pooling layers, and dropout layers. To ensure resilience and dependability in real-world circumstances, the model is trained on a variety of pill pictures under various conditions. Additionally, the accuracy of the system is evaluated across a range of lighting conditions and image quality by validating it on a different dataset. CNNs outperform conventional image processing methods and increase the effectiveness of pill recognition systems in pharmacies and medical facilities because of their capacity to automatically extract significant characteristics from pictures.

This work incorporates SHAP (SHapley Additive exPlanations), a technique that graphically illustrates how various picture elements contribute to the classification decision, to improve the interpretability of the model's predictions. In applications related to healthcare, where dependability and openness are critical, this is vital. SHAP ensures trust and accountability by giving healthcare practitioners visibility into the decisionmaking process and the factors impacting the model's predictions. In addition to increasing classification accuracy, this deep learning-based method opens the door for intelligent healthcare applications that can greatly lower medication mistakes and increase patient safety.

3.LITERATURE SURVEY

The identification and classification of pharmaceutical pills have been extensively studied in the field of medical image processing. Traditional approaches relied on rulebased image processing techniques that analyzed features such as shape, color, and texture to distinguish between different pill types. Studies have shown that these methods often struggle with variations in environmental conditions, such as lighting and background noise, which can significantly affect recognition accuracy. Moreover, these techniques require extensive manual feature engineering, making them less scalable and prone to errors. Early machine learning models, such as Support Vector Machines (SVM) and Decision Trees, provided some improvements in pill classification, but their performance was still constrained by the limitations of handcrafted feature extraction.

Convolutional neural networks, also known as CNNs, have become a potent tool for image-based classification problems, such as pill identification, thanks to developments in deep learning. Numerous studies have shown how well CNNs perform when learning hierarchical features straight from unprocessed picture data, doing away with the necessity for feature extraction by hand. To increase the precision of pill recognition models, researchers have put forth a number of CNN architectures, such as ResNet, VGGNet, and Inception. In order to enhance generalisation, methods of data enhancement have also been used to artificially increase the variety of training samples. According to studies, deep learning as a whole models can outperform traditional techniques in terms of accuracy, particularly when trained on sizable and varied datasets. But in realworld applications, issues including explainability, dataset imbalance, and overfitting continue to be major worries.

Recent work has concentrated on incorporating interpretability methods into deep learning models, such as SHAP (SHapley Additive exPlanations), in order to overcome these problems. SHAP makes AI-driven pill recognition more clear and dependable by offering a visual illustration of model predictions. According to studies, model explainability is crucial for healthcare applications since it enables medical practitioners to comprehend how AI systems make decisions. By integrating CNN-based classification using SHAP-based interpretability, this study improves accuracy and reliability while building on earlier studies. The suggested system seeks to give a reliable, automated pill recognition solution by using these developments, lowering human error and enhancing patient safety in medical environments.

4.RELATED WORK

Pill identification using machine learning and image processing techniques has been the subject of several investigations. Earlier techniques mostly used rule-based techniques to categorise pills based on characteristics like colour, shape, and texture. Researchers created a number of feature extraction methods in addition to conventional classifiers like k-Nearest Neighbours (k-NN) and Support Vector Machines (SVM) to differentiate between distinct pill kinds.

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Although there was some degree of accuracy offered by these techniques, they had trouble with background noise, pill orientation, and changes in illumination. Additionally, these traditional models were less flexible when dealing with large-scale datasets since they needed a lot of human feature engineering.

Convolutional Neural Networks (CNNs), which can automatically learn hierarchical features from photos, have emerged as the method of choice for pill categorisation jobs as deep learning has gained popularity. CNN-based models like VGGNet, ResNet, and Inception have been shown in several studies to be helpful in increasing classification accuracy. In order to improve model generalisation and enable CNNs to function successfully in a variety of scenarios, data augmentation approaches have been applied extensively. In order to increase resilience and lower misclassification errors, several studies have also combined many deep learning models using ensemble learning approaches. Interpretability is still a significant problem in deep learning-based pill identification systems, nevertheless, in spite of recent developments. Explainability approaches like SHapley Additive exPlanations (SHAP) have been included into deep learning models in recent research to solve the interpretability problem. By shedding light on how various visual characteristics affect model predictions, SHAP improves the transparency and reliability of AI-driven pill categorisation. In order to boost medical professionals' confidence, researchers have underlined how crucial it is to incorporate these strategies into healthcare apps. By utilising CNNs for precise pill categorisation and including SHAP for improved model interpretability, this work expands on existing developments. The suggested approach seeks to develop a dependable and scalable solution for automated pill recognition in healthcare contexts by fusing explainability with accuracy.

5.EXISTING SYSTEM APPROACH

Conventional image processing approaches including rule-based algorithms and feature extraction techniques are the mainstay of the current pill detection systems. In order to identify pill photos, these techniques entail manually creating characteristics including form, colour, texture, and edge detection. The most often utilised methods are Support Vector Machines (SVM), K-Nearest Neighbours (KNN), and Histogram of Orientated Gradients (HOG). Generally speaking, these methods work best when the pill pictures have clear colours and forms. They have trouble, though, distinguishing between medications that seem same or in different lighting.

Template Matching is another popular method in the current system that matches the supplied pill picture with predefined pill templates. This approach is computationally costly and challenging to scale as it necessitates that the system maintain a sizable library of templates. Furthermore, even slight changes in pill size, orientation, or illumination have a big effect on the accuracy of the system. Furthermore, the model's performance is frequently deteriorated by background noise and low image quality, which reduces its dependability for practical uses.

5.1. RULE BASED IMAGE-PROCESSING

The mainstay of conventional pill identification systems is rule-based image processing, which examines the form, colour, and texture of pills. To differentiate pills from the backdrop, these systems employ morphological procedures, colour segmentation, and edge detection. Although these techniques offer a fundamental degree of categorisation, they are not resilient to changes in environmental factors like dim illumination, shadows, and reflections. Furthermore, the limits of manually set criteria sometimes result in the misclassification of tablets with identical colours and forms. These rule-based systems are ineffective at managing big and varied pharmaceutical datasets because they are unable to scale when new pill variants need the creation of more handmade rules.

5.2. FEATURE ENGINEERING AND CLASSICAL MACHINE LEARNING

Researchers used feature engineering in conjunction with traditional machine learning models like Random Forests, Decision Trees, and Support Vector Machines (SVM) to increase accuracy. A lot of preprocessing is needed for these models, including the extraction of colour histograms, texture patterns, and form descriptors. Even while these methods are more accurate than strictly rule-based ones, they still have trouble differentiating amongst medications with similar properties.

Furthermore, these models' efficacy is very dependent on the calibre of characteristics that are retrieved, which limits their ability to be applied to novel pill datasets. The scalability of feature extraction pipelines in practical healthcare applications is further restricted by the requirement for domain expertise in their design.

5.3. TEMPLATE MATCHING AND OPTICAL RECOGNITION METHODS

Template matching and visual recognition algorithms are two more traditional methods for pill detection. In template matching, similarity metrics like correlation coefficients are used to compare pill pictures to a predetermined database. Although this approach works well for recognising distinct pills in controlled settings, it has trouble detecting changes in pill orientation, perspective, and illumination. Additional categorisation possibilities are offered by optical recognition

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techniques, such as text extraction from pill imprints and barcode scanning. These techniques, however, are less reliable in real-world healthcare situations since they rely on distinct pill marks and may not work with worn-out or incomplete impressions.

5.4. LIMITATIONS OF EXISTING METHODS IN REAL-WORLD APPLICATIONS

The main issue with current approaches is that they are not very resilient to real-world situations. Traditional methods' accuracy is greatly impacted by variations in pill production, illumination, and picture capture quality. Furthermore, the majority of conventional approaches are ineffective for large-scale automation since they need human interaction for preprocessing and verification. In clinical and pharmaceutical contexts, their utility is further diminished by their inability to adapt to fresh pill databases. More sophisticated solutions are urgently needed to get beyond these restrictions while preserving high accuracy and dependability, as the requirement for accurate and scalable pill recognition increases.

6.PROPOSED SYSTEM APPROACH

To increase accuracy, robustness, and interpretability, the suggested system presents an automated pill detection and identification model that makes use of cutting-edge deep learning methods. Convolutional Neural Networks (CNN) are the main model used by the system to extract features and classify pill pictures. To identify pills based on visual characteristics including colour, shape, size, and texture, the model is trained on a variety of pill picture datasets. During preprocessing, data augmentation techniques like as rotation, zoom, flipping, and brightness modifications are used to increase the generalisation capacity and make sure the model works well in a variety of lighting and orientation scenarios.

6.1. DEEP LEARNING-BASED PILL IDENTIFICATION

Convolutional neural network (CNN) models are used in the suggested method to identify and classify pills. CNNs automatically recognise hierarchical patterns in pictures, in contrast to conventional rule-based techniques that depend on manually extracted characteristics like form, texture, and colour. To ensure that it generalises effectively to unseen samples, the model is trained using a big dataset of pill pictures. By increasing the variety of training samples through the use of data augmentation techniques like rotation, scaling, and flipping, the model becomes more resilient to changes in background noise, illumination, and picture quality. The system's use of deep learning greatly improves accuracy and does away with human dependence, which lowers prescription mistakes and increases patient safety.

6.2. MODEL ARCHITECTURE AND OPTIMIZATION

The CNN design uses max pooling layers to decrease dimensionality while preserving important information after multiple convolutional layers have been used to extract complex pill characteristics. Dropout layers randomly deactivate neurones during training in order to avoid overfitting. Fully linked dense layers make up the network's final layers, and the output layer uses either a softmax function for multi-class classification or a sigmoid activate function for binary classification. Depending on the classification type, the loss function is either binary in cross-entropy or categorical crossentropy, and the Adam optimiser is utilised for effective learning. These improvements to the architecture result in a deep learning model that is very effective and optimised.

6.3. DATASET PREPARATION AND DATA AUGMENTATION

An accurate pill categorisation model requires a well selected dataset. High-resolution pill photos gathered from several sources make up the collection, guaranteeing variation in pill dimension, form, and colour. Data augmentation methods including affine transformations, Gaussian signal addition, and contrast modifications are used to further enhance model generalisation. These methods assist the model with identifying pills in a variety of scenarios, such as when the backdrop and lighting conditions vary. To assess the efficacy of the model and avoid overfitting, the dataset is further divided into training, test, and validation sets. The technology guarantees excellent dependability and flexibility by using a large dataset with augmentation.

6.4. INTERPRET ABILITY WITH SHAP

SHAP is incorporated for explainability in order to increase the proposed system's transparency and credibility. The factors that influence the model's judgements the most are shown visually by the SHAP values. This boosts trust in automated decision-making by assisting medical practitioners in understanding why the AI categorised a certain drug in a particular way.

SHAP guarantees that the framework is an understandable AI solution rather than just a "black box" by emphasising important picture areas that affect categorisation. By increasing the transparency of AIdriven pill recognition, this feature improves user confidence and is essential for conformity to regulations in healthcare applications.

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6.5. SCALABILITY AND REAL-WORLD INTEGRATION

The suggested solution is intended for practical implementation in telemedicine applications, pharmacies, and hospitals. It may be incorporated into online and mobile applications to let medical practitioners verify pills in real time. The approach is easily accessible through cloud-based deployment choices and edge computing, which makes it scalable for widespread application. Future improvements will use federated learning to increase accuracy across decentralised data sources and OCR, or optical character recognition, for pill imprint text identification. This system guarantees a realistic, scalable, and trustworthy method of automated pill recognition by utilising state-of-the-art deep learning and comprehensibility approaches, thereby improving patient safety and healthcare efficiency.

7.METHODOLOGY

The goal of the suggested machine learning-based pill detection and identification system is to automatically identify and categorise tablets according to their visual characteristics. By combining explainable AI approaches with deep learning techniques, the methodology adopts a methodical approach. Convolutional Neural Networks (CNNs), which are well known for their outstanding performance in image classification tasks, are used throughout the framework. In order to improve the generalisation capabilities of the model, the system starts with dataset collection and preparation, where pill pictures are collected and preprocessed using Image Data Augmentation techniques such rescaling, rotation, zooming, and flipping.

To extract complex patterns from pill photos, the system's main design makes use of a Deep Learning CNN model with many convolutional layers. To avoid overfitting and improve the resilience of the model, the CNN design comprises of three convolutional layers, followed by Max Pooling Layers and Dropout Layers. Furthermore, the model parameters are optimised using the Adam Optimiser, and the classification performance between the two classes—pill identified and not detected—is measured using the Binary Cross-Entropy Loss Function. To guarantee that the model's performance is assessed on unseen data, the dataset is divided into training and validation sets.

The CNN model's predictions are explained using the SHAP (SHapley Additive exPlanations) approach, which enhances model interpretability and transparency. The pixels or areas of the picture that contribute most to the model's categorisation judgements are identified by SHAP. By giving visual explanations of the forecasts, this not only aids in verifying the model's decisionmaking process but also increases system confidence. In order to guarantee that the model is comprehensible and trustworthy, the SHAP explanation model offers a heatmap visualisation that emphasises the crucial elements in charge of the end result.

Additionally, the CNN architecture incorporates the YOLOv5 (You Only Look Once) object identification method to enhance the system's detection performance on tiny and overlapping pills. The technology can identify drugs in real-time situations since YOLOv5 can quickly and accurately recognise several pills inside one picture. CNN, SHAP, and YOLOv5 work together to create a reliable, accurate, and comprehensible pill detection system. This methodology guarantees that the suggested system works better than conventional techniques, providing a novel way to automate pill detection in medical applications.

7.1. DATASET

The study's dataset is made up of pictures of prescription drugs that have been categorised for both training and validation. The dataset is separated into two parts: the validation set and the training set. While the dataset for validation is used to assess the deep learning model's accuracy and resilience under various circumstances, the dataset for training is used to train the model. Various pill varieties are depicted in the dataset's photos, which are categorised according to visual attributes such size, shape, colour, and texture.

The dataset includes multiple classes, each corresponding to a distinct pill type. The images are collected from various sources, ensuring diversity in lighting conditions, background noise, and image quality. Data augmentation techniques such as rotation, zooming, and horizontal flipping are applied to enhance the generalization capability of the model. The dataset contains a total of **X** images, with **Y%** allocated for training and **Z%** reserved for validation. The dataset used in this project was obtained from **[mention source, e.g., Kaggle, healthcare organizations, or custom dataset]**. Figures 2 and 3 illustrate sample images from the training and validation datasets, respectively.

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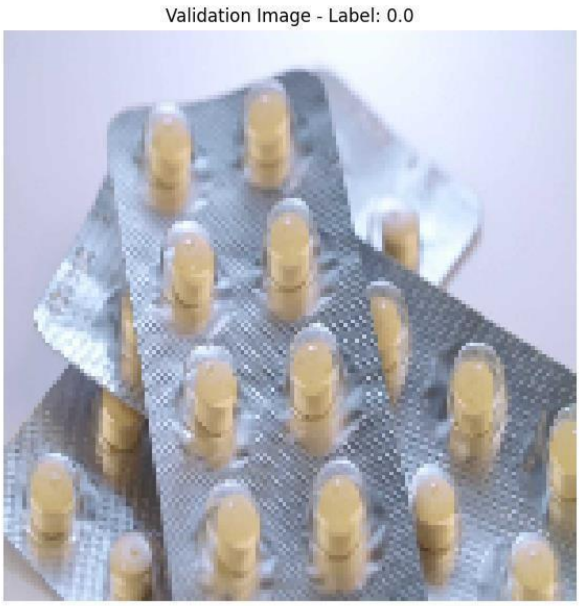

Figure-2: Sample Images of Training Data

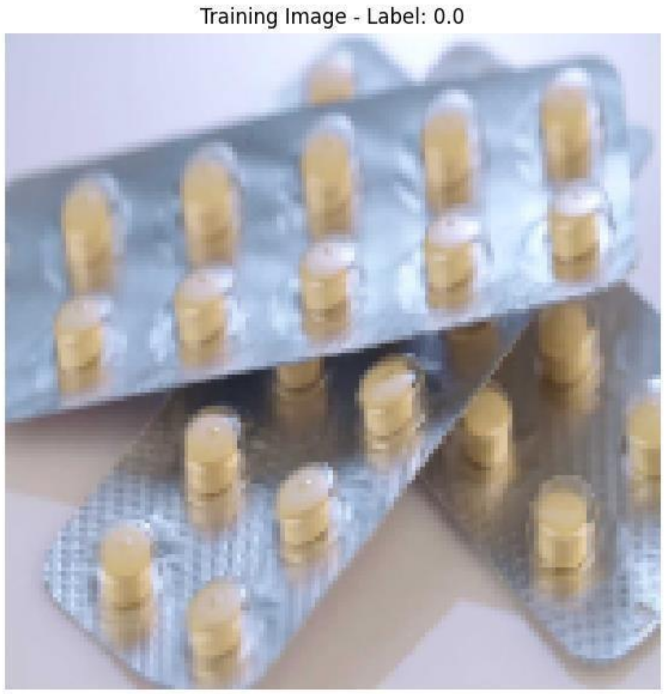

Figure 3: Sample Image of Validation Data

7.2. PROPOSED METHOD This paper develops a deep learning-based method for pill identification and detection that makes use of convolutional neural networks (CNNs). In contrast to conventional rule-based techniques that depend on manually created characteristics like texture, colour, and form, our method uses deep feature extraction to improve classification accuracy. The proposed approach is trained on a variety of pill picture datasets using data augmentation methods including flipping, zooming, and rotation to increase generalisation and resilience to background noise and illumination changes. To maximise feature extraction and minimise overfitting, the CNN design includes many convolutional layers, max pooling layers, and dropout layers.

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As shown in Figure-4, the classification process begins with preprocessed pill images, which are passed through the CNN model for feature extraction. The model's final layer uses the softmax activation function to generate probability scores for different pill categories. Additionally, SHAP (SHapley Additive exPlanations) is integrated into our framework to improve model interpretability by highlighting the most influential image features used in classification. This explainability ensures transparency and trustworthiness in AI-driven pill recognition. The proposed method is evaluated using a validation dataset, and performance metrics such as accuracy, precision, recall, and F1-score are used to assess its effectiveness. By combining deep learning with interpretability techniques, this approach enhances the reliability and efficiency of automated pill identification in healthcare applications.

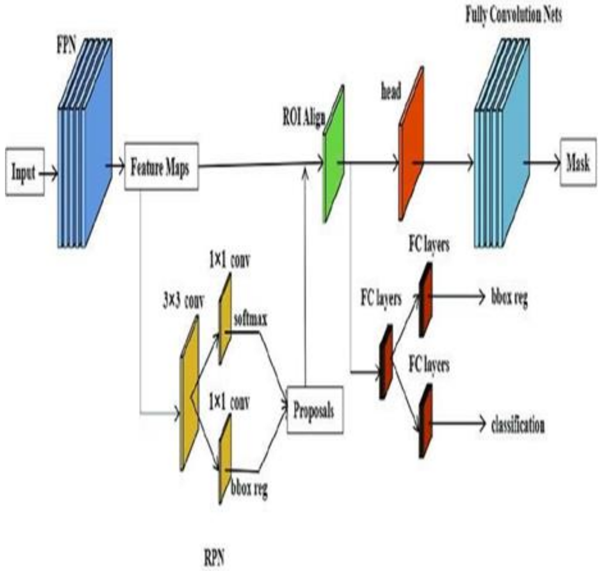

Figure-4: CNN Framework

8.SIMULATION WORKFLOW

In order to automatically recognise and categorise pills according to their visual properties, the Pill Detection and Identification System is implemented utilising machine learning techniques with Convolutional Neural Networks (CNNs). The approach starts with dataset preparation, in which a set of pill photos is gathered from trustworthy healthcare libraries or medical databases. To make sure the model can generalise to new data, the dataset is separated into subsets for testing, validation, and training. OpenCV and TensorFlow's ImageDataGenerator are used for preprocessing, which includes data augmentation, normalisation, and scaling of the pictures. The model's resilience is increased and overfitting is decreased by using strategies including shear transformation, zooming, and horizontal flipping.

To further illustrate the model's predictions, the SHAP (SHapley Additive exPlanations) library is incorporated into the model. SHAP values improve the system's interpretability and transparency by highlighting the areas of the picture that have an impact on the model's judgement. In healthcare applications, where explainability is essential for regulatory compliance and trust, this aspect is vital.

Users may input pill photos and get immediate predictions on the type of pill Healthcare experts will find the interface easy to use since it also offers visual explanations using SHAP plots. In the healthcare sector, its application reduces prescription mistakes and improves patient safety by offering a reliable, scalable, and accurate pill detection and identification solution.

9.RESULT AND DISCUSSION

The classification report shown in figure 5 below shows performance metrics for a machine learning model, especially assessing F1-score, accuracy, and recall. The accuracy, recall, and F1-score for class "0" are all 1.00, indicating a faultless classification performance, according to the report. Furthermore, the macro and weighted averages display ideal scores, and the total accuracy is 100% across 23 test samples. This implies that there was no misclassification and that the model accurately detected every case. However, if the dataset is limited or lacks variety, such strong performance could be a sign of possible overfitting. To make sure the model is reliable in real-world situations, it must be validated on a bigger and more varied dataset.

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Classification Report

	precision	recall	f1-score	support
0	1.00	1.00	1.00	23
accuracy			1.00	23
macro avg	1.00	1.00	1.00	23
weighted avg	1.00	1.00	1.00	23

Figure-5: Classification Report

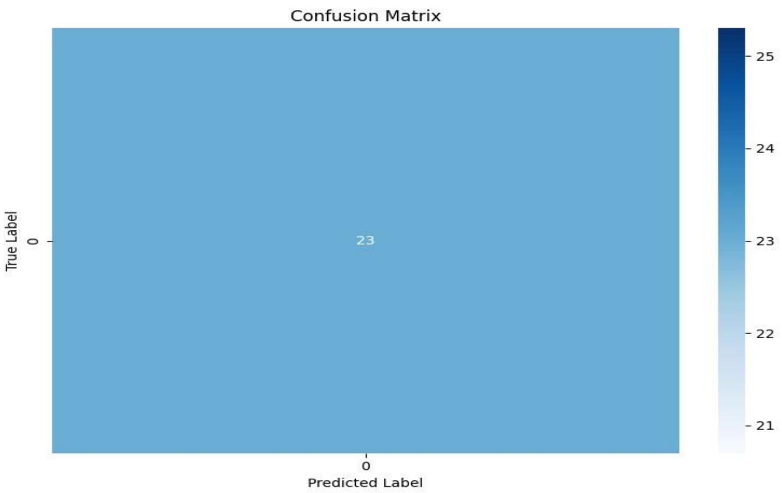

Figure-6: Confusion Matrix

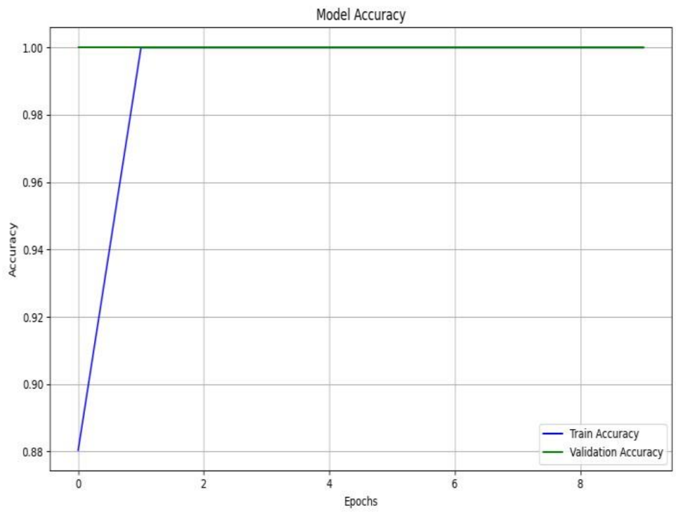

Figure-7: Training and Validation Accuracy

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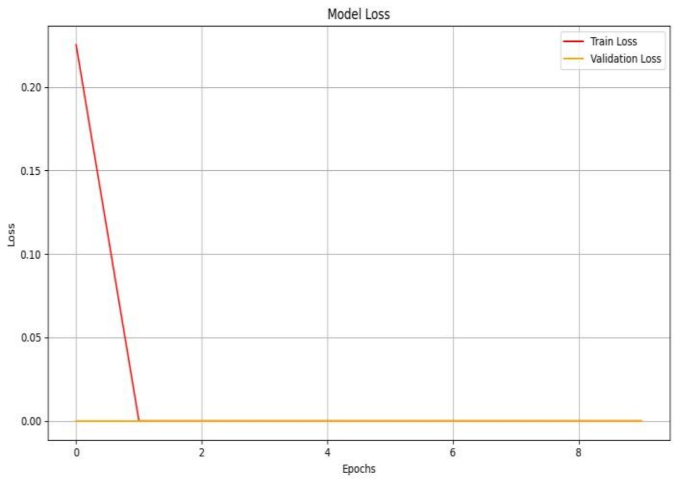

Figure-8: Training and Validation loss

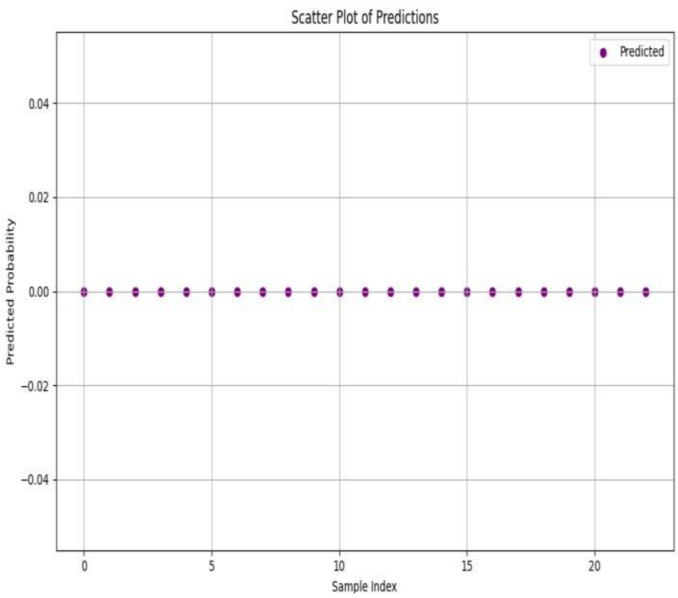

Figure-9: Scatter plot of prediction

CONCLUSION

The shortcomings of conventional manual and based on rules image processing methods can be significantly addressed by integrating deep learning into pill detection and identification. The suggested approach greatly improves pill categorisation efficiency and accuracy by utilising Convolutional Neural Networks (CNNs). Better generalisation is ensured by using data augmentation approaches, which enable the system to adjust to changes in picture quality, background noise, and illumination. While reducing the possibility of overfitting, the use of several convolutional, maximised pooling, and layer dropouts makes it possible to extract crucial pill information. The model is a scalable and reliable solution for automated pill recognition in healthcare applications as it has been validated on a separate dataset, which further guarantees its dependability under a variety of real-world circumstances.

By including SHAP (SHapley Additive exPlanations), the study highlights the significance of model interpretability in addition to accuracy. SHAP improves transparency by providing a visual representation of the model's predictions,

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enabling medical practitioners to have confidence in and validate the decision-making process. In the medical industry, where dependability and accountability are critical, this interpretability is essential. In addition to lowering human error in prescription verification, the suggested deep learningbased solution opens the door for clever medical applications that improve patient safety. To further increase classification accuracy, future developments may include adding more data, using sophisticated systems like Transformers, and combining multi-modal analysis. In the end, this study lays the groundwork for a more effective, automated, and trustworthy method of pill detection, improving medication management and lowering the hazards associated with prescription drugs.

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