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Artificial intelligence and IoT based prediction of Covid-19 using chest X-ray images

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ABSTRACT

Coronavirus illness (COVID-19), discovered in late 2019, has spread rapidly worldwide, resulting in significant mortality. This study analyzed the performance of studies that employed machines and DL on chest X-ray pictures and CT scans for COVID-19 diagnosis. ML approaches on CT and X-ray images aided incorrectly in identifying COVID-19. The fast spread of COVID-19 worldwide and the growing number of deaths necessitates an immediate response from all sectors. Authorities will be able to deal with the effects more efficiently if such illnesses can be predicted in the future. Furthermore, it is crucial to maintain track of the number of infected persons through regular check-ups, and it is frequently required to confine affected people and implement medical treatments. In addition, various additional elements, such as environmental influences and commonalities among the most afflicted places, should be considered to slow the spread of COVID-19, and precautions should be taken. AI-based approaches for the prediction and diagnosis of COVID-19 were suggested in this paper. This Review Article discusses current advances in AI technology and its biological applications, particularly the coronavirus.

1. Introduction

COVID-19 broke out in Wuhan, Hubei Province, China, in December 2019 (Ramesh et al., 2020), spreading worldwide and affecting about 265, 117, 549 people as of December 2021 (Hu et al., 2020). Many people infected with COVID-19 developed fever, dry cough, and exhaustion; others experienced a severe course of the disease (Yang and Duan, 2020). The infectious COVID-19 virus and its extraordinary number of cases worldwide have disrupted every facet of our everyday life. Covid-19 is considered high risk for pregnant women (Shah et al., 2020). To contain the impacts of this pandemic, prompt and effective countermeasures are essential; comprehensive public health policies involving monitoring and research are required (Sajed and Amgain, 2020). The corona cases and deaths recorded in December 2021 are recorded in Table 1.

Deploying automated learning and advanced technology for tackling corona spread can supplement public health initiatives (Kumar et al., 2020), such as using chatbots to answer general questions about corona. Furthermore, utilizing advanced procedures may handle COVID-19 infections in real-time and perhaps estimate its projection. AI allows robots to acquire intelligence, comprehend interrogations, and extract meaningful conclusions from raw data (Gupta and Gupta, 2022). Because of the COVID-19 epidemic, the whole planet is in lockdown mode. The researchers are working hard to find possible answers to manage this epidemic in their respective fields. Many other recently published types of research have achieved excellent prediction outcomes (Gupta, 2022; Gupta

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et al., 2021) on publicly available datasets using automated learning techniques. So far, computed tomography (CT) has shown to be a quick means of diagnosing COVID-19 patients. However, radiologists' performance in diagnosing COVID-19 was just average. As a result, more research is required to increase the performance in interpreting the performance of the coronavirus. A review on coronavirus diagnosis based on an artificial intelligence technology is presented in this work.

1.1. Contributions of the study

The study has made multiple contributions in the field of Covid-19 prediction as discussed below:

- The paper compares existing research on covid-19 diagnosis utilizing AI-based methodologies and medical imaging and medical imaging for diagnosis and automated analysis in covid-19 diagnosis.
- Most of the strategies proposed in the various publications were based on the deep learning framework and produced beneficial prediction results.
- The paper discusses covid-19 complications and clinical applications using automated learning and challenges related to cancer research using AI-based techniques.

1.2. Organization of paper

The organization of the paper has been done to facilitate the readability. Section 2 describes the search strategy used to select the research articles, followed by a brief description of artificial intelligence-based approaches in section 3. Further, section 4 carries the literature survey of the papers that have worked on coronavirus detection using automated learning strategies. Section 5 provides a discussion to summarize the paper. Lastly, the paper is concluded in section 6.

2. Search strategy

The search strategy used in this paper is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) strategy. All the research studies selected for this systematic review have been extracted from PubMed, Google Scholar, and Medline databases. All the research articles that have been published after 2020 are excluded from the analysis. The keywords used for extraction of articles include "Deep Learning", "Artificial Intelligence", "Corona Virus", "Covid-19", "Corona Detection", and a combination of these keywords. The research articles that have focused on the Covid-19 using deep learning techniques have been included in the study. Fig. 1 shows the Prisma search graph.

3. Artificial intelligence

Artificial intelligence (AI) is slowly transforming medical practice (Gupta & Gupta, 2021a, 2021b, 2021c, 2021d, 2021e). AI applications are moving into domains that were previously regarded solely as the domain of human expertise because of recent advances in digital data collecting, machine learning, and computer infrastructure. Machine learning is a subfield of Artificial Intelligence (AI) that enables a machine to understand raw data without explicit programming (Chen et al., 2021; Gupta and Kumar, 2021). It prepares the features and patterns in data and produces better future outcomes. Fig. 2 shows the automated learning process. Fig. 2 shows the automated learning process.

4. Literature survey

Computer Tomography (CT) imaging of the chest is a reliable diagnostic method for detecting COVID-19 early and controlling its spread. Authors (Polsinelli et al., 2020) proposed a novel Convolutional Neural Network (CNN) architecture based on the SqueezeNet model to identify COVID-19 CT pictures effectively. The strategy achieved 85% accuracy. Despite its modest entity, the achieved gain can be valuable for medical diagnostics, particularly in the Covid-19 situation. The suggested CNN can be run in 7.81 s which is

Table 1
Corona cases and deaths.

Country	Total Cases	Total Deaths
USA	49301070	801326
India	34587822	468980
Brazil	22084749	614428
UK	10189059	144810
Russia	9604233	273964
Turkey	8770372	76635
France	7628327	119016
Iran	6113192	129711
Germany	5825543	101652
Argentina	5328416	116554

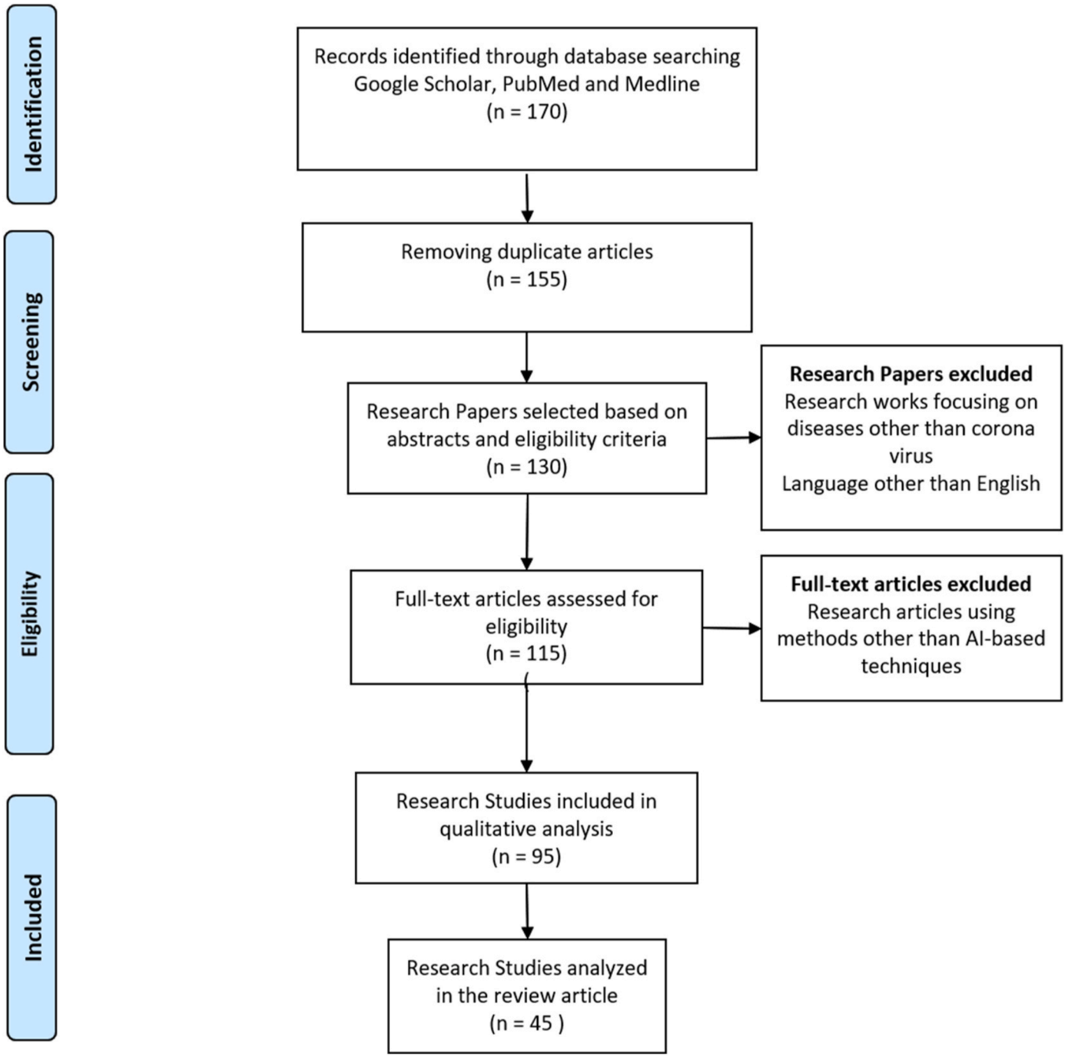

Fig. 1. Prisma search.

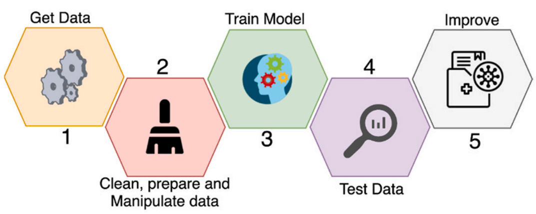

Fig. 2. Automated learning.

unfeasible for approaches that need GPU acceleration. This demonstrates that the suggested CNN model proposed in the study can analyze hundreds of photos every day even with low hardware resources. The study has further suggested improvement in CNN-2's performance even further using particular pre-processing algorithms. Sigmoid optimization is mathematically given in the equation (i).

$$Sigmoid(a) = \frac{1}{1 + e^{-a}} \tag{i}$$

The mathematical working of Hyperbolic Tangent ($Tanh$) optimization technique is given in equation *(ii)*.

$$tanh(a) = \frac{2}{1 + e^{-2a}} - 1 \quad \text{(ii)}$$

The working of Rectilinear Unit (*Relu*) optimization technique is expressed in equation *(ii)*.

$$relu(a) = \max(0, a) \quad \text{(iii)}$$

Another research study (Panwar et al., 2020) used the nCOVnet model. By including additional chest images, the study achieved more incredible accuracy. Covent also tackles the issue of RT-PCR kit scarcity by requiring just a piece of X-Ray equipment, which is currently available in most hospitals worldwide.

Given the disease's fast spread, one of the world's major concerns is detecting coronavirus disease 2019 (COVID-19). A significant research study introduced DL for COVID-19 prediction and detection. The research study (Ardakani et al., 2020a) used CT scans, analyzed a DL approach to control COVID-19 in ordinary clinical practice, and gathered the outcomes of ten CNNs. An artificial intelligence-based deep CNN was proposed in the study to detect COVID-19 patients. To see such patients, the method analyzed chest X-ray scans. Also, the study suggested such approaches be practical in COVID-19 diagnosis since X-rays are readily available and inexpensive. Empirical data from 1000 X-ray pictures of actual patients indicated that the proposed method effectively identifies COVID-19 and has an F-measure range of 95–99 percent. As a result of AI-based investigation, the study came to two significant conclusions: I The most heavily afflicted locations have comparable characteristics, and (ii) the illness spreads substantially faster in coastal areas than in other non-coastal places. As a result, seaside cities require special care and attention.

Prominent research (Mohammad-Rahimi et al., 2021) analyzed COVID-19 Epidemic using ML and DL Algorithms. Employing the Johns Hopkins dashboard data, this research recommended using ML and DL models for epidemic analysis. The results demonstrate that polynomial regression (PR) produced the lowest root mean square error (RMSE) score while anticipating COVID-19 transmission. However, if the spread follows the expected path of the PR model, it would result in a massive loss of life due to the exponential rise of the transmission globally. As shown in China, the spread of COVID-19 can be slowed and stopped by limiting the number of vulnerable persons among the afflicted. This may be accomplished by being unsocial and zealously adhering to the lockdown strategy. The research in the future is proposed to be expanded to include various ML and DL models.

Another study (Punn et al., 2020) intended to make nations and populations aware of potential threats/consequences. However, in the case of the COVID-19 outbreak, cutting-edge prediction models failed to account for critical and unprecedented

Table 2
Analysis table.

Year	Best Model	Analysis	Results
(Polsinelli et al., 2020)	CNN, SqueezNet	The method's performance can be enhanced by employing efficient pre-processing algorithms that do not require GPU acceleration	Accuracy = 87.5%
(Panwar et al., 2020)	Proposed novel approach nCOVnet	nCOVnet also tackles the issue of RT-PCR kit scarcity by requiring just an X-Ray equipment	Accuracy = 93–97%
(Mohammad-Rahimi et al., 2021)	VAE	RNN, LSTM, BiLSTM, GRUs, and VAE algorithms were compared in the study	VAE performed the best
(Punn et al., 2020)	polynomial regression (PR)	Johns Hopkins dashboard was employed to analyze covid spread	–
(Ayyoubzadeh et al., 2020)	LR, LSTM	COVID-19 Incidence Prediction Using Google Trends was used	RMSE Of LSTM = 27.5
(Ghoshal and Tucker, 2020)	Bayesian Network	Studies linking with multi "omics" datasets and treatment responses using this Bayesian DL-based categorization should give more insights.	–
(Brunese et al., 2020)	DL	COVID-19 identification from X-rays	Accuracy = 97%
Zhu, Ge, et al. (2020a)	Deep neural networks	The study predicted survival status of the 182 patients (141 survived, 41 died)	
(Ardakani et al., 2020b)	ResNet-101 and Xception	A total of 10 CNNs were employed to differentiate covid & non-covid cases.	Resnet Acc = 99.5, Xception = 99.2
Bai et al. (2020b)	Efficient Net B4	Seven substantial AI applications were proposed in the study to deal with COVID-19.	96%
(Aswathy et al., 2020)	GoogleNet CNN	The research analyzed the importance of ML for classification of the diseased and healthy lung with the nano scaling imaging practice of CT lung scans.	Acc = 88.14
(Butt et al., 2020)	3D CNN	The study used novel deep learning technique to classify pneumonia and covid cases.	99.6%
(El Asnaoui and Chawki, 2020)	Inception ResNetV2	Two deep learning models, i.e., Inception ResNetV2; Densnet201 were compared.	Inception- ResNetV2: Accuracy = 92.18%
(Kang et al., 2020)	Neural network	This proposal aims to do COVID-19 diagnosis using a set of characteristics collected from CT scans. To thoroughly investigate many features representing CT images from various perspectives.	Accuracy = 94%
(Li et al., 2020)	COVNet (ResNet-50)	Experiment findings demonstrate that our strategy can achieve greater performance while employing around half of the negative samples, resulting in a significant reduction in model training time.	Accuracy = 95%
(Liu et al., 2020)	EBT	An ensemble of bagged trees (EBT) displayed good performance	Accuracy = 94%
(Mei et al., 2020)	ResNet-18	Image segmentation is used to select relevant slices for detection of parenchymal tissue.	Accuracy = 80%
(Peng et al., 2020)	DenseNet-21	The study conducted multiple case studies to illustrate the usefulness of COVID-19-CT-CXR.	Accuracy = 85

uncertainties/factors. Predictions might be short-term or long-term depending on which elements are used/considered in their models. In an ideal world, prophecy is almost effortless, with the main problem being whether the data is vast enough. However, because of the enormous number of uncertainties in COVID-19, predictions may diverge from what they should be. A few but significant tensions may arise from various reasons, including demographics, susceptibility concerns such as lung or heart illness, hospital settings/capacity, test rate, social alienation, and income versus commodities. State-of-the-art prediction models based on SEIR/SIR, agent-based, and curve-fitting techniques hardly incorporate the abovementioned elements. To summarize the main points.

Another study (Santosh, 2020) explored DL Uncertainty and Interpretability Estimation for Coronavirus (COVID-19) Detection. The study investigated the effect of Drop weights in Bayesian CNN to estimate and improve diagnostic prediction accuracy. A Bayesian DL classifier was trained using COVID-19 X-Ray pictures using the transfer learning approach to quantify model uncertainty. The investigation revealed a substantial relationship between model uncertainty and prediction accuracy. The calculated delay gives a more reliable prediction, which can alert radiologists to incorrect predictions, increasing the acceptability of DL into clinical practice in an illness diagnosis. Another significant work (Ayyoubzadeh et al., 2020) has explained the significance of DL. The authors proposed using DL for corona identification from medical images to provide an automated and speedier diagnosis. Specifically, the study suggested a three-phase strategy, the first of which is to identify the existence of pneumonia in a chest X-ray.

Also, few studies (Ghoshal and Tucker, 2020) explored the Deep-learning and transfer learning approaches for predicting COVID-19 patients' mortality or severity using portable chest radiographs. An LSTM model with the lowest possible error was used to forecast daily and weekly instances. The suggested technique achieved great short-term prediction accuracy, with fewer mistakes than 3% for daily predictions and less than 8% for weekly predictions. To facilitate the discovery of new coronavirus hotspots, Indian states were divided into zones depending on the distribution of positive cases and daily growth rate. Preventive actions were also proposed to minimize the spread in the relevant zones. A website was built for authorities, academics, and planners where state-by-state projections were updated using the suggested model.

In a research study (Brunese et al., 2020), AI approaches have been employed for predicting COVID-19 malignant development. This information provides a high reference value for predicting people who may proceed to cancer. The subject of COVID-19 malignant progression prediction was investigated using complementary data from a quantitative CT scan and clinical data. The study had multiple limitations; for example, the number of samples available for predicting malignant development was restricted. The vast scale dataset's different data allowed DL-based approaches to understand better what triggers mild patients' malignant growth. The predictive model may perform better when using the richer original characteristics in the CT scan pixel-wise segmentation data. Finally, the DL-based technique used clinical and quantitative CT data to predict malignant development to the severe/critical stage. This study confirmed the importance of supplementary data and its unique presentation approach for this specific prediction job. Table 2 shows the analysis of multiple studies working on covid.

5. Discussion

Data mining has now begun to experiment with clinical data. There is a pressing need for effective ways of extracting unknown and valuable hidden information from medical data so that complicated interrelationships between patients, medical problems, and therapies may be studied clearly. Data mining is widely used in the healthcare and medical fields (Zhu et al., 2020b). It has many applications, including detecting insurance fraud, improving therapy management, determining the causes of diseases, and identifying practical medicinal actions. Data mining is a critical component of a larger concept termed knowledge discovery. Fig. 3 shows the importance of AI in healthcare.

The most critical role in medical science is diagnosing any ailment and treating patients. Data is becoming increasingly important in the healthcare industry. In recent years, doctors' handwritten notes have been transformed into computerized records to lower treatment costs and increase efficiency.

In reality, high-performance CNN systems rely heavily on pre-processing with GPU acceleration. The study stresses om ambitious future objective to develop unique and efficient pre-processing solutions for middle-class PCs with no GPU acceleration.

This model might assist hospital management and medical specialists in taking the essential procedures to manage COVID-19 patients following their rapid discovery.

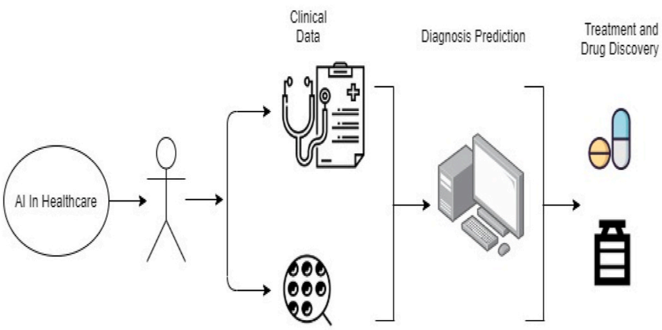

Fig. 3. Clinical applications of AI

Finally, a promising CAD technique based on CT images was developed to identify COVID-19 infection from other atypical and viral pneumonia illnesses (Haritha et al., 2020; Kumar et al., 2021). This model is inexpensive and may be used as an adjuvant approach during CT imaging in radiology departments.

The study concluded that the accuracy of recently proposed approaches varied from 76 percent to more than 99 percent, demonstrating that DL approaches used to determine the result. This forecast may help policymakers, and healthcare administrators plan and distribute healthcare resources more effectively.

DL has attained cutting-edge medical imaging capabilities. However, many disease detection strategies are only concerned with enhancing classification accuracy or prediction rather than assessing uncertainty as a choice. Knowing how confident clinicians are in a computer-based medical diagnosis is critical for increasing clinician faith in the technology and, as a result, improving therapy. Infections caused by the 2019 Coronavirus (COVID-19) are currently a severe healthcare concern worldwide. COVID-19 detection in X-ray imaging is critical for diagnosis, evaluation, and therapy. Diagnostic ambiguity in a report, on the other hand, is a challenging but unavoidable assignment for radiologists.

Studies linking with multi "omics" datasets and treatment responses using this Bayesian DL-based categorization should give more insights regarding imaging markers and discoveries towards improved diagnosis and therapy for Covid-19.

6. Conclusion

COVID-19 is a recent global outbreak that has affected 186 nations worldwide. Iran is one of the ten countries most affected. Search engines give essential demographic data, which may be used to investigate epidemics. Using data mining methods on existing data may provide improved insight into managing the coronavirus epidemic health problem for each country and the world. Medical Imaging is one of the most prevalent and successful procedures used by researchers. However, inspecting each report requires multiple radiology professionals and time, which is one of the most challenging duties in a pandemic. In this study, we present a review of the DL neural network-based technique that can be utilized to identify COVID-19 by analyzing patients' X-rays, which will seek visual indications detected in COVID-19 patients' chest radiography imaging. It is a factual truth that rigorous testing and social isolation are two of the most critical steps that governments must adopt to manage the COVID-19 epidemic. With the suggested deep learning models, these constraints may be addressed.

Credits

Dr. Surbhi Gupta worked to literature survey and collected the data for the research work. She prepared the first draft of manuscript. Dr. Mohammad Shabaz worked on research analysis and validation. Dr. Sonali Vyas worked on the final draft of the manuscript.

Conflict of Interest

The authors declare no conflict to disclose.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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