Application of Artificial Intelligence in Rehabilitation Assessment

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Abstract. Assessment is the core and fundament of rehabilitation, which can guide the whole treatment process. In the rehabilitation, doctors or therapists need to assess the function of patients in upper/lower-limb, based on subjective assessment and objective assessment. While it may cause large error and high cost by traditional ways. Therefore, artificial intelligence technology is applied to the field of medical rehabilitation. This review will summarize the application of objective assessment methods which are base on artificial intelligence including not limited, trajectory error feature, joint angels and joint angular velocity, sEMG signal feature. Finally, the review concludes that existing objective methods are generally affected by the scale of data and the number of feature. This review will give instruction for a lager application in rehabilitation field.

Keywords: Rehabilitation, artificial intelligence.

1. Introduction

In computer science, artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and animals. Leading AI textbooks define the field as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Colloquially, the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving".

In rehabilitation training, doctors or therapists need to evaluate the function of patients' limbs, which is a rather important method for judging the recovery degree of rehabilitation of patients, which can guide the rehabilitation plan. Rehabilitation assessment is divided into subjective assessment and objective assessment. Subjective assessment refers to the assessment of patients' rehabilitation based on subjective experience. This method is easy to operate and can provide quantitative scores/labels for objective evaluation. These scores/labels can be used to train the model and evaluate the quality of the features. However, subjective assessment is costly and susceptible to human influence, easily been disturbance by other factors, like different operationers. Objective evaluation refers to the rehabilitation evaluation of patients using artificial intelligence technology. This method is not
subjective and highly efficient, but it relies on subjective evaluation to provide quantitative scores/labels, which is popularized in those days with artificial intelligence. Based on this, this paper will summarize objective rehabilitation assessment methods commonly used in clinical and artificial intelligence technologies for pursuing a better clinical outcome.

2. Evaluation, based on artificial intelligence technology
The term artificial intelligence has been highly concerned in recent years. It is a branch of computer science that aims to produce intelligent machines with human intelligence. Artificial intelligence technology has been widely used in the field of medical rehabilitation, such as upper and lower limb rehabilitation assessment, traditional Chinese medicine (TCM) tongue image quality evaluation and classification, TCM pulse diagnosis and classification, tumor detection and diagnosis, etc. These intelligent algorithms can objectively evaluate the patient's condition and have achieved good results, and have great research prospects. Artificial intelligence consists of different fields, such as machine learning and computer vision. Among them, machine learning is an important method to achieve its "intelligence". Machine learning covers a wide range, including not only algorithm models such as support vector machine (SVM), artificial neural network (ANN), but also many disciplines such as statistics and probability theory. In recent years, it has played an important role in many fields such as image recognition and speech recognition. Machine learning needs to preprocess the input signal and extract "features", then use the features as input to the model to learn/optimize the best model. Machine learning can also be understood as a process of learning deep/abstract features. The following four objective evaluation methods based on artificial intelligence technology, these methods extract different features for different signals, and these features play an important role in learning/optimizing the objective evaluation algorithm.

3. Evaluation based on sEMG signal characteristics
In recent years, surface electromyogram signal (sEMG) has been deeply applied to clinical medicine, sports medicine and other fields. sEMG is an electrical signal accompanied by muscle contraction during limb movement. These electrical signals are superimposed on the skin surface and are a non-stationary weak signal. In the field of upper limb rehabilitation assessment, the application of sEMG is also very common. The study found that sEMG is the combined effect of superficial muscle and nerve electrical activity on the skin surface. Signal acquisition has the advantages of non-invasive, non-invasive and simple operation. In addition, sEMG contains rich information reflecting exercise patterns and exercise wishes, and has important practical value(Fig 1). In 2012, Wang Yuan et al used electromyography acquisition equipment to collect the surface electromyogram signals of human trapezius, pectoralis major, triceps, and brachioradial muscles under different tasks. After wavelet denoising, the signals were integrated Extraction of features such as electromyogram (iEMG) and root mean square (RMS), and use these features to assess the degree of fatigue recovery of the patient's upper limbs. However, the amount of data used in this method is relatively small, and the characteristics are somewhat simple. In 2013, Gao Yunyuan of the Institute of Intelligent Control and Robotics, School of Automation, Hangzhou Dianzi University used sEMG as the original signal. The EMG signal used non-invasive surface electrodes. The EMG collector recorded the bioelectric activity of the muscle. It is the superposition of the unit action potential in the numerous muscle fibers of the superficial muscles, reflecting the functional state of the entire muscle. The surface myoelectric signal acquisition instrument is mainly composed of a pickup electrode part composed of a pickup electrode and an instrument amplifier, a secondary signal processing part composed of filtering, amplification and A/D output, and a part that communicates with the computer. The signal is transmitted to the computer in real time.
According to different task movements, sEMG (Fig 2) and other signals of the patient's upper limbs under different task movements are collected. Then extract features such as root mean square, wavelet packet energy and basic scale entropy from the surface EMG signals, and filter the features. The screening principles are: one is to select appropriate distinguishing and representative feature values for different types of actions; the second is to target different ability to perform actions, that is, when performing complete and incomplete actions, the selected feature values need to be reflected. The difference between the two. Finally, the scores of the simple Fugl-Meyer scale are used as training labels to train the selected features to optimize the best model. However, the amount of data used in this method is too paucity, whose evidence is not enough to make recommendations.

4. Evaluation based on motion trajectory error features

Human motion trajectory tracking and analysis technology has been studied in the field of medical rehabilitation for nearly 30 years. Today, trajectory tracking and analysis techniques have been used in the study of upper limb rehabilitation assessment algorithms. Among them, the movement is dynamic, which is the process of making the trajectory of the patient's upper limb approach a desired trajectory. The upper limbs can complete a series of complex and precise movements, most of which require the coordination of multiple joints and muscles. A problem in any link will cause the actual trajectory to deviate from the ideal trajectory. In 2014, Costin and others of the School of Medical Bioengineering of Yasi Grigory Popa Medical University, used image processing technology to extract the trajectory of the patient's limbs and calculate the ideal trajectory. Then use the ideal trajectory and the actual trajectory to calculate their normalized root mean square error, percentage error and arc length ratio. Finally, with the obtained three values as features, train the upper limb rehabilitation evaluation model. However, this method is affected by the image processing effect, and the number of features is relatively small.

5. Assessment, based on joint motion angle characteristics

Recent studies have shown that human motion parameters are of great significance for rehabilitation assessment. The upper limb motion range (maximum angle of movement) is often used in the study of rehabilitation assessment algorithms. Under normal circumstances, the maximum movement angle of human joints fluctuates within a limited range. The loss of upper limb function will cause a significant change in the maximum angle of movement of the joint. In 2014, Kusaka et al. used Kinect to collect...
human activity images and calculate real-time parameters of upper limb joint angles. After verification, the average error between the calculated angle parameter and the actual measured angle parameter is within 10°. The patient is asked to perform certain actions and calculate the angle parameters. Calculate the angle parameters of upper extremity activity when the patient performs specific movements before and after rehabilitation treatment. From the results of the data, the range of joint movement (maximum angle of movement) of patients undergoing rehabilitation treatment increased significantly. This also shows that the range of joint activity can be used as a feature to reflect the degree of rehabilitation of the patient’s upper limbs, which is very important in quantitative evaluation. However, this method will also be affected by the image processing effect, the amount of data is too small, and the features are too single.

6. Assessment, based on joint angular velocity characteristics
In recent years, it is believed that the maximum angular velocity of a patient’s joint can reflect the degree of rehabilitation of his upper limb. The experiment compared the clinical (subjective) evaluation score of the same patient with the maximum angular velocity of the joint. It was found that as the clinical evaluation score increased, the maximum angular velocity of the patient's joints also increased significantly. In 2015, Taniguchi et al. designed an upper limb rehabilitation evaluation robot with limited degrees of freedom as shown in Figure 8. The device can fix elbow joint or shoulder joint to achieve the purpose of restricting joint freedom. The rehabilitation training position is supine, in order to minimize the impact of limb weight. During training, record the size of joint angle and angular velocity with time and gradually add functional electrical stimulation (FES) as an auxiliary treatment. This year, FES has been used as an auxiliary method in rehabilitation therapy. FES technology is to stimulate dysfunctional limbs with low-frequency pulse currents, replace or correct the lost functions with the immediate effects it produces, and adjust through the advanced nerve center. Promote functional reconstruction. FES can alleviate the pain of patients with impaired limbs, can bypass the damaged parts of nerve pathways, stimulate muscles according to preset stimulation methods, induce muscle movements and even simulate normal voluntary movements to achieve improvement or recovery of dysfunction. The purpose of normal contraction of muscles or muscle groups. The maximum angular velocity of the joints of patients was measured before and after electrical stimulation treatment. Clinical trials have shown that as the maximum angular velocity of the joint increases, each UE-FMA (upper extremity Fugl-Meyer assessment) score of the patient increases significantly. This provides a new idea for upper limb rehabilitation assessment, and also shows that the maximum angular velocity of the joint can be used as an evaluation feature in upper limb rehabilitation assessment. However, the characteristics of this method are too simple.

7. Conclusion
This review introduces four widely used upper limb rehabilitation assessment algorithms. Among them, joint angle, joint angular velocity, EMG signal, trajectory description and other data are widely used in rehabilitation evaluation algorithms, and achieved good results. However, these methods still have limitations. For example, the accuracy of some algorithms is affected by the effect of image processing, the evaluation characteristics are too single, and the amount of data for rehabilitation evaluation algorithms needs to be improved.

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