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APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMBATING THE COVID-19 PANDEMIC: CURRENT TRENDS AND PROSPECTS. REVIEW

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Abstract

Background. The study focuses on the need for effective strategies to address global challenges, such as the COVID-19 pandemic, which requires not only medical but also technological responses. In this context, the research aims to analyze issues and assess the potential use of artificial intelligence (AI) in predicting the spread of the virus, taking into account current knowledge and identifying gaps in understanding this field.

The aim of this study is to analyze scientific publications dedicated to the use of artificial intelligence in the field of forecasting and prevention of COVID-19 infection.

Search strategy. The search for literary sources was conducted in the PubMed database, and the selection of scientific works was based on keywords related to the COVID-19 pandemic and forecasting using artificial intelligence technologies. The search yielded 3,894 publications, extracted on December 27, 2023. Bibliometric analysis was performed using VOSviewer software version 1.6.19, visualizing the interconnections between keywords, identifying clusters of similar terms, and facilitating a deeper understanding of the research topic, trends, and directions in the field of artificial intelligence for combating the COVID-19 pandemic. Exclusion of articles not meeting the keyword criteria was done manually. From the initial pool of 3,894 works, a final set of 23 most relevant publications was selected, reflecting the researched theme and meeting the established search criteria.

Conclusions. Contemporary trends and prospects of utilizing models and AI for forecasting COVID-19 outbreaks demonstrate an interdisciplinary approach, encompassing statistical analysis, simulation models, machine learning, and intelligent data analysis. The study emphasizes the importance of data quality, the selection of appropriate algorithms based on country-specific data, and the potential of AI to make a significant contribution to decision-making in public health and pandemic management.

Keywords: *COVID-19, 2019-nCoV, SARS-CoV-2, forecasting, prediction, artificial intelligence, machine learning, deep learning.*

Резюме

ПРИМЕНЕНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В БОРЬБЕ С ПАНДЕМИЕЙ COVID-19: ТЕКУЩИЕ ТЕНДЕНЦИИ И ПЕРСПЕКТИВЫ. ОБЗОР ЛИТЕРАТУРЫ

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Введение. Исследование фокусируется на необходимости эффективных стратегий борьбы с глобальными вызовами, такими как пандемия COVID-19, требующей не только медицинских, но и технологических ответов. В

данном контексте, исследование направлено на анализ проблем и оценку потенциала использования искусственного интеллекта (ИИ) для прогнозирования распространения вируса, с учетом текущих знаний и выявления пробелов в понимании этой области.

Целью настоящего исследования является анализ научных публикаций, посвященных использованию искусственного интеллекта в области прогнозирования и профилактики инфекции COVID-19.

Стратегия поиска. Исследование литературных источников о пандемии COVID-19 и прогнозировании с применением технологий искусственного интеллекта проведено с использованием базы данных PubMed. Результаты поиска включают 3,894 публикации, выгруженные 27 декабря 2023 года. Библиометрический анализ с применением программного обеспечения VOSviewer 1.6.19 позволил визуализировать взаимосвязи ключевых слов, выявив кластеры схожих терминов и обеспечив глубокое понимание темы исследования в контексте использования искусственного интеллекта для противостояния пандемии COVID-19. Ручная фильтрация исключила статьи, не соответствующие критериям по ключевым словам, и сформировала окончательный набор из 23 наиболее релевантных работ, отражающих тематику и соответствующих установленным критериям.

Выводы. Современные тенденции и перспективы применения моделей и ИИ для прогнозирования вспышек COVID-19 демонстрируют междисциплинарный подход, включающий статистический анализ, имитационные модели, машинное обучение и интеллектуальный анализ данных. В исследовании подчеркивается важность качества данных, выбора подходящих алгоритмов на основе данных по конкретной стране, а также потенциал ИИ для внесения значительного вклада в принятие решений в области общественного здравоохранения и управление пандемиями.

Ключевые слова: *COVID-19, 2019-nCoV, SARS-CoV-2, прогнозирование, предсказание, искусственный интеллект, машинное обучение, глубокое обучение.*

Түйіндеме

COVID-19 ПАНДЕМИЯСЫМЕН КҮРЕСУДЕ ЖАСАНДЫ ИНТЕЛЛЕКТТІ ҚОЛДАНУ: ҚАЗІРГІ ТЕНДЕНЦИЯЛАР МЕН ПЕРСПЕКТИВАЛАР. ӘДЕБИЕТКЕ ШОЛУ

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Кіріспе. Зерттеу тек медициналық ғана емес, сонымен қатар технологиялық жауаптарды қажет ететін COVID-19 пандемиясы сияқты жаһандық сын-қатерлермен күресудің тиімді стратегияларының қажеттілігіне бағытталған. Осы тұрғыда зерттеу проблемаларды талдауға және қазіргі білімді ескере отырып және осы саланы түсінудегі олқылықтарды анықтай отырып, вирустың таралуын болжау үшін жасанды интеллектті қолдану әлеуетін бағалауға бағытталған.

Бұл **зерттеудің мақсаты** COVID-19 инфекциясын болжау және алдын алу саласында жасанды интеллектті қолдануға арналған ғылыми жарияланымдарды талдау болып табылады.

Іздеу стратегиясы. COVID-19 пандемиясы және жасанды интеллект технологияларын қолдану арқылы болжау туралы әдеби дереккөздерді зерттеу PubMed дерекқорын пайдалана отырып жүргізілді. Іздеу нәтижелеріне 2023 жылдың 27 желтоқсанында түсірілген 3,894 басылым кіреді. VOSviewer 1.6.19 бағдарламалық жасақтамасын қолданатын библиометриялық талдау ұқсас терминдердің кластерлерін анықтау және COVID-19 пандемиясына қарсы тұру үшін жасанды интеллектті қолдану контекстінде зерттеу тақырыбын терең түсіну арқылы кілт сөздердің өзара байланысын визуализациялауға мүмкіндік берді. Кілт сөздер бойынша критерийлерге сәйкес келмейтін мақалалар қолмен алынып тасталды және тақырыпты көрсететін және белгіленген критерийлерге сәйкес келетін ең маңызды 23 жұмыстың соңғы жиынтығын құрады.

Қорытындылар. Коронавирустық инфекцияның өршуін болжау үшін модельдер мен жасанды интеллектті қолданудың заманауи тенденциялары мен перспективалары статистикалық талдауды, имитациялық модельдерін, машиналық оқытуды және деректерді өндіруді қамтитын пәнаралық тәсілді көрсетеді. Зерттеу деректер сапасының маңыздылығын, белгілі бір елдегі деректерге негізделген қолайлы алгоритмдерді таңдауды және қоғамдық денсаулық сақтау шешімдері мен пандемияны басқаруға айтарлықтай үлес қосу үшін жасанды интеллекттің әлеуетін көрсетеді.

Түйін сөздер: *COVID-19, 2019-nCoV, SARS-CoV-2, алдын ала анықтау, болжамдау, жасанды интеллект, машиналық оқыту, терең оқыту.*

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Омарбеков Е.Д., Токанова Ш.Е., Оспанов Е.А., Наурызбаев Б.А., Жахиянов А.Ж. COVID-19 пандемиясымен күресуде жасанды интеллектті қолдану: қазіргі тенденциялар мен перспективалар. Әдебиетке шолу // Ғылым және Денсаулық сақтау. 2024. 1 (Т.26). Б. 140-146. *doi 10.34689/SH.2024.26.1.018*

Introduction

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has become a global challenge requiring not only medical but also technological responses. These strategies must be based on accurate and scientifically substantiated information, emphasizing the importance of prior knowledge of possible scenarios that may unfold in the future. Regular forecasting of infection rates in the future on a daily, weekly, or monthly basis plays a key role in decision-making for managers facing the need to formulate policies to mitigate consequences. This becomes particularly crucial against the backdrop of changes in the virus spread behavior. In this context, artificial intelligence (AI) serves as a powerful tool for predicting and analyzing virus spread [6, 14, 18]. An example could be the use of chatbots to provide information about COVID-19 [12, 21]. Digital tools also enable healthcare professionals to track infection spread in real-time and model its development [4, 23]. Despite significant progress in this field, there is a need for deeper research into the potential and limitations of AI in the context of a pandemic. Early studies have shown promising results in the use of AI for analyzing COVID-19 spread data; however, these methods often encounter issues related to data quality and availability, as well as model interpretability [3]. This study aims to analyze problems and assess the effectiveness of using AI in forecasting the spread of COVID-19, relying on existing research and identifying gaps in the current understanding of this area.

The aim of this study is to analyze scientific publications dedicated to the use of artificial intelligence in the field of forecasting and prevention of COVID-19 infection.

The **research methodology** was conducted according to the scheme presented in Figure 1.

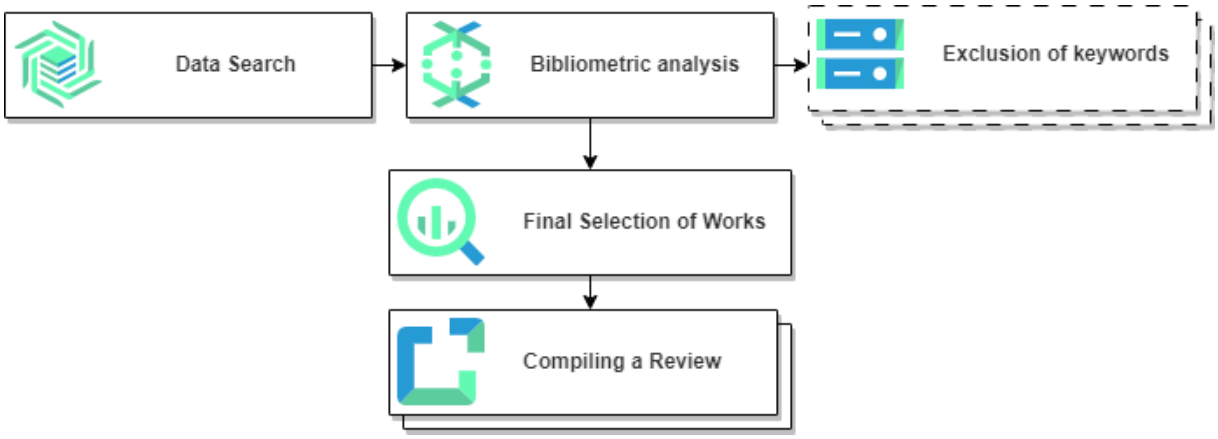

Figure 1. Stages of Research Analysis.

The search for literary sources was conducted in the PubMed database. The selection of scientific works was carried out based on keywords related to the COVID-19 pandemic and forecasting using artificial intelligence technologies: "COVID-19", "2019-nCoV", "SARS-CoV-2", "forecasting", "prediction", "artificial intelligence", "machine learning", "deep learning". As a result of the search, 3,894 publications were obtained. The results were downloaded on December 27, 2023 (Figure 2).

Figure 2. Trend of publications related to forecasting COVID-19 and the use of artificial intelligence.

The bibliometric analysis was conducted using VOSviewer software version 1.6.19, which allowed visualizing the relationships between keywords and identifying clusters of related terms. This approach facilitated a deeper understanding of the researched topic, revealing key trends and directions in the field of artificial intelligence for combating the COVID-19 pandemic.

The exclusion of articles not meeting the keyword criteria was done manually. From the initial pool of 3,894 works, a final set of 23 most relevant papers was selected, reflecting the researched theme and meeting the established search criteria.

Results and Discussion

Bibliometric analysis

During the analysis of publications extracted from the PubMed database, 3,894 studies were considered. In the course of the research, 8,836 keywords were identified. To ensure the significance of the results, a limitation on the minimum frequency of keyword occurrence was set at 10 mentions. According to this criterion, only 439 out of the initial number of keywords reached the established threshold of significance. For each of the selected keywords, the overall strength of connections was calculated based on the frequency of their co-occurrence with other keywords. The selection of keywords for further analysis was based on the highest cumulative strength of connections, allowing for a focus on the most significant terms in the investigated field (Figure 3, 4).

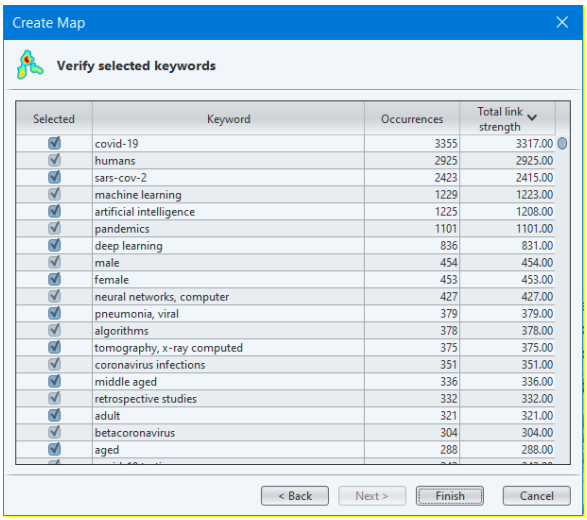

Figure 3. Analysis of keywords with frequency of occurrence and overall strength of connections.

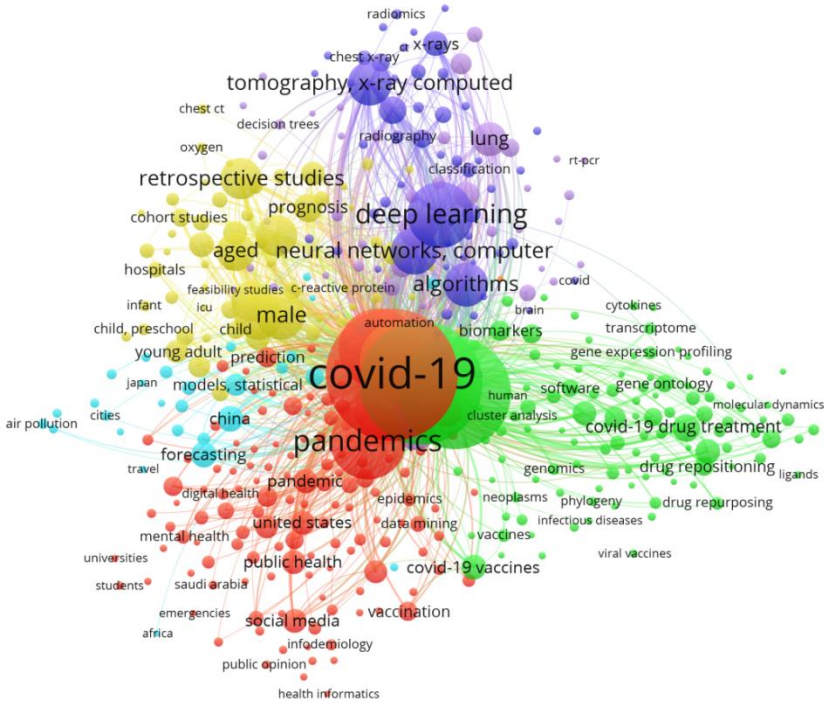

Figure 4. Data clustering using the Fractional Counting methodology.

In Figure 2, a tag cloud is presented in the form of a network, where each node corresponds to a specific keyword associated with COVID-19 research and related topics. The node colors vary by clusters, which group terms based on common themes or areas of research:

Cluster 1, highlighted in red, is tentatively labeled as "Information Technology and Healthcare," containing 133 elements. It represents a multidisciplinary collection of keywords related to the development and application of artificial intelligence (AI) in the context of the COVID-19 pandemic. Terms such as "big data," "data mining," "data science," and "cloud computing" reflect the emphasis on using advanced analytical technologies to process large volumes of data for monitoring and predicting the virus's spread. Terms like "epidemiology," "public health," and "healthcare" indicate that this cluster also addresses the importance of collecting and analyzing epidemiological data to inform the public and maintain population health. "Digital health" and "telemedicine" underscore the role of technology in providing medical services and improving access to healthcare. The cluster also includes social aspects of the pandemic, reflected in words such as "mental health," "social distancing," and "quarantine," highlighting the impact of COVID-19 on the psychological state and

social behavior of the population. "Sentiment analysis" and "social media" focus on the role of digital platforms in disseminating information and sentiments related to the pandemic. "Contact tracing," "infection control," and "personal protective equipment" point to practical measures to combat disease spread, while "vaccination" and "vaccine" address approaches to prevention.

Cluster 2, highlighted in green, is tentatively labeled as "Molecular Biology and Pharmacology," consisting of 109 elements. The cluster combines terms related to fundamental research on the SARS-CoV-2 virus and the development of methods for treating and preventing COVID-19. Included keywords cover a wide range of topics, from viral genomics such as "2019-ncov," "genome, viral," "rna-seq" to the study of protein structures and functions, for example, "amino acid sequence," "spike glycoprotein, coronavirus," "protein interaction maps." A significant part of the cluster focuses on the development of antiviral agents and vaccines, as reflected in terms like "antiviral agents," "covid-19 drug treatment," "vaccines." The cluster also emphasizes the role of bioinformatics and systems biology in modern research: "bioinformatics," "computational biology," "systems biology." Research in this cluster includes both computer modeling of molecular processes and real clinical trials, highlighting a multi-level approach to understanding and combating the disease. Aspects of preclinical and clinical evaluation of new drugs also occupy a significant place in this cluster, as shown by "drug design," "drug discovery," "clinical trials as a topic." The inclusion of terms such as "drug repurposing" and "drug repositioning" reflects the strategy of seeking new applications for existing medications to treat COVID-19.

Cluster 3, highlighted in yellow, is provisionally labeled as "Clinical Research and Patient Health Assessment" and comprises 64 elements. This cluster focuses on clinical aspects and consequences of COVID-19, as well as demographic and prognostic factors influencing the disease outcome. Terms cover patient age categories from infants to the elderly, considering risks and outcomes associated with each group. Keywords such as "comorbidity," "cardiovascular diseases," and "diabetes mellitus" emphasize the significance of comorbidities in the context of COVID-19. The cluster also highlights important clinical indicators, including "c-reactive protein" and "oxygen," used to monitor disease severity and treatment response. Research methods include "cohort studies," "prospective studies," and "retrospective studies," underscoring the importance of long-term and retrospective analysis of the virus's impact on health. The cluster also encompasses technological and methodological terms like "machine learning," "predictive model," and "xgboost," emphasizing the role of analytical models in understanding and predicting disease outcomes.

Cluster 4, highlighted in blue, is provisionally labeled as "Artificial Intelligence in Medical Visualization and Diagnosis" and comprises 56 elements. This cluster is centered on key terms related to the use of AI algorithms, particularly convolutional neural networks (CNN), for analyzing medical images such as chest X-rays and CT scans in the context of detecting and diagnosing COVID-19. Terms indicating deep learning and computer vision, such as "deep learning," "feature extraction," and "image classification," play a crucial role in automating the interpretation of medical images. Elements related to the diagnosis of specific lung diseases, including pneumonia and tuberculosis, underscore the importance of accuracy and precise identification in image processing. Additionally, the cluster includes concepts related to explainable AI, crucial for increasing transparency and understanding of decisions made by algorithms. Technologies improving image quality and data for model training, such as "data augmentation" and "transfer learning," are also mentioned.

Cluster 5, highlighted in purple, is denoted as "Laboratory Diagnostics" and comprises 46 elements. The cluster includes keywords related to the automation and improvement of laboratory procedures, encompassing cutting-edge biosensor technologies, computer-assisted interpretation of medical images, and precise laboratory analysis methods. Elements such as "covid-19 nucleic acid testing" and "rt-pcr" draw attention to the critical role of molecular diagnostics in the identification and monitoring of COVID-19 infections. The cluster also emphasizes the significance of early diagnosis and data accuracy, crucial in the context of public health during the pandemic. Terms related to "point-of-care testing" and "mass screening" indicate a commitment to ensuring widespread access to diagnostic services and enhancing the efficiency of screening programs. Keywords like "lung ultrasound" and "thoracic radiography" reflect the importance of visualization methods in diagnosing viral pneumonias and other lung conditions caused by COVID-19.

Cluster 6, highlighted in blue, is denoted as "Modeling and Analysis of the Environmental Impact on the Pandemic" and consists of 30 elements. The cluster focuses on the interaction between the environment and the pandemic, including the study of air quality ("air pollution," "air pollutants"), environmental monitoring, and the analysis of wastewater as indicators of COVID-19 spread. The integration of machine learning and artificial neural networks, including "LSTM" (Long Short Term Memory) and "Random Forest," underscores the application of these methods for predicting and analyzing disease incidence, as well as assessing their socio-economic impact. Terms related to geographical areas ("africa," "brasil," "china," "europe," etc.) emphasize the global dimension of health, as well as the importance of travel and population movement in the pandemic context. Cluster 6 also includes statistical and biological models, highlighting the significance of data and statistical analysis in understanding and responding to the pandemic.

Cluster 7, highlighted in orange, contains a single element - "intelligence." The term may indicate a unique area of research that has not gained widespread attention in the context of COVID-19-related studies.

The analysis of COVID-19 and artificial intelligence research clusters reveals the interdisciplinary nature of current efforts in the field of medical science and technology [20, 22]. From the use of data and information systems in healthcare to molecular biology and pharmacology, research is unified by the common goal of developing strategies to combat the pandemic. Keyword analysis has identified key themes crucial for predicting, diagnosing, and treating COVID-19, emphasizing the role of accuracy in clinical trials and the significance of public health [18].

These clusters illustrate a global approach to tackling the pandemic, spanning from fundamental research to applied medical technologies.

Thus, modern directions and prospects for the application of models and artificial intelligence for forecasting COVID-19 outbreaks point to the necessity of a multidisciplinary approach, including statistical analysis, simulation models, machine learning, and intelligent data analysis. The study underscores the importance of data quality, the selection of appropriate algorithms based on specific country data, and the potential of artificial intelligence to make a significant contribution to decision-making in the field of public health and pandemic management [2, 10].

Multidisciplinary Approaches in Modeling and Artificial Intelligence for Predicting COVID-19 Outbreaks

The application of Artificial Intelligence (AI) and Machine Learning (ML) models in predicting and managing COVID-19 outbreaks is a significant area of research. A literature review demonstrates that various AI techniques, including neural networks, deep learning, and simulation tools, have been employed to forecast the spread of COVID-19, assess the impact of intervention measures, and aid decision-making processes for healthcare systems and government policies [1, 5, 11].

Simulation models have been identified as primary tools for predicting the spread of COVID-19, providing the ability to model the virus's spread over large areas and within individual facilities. These models describe the structures and behavior of systems at different levels, highlighting their key elements, and allow for the testing of hypotheses on how certain measures might affect morbidity.

AI-driven tools have also been used for coronavirus outbreak management, such as identifying possible COVID-19 cases more quickly using mobile phone-based surveys, especially when cities and towns are under quarantine. This method could reduce the spread of the virus in susceptible populations [19].

The effectiveness of AI in infection prevention and control during the first wave of COVID-19 in China has been systematically assessed, showing that AI had significant effects on screening and detecting the disease, monitoring and evaluating the epidemic evolution, and aiding in production resumption in cities with high risk to reopen [13].

Furthermore, the literature review reveals that the input data quality is a key element that affects the forecast result's quality. The original data may be incomplete, contradictory, or even partially inaccurate, and methods exist to obtain stable simulation results despite defects in the original data [15].

Research based on literary data highlights the importance of using artificial intelligence for modeling the spread of COVID-19. Promising methodologies, largely leveraging existing machine learning algorithms, demonstrate high accuracy in creating epidemiological models. Trends include the utilization of public data, algorithm comparisons, and the creation of hybrid models. However, despite numerous preprint materials, it is important to note that not all of them are of sufficient quality, and the decision to use such data should be cautious.

Along with this, machine learning methods such as neural networks and LSTM (Long Short-Term Memory networks) demonstrate high effectiveness in forecasting the number of new cases. Analyzing the performance of models using metrics such as RMSE (root mean squared error), MAE (Mean absolute error), R2 (coefficient of determination), and MAPE (Mean absolute percentage error) allows for comparing prediction accuracy. Applying these methods can assist in accurately shaping policies, selecting effective measures, and avoiding unsuccessful constraints [7].

In terms of research methodology, it is crucial to select the most accurate learning algorithm based on the temporal distribution of infection evolution data for a country. An intelligent agent integrated within an automated AI system can analyze the trend of infection growth in a country and select the most accurate algorithm for that country [8, 16-17].

Lastly, the challenges and potential directions for AI in fighting against COVID-19 are discussed, with a focus on medical image inspection, genomics, drug development, and transmission prediction, highlighting that AI still has great potential in this field.

In summary, the current trends and perspectives in the application of models and AI for predicting COVID-19 outbreaks demonstrate a multidisciplinary approach involving statistical analysis, simulation models, machine learning, and intelligent data analysis. The research emphasizes the importance of data quality, the selection of appropriate algorithms based on specific country data, and the potential for AI to contribute significantly to public health decision-making and pandemic management.

Conclusion

The application of artificial intelligence (AI) in addressing the COVID-19 pandemic has become a key area of research, where AI methods are used for various purposes, including diagnosing COVID-19 cases, detecting suspicious cases through computer tomography (CT) and X-ray images, laboratory tests, genomic sequences, and respiratory patterns. Bibliometric analysis of AI application in combating COVID-19 has highlighted AI's major contributions in disease detection and diagnosis, virology and pathogenesis, drug and vaccine development, epidemic forecasting, and transmission. AI has also been used for infodemiology and information provision, analyzing data from social platforms to assess public concerns, risk perception, and tracking societal behavior in response to the outbreak. In China, the development of AI has played a significant role in screening and detecting COVID-19, monitoring and evaluating the epidemic's evolution, and aiding in the recovery of production in high-risk cities for resuming work.

Thus, current trends and prospects for AI application in forecasting and managing COVID-19 outbreaks demonstrate a multifaceted approach, including statistical analysis, simulation models, machine learning, and intelligent data analysis. The research underscores the importance of data quality, the selection of appropriate algorithms based on a country's specific data, and the potential of AI in significantly contributing to decision-making in public health and pandemic management.

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