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Investigation of Rehabilitation Training Research Based on Deep Learning Models

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Abstract:

The paper will survey the current status of the Deep Learning (DL) technology application and the trend of the rehabilitation training development. Rehabilitation treatment aims to help patients regain their physical function and improve their quality of life. The introduction of artificial intelligence, especially deep learning, provides new technical support for it. This paper focuses on the typical applications of Convolutional Neural Network (CNN) and its hybrid model in rehabilitation training. It covers the body movement identification, rehabilitation assessment, such as virtual reality interactive multiple dimensions. In the discussion section, current challenges are pointed out, such as poor model interpretability, lack of generality and adaptability, and excessive model size. In order to solve the above problems, the introduction of domain experts to guide optimization strategies, such as distillation using domain adaptive methods is proposed and the knowledge. Think deep learning application prospect in the rehabilitation training, but still needs a multidisciplinary collaborative promote its clinical application and promotion.

Keywords: Deep learning; rehabilitation training; pose quality evaluation.

1. Introduction

Rehabilitation therapy also is aimed at restoring the functioning of the patients and also to enhance the quality of their life. The symptoms are eased with physical therapy, occupational therapy and others to increase mobility and avoid complications, as well as increase the ability to live independently. Rehabilitation not only focuses on the disease itself, but also rebuilds the overall function and encourages social participation, which has important medical and social significance.

The field of artificial intelligence has developed rapidly in today's society, and Chat GPT and deepseek have pushed its popularity to a climax. Artificial intelligence has been widely used in several fields. For instance, in the financial industry, the application of artificial intelligence has improved risk control, customer service and decision-making efficiency, and has created intelligent and automated financial services. The use of artificial intelligence in the sphere of medicine ensured an increase in efficiency and ac-

curacy of the disease diagnosis, making decisions regarding treatment and management of the patient, and achieving the objective of intelligent healthcare. In rehabilitation training, artificial intelligence also plays a very important role. Among these studies the concept of posture-guided matching according to paired Siamese convolutional neural network (SCNN) was proposed known as ST-AMCNN and another one the concept of posture-guided matching according to paired Siamese convolutional neural network (SCNN) known as ST-AMCNN [1]. Another study has proposed a hand surface segmentation network (HSSN) for intelligent hand function rehabilitation in the virtual reality, which combines 3D graph deep learning and laser point cloud. HSSN integrates a series of methods, with edge convolution layers effectively addressing the complex morphology of hand surfaces, multi-scale edge convolution solving the problem of missing or redundant local features, multi density processing enhancing the robustness of the model to point cloud density, and normal vector feature enhancement solving the problem of insufficient geometric features of actual hand surface point clouds [2]. In the other paper, the authors have suggested an attention mechanism-based Convolutional neural networks-long-term memory (CNN-TLSTM) network to evaluate the degree of knee pain of a person. The current research employed frontal, parietal, and temporal electroencephalogram (EEG) signals, electromyography (EMG) muscle signals of hamstring and quadriceps, and the knee flexion angles to identify knee pain [3]. Because this field has its unique innovation, and in this field, there has been a lot of research recently, so it can be believed that the exploration and summary of this field is very necessary.

Following this introduction, there are three further sections: methods, discussion, and conclusion. In the Methods section, this paper goes back to summarize some algorithms for motor therapy based on deep learning in recent years, and summarize, investigate and analyze these methods. This paper will deal with some of the challenges faced, the lack of design, and the future outlook of the paper in the discussion section. Lastly, the summary of the entire text is drawn in the conclusion.

2. Method

Nowadays, researchers have developed various approaches to achieve behavior recognition and quality evaluation in rehabilitation training. It can be roughly divided into CNN and Hybrid model.

2.1 CNN

2.1.1 SCNN

In one study, the authors used the SCNN model. Based on depth estimation of RGB images in supine position, a new method for 3D human pose detection is proposed. First, the researchers implemented the pose estimation method of the human body on RGB images using the current whole-body 2D points. Using depth details and coordinate mapping, it is possible to measure the 3D position of the human body lying down in this way. The researchers use two public datasets to validate the approach. The authors employed Kinect in registering the color and depth video motion of the individual. The two-dimensional motion of an object is estimated under the open pose which is also referred to as PAF. Together with the respective depth data, the coordinate transformation is done to derive the crude 3D pose. Next, there is need to align the crude 3D pose on the part of the researchers involved. The last one is the 3D pose estimation in the supine position [4].

2.1.2 ST-AMCNN

Modern society of traditional rehabilitation therapy to patients for dynamic tracing. Hence, in this article, one particular type of rehabilitation training test system is introduced, where deep learning model is used in order to aid in determining how effective rehabilitation training is. Based on Chinese traditional rehabilitation training eight jin data set is put forward based on the matching convolution neural network (SCNN) position matching concept (hereinafter referred to as STAMCNN). Another study using a variety of training programs for wear of IMU output layer classification of different patients with shoulder pain rehabilitation. Used in rehabilitation training of IMU sensors will take time to analyze the data and feedback data, robots have more effective research by giving patients gloves to promote finger movements, and shots to help stroke survivors for active rehabilitation system. In addition, the use of intelligent Movement and Rehabilitation monitoring systems (SMRMS) is recommended to pay more attention to the training accuracy and rehabilitation of participants. The experimental results show that the rehabilitation training evaluation system on privacy, reading ability and still have the development of space application scenarios, etc. Researchers may respectively by using the expert system for learning, development and use of learning areas adapt to solve the above problems [1].

2.1.3 MPLCNN

A movement disorder (including the abnormal muscle tone, range limited or sublimed and exception) coordination and balance is a consequence in the development of a medical emergency in the form of stroke. To enable the patient who has had a stroke to recover once in a very short time, the rehabilitation training technique uses the typical movement patterns, including movement, joint response causing the positive reaction of the body, and little

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by little the normal operation was restored. Rehabilitation assessment may also benefit the physician to learn about the rehabilitation requirements of various patients, establish an appropriate technique and approaches of treatments, and enhance the performance of treatments. This paper presents a model of MPL - CNN algorithm in order to achieve the requirement of real-time and motion detection accuracy through the mediappe motion detection. The key point features of the upper limb of the patient can be identified with Mediapipe, but it is also possible also to identify the key point features of the hand. In order to explore the influence of rehabilitation training on the movement disorder of the upper limbs, LSTM and CNN had linked each other to become a brand-new LSTM-CNN model to identify the action by the extracted feature of the Medipipe upper limb rehabilitation training. Broach to the rehabilitation training (upper limb) in patients with cerebral apoplexy can be identified safely in MPL - CNN model, with respect to the accuracy of rehabilitation training. To ensure the recovery training of scientific and unified standard action, it is planned to create FMA upper limb rehabilitation experiment validation data sets by establishing the position type Fugl - Meyer upper body rehabilitation training functioning assessment (FMA) in this paper. The experiment indicated that the recognition rate of the mpl-cnn-based approach was 95 in each evaluation stage effect detection results of the Fugl-Meyer upper limb rehabilitation training. Meanwhile, the overall accuracy of any upper limb rehabilitation training movement was 97.54%. It proves that MPL - CNN model is an effective solution because there is suspected high robustness in the category of different movements. The MPL - CNN based method can have an effect upon stroke rehabilitation assessment of upper limb movement disorders, give a high-resolution detection method, provide assistance to the clinician to assess rehabilitation progress of the patient and accordingly modify the rehabilitation program following the evaluation outcome. It will facilitate effective individualization and precision rehabilitation that will aid patients to recover [5].

2.2 Hybrid CNN

2.2.1 CNN+BCI+EEG

Researchers observe that stroke is one of the major causes of disability on the globe. The modality of brain-computer interaction (BCI) has also been reported to have good potential in facilitating motor recovery. Nevertheless, because of the varying neurocritical presentation of every single patient, the potential of recovery by carrying out the BCI training is highly varied, which is the significant issue in clinical rehabilitation practice. To address this issue, this study aims at acquiring the motor state electroencephalogram (EEG) at the preliminary stage of the BMI task to predict outcomes of the BMI training thus to develop respective BMI training. Convolutional neural network (CNN) was used to establish a prediction model based on prognosis. Eleven patients began rehabilitation training combined with BCI after 2 weeks. In the study, the author evaluated functional connectivity and power spectra and used them as input to a CNN to regression patient cure rates. Significance maps were used to determine the correlation between EEG channels and recovery. Leave-one-out cross validation was used to check the performance of the model.

2.2.2 Ycbcr and CNN

Robot technology in rehabilitation medicine, especially hand rehabilitation, shows a broad application prospect. There is the role of hand activities in everyday life that cannot be neglected, and its most important characteristic is reflected on various levels. Hand functions are critical in everything, not only in driving and playing sports, but also in simple aspects of life like occupational health needs. Hand is the basis of the performance of the daily skills of life including care, diet, dressing and grooming etc. The possibilities of using hand freely are in direct connection with the quality of life of the individual and their possibility of being independent. Scholarly work has advanced to a neural network devised Ycbcr kind of fusion color space as well as convolution gesture recognition. This is done as a result of the method first converting the gesture image and then identifying the gesture image through the conversion. The next step is to develop the Ycbcr and CNN-based hand function rehabilitation training robot to the patients with the hand rehabilitation impairment [6].

2.2.3 CNN-LSTM

Exoskeleton-aided home rehabilitation appears to be significant to the early home-based rehabilitation of stroke patients on his/her upper limbs. Friendly interaction of the person with the rehabilitation exoskeleton can be realized through the managing of the surface electromyography. Home-based rehabilitation needs can also be met using exoskeletons, such as affordability, portability, safety, and active participation. Even though numerous systems have been suggested to augment limited upper limb movement training, limited exploration has been done regarding interindividual variability of EMG signals, which reduces the generalization capability of intention estimation models. This paper proposes an agent-independent continuous motion estimation method using the combination of convolutional neural network (CNN) and long short-term memory (LSTM) and uses them in a home-based bilateral training system. The CNN-LSTM model that is based

on semG determines the connection between continuous motion and sEMG signal. To determine the effectiveness of CNN-lstm model in subject independent estimation, the paper made a comparison of the offline estimation with back propagation neural networks and CNN-lstm.

3. Discusssion

3.1 Challenges

Naturally, the use of artificial intelligence in rehabilitation training has a lot of issues remaining.

3.1.1 Interpretability

The explanation of deep network operations is generally to explain the processing of network data, or to explain the representation of data within the network [7]. In the process of general rehabilitation training, staff pay more attention to the results calculated by the model, but this leads to some problems. The staff does not know how it works internally, which indirectly leads to the fact that when there is a problem inside a model and the external performance does not meet the expectations, the staff finds it difficult to find the exact way to explain the problem quickly, which delays the process of rehabilitation treatment.

3.1.2 Generalization and applicability

The second is generalization and applicability. During the research, the author found that many models can only be applied to specific circumstances, which will cause some problems. If modeling and deep learning are carried out for every extremely subtle action, the workload and cost are extremely high, which is unrealistic. Therefore, it is necessary to find a method that has wide applicability.

3.1.3 Model size

There is also the question of model size. Normally, models capable of dealing with such complex problems would be large and require sophisticated machinery to perform the task, but staff and researchers understand that this is not practical. Most rehabilitation facilities cannot be equipped with extremely complex and expensive equipment, so miniaturized models are necessary. Ultimately, the authors even argue that researchers need to develop models that can be used on mobile phones. Only in this way, rehabilitation training based on deep learning can be truly enjoyed by everyone.

3.2 Future Prospects

3.2.1 Expert system and domain knowledge

In terms of deep learning model can be interpreted, the author thinks that the introduction of domain experts and clinical guidance and assistance is of great significance [8, 9]. Due to the excellent performance of deep learning model in medical image analysis, disease prediction, diagnosis support and other clinical application scenarios, its “black box” feature often makes it difficult for medical staff to fully trust the decision-making results of the model. At this point, the experts and clinicians in the field of participation not only can help the development team to understand the medical knowledge background, the reasonable design feature extraction and label process, also can be applied to the model training, validation, and stage for professional judgment and correction model output. For example, when the model identifies diseased areas or predicts disease risk, clinicians can point out potential deviations and blind spots of the model based on actual pathological characteristics and diagnosis and treatment experience, thus improving the explanatory rationality and clinical applicability of the model. In addition, the participation of experts helps develop more in line with the visual interpretation of clinical logic tools, make the doctor quickly understand the decision basis of the model, the model increased acceptability and credibility in clinical practice. Through multidisciplinary collaboration, deep learning interpretability of the model would increase greatly, and finally promote its reliable application in the field of medicine.

3.2.2 Domain adaptation

On rehabilitation training model in the process of training to use adaptive domain (adapt) method, some improvement strategy can be employed, to further enhance the generalization ability and stability of model in the actual application scenario [10]. Traditional domain adaptive methods in the treatment of different people, different distribution of training data and practical application of patients, adaptive or fitting may be faced with the lack of specific risk characteristics. To address this challenge, domain alignment, feature extraction, and target domain supervision can be optimized. In terms of loss function design, adversarial training and regularization constraints are combined to balance feature consistency and individual differences between source and target domains. In addition, the limited target domain annotation data, through semi-supervised learning strategies can be used to further improve the model under the condition of small sample’s ability to adapt. These measures effectively enhance the rehabilitation training patterns across the crowd, across different equipment and application scenario of robustness and generalization, providing a more reliable clinical rehabilitation intervention intelligence auxiliary tool. To control the size of the rehabilitation training model, var-

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ious effective strategies can be investigated and applied, aiming to reduce parameter count and computational complexity without compromising performance. Considering the rehabilitation training system in the process of actual deployment, there tend to be hardware resources and the limitation of portability, real-time requirements, so the miniaturization design of the model is of great significance for its clinical application.

3.2.3 Knowledge distillation

Techniques such as model pruning, parameter quantization, and knowledge distillation can be employed to progressively compress the model volume [11]. By pruning technology, for example, it is possible to retain key characteristic pathways while removing redundant neurons and unnecessary connection and reduce the computation burden of the model. Through parameter quantization, the high-precision floating point weights are converted into low-order wide integer representations, which effectively reduces the storage overhead and energy consumption. At the same time, adopt the method of knowledge distillation, through the knowledge transfer to the elementary school students will be teachers' model, realized the lightweight model in predictive ability and generalization performance. Integrated use of optimization strategy, not only make the rehabilitation training model in the equipment of limited resources to work effectively, but also widely used in the actual recovery scenarios for it laid a solid technical foundation.

4. Conclusion

This article gives an extensive overview of the subject of applying deep learning in rehabilitation training. This paper takes two models of basic CNN and Hybrid CNN, involving SCNN, ST-AMCNN, MPLCNN, CNN+BCI+EEG, Ycbcr and CNN and CNN-LSTM. Through discussion and analysis, it is believed that the current field has challenges such as Interpretability, Generalization, applicability and Size, and puts forward corresponding solutions, and introduces the guidance and assistance of domain experts and clinicians. The domain adaptive method was used to train the rehabilitation training model. The technical means such as model pruning, parameter quantification and knowledge distillation were used to gradually compress the model volume. The current review mainly considers deep learning models and does not investigate traditional machine learning models. In the future, the article will further combine traditional machine learning models for more in-depth research.

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