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Application of Artificial Intelligence in Occupational Therapy

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ABSTRACT

Aims New developments in artificial intelligence offer promising prospects for transforming therapeutic approaches and enhancing outcomes for individuals with a range of abilities. Therefore, the aim of this systematic review was to investigate the applications of artificial intelligence in occupational therapy.

Information & Methods In this systematic review, adhering to the PRISMA guidelines, we searched English-language studies regarding the use of artificial intelligence in occupational therapy, on February 18, 2024, using the databases PubMed, Embase, Scopus, and Web of Science.

Findings Six eligible studies were included in this review. The artificial intelligence approaches used in these studies included artificial neural networks, multi-core learning models, deep learning models, machine learning models, and classification and regression trees. All the studies reported promising results regarding the use of artificial intelligence in evaluating and predicting return to work, alleviating symptoms, recovering social function, reducing disease recurrence, improving re-employment rates, and enhancing the overall health level of patients.

Conclusion One of the most common issues with artificial intelligence models is their low accuracy and the potential for errors.

Keywords Occupational Therapy; Rehabilitation; Artificial Intelligence; AI

CITATION LINKS

[1] The influence of occupational therapy on college students' home physical ... [2] Information systems, E-learning, and knowledge management ... [3] Artificial intelligence in physical rehabilitation ... [4] Telerehabilitation in response to critical coronavirus ... [5] Outcomes of an interdisciplinary return to work intervention including occupational ... [6] Teleophthalmology and its evolving role in a COVID-19 ... [7] Evaluating the cost effectiveness of tele-rehabilitation ... [8] Occupational therapy in the fourth industrial ... [9] Artificial intelligence for skeleton-based physical rehabilitation ... [10] Medical education trends for future physicians in the era of ... [11] The present and the future of occupational ... [12] Toward an AI-assisted assessment tool to support online ... [13] Artificial intelligence and machine learning ... [14] Virtual reality gaming as a neurorehabilitation tool for brain injuries in ... [15] Investigating the effect of virtual reality on reducing the ... [16] The changing landscape of occupational therapy intervention and research ... [17] Current state of robotics in hand rehabilitation after stroke ... [18] Rehabilitation registration systems: Current recommendations ... [19] Effect of mobile health interventions for side effects management ... [20] Attitudes, knowledge, and skills towards artificial intelligence among ... [21] Artificial intelligence literacy among healthcare ... [22] The effect of machine learning algorithms in the prediction, and diagnosis ... [23] The PRISMA statement for reporting systematic reviews and meta-analyses ... [24] Artificial intelligence-based prediction of individual ... [25] Applying wearable technology and a deep learning ... [26] Predicting return to work after cardiac rehabilitation using ... [27] Artificial neural network analyzing wearable device gait data for identifying ... [28] An intelligent model for the classification of children's occupational therapy ... [29] Occupational therapy, artificial intelligence and ... [30] Artificial intelligence in occupational therapy and special education ... [31] The effects of learning through discussion in a course in occupational therapy ... [32] Using artificial intelligence to identify the associations of children's performance of coloring ... [33] Artificial intelligence to improve back pain outcomes and lessons learnt from clinical classification approaches ... [34] An expert model for self-care problems classification using probabilistic neural network and feature ... [35] A systematic review on the use of E-health for COVID-19 pandemic ... [36] Applying artificial neural network in prediction behavior of alkylation of m-cresol with isopropanol process and yield ...

Introduction

In order to improve the functional abilities, independence, and overall quality of life for individuals with disabilities and special needs, occupational therapy (OT), special education, and rehabilitation are essential professions [1-4]. On the other hand, OT has the potential to alleviate symptoms, improve social function, lower the risk of illness recurrence, increase the likelihood of patient re-employment, and enhance overall health [5-7]. Historically, the provision of individualized treatment and educational support in these fields has relied on human knowledge and evidence-based solutions. However, recent developments in artificial intelligence (AI) offer promising opportunities to transform therapeutic approaches and improve outcomes for individuals with varying abilities. AI, defined as the creation of computer systems capable of performing tasks that require human intelligence, has shown promise in the fields of education and healthcare for enhancing diagnostic and evaluation procedures, personalizing therapies, and promoting independent living [8-10]. By tailoring treatments to meet specific needs, the integration of AI technologies in OT and rehabilitation can enhance the delivery of personalized care [11]. Algorithms have been utilized in the development of assessment tools that can analyze data from multiple sources, facilitating accurate evaluations of cognitive, physical, and emotional capacities [12, 13]. With these resources, occupational therapists can quickly identify the needs of their patients and develop specialized treatment programs.

For example, the Cognitive Assessment and Rehabilitation Environment (CAREN) system, developed by Aulisio *et al.* [14], serves as an illustration of an AI-based assessment tool. The CAREN system evaluates cognitive processes, including executive function, memory, and attention, in individuals with cognitive disorders by utilizing motion capture, virtual reality technology, and AI algorithms. These algorithms analyze how users interact with the virtual reality environment, gathering information on cognitive function. This research provides valuable insights into a person's cognitive capacities, facilitating accurate evaluation and customized intervention planning [15].

The Kinect-based Movement Assessment System (KMAS) is another noteworthy AI-based evaluation tool. KMAS assesses motor abilities and movement patterns in individuals with motor impairments by employing AI algorithms in conjunction with Kinect's depth-sensing technology. The AI algorithms analyze body movements, accurately identifying and measuring motor deficits. This AI-powered analysis enables objective evaluations of motor function, allowing therapists to assess patient progress, modify treatment regimens, and tailor therapies to meet the specific needs of individual patients.

Furthermore, AI-driven assistive technologies, including smart home systems and robotic appliances, have shown potential for improving the freedom and quality of life of people with impairments [16, 17]. These technologies adapt to the needs of users, providing individualized assistance with everyday tasks, mobility, and communication. Healthcare practitioners can enhance treatment, evaluation, and intervention procedures by utilizing AI in OT and rehabilitation [18]. This will ultimately improve outcomes for clients with impairments and special needs. Although studies in the fields of OT and AI are progressing, a systematic review that summarizes and synthesizes these studies has not yet been conducted.

Review articles offer readers insights into the current state of knowledge in the field, as well as future research directions on related issues [19, 20]. Subject topics are advanced through a literature review that incorporates current work and identifies research gaps [21, 22].

A literature review, which examines the existing body of research in a field with clarity, accuracy, and reproducibility, helps to shape future directions in that field. Therefore, the aim of this systematic review was to investigate the applications of AI in OT.

Information and Methods

Study design

We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for reporting the evidence from the studies included in this systematic review [23]. We conducted a literature search on February 18, 2024, using the databases PubMed, Embase, Scopus, and Web of Science. The databases were searched using the following Medical Subject Headings and Emtree keywords and terms: ("Occupational Therapy" or "Occupational Therapies" or "Ergotherapy" or "Ergotherapies" or "Return to Work" or "Occupational Rehabilitation" or "Vocational Rehabilitation") AND ("Artificial Intelligence" or "Computational Intelligence" or "Computer Reasoning" or "Computer Vision System" or "Knowledge Acquisition" or "Knowledge Representation" or "Machine Intelligence" or "Machine Learning" or "Transfer Learning" or "Deep Learning" or "Hierarchical Learning" or "Computer-assisted Diagnosis" or "Computer-assisted Diagnosis"). Figure 1 shows the steps of searching and selecting studies.

Inclusion and exclusion criteria

English-language studies that investigated the use of AI in OT were included in this study. Conversely, review studies, letters to the editor, conference abstracts, and studies for which the full text is not available in English were considered exclusion criteria.

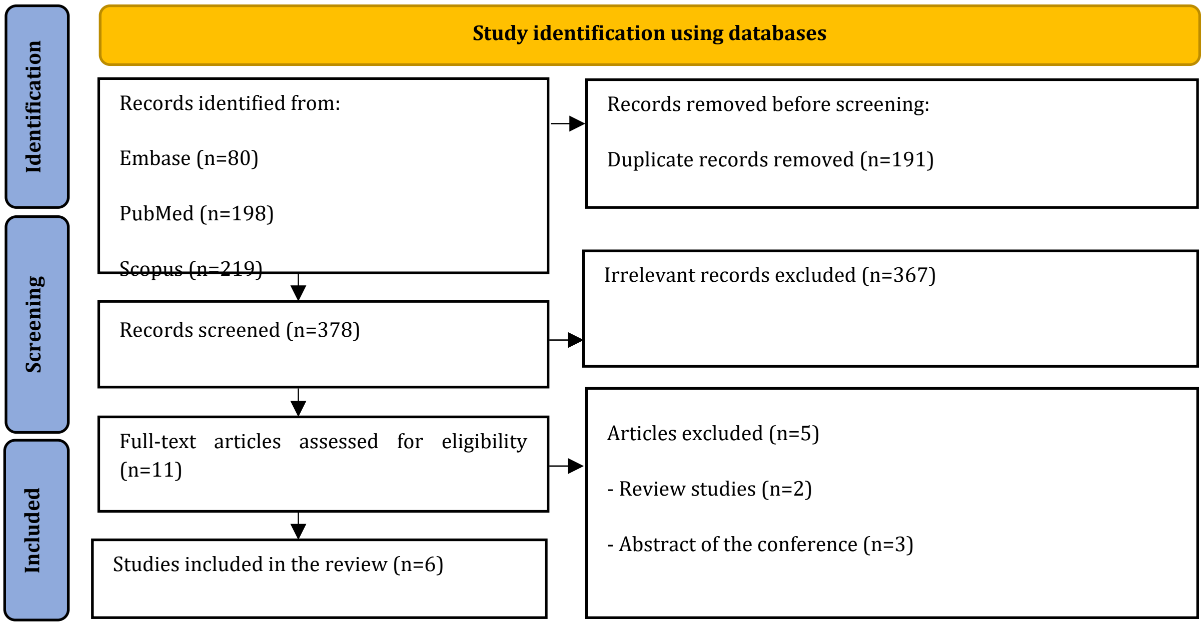

Figure 1. The searching and selection process

Data extraction and synthesis

Independent screening was conducted to ensure that titles and abstracts met the qualifying standards. No items that did not meet the inclusion requirements were included in the review. The complete set of texts was then obtained by two independent researchers, who evaluated them in accordance with the qualifying requirements. Discussions were held to resolve disagreements, and in the event of a tie, the third author made the final decision. For data extraction, the same standardized checklist was applied. The data items included in this form comprise the following: source (country, year, and first author), study objectives, study method, AI approach, and study results.

Findings

A total of 569 papers were identified after searching the databases. The titles and abstracts of 378 papers were examined after eliminating 191 duplicates. Three hundred sixty-seven studies were removed after their titles and abstracts were reviewed for relevance to the objectives of the study. Eleven papers were then selected for full-text evaluation. In total, six papers met the inclusion criteria for this review (Table 1).

Of the six included studies, two were conducted in China [1, 24], while the others were conducted in the USA [25], Malaysia [26], Italy [27], and Taiwan [28].

The AI approaches used in the studies included artificial neural networks (ANN) [27, 28], multi-core learning models [24], deep learning (DL) models [25], machine learning (ML) models [26], and classification and regression trees (CART) [28]. One study conducted a survey regarding the effect of OT on college sports behavior and the mental health of college students under AI technology [1]. All the studies reported promising results from the use of AI in evaluating and predicting return to work, relief of symptoms, recovery of social function, reduction of disease recurrence, improvement of re-employment rates, and overall health levels of patients [1, 24-28].

Jin *et al.* [24] investigated individual differences in psychological OT intervention (POTI) under the guidance of the realization of occupational values. First, a theoretical model was established, and a full model map was created to illustrate the impact of the realization of occupational values on POTI. This involved logical reasoning through the correlations between psychological issues and job attitude, job involvement, and the psychological health level of a specific group of employees. The assessment data on the psychological intervention impact of 2,800 workers were then explored using multikernel learning. Furthermore, an individual difference prediction model was built using multikernel learning. Various prediction outcomes for a particular set of workers were obtained in the experimental segment. It was noted that the variation in POTI impact across employees progressively decreased as the intervention time was extended. Plotting was then performed to show the correlation between the expected and actual differences among the workers in that specific group. The outcomes demonstrate how well their model predicts the differences in POTI. Following that, a control group and a test group were established. The results from the psychological intervention effect for the two employee groups were calculated using an independent sample t-test and a normality test. The findings indicated no statistical difference between the scores and that both groups followed a normal distribution. Additionally, it was noted that the assessed occupational values and POTI impact of the test group, examined immediately after the intervention, did not substantially differ from those recorded eight weeks later. As a result, the POTI has a consistent impact on workers when occupational values are realized.

Song *et al.* [1] thoroughly explored the internal relationship between the mental health status and physical exercise habits of students during home isolation. The physical exercise habits and mental health states of college students were examined using the "Physical Exercise Behavior Questionnaire" and the "Symptom Self-Assessment Scale." Overall, physical exercise techniques and mental health were shown to be positively correlated, with a significant difference observed between the two variables regarding students' mental health ($p<0.05$). The score on the "Symptom Self-Assessment Scale" initially declined and then increased as exercise intensity rose; the best psychological states were demonstrated at medium and high exercise intensities. Furthermore, depression exhibited the greatest correlation dimension, suggesting that adolescents who enjoyed engaging in physical activity with their families had lower rates of depression. Additionally, the most relevant dimension for self-directed physical exercise was despair, while the most relevant dimension for social engagement through physical exercise was interpersonal sensitivity. The findings indicate that students' mental health improves with increased participation in family physical activities. OT has been shown to positively impact the quality of life, social functioning, and reduction of depressive symptoms in patients with depression. Meanwhile, big data technology analysis reduces human labor and increases the accuracy and efficiency of data processing. The plan presented here offers suggestions for utilizing big data technologies in OT.

Yan *et al.* [25] conducted a laboratory study, in which they collected kinematic data from eight IMUs worn on eight different body parts by participants performing occupational physical activities (OPAs) common in manual materials handling (MMH) occupations. This pilot validation study employed a frame-by-frame analysis of video collected during simulated tasks to validate the model predictions of the OPAs. The kinematic data were used to train a DL model for pattern recognition. The trained model was then used to predict OPAs performed on three simulated work tasks. When applied to isolated OPAs, a convolutional neural network model and inertial measurement units (IMUs) predicted fifteen activities with an overall accuracy of 95%. However, when applied to simulated work tasks that included multiple OPAs, the prediction accuracy varied greatly and was low. Future research may explore sequential modeling techniques, model selection, and the integration of lower extremity IMUs and/or pressure insole sensors to address the reasons for the decreased accuracy. An essential first step toward more accurately assessing physical job demands than existing techniques is the prediction of OPAs using wearable sensors and DL algorithms.

Jia Yuan *et al.* [26] conducted a study aimed at investigating ML models for forecasting return to work following cardiac rehabilitation.

This research included patients who were hospitalized at the University of Malaya Medical Centre due to cardiac incidents. They assessed eight distinct ML models. Three different feature sets were incorporated into the models: features selected using a recursive feature elimination approach, important features identified from multiple logistic regression, and a complete set of features. The performance of the prediction models was compared for each feature set. Among the various prediction models, the AdaBoost model using the top 20 features achieved the best performance score, with an area under the curve (AUC) of 92.4%. The results of their study demonstrated the potential of ML models for predicting post-cardiac rehabilitation return to work.

Iosa *et al.* [27] conducted a pilot study that combined two new technologies (a wearable inertial measurement unit for gait monitoring and an ANN) with the goal of creating a prognostic tool for identifying patients who can return to work. Compared to traditional statistics, the ANN demonstrated superior accuracy in classifying patients versus healthy participants (90.9% vs. 75.8%) and in classifying subjects who were unable to resume their jobs (93.9% vs. 81.8%). In this final analysis, the duration of the double support phase provided the most significant input for the ANN. The potential of ANNs, which have already been developed in other fields such as social network marketing, could offer physicians substantial assistance in managing the numerous instrumentally recorded parameters that patients who have experienced strokes need to monitor today.

Yeh *et al.* [28] conducted a study aimed at developing an intelligent model for classifying children's OT problems. Between 2007 and 2010, 127 outpatients from a regional hospital in Taiwan were selected as the data set for categorizing issues related to children's occupations, based on the recommendations and assistance of therapists, as well as the OT treatments required. In light of this, the study proposes an intelligent classification model that combines Classification and Regression Trees (CART) and ANN.

The findings of their study demonstrated that this model could serve as a supportive framework for deciding how to classify and treat children with OT-related issues. Therapists found it beneficial to categorize the children's actual problems using the CART guidelines. This study predicts that additional ML methods will undoubtedly be crucial for the development of pediatric OT applications in the future.

Table 1. Summary of characteristics of the included studies

Author(s), year, reference	Aim(s)	Study design	Artificial intelligence (AI) approach	Findings
Jin *et al.*, China, 2022 [24]	Examining individual differences in psychological occupational therapy intervention (POTI) through the realization of occupational values	A practical development	Multicore learning model	An individual difference prediction model was built through multi-kernel learning. The results show that the scores followed the normal distribution and there is no statistical difference. POTI has a lasting effect on employees, guided by the realization of job values.
Song *et al.*, China, 2022 [1]	Investigating the in-depth study of the internal relationship between mental health status and physical exercise status of students and the physical exercise behavior of students during home isolation	Questionnaire-based survey	AI technology	There is a positive correlation between physical exercise methods and mental health in general, and the difference in the amount of exercise with the mental health of students has a significant difference. OT has an obvious therapeutic effect on depression, which can improve patients' negative symptoms, ability to live, and social functioning. Data analysis through big data technology reduces human workload and improves the efficiency and accuracy of data processing.
Yan *et al.*, USA, 2021 [25]	Applying deep learning (DL) models to data obtained from eight IMUs to predict physical activities performed during simulated job tasks	A practical development	DL model	Fifteen occupational physical activities were predicted using a convolutional neural network model and inertial measurement units, with an overall accuracy of 95% when performed separately. However, the prediction accuracy is low and highly variable when applied to simulated work tasks involving multiple OPAs. Reasons for reduced accuracy may be addressed in future studies by examining sequential modeling approaches, model selection, and adding lower limb IMUs and/or insole pressure sensors.
Jia Yuan *et al.*, Malaysia, 2023 [26]	Exploring machine learning (ML) models to predict return to work after cardiac rehabilitation	A practical development	ML model	The AdaBoost model with the top 20 features achieve the highest performance score of 92.4% (area under the curve; AUC) compared to other prediction models. The findings show the potential of using ML models to predict return to work after cardiac rehabilitation.
Iosa *et al.*, Italy, 2021 [27]	Combining two emerging technologies with the aim of developing a prognostic tool to identify patients who are able to return to work	Pilot study	Artificial neural network (ANN)	ANN can provide powerful support to clinicians who nowadays have to manage a large amount of instrumentally recorded parameters in stroke patients.
Yeh *et al.*, Taiwan, 2012 [28]	Developing an intelligent classification model to provide a comprehensive framework to help therapists improve accuracy when classifying children's problems for OT	A practical development	ANN and classification and regression trees (CART)	The actual implementation shows that the intelligent classification model is able to integrate ANN and CART techniques to clarify children's occupational therapy problems with considerable accuracy.

Discussion

The aim of this systematic review was to investigate the applications of AI in OT. Recent advances in AI offer promising opportunities to revolutionize OT practices. A total of five eligible studies were included in this review. All the studies reported promising results regarding the use of AI in evaluating and predicting return to work, alleviating symptoms, recovering social function, reducing disease recurrence, improving re-employment rates, and enhancing the overall health level of patients [1, 24-28].

In line with our study, a systematic literature review on the role of AI in future rehabilitation services reports three categories of AI use in rehabilitation, including activity identification, which generally tracks a person's adherence to prescribed treatment and helps measure real-world treatment outcomes, motor classification, which assists in evaluating the quality of rehabilitation exercises performed remotely, and clinical performance prediction, which helps forecast the client's clinical performance status [29]. On the other hand, Medenica *et al.* [30] found that AI has the potential to improve the accuracy of assessments, personalize interventions, increase independence, and enhance interaction and social communication in special rehabilitation and staff training. However, challenges related to data privacy and security, bias and fairness, transparency and explainability, human-AI collaboration, and the ethical use of AI-generated content must be addressed. By embracing AI technologies while tackling these challenges, healthcare professionals can optimize care and empower individuals with disabilities and special needs to reach their full potential.

According to our review, the majority of the applications of AI in OT focused on predicting return to work by utilizing AI models, such as ML, ANN, DL, etc. The findings of these studies demonstrate the potential of using AI models to predict patients' return to work and associated challenges [1, 24-28, 31].

In this review, only one study focused on the design of an AI-based prediction model for OT for children [28]. This study demonstrated that the intelligent classification model is capable of integrating ANN and CART techniques to classify real problems in children's OT with significant accuracy. Also, the ANN classifier can correctly identify over 80% of real problems. The study also established that evenly distributed data sets yield higher predictive accuracy. If validated, AI classification can not only save time, manpower, and other medical resources but also eliminate potential human bias. However, there is still work to be done in the future. Based on the results, the proposed model consists of two stages for classifying the vital features of children's specific occupational problems. The results of the validation study highlighted the usefulness of the proposed model for therapists. While 127 feature values were considered in this study, only nine were identified, suggesting that there may be additional features that characterize each problem. Furthermore, more comprehensive information could enhance the ability to build an intelligent classification model for future predictions. Therefore, a well-supported model could serve as the foundation for developing an expert system with a user-friendly interface to assist in the occupational classification of children in hospitals and clinics.

Another study in this review also utilized wearable technology and a DL model to predict occupational performance activities (OPAs). Fifteen OPAs were predicted using a convolutional neural network model and inertial measurement units (IMUs), achieving an overall accuracy of 95% when performed separately. However, the prediction accuracy is low and highly variable when applied to simulated work tasks involving multiple OPAs. Reasons for the reduced accuracy may be addressed in future studies by examining sequential modeling approaches, model selection, and incorporating lower extremity IMUs and/or insole pressure sensors [25].

Additionally, Jin *et al.* [24] established a theoretical model in their study, and a complete map of the model was created to illustrate the influence of the realization of job values on POTI. Subsequently, multi-kernel learning was applied to evaluate the data on the effect of the psychological intervention on 2,800 employees. Furthermore, an individual difference prediction model was developed using multi-core learning. It was observed that POTI has a positive effect on the realization of career values. The relationship between predicted and actual differences among employees in the specific group was then plotted. An experimental group and a control group were formed. The psychological intervention scores for the two groups of employees were subjected to a normality test and an independent samples t-test. The results indicated that the scores followed a normal distribution and that there was no statistical difference. It was also noted that for the test group, the assessed occupational values and the measurement of the POTI effect immediately after the intervention did not differ from the measurements taken eight weeks later. Therefore, the POTI had a lasting effect on employees, guided by the realization of work values. Additionally, the study by Jia Yuan *et al.* [26] demonstrated the potential of ML models in predicting the return to work after cardiac rehabilitation. The AdaBoost model provide the best predictive performance, while support vector machines (SVM) also yield comparable results. Models that employed a boosting approach to ML, such as AdaBoost, XGBoost, and CatBoost, consistently ranked among the top four in terms of performance, with AdaBoost frequently appearing in the top three across various feature sets (including the top ten, top 20, and top 30 features). Enhancing algorithms that assigned greater weight to disadvantaged classes improved the performance of the minority class in this study, which predicted non-return to work. Iosa *et al.* also utilized ANN to analyze gait data from a wearable device to identify stroke patients unable to return to work. They concluded that ANN can provide significant support to physicians who must manage a large volume of instrumentally recorded parameters in stroke patients [27].

Song *et al.* in China investigated the effect of OT on exercise behavior and the mental health status of university students at home under AI technology. They reported that data analysis through big data technology reduces human workload and improves the efficiency and accuracy of data processing [1]. In addition to predicting returns to work, AI-based assessment tools have emerged as valuable resources in the field of OT. These tools utilize AI and ML algorithms to analyze various data sources and provide comprehensive assessments of individuals' cognitive, physical, and emotional abilities [24].

In summary, this study provided an overview of AI applications in OT.

All the included studies reported promising results from the application of AI in assessment, relief of symptoms, restoration of social function, reduction of disease recurrence, improvement of re-employment rates, and overall health levels of patients [1, 24-28]. Conversely, the findings of the included studies demonstrated the potential of using AI models to predict return to work and address patients' problems [1, 24-28]. However, one of the most common issues with these models is their low accuracy and the potential for errors [32-36].

Therefore, it is suggested that future studies investigate the barriers and facilitators to improving the prediction accuracy of AI models in OT.

Conclusion

One of the most common issues with AI models is their low accuracy and the possibility of errors.

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