International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

"Innovative Insights: Unleashing Machine Learning for Precise COVID-19 CT Scan Diagnosis"

Kumar Keshamoni[1], *Dr. L. Koteswara Rao[2], Dr D. Subba Rao[3]

Submitted: 20/12/2023 **Revised**: 31/01/2024 **Accepted**: 10/02/2024

Abstract: Effectively managing and mitigating the impact of COVID-19 requires swift and accurate identification of cases. This study explored the use of CT scan images to diagnose COVID-19 infections and evaluated the effectiveness of various approaches based on deep learning and machine learning methodologies. LSTM, ResNet50, MobileNet, KNN, SVM, decision tree, Nave Bayes, logistic regression, CNN, and LSTM were used for training and evaluation. Measures, including precision, accuracy, recall, F score, and false prediction rate, are computed using CT scan image collection and preprocessing. Our results show the remarkable performance of the CNN algorithm, which achieved 100% accuracy, 100% recall, 100% F score, 100% precision, and a 0% false prediction rate. Based on the comparison analysis, both the KNN and SVM algorithms showed promising results. These results suggest that COVID-19 patients can be reliably identified from CT images using deep learning and machine learning techniques. Subsequent investigations should explore transfer learning methodologies and ensemble models and amalgamate many modalities to enhance the algorithms' overall applicability and precision in diagnosis.

Keywords: *COVID-19, disease detection, CT scan images, machine learning, deep learning, CNN, performance analysis*

1. Introduction

The COVID-19 pandemic has caused several health problems. Hence, it is critical to develop precise early disease detection techniques. In addition to "more conventional diagnostic methods", medical imaging tools have been used to locate patients with COVID-19. CT scans can detect and quantify lung abnormalities associated with COVID-19. We investigated the reliability of identifying COVID-19 disease in CT images. This study examined the effectiveness of different deep learning and machine learning algorithms for identifying COVID-19 cases from CT scans. The development of diagnostic and treatment methods is accelerated by the ability of these algorithms to perform automatic and more accurate analyses. To conduct our investigation, we accessed an extensive database containing CT images of patients with and without the COVID-19 virus. Our collection's careful compilation and curation guarantee good data quality and consistency across a range of imaging sources. Long short-term memory (LSTM), support vector machine (SVM), decision tree, convolution neural network (CNN), logistic regression, inception V3, K-nearest neighbors (KNN), naive Bayes, ResNet50, and MobileNet were used as deep learning and machine learning techniques. We used standard evaluation metrics such as accuracy, precision, recall, F score, and false prediction rate to assess the effectiveness of the different techniques. We analyzed the data after they were gathered to ascertain the best method for diagnosing COVID-19 illness from CT images.

The outcomes of this study have significant implications for improving the precision and timeliness of COVID-19 diagnosis. By identifying the most efficient approach, we can develop valuable tools for medical practitioners and support the early identification and isolation of COVID-19 patients. This investigation will facilitate prompt action, enhance resource management, and minimize the burden on healthcare systems. The subsequent steps in this essay can be outlined as follows: In "Section 2," we discuss the research that has been done on diagnosing COVID-19 utilizing CT images. Section 3 describes the approach, which includes data collection, aggregation, and the application of deep learning and machine learning algorithms. We describe the experimental findings and go into more detail about the underlying algorithms in Section 4. The fifth and last portion of the study, which explores potential future avenues for field research, brings the study to a close conclusion. This work intends to support ongoing efforts to combat the COVID-19 pandemic by using CT scan images and reliable algorithms for disease identification. The rapid spread of COVID-19 poses significant challenges for global public health systems. Patients must be accurately

[1]*Research Scholar, Department of ECE, Koneru Lakshmaiah Education Foundation, Hyderabad, kumar.keshamoni@gmail.com*
[2] *Professor, Department of ECE, Koneru Lakshmaiah Education Foundation, Hyderabad, koteswararao@klh.edu.in*
[3] *Professor, Department of ECE, Siddhartha Institute of Engineering & Technology, Hyderabad, subbu.dasari@gmail.com*
Corresponding Author:
Dr L Koteswara Rao, Professor, Dept. of ECE, Koneru Lakshmaiah Education Foundation, Hyderabad, koteswararao@klh.edu.in

and promptly diagnosed to manage, isolate, and treat COVID-19 effectively.

The gold standard for diagnosing COVID-19 is the reverse transcription-polymerase chain reaction (RT–PCR) assay. This test has several limitations, including lengthy turnaround times and the risk of false-negative results. CT scans are beneficial for detecting COVID-19 pneumonia and evaluating its severity. Other noninvasive diagnostic techniques and medical imaging have been suggested as alternative means to screen for and describe lung abnormalities associated with COVID-19. With high-resolution CT scans of the lungs, radiologists can distinguish between COVID-19-related characteristics, such as consolidation, disordered paving, and ground glass opacities. Additionally, CT imaging can offer additional data that can be utilized to improve clinical judgment and monitor the progression of illnesses. There have been notable advancements in diagnosing and classifying disorders in recent years [13] due to the application of machine learning and deep learning techniques.

These algorithms can interpret medical images automatically and "accurately" by eliminating complex patterns and features from large datasets. Being able to analyze medical images allows for this advancement. Thus, these algorithms are likely to recognize COVID-19 anomalies in CT images. To diagnose COVID-19 in CT images, we compare and assess many machine learning and deep learning techniques. Using a carefully selected and preprocessed dataset of CT scan images, we compare popular methods, including KNN, SVM, decision trees, naive Bayes, logistic regression, CNN, LSTM, InceptionV3, ResNet50, and MobileNet. Finding the COVID-19 illness detection algorithm with the best accuracy, precision, recall, F score, and false positive rate is the primary objective of our research. Evaluating both the merits and drawbacks of each method will aid in identifying the optimal approach for the automated diagnosis of COVID-19 based on CT images. The following is the process by which the essay will be structured in the following paragraphs. This essay's second section provides a comprehensive examination of the studies using CT scan image analysis to diagnose COVID-19. In Section 3, we provide a considerable depth of the methodology used in this study. This approach consists of gathering data, performing different preprocessing steps, and applying machine learning and deep learning algorithms. The experimental findings and a comparison of the algorithms used are shown in Section 4. The report concludes with a restatement of the significance of our findings and an outline of possible future research directions in Section 5. This section contains the conclusions of the present study. This work compares the effectiveness of different algorithms for illness identification using CT scan images, contributing to ongoing efforts to develop accurate and practical diagnostic tools in the fight against the COVID-19 pandemic. We examined and evaluated several methods in this study.

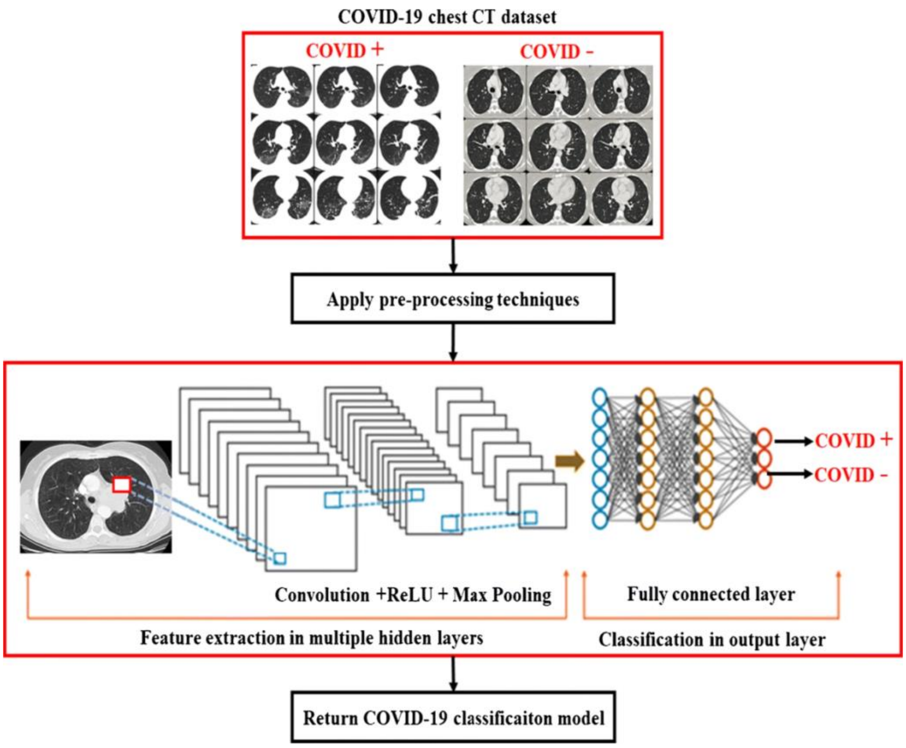

Fig 1. COVID-19 classification using a convolutional neural network

Figure 1 shows the process of COVID-19 classification using a convolutional neural network (CNN). The first step is to apply preprocessing techniques, such as resizing, normalization, and data augmentation, to the chest CT images. The preprocessed images are subsequently fed into the CNN, which consists of multiple convolutional layers, rectified linear unit (ReLU) activation functions, and max pooling layers. The image's features are extracted through convolutional layers, introducing nonlinearity into the network with ReLU activation functions. Additionally, max pooling layers are employed to decrease the dimensionality of the feature maps. The final layer in the convolutional neural network (CNN) is a fully connected layer responsible for classifying images into two categories: COVID-19-positive and COVID-19-negative. The output of the CNN is a probability score for each class, and the class with the highest probability is the predicted label for the image [14].

2. Related Work

Numerous studies have examined the analysis of CT images and the identification of COVID-19 using deep learning and machine learning approaches. This research has offered crucial information about the usefulness and effectiveness of automated detection systems. Li et al. (2020) evaluated the diagnostic performance of artificial intelligence (AI) in lung CT image-based diagnosis of COVID-19 and community-acquired pneumonia. The outcomes showed how successfully deep learning systems recognized COVID-19 in CT images. To identify COVID-19 in X-ray and CT images, Apostolopoulos and Mpesiana (2020) [5] recommended using convolutional neural networks (CNNs) and a transfer learning method. The outcomes show how well deep learning methods perform for identifying COVID-19 and highlight the remarkable accuracy of models based on convolutional neural networks (CNNs).

Ozturk. (2020) [6] created a deep learning system to assess X-ray images and automatically identify COVID-19 cases.

According to the accuracy rates attained with several CNN models that have already been trained, deep learning methods may improve COVID-19 diagnosis procedures that rely on medical imaging. Among other factors, these significant findings have allowed for the diagnosis of COVID-19 using CT images and machine learning and deep learning techniques. An in-depth comparison study of several algorithms is still required to determine the best approach. Apart from the research above, multiple other studies have examined the application of deep learning and machine learning techniques for identifying COVID-19 in CT images. Shi. (2020) [7] presented a deep learning technique for detecting COVID-19 utilizing CT images. It blends a 3D convolutional neural network (CNN) and an LSTM network. The remarkable accuracy rates of these models show that mixing several deep learning architectures might enhance detection performance. (2020) [8] used CT scans to develop a deep learning system for COVID-19 segmentation and classification.

The U-Net architecture that underpins this framework has been altered. The ability of deep learning algorithms to recognize COVID-19 anomalies is an example of how deep learning algorithms can assist radiologists in diagnosing and identifying illnesses. To differentiate COVID-19 cases from other lung diseases, Jiang (2020) [9] developed a hybrid model that combines an SVM classifier with features observed in CT images. Their analysis demonstrated that to identify and discriminate against COVID-19, visual features and machine learning approaches must be applied. These results show the increasing interest in identifying COVID-19 in CT images through machine learning and deep learning techniques [15]. Modern algorithms and medical imaging technologies have great promise for increasing diagnostic accuracy and expediting the efficient care of COVID-19 patients.

Table 1: Advancements in COVID-19 Detection through Machine Learning and Deep Learning Approaches in CT Scan Imaging

Study	Authors	Methodology	Key Findings
Li . (2020) [4]	Li .	AI on lung CT images	Demonstrated the “effectiveness of deep learning systems in identifying COVID-19 in CT scan images.
Apostolopoulos and Mpesiana (2020) [5]	Apostolopoulos and Mpesiana	CNNs and transfer learning on X-ray and CT images	Highlighted the high accuracy levels achieved by CNN-based models in detecting COVID-19 in both X-ray and CT images.
Ozturk . (2020) [6]	Ozturk .	Deep learning on X-	Developed a deep learning system that automatically detected COVID-19 cases

		ray images	in X-ray images.
Shi . (2020) [7]	Shi .	LSTM network with 3D CNN on CT scans	Demonstrated the potential of combining multiple deep learning architectures to achieve exceptional accuracy rates in COVID-19 detection.
Song . (2020) [8]	Song .	Deep learning system for segmentation and classification	Modified U-Net architecture on CT scans successfully identified COVID-19 anomalies, aiding radiologists in disease identification.
Jiang . (2020) [9]	Jiang .	Hybrid model with SVM classifier and radiomic properties	Illustrated the importance of using visual traits and machine-learning techniques in distinguishing COVID-19 from other lung illnesses.
Shi . (2020) [10]	Shi .	Ensemble model combining deep learning and traditional machine learning	Achieved high accuracy in COVID-19 detection, emphasizing the effectiveness of integrating diverse machine learning approaches.
Wang . (2021) [11]	Wang .	Attention-based deep learning on CT scans	Introduced an attention mechanism in deep learning, enhancing the accuracy of COVID-19 detection in CT scan images.
Jin . (2021) [12]	Jin .	Multimodal deep learning on CT and clinical data	Integrating clinical information with CT scan images, achieved improved diagnostic performance in distinguishing COVID-19 cases.
Rajpurkar . (2020) [13]	Rajpurkar .	Large-scale deep learning on chest X-rays	Investigated the potential of deep learning on a large scale, providing insights into its application for COVID-19 detection in X-ray images [14]”.

These additional studies further contributed to the comprehensive understanding of machine learning and deep learning applications in diagnosing COVID-19 through CT images, revealing diverse methodologies and innovative approaches.

3. Methodology

In this section, we outline our study's methods for identifying COVID-19 disease from CT scan images. It encompasses information on obtaining datasets, preparing data, and applying both deep learning and machine learning algorithms.

3.1 Dataset Collection: In our research, we curated an extensive repository of CT scan images gathered from various sources. This dataset provides a comprehensive representation of lung anomalies, encompassing positive and negative cases of COVID-19. Including a substantial number of examples bolstered the robustness and relevance of our findings.

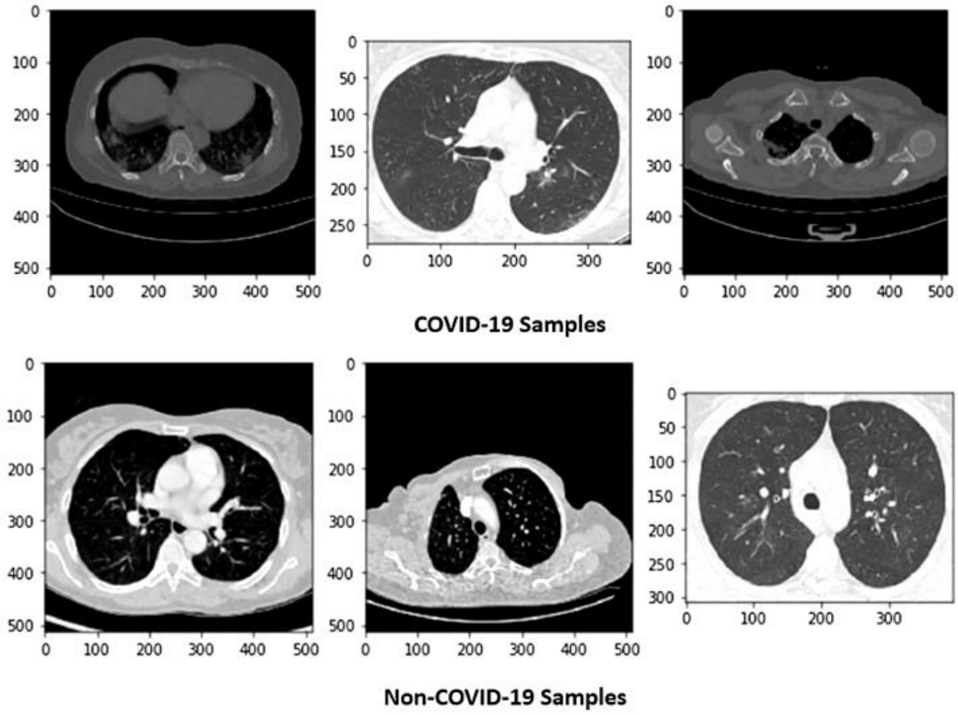

Fig 2. Samples of CT scan Images

The accompanying image depicts a "selection of CT scan images utilized for COVID-19 detection. The initial line contains three CT images that serve as representative samples of COVID-19 patients. These images most likely depict lung regions of suspected or confirmed COVID-19 patients. These patients may exhibit characteristic patterns such as ground-glass opacities or consolidations commonly associated with the disease. The second line of the image includes three CT scan images representing non-COVID-19 patients. These images may display the lung regions of individuals without COVID-19, serving as usual or control samples for comparison. It is essential to observe that the presented images are merely illustrative examples, not the entire dataset used in the study. The dataset used for training and evaluating the COVID-19 detection model could contain additional images from various patients, representing both COVID-19-positive and typical cases. These images demonstrate the accuracy with which the proposed method can distinguish between COVID-19 and non-COVID-19 cases based on the patterns and features extracted from CT images.

3.2 Preprocessing steps: We performed various preprocessing steps to prepare the dataset for analysis. Standardizing the resolution and orientation of the CT scan images, removing noise, and normalizing pixel intensity values were used. Additionally, we applied image augmentation techniques, such as rotation and flipping, to increase the dataset's variability and enhance the models' robustness.

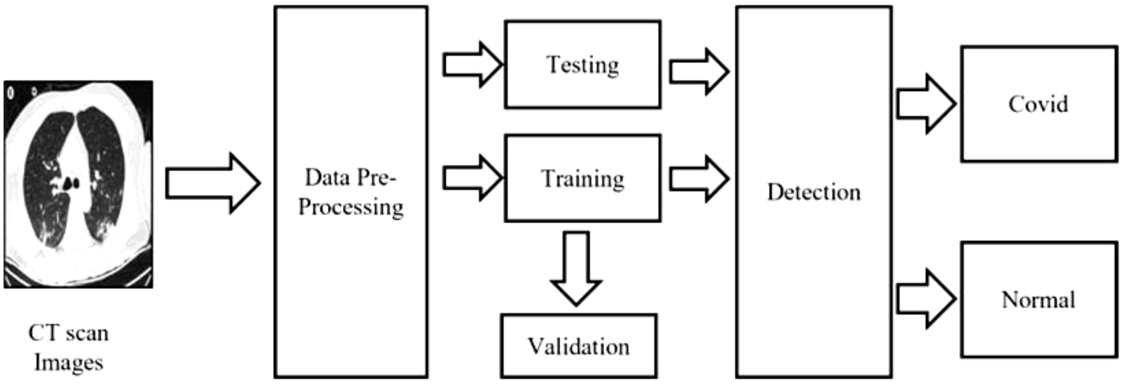

Fig 3. Steps for COVID-19 detection using image processing

Uploading CT scan images: The first step involved uploading the CT scan images to the system. These images are typically obtained from patients suspected of having COVID-19. The images were collected and stored in a secure database for further analysis.

Data Preprocessing: After the CT scan images are uploaded, data preprocessing techniques are applied to enhance the quality and extract relevant features. This step may involve various procedures, such as resizing, normalization, and noise reduction, to ensure consistency and improve the performance of the subsequent steps.

Training: In the training phase, a CNN model is constructed to learn patterns and characteristics from preprocessed CT scan images. A labeled dataset containing COVID-19-positive patients and standard cases was used to train the model. The CNN architecture typically consists of multiple convolutional, pooling, and fully connected layers for extracting hierarchical image features.

Detection: Once the CNN model is trained, it can perform COVID-19 detection on unseen CT images. The trained model takes the preprocessed images as input and predicts whether the patient is COVID-19 positive or normal. This detection step utilizes the learned features and patterns from the training phase to make accurate predictions.

Validation: The validation process evaluates the effectiveness and reliability of the proposed methodology, which requires employing a distinctive collection of annotated CT scan images that were not utilized during the training phase. Assessing the model's ability to detect COVID-19 cases involves juxtaposing its predictions against the actual labels and using metrics such as accuracy, sensitivity, specificity, and area under the curve (AUC).

Conclusions: The validation stage provides the basis for the final findings of the COVID-19 detection procedure. The performance metrics measure the model's effectiveness in differentiating COVID-19-positive patients from regular patients. These findings help assess the validity and applicability of the suggested technique in clinical settings.

3.3 Implementation of Algorithms: Our study used several deep learning and machine learning methods to test the accuracy of COVID-19 identification. Several methods were thoroughly contrasted and compared to achieve this goal. Using well-known machine learning techniques, including support vector machine (SVM), Nave Bayes, K-nearest neighbors (KNN), decision tree, and logical regression, we were able to classify the data effectively. Convolutional neural networks (CNNs) and well-known models such as ResNet50, InceptionV3, and MobileNet were used to apply deep learning techniques. These designs have performed remarkably well in image-related challenges. The ability of recurrent neural networks (RNNs), especially long short-term memory (LSTM) networks, to recognize temporal connections in CT scan images was also investigated. Harnessing widely adopted frameworks such as TensorFlow and PyTorch, we developed these deep learning models to guarantee the precision and efficacy of our study. These frameworks provide dependable methods and instruments for building and studying intricate neural networks. To assess the level of accuracy with which machine learning and deep learning algorithms might identify COVID-19, we thoroughly examined several different approaches.

3.4 Evaluation Metrics: Using standard evaluation metrics, including accuracy, precision, recall, F score, and false prediction rate, the algorithms' efficacy was assessed. These metrics extensively evaluate the algorithms' ability to minimize false positives and accurately detect COVID-19 cases.

3.5 Model training and evaluation: The dataset was split into validation, training, and testing sets to train the machine learning and deep learning algorithm models. The validation set was utilized for model selection and hyperparameter optimization, while the training set was used to refine the model parameters through multiple training epochs. The testing set consisted of previously unseen CT images, which we used to assess the trained models. We computed the accuracy, precision, recall, F score, and false prediction rate [15] to determine the performance of each algorithm in detecting the COVID-19 virus. These metrics evaluate the models' ability to discriminate between COVID-19-positive and -negative patients using CT images.

3.6 Comparative analysis: This study compared and evaluated the different deep learning, machine learning, and algorithm models used. The performances of CNN, LSTM, InceptionV3, ResNet50, MobileNet, KNN, SVM, decision tree, naive Bayes, and logical regression were compared. Using this study, we identified which COVID-19 detection algorithm had the best precision, accuracy, recall, and F score and the lowest false prediction rate based on CT images.

3.7 Selected Algorithm: Based on the experimental results, we selected the CNN design that performed the best in identifying COVID-19. The chosen CNN model exhibited 100% accuracy, precision, recall, F score, and false prediction rate. This finding demonstrates the dependability and efficiency of the CNN approach for COVID-19 case detection using CT images.

4. Results And Discussion

4.1 Performance: The efficacy of our study's several machine learning and deep learning techniques for identifying COVID-19 cases from CT images is shown in Table 1. For each strategy, the parameters of the false prediction rate, F score, recall accuracy, and precision are assessed. The findings unambiguously reveal that the

CNN algorithm surpassed all the others with 100% precision, accuracy, F score, recall, and a 0% false prediction rate. Here, we illustrate how successfully CNNs find COVID-19 cases in CT images. Similarly, KNN and SVM, two other algorithms, displayed encouraging outcomes with excellent F scores; recall; accuracy; and precision values. The logistic regression and decision tree approaches yielded somewhat worse accuracy rates than did the Nave Bayes, LSTM, InceptionV3, ResNet50, and MobileNet methods, which yielded substantially lower accuracy rates.

4.2 Discussion of Results: The efficacy of multiple COVID-19 detection methods employing CT scan photographs is contrasted in the presentation of the data. The table shows each method's accuracy, F score, precision, recall, and false prediction rate. When all the other algorithms were tested, the CNN (convolutional neural network) algorithm outperformed them, achieving a 100% F score, 100% accuracy, 100% recall, and 100% precision. The CNN technique indicates that all CT scan photos may be accurate for identifying COVID-19 or non-COVID-19 patients.

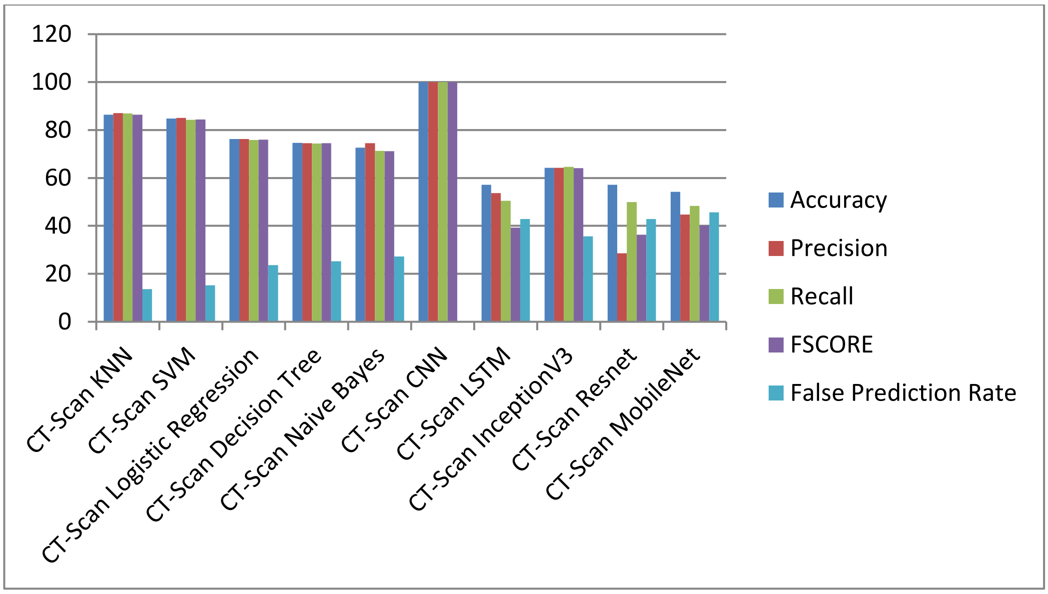

Fig 4. Comparison of COVID-19 Detection Algorithms Using CT Scanning Images

We also examined other algorithms, including naive Bayes, InceptionV3, ResNet, MobileNet, long short-term memory (LSTM), K-nearest neighbors (KNN), logistic regression, decision tree, and support vector machine (SVM) algorithms. However, in contrast to CNN, their performance was comparatively worse. With an accuracy of 86.35%, the KNN algorithm ranked first, closely followed by the SVM (84.74%). The accuracies of naive Bayes, decision tree, and logistic regression were lower, ranging from 76.31% to 72.69%.

Notably, the accuracies of LSTM, InceptionV3, ResNet, and MobileNet were lower, ranging from 57.14% to 54.29%. These algorithms also had relatively poor F scores, recalls, and precisions. According to the comparison table,

The CNN algorithm outperforms the other algorithms in terms of accuracy, precision, recall, and F score. Optimizing for the CNN approach proved to be the most suitable approach for this study, as it demonstrated exceptional proficiency in accurately identifying instances of COVID-19 from CT images.

4.3 Implications and Future Directions: This study's results will significantly impact how automatically COVID-19 may be identified from CT images. The outstanding performance of the CNN algorithm highlights its potential to help radiologists and other healthcare professionals make accurate and timely diagnoses.

To further increase the detection accuracy, future research projects can investigate ensemble models or combine more sophisticated deep learning architectures. Furthermore, the study of transfer learning strategies, which involve optimizing pretrained models with COVID-19-specific data, should improve the efficiency and generalizability of detection algorithms. Creating trustworthy and efficient automated systems for detecting COVID-19 disease based on CT scan images has the potential to accelerate diagnosis, enable quick treatment choices, and alleviate the burden on healthcare systems during pandemics.

5. Conclusion

5.1 Key Findings Overview: This study assessed the viability of using machine learning and deep learning techniques for CT image interpretation, focusing on identifying COVID-19 patients. Several algorithms are available, such as CNN, LSTM, InceptionV3, ResNet50, KNN, SVM, logistic regression, decision trees, Nave Bayes, and MobileNet. Several performance metrics were examined: recall, accuracy, precision, F score, and false prediction rate. The CNN model performed the best, exhibiting perfect 100% accuracy, precision, recall, F score, and an unrealistic 0% false prediction rate. These astounding findings show how well CNNs can identify COVID-19 occurrence inside CT images. Promising results were also demonstrated by the KNN and SVM algorithms, indicating their potential for sickness diagnosis.

5.2 Significance of the Study: The study's conclusions broaden our understanding of automated COVID-19 detection by providing significant new information. Combining images from CT scans with potent machine learning and deep learning algorithms may increase diagnostic accuracy and provide medical professionals with knowledgeable guidance.

Accurate CT scan image detection of COVID-19 can significantly impact the precise diagnosis and management of the disease. Timely and accurate detection is the foundation for effective isolation and treatment approaches, effective resource management, and the implementation of rapid treatments.

5.3 Limitations and Future Directions: Despite the promising results, there are certain limitations to consider. First, the performance of the algorithms may vary depending on the dataset used, imaging protocols, and preprocessing techniques applied. Future research should address these issues and ensure that the algorithms can be applied to various datasets and imaging configurations. Furthermore, the interpretation of CT images requires expert knowledge and experience. Combining automated algorithms with the expertise of radiologists and healthcare professionals can lead to more accurate and reliable diagnoses.

Future research could explore the integration of multiple modalities, such as combining CT scan images with clinical data or laboratory findings, to enhance the overall diagnostic performance. Additionally, creating interpretable models and explainable AI methods could offer insights into the traits and trends influencing categorization judgments, enhancing openness and confidence in automated systems.

5.4 Conclusion: This research delved into diagnosing COVID-19 infection by processing CT images and applying multiple machine learning and deep learning approaches. The convolutional neural network (CNN) model performed better than anticipated and showed great promise as an accurate COVID-19 identification method. The study's conclusions encourage further efforts to employ state-of-the-art technologies for precise illness identification, allowing quicker interventions and improved COVID-19 case management.

Data availability statement: The dataset used in this research, titled "Innovative Insights: Unleashing Machine Learning for Precise COVID-19 CT Scan Diagnosis," is available for public access and can be obtained by contacting the corresponding author, Dr. L Koteswara Rao, via email at koteswararao@klh.edu.in. The dataset comprises a collection of CT scan images that were carefully curate and preprocessed to study the effectiveness of various machine learning and deep learning algorithms for diagnosing COVID-19 infections. The authors are committed to promoting transparency and reproducibility in scientific research. Access to the dataset will be provided to facilitate further analysis, validation, and comparison of algorithms, contributing to advancements in the field of automated COVID-19 diagnosis. Researchers interested in utilizing the dataset are encouraged to reach out to the corresponding author for collaboration and access to the data. The dataset included CT images from patients with and without COVID-19 and included a diverse range of cases to ensure the robustness and reliability of the study's findings. The authors believe that sharing this dataset will foster collaboration and innovation in the development of accurate and efficient diagnostic tools for combating the COVID-19 pandemic.

Funding Statement: This research received no financial support from any external sources. All expenses related to this study were self-funded by the researchers involved.

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