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A Comprehensive Review of AI and ML Applications in Combating the Covid-19 Pandemic

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Abstract: *By examining medical data, artificial intelligence (AI) and machine learning (ML) have shifted the paradigm in healthcare and may be utilised for forecasting and decision assistance. Recent research has demonstrated that COVID-19 can be fought with the use of AI and ML. This article's goal is to provide an overview of current research that have used AI and machine learning to analyse the epidemic. 49 articles were ultimately chosen through an inclusion-exclusion procedure from an original collection of 634 articles. In this article, we looked at the goals of the research that have already been done (such as the use of AI and ML to combat the COVID-19 pandemic); the background of the studies; and (i.e., whether it had a global view or was centred on a particular geographical setting; the kind and size of the dataset; and the methodology, algorithms, and methods employed in the prediction or diagnosis procedures.) By emphasising the prediction/classification accuracy of the algorithms and methodologies, we have mapped them with the different types of data. We divided the study goals into four divisions based on our analysis: illness detection, epidemic forecasting, sustainable development, and disease diagnostics. We noticed that the majority of these investigations utilised chest X-ray and CT scan image data along with deep learning techniques. In this study, we provide an overview of the six potential areas for further research that we have identified.*

Impact Declaration: In the fight against the COVID-19 pandemic, machine learning (ML) and artificial intelligence (AI) techniques have been extensively deployed. A relatively small number of comprehensive literature reviews have been undertaken to synthesise the information and determine the future research agenda, including the review on data science for COVID-19 in this article that was previously published. We analysed and aggregated contemporary material that focuses on the uses and applications of AI and ML to combat COVID-19 for this study. In order to direct researchers in doing future study, we have chosen seven potential research paths. These are the ones that are most crucial: develop Support the health care workforce, investigate the influence and variety in research findings based on various forms of data, investigate novel treatment alternatives, and so on.

Keywords: Artificial intelligence, COVID-19, coronavirus, deep learning, epidemic, literature review, machine learning, pandemic.

I. INTRODUCTION

As of October 2020, COVID-19 (Coronavirus disease-2019), a novel and infectious viral pneumonia, has sickened more than 42 million individuals and killed more than 1.2 million [1]. The COVID-19 epidemic might be slowed down by early discovery, isolation, and timely treatment, according to the WHO, which labelled it a worldwide pandemic [2]. As a result, a number of organisations have committed to carrying out research on COVID-19.

Artificial intelligence (AI) has remerged in the scientific community as fresh findings are reported at an incredible rate. AI is a subfield of computer science that may be applied to the creation of intelligent systems and is frequently implemented as software. The current use of AI in illness diagnosis has expanded its potential. One of the most promising application fields, which dates back to the middle of the 20th century [4], is medicine and healthcare systems. Several decision support systems for diagnosing health and illness have been suggested and successfully developed by researchers [5]. The rule-based AI system was successful in the late 1970s [6] and has since helped doctors diagnose patients, interpret ECG pictures, select the best course of therapy, and come up with hypotheses.

Modern AI uses machine learning algorithms to detect patterns and relationships in data, as opposed to this first-generation knowledge-based AI system, which depends on the past medical knowledge of specialists and the formulation-based rules. The effective implementation of deep learning by training an artificial neural network with massive labelled datasets is largely responsible for the recent renaissance in AI. Numerous hidden layers are often present in a contemporary deep learning network [13]. The debate of whether AI-doctor will soon replace human doctors has been driven by the recent return of AI. Researchers think that AI-driven intelligent systems can considerably aid human doctors in making better and quicker judgements, and even occasionally reduce the need for human decisions (for example, in radiography), however this needs to be seen [14].

The current success of AI in healthcare may be ascribed to the growing amount of data in the industry as a consequence of the greater usage of digital technologies and the development of big data analytics [14]. It is now simpler to gather and get this data using mobile applications due to the widespread use of mobile devices [15]. Even though AI research in medicine is still in its infancy, the majority of it is concentrated on three diseases: cancer, neurology, and cardiology. A powerful AI can uncover insights from medical data with the use of evidence, which may then be applied for forecasting and decision support [16]– [18]. Researchers believe AI might be valuable in the fight against COVID-19 since it has already shown promise in the healthcare industry. AI has triggered a paradigm change in health care, from pandemic predictions to creating anti-viral-replication chemicals.

Recent studies on COVID-19 infection and infected populations imply that AI may be useful in predicting the next epidemic, identifying the attack pattern, and potentially discovering a treatment [19], [20], [21]. Recent studies have demonstrated the use of AI [22], including biological data mining and machine learning (ML) techniques [23], in the identification, categorization, and creation of COVID-19 vaccines. Eight papers were chosen for evaluation, and authors in [23] focused on the validity and acceptability of these strategies. In [22], the authors provided a set of future criteria for the assessment measures as well as an evaluation and benchmarking of the AI approaches used to the picture data. Our study, on the other hand, examines a wider range of activities, such as the use of AI in detection, diagnostics, epidemic forecasting, and performance evaluation. We also offer suggestions for future researchers on how AI and machine learning may be used to combat additional pandemics besides COVID-19. Together, this analysis examines the research that has been done using AI to combat the COVID-19 epidemic.

The remaining parts are arranged as follows. Section 2 of this review research discusses the approach used to carry it out. Section 3 discusses the review data analysis and findings. The key conclusions and the prospective scope of future study to combat COVID-19 are described in Section 4, and the concluding remarks, restrictions, and research proposal ideas are offered in Section 5.

II. METHODOLOGY

A comprehensive literature review technique [25] was used in this study.

Criteria for Inclusion and Exclusion

The following criteria were used to choose an article: The article adopts, develops, or suggests AI and ML approaches, algorithms, systems, methods, or applications to combat the COVID-19 epidemic. It is published in English. Additionally, we applied the subsequent exclusion standards: Earlier versions of any article that has been published on the same set of data exploring the same objective, (a) duplicate articles that are discovered through multiple scholarly databases, (b) articles that are not focused on our research objectives, (c) articles that are not written in English, and (d) articles that are not focused on our research objectives.

Study Choice

913 articles from the mentioned databases were included in the search results. According to the exclusion-inclusion criteria, the article selection process is shown in various steps on the Prisma flowchart in Fig. 1. Duplicate articles were eliminated from 913 articles before the study selection procedure began, and a total of 619 articles were eliminated during the initial screening. After that, English-language publications were assessed to see if they met the requirements for inclusion based on their abstracts and, in certain cases, introductions. A total of 66 articles were included at the conclusion of the second round of the selection process. In the third round, 17 publications were disqualified because more current versions had already been published on the same dataset and focused on the same topic. 49 items in total

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were included in the evaluation after three phases of the indicated inclusion-exclusion method were applied. The last batch of papers consists of original research, reviews, and brief pieces with viewpoints, editorial comments, and letters to the editor.

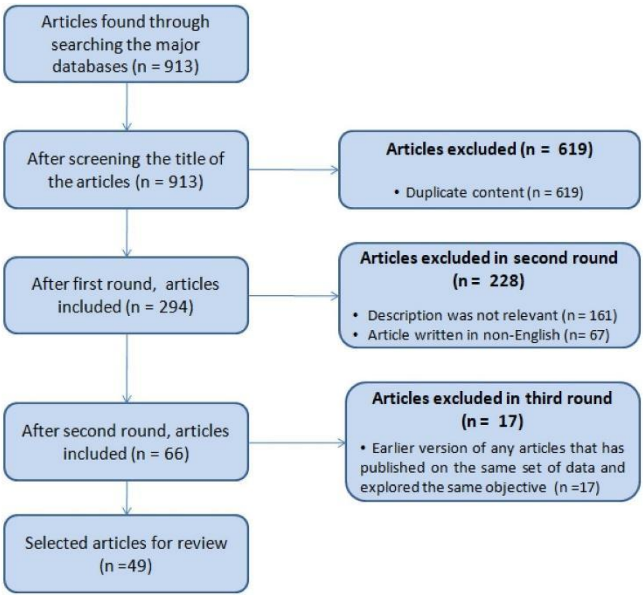

Fig. 1. Article inclusion and exclusion process flowchart.

Extraction of Data

To investigate various AI and ML approaches, algorithms, and systems and their implications for battling the COVID-19 epidemic, data extraction was carried out. Thus, in order to gather and extract research material and to build the review paper, the selected publications were carefully examined. To assure the accuracy and calibre of this review paper, two senior academics with backgrounds in AI, ML, and health information oversaw and reviewed the whole search process. The study's data extraction process for each chosen article focused mostly on the paper's kind, publication date, research goals, study context, results, and methodology, algorithm, and techniques employed, dataset, and study topic. The retrieved data were then combined and evaluated to provide a summary of the previous study and to pinpoint prospective areas for further investigation.

III. ASSESSMENT OF DATA AND FINDINGS

Publications Types

33 (67%) of the 49 papers were original research publications. The remaining 16 were divided into 10 review pieces, 2 editorials, and 4 research views (short conceptual articles). 35 papers (or 73%) were published in scholarly journals, while 14 (or 27%) were stored as pre-prints. 10 (71%) of the pre-prints contained unique research. Between January and August 2020, all of the chosen articles were either published or stored in internet databases.

Goals and Purposes of the Research

We compiled the research that has already been done in order to examine how AI may help combat the COVID-19 outbreak. Table I, which displays the study areas and goals of the original research, summarises the synthesised data. (n = 19, 39%) The majority of the articles were various AI-based techniques, such as the convolutional neural network (CNN) model, support vector machine (SVM), generative adversarial network (GAN), and transfer learning, have been published with the goal of recognising COVID-19 infected individuals. To predict or identify COVID-19 patients, chest X-ray pictures, CT images, mobile sensor data, and COVID-19 symptoms were employed.

Studies that focused on predicting or detecting illnesses largely intended to identify, screen for, and detect COVID-19 individuals as well as to predict, distinguish from, or categorise the patients into infection categories, no infection categories, and other viral or bacterial infection categories. For instance, Wang et al. [26]] proposed COVID-Net, a

Purposes	Brief Description	Reference	Frequency
Diseases detection	Identify the infected individual more quickly	[21]	19
	Screen coronavirus diseases using deep learning	[27]	
	Identify the coronavirus patients	[28]	
	Develop a CNN-based algorithm to detect COVID-19 from CT images	[20]	
	Detect COVID-19 with the help of AI and smartphone sensors	[29]	
	Use an anomaly model based on a deep learning network to make the screening process faster for COVID-19 detection from X-ray images	[26]	
	Detect COVID-19 from X-ray images using transfer learning with CNN	[30]	
	Detect COVID-19 from X-ray images using a deep CNN model	[31]	
	Propose an algorithm to detect COVID-19 from CT images using a deep CNN model and SVM classifier	[32]	
	Develop a deep learning model CoroNet using the Xception CNN to detect COVID-19 from X-ray images	[33]	
	Build a framework that uses smartphone sensors to detect COVID-19	[29]	
	Classify patients into non-COVID 19 infection, COVID-19 infection, and no infection from X-ray images using a deep CNN model	[26]	
	Compare the performance of seven DL models to find the best model for COVID-19 detection	[34]	
	Develop and evaluate the performance of an AI model to detect COVID-19 and also evaluate the performance of radiologists to detect the disease by using and without AI support	[35]	
	Detect the COVID-19 by identifying the characteristics from chest X-ray using a deep learning model(CAD4COVID-XRay)	[36]	
	Detect COVID-19 from X-ray images using generative adversarial network (GAN) and deep learning transfer	[37]	
	Develop and evaluate and AI-based system for detecting COVID-19 from a globally diverse and multi-institution dataset	[38]	
	Develop several AI models to identify COVID-19 positive patients using blood counts without knowledge of symptoms or history of the individuals	[39]	
	Detect COVID-19 with faster R-CNN using X-ray images for real-time assessment	[40]	
Diseases diagnosis	Diagnose the identified patients to classify (in to patients' categories) and tracking the progress COVID-19 patients	[41]	9
	Distinguish COVID-19 from pneumonia using deep learning	[42]	
	Efficiently diagnose COVID-19 using X-ray images through deep CNN models	[43]	
	Develop a tool to predict survival and death for severe COVID-19 patients	[44]	
	Diagnosis COVID-19 positive case faster using both non-image and image clinical data	[45]	
	Develop a system to identify patients who would develop more severe illness among the patients with mild cases of COVID-19	[46]	
	Develop a system to improve the diagnostic performance from posterior-anterior (PA) X-ray images of lungs with COVID-19 cases	[47]	
	Analyse and predicting the risk of COVID-19 patients based on ML models using patient's baseline clinical parameters	[48]	
	Develop a deep learning-based model to repurpose commercially available drugs to disrupt viral proteins of SARS-Cov-2	[49]	
Epidemic forecasting	Forecast of the COVID-19 to estimate size, lengths and ending time of COVID-19 across China	[19]	3
	Predict the trend of the infection for the next 80 days using deep learning as well as the progress of the epidemic (epidemic sizes and peaks)	[50]	
	Predict the growth of the COVID-19 pandemic using mathematical modeling, ML and cloud computing	[51]	
Sustainable development	Analyze the correlation among environmental factors and confirmed cases of COVID-19	[52]	1
Performance comparison	Compare the prediction performance of the proposed algorithms with the existing methods	[32]	4
	Compare seven different DL models to find out the best model for disease detection	[34]	
	Compare the performance of radiologists in distinguishing COVID-19 from other pneumonia with and without AI assistance	[35]	
	Compare the performance of a DL model with six other radiologists	[36]	
Patient management	Improve management of COVID-19 ICU patients	[53]	1

Table 1: Key Purposes of the Reviewed Studies

Purposes	Brief Description	Reference	Frequency
Review Literature	Review the related work to highlight the contributions and constraints of AI in fighting the COVID-19 pandemic	[56]	10
	Review related work to identify a roadmap of AI applications to fight against the pandemic	[57]	
	Review the AI based techniques used in the CT and X-ray based medical imaging data acquisition, segmentation, and diagnosis to fight against the COVID-19 pandemic	[25]	
	Review the articles focusing on AI in radiology and pandemic control to highlight the current status and common problems of AI-based systems to diagnosing the COVID-19	[63]	
	Synthesize the importance and performance of 12 different data mining and ML techniques to detect and diagnose the CoV family diseases, including MERS-CoV and SARS	[64]	
	Examine the COVID-19 epidemic to depict how the modern AI and ML technologies have recently been employed to address the challenges during the outbreak	[65]	
	Explore the importance of AI, ML, and deep-learning based techniques in speeding up the vaccination development	[24]	
	Explore the significance of AI in drug repurposing for coronavirus diseases and propose an AI based model adopting different deep learning algorithms (RNN,CNN,DBN) for drug repurposing	[54]	
	Review the AI techniques for detecting COVID-19, classifying COVID-19 medical images patients, and propose a method for evaluating and bench-marking AI techniques suitable for detection and classification of COVID-19 medical images	[66]	
	Explore three technology based initiatives for fighting with COVID-19, including AI based search tools, COVID-19-focused datasets, and the contact tracing mobile applications	[67]	
Editorial	Highlight how AI-based solutions may assist in fighting against the COVID-19 pandemic	[55]	2
	Review existing works, current efforts, and potential work ideas to fight against COVID-19 using AI, ML algorithms, deep learning, and neural networks.	[58]	
Perspective	Highlight the needs of AI and methods of data sharing via smart city networks for better monitoring and management of urban health during the COVID-19 outbreak	[59]	4
	Discussed the importance of active learning based AI tools for coronavirus outbreak.	[60]	
	Introduce AI and Blockchain and suggest how they can be used to effectively help the community with equipment and donations	[61]	
	Highlight the utility of evidence-based prediction tools/models in a number of clinical settings to fight the COVID-19 pandemic	[62]	

Table 2: Scopes of other type of research

CNN-based prediction system that distinguishes between patients who are infected with COVID-19 and those who are not using chest X-ray images. The Covid dataset, which had 13 800 chest X-ray pictures of 13 725 persons, was used to train the proposed model after it had already been pre-trained on the open-source ImageNet dataset. The collection consists of 5538 photos from non-COVID-19 patients, 8066 images from healthy individuals, and 183 images from 121 patients who tested positive for COVID-19. Nine publications (18%) in total concentrated on using AI to identify COVID-19 patients (Table I).

Articles that were primarily concerned with identifying COVID-19 patients are included under "diseases diagnosis." These articles describe how AI was used to diagnose COVID-19 patients, classify them into patient categories (severe, mild), track their progress, differentiate COVID-19 from pneumonia, predict survival and death for severe COVID-19 patients, identify patients who would develop more severe illness, estimate uncertainty to improve diagnostic performance, and predict the risk of COVID-19 patients. Three (6%) papers attempted to anticipate the COVID-19 pandemic, estimating its progression or growth in terms of its magnitude, duration, peaks, and ending times as well as projecting the epidemic's development tendency in a particular nation or geographic area [19], [50], [55]. Only one research [52] that used binary classification and regression analysis to examine confirmed COVID-19 cases was discovered.

It examines the relationship between environmental variables and COVID-19 instances that have been confirmed in four countries (China, Italy, South Korea, and Japan) (low, high and average temperature, humidity and wind flow) Another paper [32] used two distinct subsets of data to evaluate the prediction performance of the proposed algorithm with the current VGG-16, Google Net, and ResNet50 approaches. Review articles, editorials, opinions, commentary, and brief communications make up the remaining pieces (around 33%). Table II gives an overview of the synthesised data. Ten review studies altogether were considered. Each research approaches the COVID-19 pandemic from a different angle and with a different goal in mind. Bullock et al. [57] presented a roadmap of AI applications to fight the virus, whereas Naude [56] underlined the contributions and limitations of AI. The AI-based methods applied in CT and X-ray-based medical imaging were examined in another review [25]. One of the two editorials highlighted how human oversight will be necessary for AI-based solutions to create anti-viral replication chemicals [55].

A workflow was described in another editorial to emphasise the methods and uses of AI in the pandemic battle [58]. In articles about perspectives, many viewpoints are highlighted. First, the viewpoint papers showed how data sharing through smart city networks and the demands of AI may improve monitoring and control of urban health [59]. Second, research has examined the value of AI technologies that use active learning for coronavirus epidemics [60]. Third, research has shown that blockchain and AI may be utilised to support the community with donations and equipment during the COVID-19 epidemic [61]. The use of evidence-based prediction tools or models to combat COVID-19 in a variety of clinical settings has also been addressed by certain study [62].

Literature	Objective	Data Source	Data Volume	Data Type
[19]	Epidemic forecasting	WHO and local Chinese news media collected Data	15,384 and 36,602 cases Clinically confirmed and lab confirmed cases respectively	Time series data (Non -Image)
[52]	Sustainable development	Data from 42 province of China, Japan, Italy and South Korea	-	Environmental, geographical and demographical data from 28 January 2020 to 26 February 2020(Non -Image)
[28]	Diseases diagnosis	Chainz(development dataset), data from hospital in Wenzhou, China, Chainz, El-Camino Hospital (CA), LIDC (testing dataset), El-Camino Hospital (CA) (lung segmentation development)	157 patients	CT scan images of lungs(Image)
[70]	Disease detection	China	453 images from 99 patients	CT images of chest (Image)
[50]	Epidemic forecasting	Covid-19 outbreak data reported by the National Health Commission of China(Wuhan, Hubei province, Guangdong province, Zhejiang province) , Migration data was retrieved from a web based program, 2003 SARS epidemic data was retrieved from an archived news-site (SOHU)	-	Non -Image
[32]	Disease detection	Societa Italiana di Radiologia Medica e Interventistica (Itali)	150 CT images	Time series data(Non -Image)
[44]	Diseases diagnosis	Wuhan (China) clinical Data	3129 cases of COVID-19 patients	Time series(Non -Image)
[46]	Disease detection	Clinical data from Wenzhou, Zhejiang, China.	53 hospitalized patients'	Medical data (Non -Image)
[45]	Disease diagnosis	Chest CT studies and clinical data from China	905 patients	Chest CT images And clinical data (Non-image)
[35]	Disease detection	Chest Xray from Hunan province, China	512 patients	Chest X-ray (Image)
[68]	Disease detection	Chest CT images of patients from China, Italy, Japan, USA	2724 scans from 2617 patients	Chest CT images
[69]	Disease detection	Full blood count of patients from The Hospital Israelita Albert Einstein, Sao Paulo, Brazil	Total 527 admitted and only tested patients	Full blood count

Table 3: A brief detail on data used in the contextual literature

Study Context

While some publications performed research from a local viewpoint, others did it from a global one. According to Table III, a total of 12 pieces (or 24%) concentrated on a particular nation. One of these studies focused on 42 provinces in Japan, China, South Korea, and Italy for environmental parameters, weather trends, and confirmed cases to measure correlations and also build a classification model [52], while another study examined confirmed cases from 34 provinces of China to propose a forecasting system [19]. The training and testing of automated AI-based tools for diagnosis and tracking employed CT scans of the lungs from patients in both the USA and China [28] [35] as well as CT scans of the lungs just from China [20] [45]. While in [68], data from patients' chest CT scans from the USA, China, Japan, and Italy were gathered to look for COVID-19.

To forecast the outbreak nationwide, SARS 2003 epidemic data from all of China and epidemiological data from three provinces (Hubei, Guangdong, and Zhejiang) were combined [50]. For the purpose of identifying COVID-19, patients' CT scans and complete blood counts were gathered from Italy [32] and San Paolo, Brazil [69], respectively. For the purpose of identifying and diagnosing COVID-19, non-image data were only acquired from two locations: Wuhan, China [44], and Wenzhou, in the province of Zhejiang [46]. As can be seen, the majority of papers focused on data from China, the pandemic's original epicentre. Contextual papers mostly discussed predicting epidemics and sustainable development. The majority of the articles on illness detection and diagnosis, as well as all of the recommendation-type articles, employed global viewpoints and public statistics and lacked context (see Fig. 2).

The results showed that while studies concentrating on epidemic forecasting and sustainable development incorporated contextual data, illness detection and diagnosis approaches were often not context-dependent. There were four cross-country studies, one of which [52]] sought to correlate the COVID-19 instances of various nations. Additional research [28], [35], and [46]

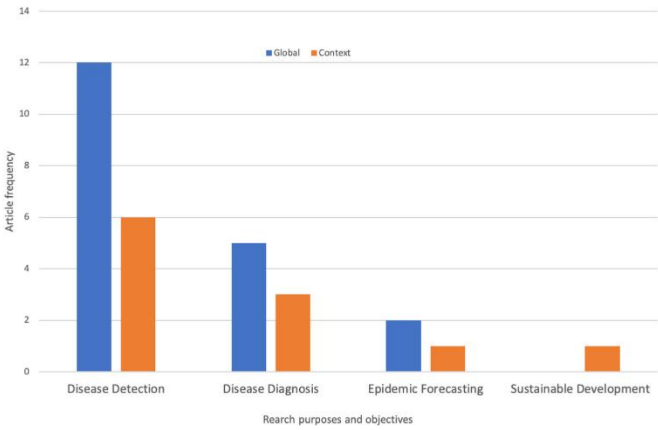

Fig. 2. A brief overview of the study.

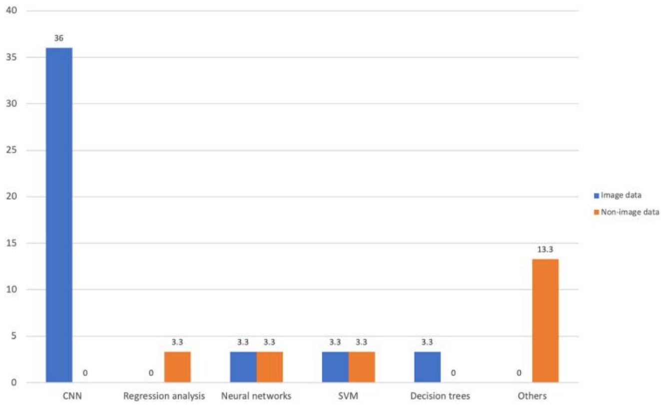

Fig. 3. The percentage of literature using different data type for different algorithm.

IV. FUTURE RESEARCH OPPORTUNITIES

In this part, we've briefly discussed the difficulties and potential directions for future study in AI/ML, both for the COVID-19 pandemic and other potential pandemics.

Conduct Research Taking into Account Various Study Contexts

We discovered that just 37% of the studies employed contextual data, while the remaining 63% used data from several countries. Due to the availability of more data and the fact that China was the pandemic's main hotspot, a disproportionately higher number of contextual studies have been carried out there. As the virus spread, information from other nations was also made accessible.

Examine the Potential Research Goals

Research has already been done to identify and classify COVID-19, anticipate epidemics, promote sustainable development, and manage patients. We see that just 11% of research have been done on topics like patient management, sustainable development, and epidemic predictions. These topics can be the subject of more research. Contextual data were found to be utilised in research on epidemic forecasting and sustainable development. We think that research based on epidemic predictions should always be contextual.

Create fresh treatment possibilities

Globally, scientists are now striving to provide novel COVID-19 treatments, including medications and vaccinations. The search for a vaccination has already included several organisations employing AI. AI may be useful for a variety of tasks, such as data processing and decoy generation, and there are many chances for advancement with these algorithms (e.g., Rosetta [85] and Quark [86]). AI may also be used to simulate and analyse various vaccination candidates.

Encourage the medical workforce

In severely damaged locations, a paucity of medical personnel has been noted [83,84]. They were forced to work past their capacities, which left them open to human mistake. AI-assisted systems may be useful in this situation. An AI with rules may keep track of all the data in the ICU and recommend that staff members take the appropriate action. A vital treatment given to COVID-19 patients, the allocation and management of oxygen flow, can be assisted by an effective AI.

V. CONCLUSION

In this work, we sought to assess the importance of deep learning, machine learning, and other methods under the general heading of artificial intelligence in combating the COVID-19 worldwide pandemic. Based on the goals of the research, we divided it into five main groups. In our investigation, we also determined that utilising AI and ML can be beneficial in accurately discriminating between COVID-19 infections and seasonal flu (AUC of 0.86 [69]). Furthermore, our research revealed that detection and diagnosis are the main uses of AI and ML. Deep learning algorithms were utilised in the majority of these investigations to image data, particularly on chest X-rays and CT scans [26]. The majority of the contextual research revealed in our work was conducted. Chinese [19]. We have suggested six potential future study areas based on these findings.

Our comprehensive analysis of AI and ML techniques has given us a thorough understanding of how to combat the COVID-19 outbreak. Modern techniques covering anything from pandemic predictions to illness detection were discussed. These were examined and contrasted in a number of ways, taking into account the data utilised, the input characteristics, the AI and ML methodologies, as well as their distinct goals in the field. We have included a number of informative details throughout the study, such as the application type, the use of AI and ML, and the associated assessment carried out for each study. Our study has a lot of shortcomings, but it also opens up some possibilities for further investigation in the indicated directions. First, we conducted a thorough keyword search of the pertinent papers. Despite the fact that our search terms produced useful results for achieving our study's objective, there is a chance that we missed some crucial items. Second, we believe that the essential components that we have uncovered, investigated, and presented in this research are current and relevant materials relating to coronavirus and AI approaches. Third, we are exclusively concerned with using AI and ML in the framework that is detailed in section II to combat COVID-19.

Despite the fact that we came across several papers that combined AI and ML with other biological methodologies, we did not include these kinds of studies for the review since they did not appropriately align with our research purpose. We perceive this as a limitation of our study. However, as we broaden our search criteria and our study goal in the future, this may be addressed and assessed. Future effort is thus required to gather and examine more pertinent data. Supportive data, such fresh datasets with high-dimensional characteristics, more classes, and collaboration with the medical community, might improve how AI and ML handle this health danger and help governments and communities limit the virus's effects early on. Future study may be done to examine data privacy and security in the pertinent domains in addition to information extraction. To further aid COVID-19 patients remotely, it is strongly advised to use cutting-edge technologies like the Internet of Things with a focus on reviewing and developing the pertinent AI and ML algorithms with enhanced efficiency.

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