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APPLICATION OF ARTIFICIAL INTELLIGENCE IN PREDICTING THE CLINICAL COURSE OF COVID-19 PATIENTS

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Abstract: This thesis explores the application of artificial intelligence (AI) in predicting the clinical course of COVID-19 patients, with emphasis on diagnostic imaging, outcome prediction, and risk stratification. AI-based methods, including machine learning and deep learning, have demonstrated strong potential in identifying radiological patterns of viral pneumonia, forecasting patient deterioration, and supporting intensive care decision-making. Modern multimodal systems integrate clinical, laboratory, radiological, and demographic data, enabling more accurate and personalized prognostic models. The expanded text highlights new directions such as temporal modeling, federated learning, and resource optimization algorithms. Challenges remain, including limited annotated datasets, variability in data quality, and ethical considerations regarding clinical implementation. Despite these limitations, AI continues to play an increasingly important role in improving diagnostic accuracy, reducing delays in clinical decision-making, and enhancing healthcare delivery during pandemics.

Keywords: Artificial Intelligence; Machine Learning; COVID-19; Clinical Course Prediction; Deep Learning; Risk Stratification; Medical Imaging.

The COVID-19 pandemic has revealed not only the vulnerability of the global healthcare system but also the urgent need for novel tools to predict the clinical course of patients. With a sharp increase in the number of cases and limited resources in intensive care and anesthesiology services, intelligent technologies have become particularly important for facilitating diagnosis, risk stratification, and outcome prediction.

The classical method for diagnosing COVID-19 is reverse transcription polymerase chain reaction (RT-PCR). However, this method has significant limitations, including low sensitivity, reagent shortages, and time-consuming procedures. In this context, medical imaging analysis using artificial intelligence has been rapidly developing in recent years. Machine learning and deep learning algorithms are capable of interpreting chest radiographs and computed tomography scans, detecting patterns of viral pneumonia, and distinguishing them from bacterial infections.

Another crucial area is the prediction of patient outcomes in intensive care units. AI-based systems can analyze complex clinical data, such as hemodynamic parameters, oxygen saturation levels, laboratory test results, and comorbidities. Neural network-based algorithms are able to forecast the likelihood of a patient deteriorating into a critical condition, the risk of complications (e.g., respiratory failure or sepsis), and the probability of mortality. Such systems can serve as decision-support tools for physicians when determining treatment strategies and allocating scarce medical resources.

The advantages of applying AI in this field are well-documented. First, diagnostic accuracy is enhanced by integrating multimodal data. Second, the use of intelligent algorithms accelerates diagnostic processes, which is critically important under conditions of healthcare system overload. Third, AI facilitates personalized medicine, as predictions are based on individual patient characteristics.

Nevertheless, the widespread implementation of these technologies faces several challenges. These include the limited availability of annotated medical imaging datasets, which complicates neural network training; high sensitivity of algorithms to data quality; potential classification errors and false-positive results. Moreover, ethical and legal concerns regarding the use of AI in clinical practice remain unresolved.

Future progress in this area is expected to be associated with the creation of international clinical databases containing diagnostic results and treatment outcomes of thousands of patients. The

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integration of AI methods with decision-support systems, the implementation of more advanced deep neural network architectures, and the use of optimization techniques will contribute to even greater predictive accuracy.

In conclusion, the application of artificial intelligence for predicting the condition of COVID-19 patients represents one of the most promising directions in modern medicine. Achievements in this field already allow for improved diagnostics, reduced time to diagnosis, and increased probability of favorable outcomes. By addressing current limitations and further advancing intelligent systems, AI is expected to make a significant contribution to improving healthcare delivery not only during pandemics but also in other global health crises.

In addition to the established applications of AI in diagnostic imaging and risk stratification, recent studies have highlighted the rapid growth of multimodal deep learning systems capable of processing heterogeneous patient data. These models integrate radiological findings, laboratory biomarkers, vital signs, demographic characteristics, and longitudinal electronic health records to produce highly accurate predictions of disease progression. Such systems enable clinicians to identify silent deterioration, anticipate the need for advanced respiratory support, and intervene earlier in the clinical timeline.

Moreover, AI-driven predictive models increasingly incorporate temporal analysis, allowing them to track physiological changes over hours or days. Recurrent neural networks and transformer-based architectures have demonstrated superior performance in predicting respiratory failure, septic shock, thromboembolic complications, and multi-organ dysfunction. These temporally aware algorithms support dynamic updating of risk scores, helping physicians adapt treatment strategies in real time.

AI applications are also expanding into resource optimization, including automated triage, ICU bed forecasting, and ventilator allocation modeling. During periods of peak healthcare system overload, these tools can improve decision-making efficiency and reduce mortality by prioritizing patients at highest risk.

Despite these advancements, the need for high-quality annotated datasets remains a central challenge. Differences in imaging protocols, laboratory standards, and documentation quality across countries complicate model generalization. Federated learning has emerged as a promising approach, allowing hospitals to collaboratively train AI systems without sharing sensitive patient data.

Future development will require stronger regulatory frameworks, standardized data collection, and international cooperation. As AI systems become more interpretable and clinically validated, they are expected to become integral components of critical care workflows, supporting physicians during pandemics and beyond.

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