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A study of machine learning applications in healthcare

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Abstract. Machine learning, a sub-field of artificial intelligence, has numerous algorithms with applications in image recognition and classification, natural language processing, data prediction, medical diagnosis, and more, achieving significant results. Nowadays, the application of many algorithms of machine learning in the medical field has become a research hotspot and attracted wide attention from society, which plays a key role in disease screening, disease prediction, and assisted diagnosis of diseases. In this paper, we have developed a new approach to the medical field that can be applied in the healthcare industry by using technologies such as k-nearest neighbor (KNN), recurrent neural network (RNN), plain Bayesian (NB), decision tree (DTT), random forest (RF), deep convolutional adversarial network (DCAN), generative adversarial network (GAN), deep convolutional generative adversarial network (DCGAN),deep convolutional neural network (CNN), and support vector machine (SVM). By referring to the existing related literature and application practice results, this paper provides a systematic introduction to the application and research of machine learning in the medical field. This paper also analyses and describes the challenges and difficulties in the implementation of machine learning in the medical field.

Keywords: Machine learning, Medical field, Artificial intelligence.

1. Introduction

Currently, machine learning algorithms have a wide range of applications in many industries, and their development is quite rapid. There have been breakthroughs and achievements in fields such as image recognition and classification, natural language processing, prediction and recommendation systems, medical diagnosis and image analysis. In medical image diagnosis, clinical medical diagnosis, dental prosthetics, intelligent health management, robotic surgery, and other aspects, machine learning applications hold certain value.

With the continuous development of society, people's demand for physical and mental health is gradually improving, and they pay more attention to their own physical health status. Therefore, the application of machine learning in the medical field is emerging as a result. In this paper, we use classical machine learning algorithms such as RNN, CNN, GAN, DCGAN, DT, PF, SVM, KNN, NB, and so on to describe their applications in the medical field, including dental defect repair, heart disease prediction, eye health management, and other applications. We focus on achieving functions such as disease prediction, disease screening, disease-assisted treatment, and medical image analysis.

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Studying how machine learning is being used in the medical field,this paper fully embodies the importance of machine learning algorithms and their value for the development of their classical algorithms.

2. Machine learning and its algorithms

2.1. Concepts of machine learning and its algorithms

Machine learning is a study of how to make computers learn from data and reasoning science and technology. By learning the existing knowledge and computer training, it acquires new knowledge and automatically constructs a more suitable machine model to handle complex logical relationships. This technology can achieve self-optimization and self-improvement to enhance the accuracy of the model and ultimately reach the best model state. [1]

Machine learning algorithms are specific methods for implementing machine learning; they can be classified and compared according to different objectives, data types, and application scenarios.

2.2. Machine learning classification

Machine learning algorithms, categorized into three groups based on the learning mode, namely, supervised learning, semi-supervised learning, and unsupervised learning; while classified by task objectives, the algorithms can be divided into regression algorithms, classification algorithms, and clustering algorithms.

Supervised learning is a machine learning task that involves inferring a function using labelled training data, which consists of a collection of training samples, and learning a function that maps an input to an output based on "input-output pairs". [2] Explicit labeling or outcomes are necessary in the training set used to train the algorithm in supervised learning. When developing a prediction model, supervised learning creates a learning procedure that evaluates the model's predictions against the actual outcomes of the training data and makes iterative adjustments until the model's predictions achieve the required accuracy. Classification and regression issues are common uses for supervised learning.

An unsupervised learning algorithm extracts very few features from the data, and when new data is introduced, it uses the previously learnt features to identify classes of data. In unsupervised learning, the data is not specifically labelled and the model is learned to infer some intrinsic structure of the data. Common applications include learning association rules and clustering.

Regression algorithms obtain the correlation between a variable and the dependent variable through a learning process by building a regression model between the variables. Regression analysis can be applied to predictive or classification models. Common regression algorithms include Polynomial, Ridge, Lasso, Elastic Net, Non-linear, Linear, and Logistic regressions; Linear, Non-linear, and Logistic regressions are the most often used.

The goal of classification algorithms is to learn the data features of a dataset and map the original data features to the target classification categories.Among the classification techniques are Decision Tree (DT), Support Vector Machine (SVM), Naive Bayesian Model (NBM), K-Nearest Neighbor (KNN), Hidden Markov Model, and Logistic Regression (LR).

Clustering algorithms involve grouping input data into categories that are not pre-defined, i.e., the output is unknown or unlabelled. Clustering can be hard clustering (each data belongs to only one category) or soft clustering (each data can belong to multiple categories). K-Means, Hierarchical Clustering, and Gaussian Mixture Model are examples of clustering techniques.

3. The value of machine learning in healthcare

3.1. Improvement of the quality of medical services

In today's society, with its rapid economic development, more and more people pay attention to the quality of services. In many fields, people have high expectations for the service quality of medical

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services. The application of machine learning in the field of medical service has made a qualitative leap in the quality of its service level and improved people's experience of medical service.

In the previous medical service system, there are certain limitations in information processing, work efficiency, and service technology, such as insufficient medical service personnel, aging medical equipment, insufficient medical venues, etc. Using algorithms for machine learning can reasonably and efficiently improve the deficiencies and enhance the quality of service in the field of medical service. With the support of the Internet, the rational use of machine learning algorithms in medical services can process and analyse the patient situation in a timely manner, including patient diagnosis, information transfer, prescription analysis, programme issuance, cost review, and other aspects. This enables a series of online operations, greatly improving hospital efficiency, reducing the chances of error, ensuring the accuracy of medical services, and significantly enhancing the efficiency and quality of hospital services. [3]

3.2. Promotion of medical technology level

The application of machine learning in the medical field can greatly promote the development of medical technology. For the traditional medical service system, there are a lot of technical problems, such as medical equipment aging, medical equipment operation difficulty, medical equipment operating system complexity, and other problems. These are urgent issues that need to be addressed in the medical field.

The rapid development of machine learning in artificial intelligence, as well as the integration with the medical field, has promoted the innovation of medical field technology, accelerated technological change, and simplified the operation of the equipment day by day. Besides, the equipment system becomes more accurate, facilitating advanced medical technologies such as remote consultation, remote surgery, and remote medical rescue, thereby improving the quality of care provided by doctors to patients. Additionally, the use of machine learning algorithms in the medical field has significantly enhanced medical image processing, medical diagnosis, and other technologies, thereby improving the level of medical technology and promoting the development of medical care.

4. Machine learning in healthcare

4.1. Application of machine learning algorithms in restoration of dental defects

The efficiency and precision of fixed restorations in digital restorative dentistry have significantly increased because to the use of computer-aided design and computer-aided manufacturing (CAD/CAM) technology, which has been made possible by the rapid growth of digital technology. It also partially solves the problem of cumbersome production in the previous restorative process. However, it still requires a lot of time and effort to produce and adjust the personalised restorations required by the patients. [4] In the process of restoration design, machine learning algorithms are reasonably used in the design of inlays and partial crowns, the design of full crowns, and the automatic detection of the edge of the preparations, leading to technological innovation in the restoration of dental defects.

In the design of inlays and partial crowns, the depth-adversarial driven inlay restoration system (DAIS) is used for automatic reconstruction of the surface morphology of the defective teeth. By introducing the Wasserstein's distance as a kind of index to measure the degree of discrepancy between the generator and the discriminator, the accuracy, rigour, and stability of the training process of the model are greatly improved, ultimately enabling the practical application of the system in dental defect restoration. However, studies have shown that there are still some difficulties and challenges in this technique, such as the uncertainty of the location and extent of the defects, and the match between the new dentin and the original dentin generated by this technique. [5]

Therefore, the use of machine learning algorithms in the field of dental defect restoration still has a certain amount of room for progress, which needs to be achieved through certain technological innovation and a large number of model training, and more importantly, the optimisation of the machine learning algorithms and models to achieve a more accurate restoration process, improve the medical level, so that it can be better applied to the clinic.

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4.2. Application of machine learning algorithms in heart disease prediction

In recent years, the probability of heart disease is getting higher and higher, and people's concern about heart disease is increasing day by day. Meanwhile, heart disease has a sudden and insidious nature, [6] which significantly raises the mortality rate and makes the prediction and diagnosis of heart disease more complicated and challenging. [7]

Machine learning algorithms such as Decision Tree (DTT), Random Forest (RF), Support Vector Machine (SVM), K Nearest Neighbours (KNN), and Plain Bayes (NB) are used to build more accurate and efficient machine learning models. A test set of samples is used to assess the prediction models that were created and the confusion matrices, accuracy, precision, recall, F1 scores, and the area under the subject's job characteristics (ROC) area under the curve (AUC). In terms of accuracy, RF and NB models have the highest accuracy for heart disease prediction, while SVM and KNN models have poorer accuracy; in terms of precision and recall, RF model has lower precision than NB model, but RF model has the best recall among all the models. The relationship between the actual rate and the false-positive rate at various thresholds is shown by the ROC curve;The model performs better the closer the curve is to the upper-left corner. The AUC value is a measure of the classification performance of the model for positive and negative categories, and the larger the value is, the better the performance is.

Using these models, we can better prevent the occurrence of heart disease, and lay the foundation for clinical application and further related research, and raise the heart disease prediction's accuracy, which is of great significance.

4.3. Application of machine learning algorithms in the field of eye health

Eye health is one of the most important health issues for people, as the main source of information for human beings is the eye. If the eye health is threatened, the human life will be greatly affected. The use of machine learning algorithms to the field of eye health using artificial intelligence technology will significantly reduce the pressure on medical personnel and improve the level of eye care services.

Using machine learning to build models that can effectively prevent cataracts, retinopathy, and glaucoma, and meanwhile, generate certain treatments. A hierarchical learning classification model is constructed for automatic cataract diagnosis using deep learning techniques. [8] The model takes slit lamp images as input, where CNN learns features related to the severity of nuclear cataract from the images, and these features are then fed into an RNN to extract more advanced features. Finally, the advanced features are used as the input of SVR, which undergoes a series of processing and outputs the severity level of cataract.Machine learning is mostly focused on three types of retinal diseases: Retinopathy of Prematurity (ROP), Diabetic Retinopathy (DR), and Age-related Macular Degeneration (AMD). We have built a predictive model for AMD, an intelligent screening and diagnostic model for DR and an early feature recognition model for DR using CNN. We use the CNN model to monitor Plus disease, to determine whether DR needs treatment, and to combine it with the AUC value so as to make a joint judgement of the disease. In order to diagnose and treat glaucoma, machine learning techniques will be employed. Various machine learning models, including Random Forest and SVM, will be utilized to identify whether a patient has glaucoma.

Even though machine learning algorithms have been applied more in the field of eye health and have certain achievements, there are still certain problems. These include the limited types of eye diseases covered, regional variability leading to significant data gaps, and the challenge of highly specialized treatment using this technology. Additionally, deep learning in eye health is still primarily based on image data, and the interpretability of deep learning remains a significant issue. These problems require further research and technological changes to achieve better prevention, diagnosis and treatment of eye diseases.

5. Challenges of machine learning implementation in healthcare

In deep machine learning, a neural network with a modest prediction error may nearly always be produced with a large number of annotated datasets. However, there is still a lack of relevant theories and methods to explain the causal relationship, which is a long-term need to solve the problem. [9]The

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absence of explanatory models or techniques makes it difficult to gain the full trust from doctors and patients, hindering the rapid and smooth development of these technologies.

Additionally, medical data is often large and complex, with common issues such as limited annotations, uneven sample distribution, and missing data. These problems can lead to errors in model training, resulting in models that are not optimal and raising concerns about their reliability and trustworthiness. Data enhancement techniques can help address these issues by supplementing training samples. Classic image enhancement methods include changing the image contrast, superimposed noise, changing the image brightness, saturation, contrast, as well as rotating, cutting, scaling, and deformation. These adjustments can help expand the annotation data and address the aforementioned problems.[10]

The application of machine learning algorithms in the medical field requires patient data, whether provided by hospitals or patients themselves. This raises privacy concerns, and compliance with privacy regulations is an urgent issue that needs to be resolved.

6. Conclusion

This paper systematically explains the research on the application of machine learning in the medical field, and demonstrates the wide application of various machine learning algorithms such as RNN, CNN, GAN, DCGAN, DT, PF, SVM, KNN, NB, and so on, along with their significant results in dental defect repair, heart disease prediction and eye health management. In dental defect restoration, machine learning algorithms such as Deep Adversarial Impacted Inlay Restoration System (DAIS) have significantly improved the efficiency and accuracy of dental defect restoration, which has shown great potential for application, although it still faces the challenges of uncertainty in the location and scope of dental defects; in heart disease prediction, heart disease prediction models constructed by algorithms such as DTT, RF, SVM, KNN, NB, etc., have achieved the goal of predicting heart disease with high accuracy and high recall. Among them, the RF and NB models have the best performance in terms of accuracy and the RF model has the best performance in terms of recall, which provides strong support for early prevention of heart disease. In eye health management, automatic diagnosis and screening models for eye diseases such as cataract, retinopathy, and glaucoma have been constructed by using deep learning techniques, such as CNN and RNN, in combination with algorithms such as SVM and RF. These models not only improve diagnostic efficiency, but also reduce the burden on medical personnel, and provide important help for the early detection and treatment of eye diseases.

The application of machine learning algorithms not only improves the quality and efficiency of medical services, but also promotes the improvement of medical technology. While acknowledging certain limits, this paper highlights studies on the use of machine learning algorithms in the medical profession, and it does not completely summarise all its applications but only gives three examples for elaboration. However, the use of machine learning in the medical field still faces challenges such as insufficient data labelling, poor model interpretation, and patient privacy protection, which need to be solved. In the future, we need to further explore the optimisation of algorithms, improve the performance of models, and ensure the compliance and credibility of technological development, so as to better serve the medical field.

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