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Decoding Posture: Distinguishing Between Good and Bad Body Alignment

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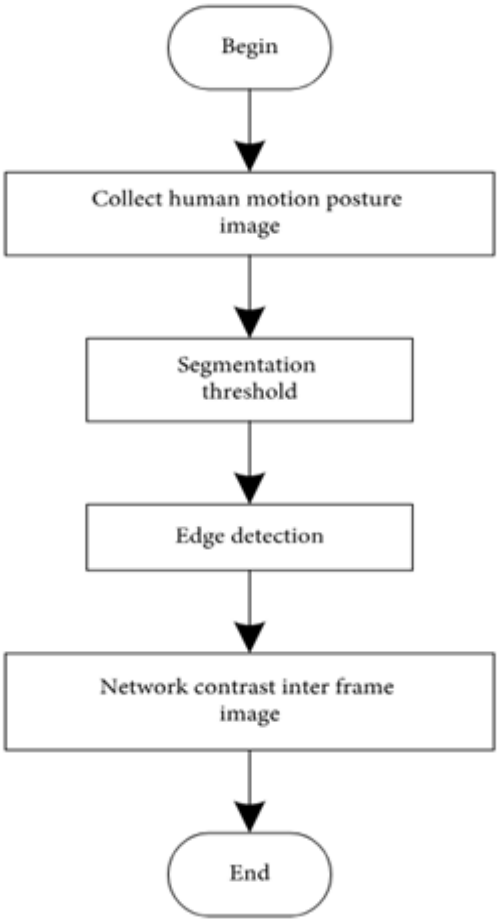
Abstract: On the grounds of artificial intelligence sensors, the research focuses on achieving precise detection of intelligent posture to minimize the risk of injuries resulting from incorrect body positioning and to mitigate the negative impact on both performance and physical well-being. Utilizing an attitude analysis and recognition system that relies on the nertial measurement unit enables not only the measurement of human body motion information but also the acquisition of data pertaining to motion characteristics and body movement states through the examination of posture data. A proposition is presented for intelligent posture training that is centered on accuracy and real-time feedback. Furthermore, it is elucidated that the accuracy of posture recognition through machine learning is significantly influenced by variations in user BMI. This paper will introduce the most recent advancements in posture recognition techniques, providing an overview of the various methodologies and algorithms that have emerged in recent years. Additionally, it delves into enhanced approaches such as stacked hourglass networks, multi-stage pose estimation networks, convolutional pose machines, and high-resolution nets. The study thoroughly dissects and consolidates the general procedures and datasets involved in posture recognition, comparing several enhanced CNN methodologies alongside three principal recognition techniques. Moreover, it delves into the utilization of advanced neural networks in posture recognition, including but not limited to transfer learning, ensemble learning, graph neural networks, and explainable deep neural networks. Researchers have observed that CNN has made significant strides in the realm of posture recognition and has garnered favor, yet emphasize the necessity for further exploration into areas such as feature extraction and information fusion.

Keywords: Posture recognition; artificial intelligence; machine learning; deep neural network; deep learning; transfer learning; feature extraction; classification

I. INTRODUCTION

Humans dedicate a significant portion of their daily activities to sitting, exceeding fifty percent on average. Extensive research has been conducted on the negative impacts of improper sitting positions and prolonged sedentary behavior on both physical and mental well-being. In recent years, there has been a notable emphasis on developing solutions to combat this sedentary lifestyle, particularly through the integration of advanced sensing technologies and Artificial Intelligence (AI). Addressing sitting posture monitoring and correction stands out as a crucial challenge in leveraging AI to enhance human health. The utilization of smart techniques for sitting posture training is introduced, incorporating innovative pressure sensing technology, a smartphone application interface, and machine learning (ML) for instantaneous sitting posture assessment and guidance on seated stretches. A detailed account of the experimental framework employed for collecting data on sitting postures and stretch poses through the posture training system is provided. A remarkable accuracy rate of 98.93% was achieved in identifying over thirteen distinct sitting postures through the implementation of a swift and resilient supervised learning algorithm. Furthermore, the significance of factoring in variations in user body mass index during posture monitoring is underscored. Moreover, the development of the initial ML-driven system for recognizing human stretch poses based on pressure sensor data is outlined, along with an evaluation of its efficacy in categorizing six prevalent chair-bound stretches. The primary objective of this study is to offer a comprehensive and efficient approach to enhance proper sitting posture and integrate seated stretching exercises within the workplace environment.

This intervention has the potential to significantly influence multiple areas such as workplace ergonomics, individual physical fitness, and overall health. Furthermore, apart from the proposed strategy, this research aims to contribute to the continuous endeavor of promoting well-being across different sectors by tackling the obstacles associated with maintaining appropriate sitting posture and integrating seated stretches promptly. The significance of these interventions in averting musculoskeletal disorders and ensuring overall health is increasingly acknowledged in occupational health promotion initiatives. Through attaining remarkable precision in identifying a wide array of sitting postures and specific stretches performed while seated, the system showcases its capacity to significantly influence workplace ergonomics, individual fitness, and overall health. According to the human motion posture information obtained from the analysis, deep learning and reinforcement learning are combined, and the detection process of human motion posture is designed, as shown in Fig 1 below. To sum up, according to the edge detection algorithm process, the edge contour of the human motion posture is roughly outlined, and deep learning and reinforcement learning are combined to complete the design of the human motion posture detection algorithm and realize the detection of human motion posture.



II. RELATED WORK

The algorithm for detecting human motion posture has attracted extensive research both domestically and internationally due to its significant economic and social impact. Addressing issues in human posture data recognition, Cai et al. [11] identified key sequence frames from motion images and developed a recognition approach based on this extraction. By selecting the original motion posture sequence beforehand, they established the initial keyframe sequence for human body posture. This sequence, coupled with a frame elimination algorithm, was utilized to derive the key frame sequence for posture, and the posture model was trained using the Baum-Welch method for recognition. The approach demonstrates enhanced performance in accurately recognizing human body postures. Recognizing the limitations of the sliding window algorithm in human posture data collection, Zheng et al. [12] curated a dataset on human body postures by gathering time series data. Furthermore, they differentiated and classified persistent behavior postures and sudden behavior postures of the human body by comparing long short-term memory (LSTM) with alternative networks and algorithms. This methodology can elevate the accuracy of human posture detection by 4.49%. devised a recognition technique employing the posture signal sequence and implemented a three-layer recognition algorithm to identify various postures. The outcomes demonstrate that the recognition algorithm meets the specified criteria.

The developed a monitoring device for tracking human hand movements, utilizing nanogenerators to observe hand movement postures. This integrated human prior knowledge with performance capture from the human motion capture system. To enhance the system's usability while upholding high fidelity, the model was continuously updated during motion capture. Experimental results indicate that this approach offers a certain level of convenience.Few authors likeZhao and Chen introduced a methodology aimed at identifying and classifying the stance of a mobile individual by leveraging sensor technology that employs inertial sensors for the recognition of activities such as shooting, passing, dribbling, and catching. An inertial sensor positioned on the arm is utilized for data collection in the experimental setup. Subsequent to the application of smoothing and normalization techniques, frequency domain characteristics are isolated, yielding 30 feature vectors through principal component analysis. Subsequent to reducing dimensions, enhancements are made to the methodology. Nevertheless, there is a significant loss of intricate details pertaining to human posture. HSIU-YU LIN et al. put forth a technique for posture assessment employing a convolutional regression neural network (RNN) within the context of fall detection, proposing a continuous deep learning framework. The framework processes a sequence of continuous images for posture classification purposes, with Microsoft Kinect serving as the non-wearable sensor. Furthermore, an LSTM architecture is established through RNN for the identification of human postures within fall detection scenarios. This approach involves the extraction of features from preprocessed high-resolution RGB images, allowing for the capture of body contours with realistic motion and depth details. Nonetheless, the precision of human body posture identification remains suboptimal.

III. TECHNIQUES

Posture detection and correction Techniques

Machine-Learning-Powered Human Sitting Posture: Various systems have been previously proposed to monitor sitting posture in order to encourage adopting an upright posture with both passive approaches (ergonomics, materials, and fabrics) and active approaches (IoT and sensors). Passive solutions include ergonomic chairs, cushions, elastic bands, and foot rests. Active solutions track sitting posture and include smart cushions, wearable point trackers, and smartphone applications. Recent advances in Artificial Intelligence (AI) and ubiquitous sensing have highlighted the practicality and effectiveness of collecting and mining human-health-related data in real-time for the assessment and improvement of human health and well-being . Better sensing technologies and the large quantities of data they generate have facilitated the application of machine learning to detect and monitor various problems related to well-being such as poor sitting posture. Real-time sitting posture recognition and prolonged sitting monitoring are challenging tasks that require accurate tracking of sitting posture and seated behavior. Sitting is a dynamic task that comes with a wide range of inter-individual variability in body characteristics and differences in working environments, sitting habits, and various other user-specific parameters, which current active posture tracking solutions have yet to address. Moreover, the lack of a standard source of sitting posture and seated behavior data hinders progress in research to achieve active and accurate sitting posture monitoring. Accurate posture tracking leads to effective feedback for active posture correction and good sedentary habits' promotion. The empowerment of human well-being through posture tracking and correction has important benefits in many domains including the workplace, personal fitness, driver assistance, and entertainment.

Human Motion Posture Detection Algorithm Using Deep Reinforcement Learning: The perception ability of deep learning is used to match the feature points of human motion, and by locating feature points of human motion posture, the position and direction of the human motion posture feature are determined, and the human motion posture feature is obtained. This method analyzes the contour of the human body motion posture, uses the training characteristics of the deep learning network and the reinforcement learning network to obtain the human body motion posture change information, obtains the general direction of the human body motion posture, and realizes the design of the human body motion posture detection algorithm. The contribution of this paper is as follows: (1) the algorithm in this paper uses deep reinforcement learning to detect human motion posture, determine the position and direction of human motion posture features, and obtain human motion posture features, which can improve the accuracy of human motion posture detail feature extraction. (2) The paper proposes an antigen-antibody binding method to detect human motion posture. This method uses the color histogram distribution of the human body motion posture as an antigen, searches for an area similar to the human body motion posture in the human body motion image, and uses the candidate region of the human body motion posture as an antibody. At the same time, this method realizes the extraction of human body motion posture features by calculating the affinity between the antigen and the antibody. (3) In this paper, the deep learning network is used to obtain the information of the human body movement posture change to improve the clarity of the human body movement posture contour, thereby obtaining the general direction of the human body movement posture, which can effectively reduce the amount of detail loss.

A wearable-based posture recognition system with AI-assisted approach for healthcare IoT: The entire industry is trying many ways to solve fall detection and even recognize more human behaviors, so as to serve smart medical healthcare [3]. Currently, a human posture recognition system can be utilized to 24/7 monitor the daily behaviors of humans, detect and analyze normal and abnormal postures such as falls and unusual motions.

However, identifying human postures more accurately, efficiently and intelligently is still a very challenging task in the healthcare industry [4,5], since it is always impacted by various internal or external factors. To complete the aim of accurately recognizing postures, Matsumoto et al. [6] design a detection system that incorporates multiple sensors such as acceleration, sole pressure sensors. However, it seems low reliability since the adopted framework is heavily relying on the Bluetooth signal strength and manual recording. Manupibul et al. [7] design a smart insole that measures the balance of the foot pressure and detects the balance of the body by deploying a force sensitive resistor (FSR) on the insole. The scenario is interesting, but the relatively simple structure limits the usability of the application since only the force and resistance of membrane pressure sensors are used and the pressure distribution is not considered for each specific motion combination. Furthermore, the intelligent information process is another way to enhance the identification effectiveness of the system. Without better information process mechanisms, we cannot reach the target of accurately recognizing human behaviors. Therefore, it not only needs high-sensitivity multi-sensors, but also requires more reliable Internet of Things (IoT) network and artificial intelligence (AI) techniques [8], when to achieve smart healthcare.

Using Human Pose Estimation in Fitness: Human pose estimation is a task in computer vision, where the model tries to identify the key points on the human body, like limbs and joints, which can help us determine the pose a person is in right now. With HPE models we can dynamically track those points through motion in real time. Which basically means, we can analyze motion patterns and make further decisions based on this input. Most HPE methods are based on recording an RGB image with an optical sensor, like a smartphone camera or surveillance lens, to detect body parts and track them through motion in 3D space. In conjunction with other computer vision techniques, this allows for automating routine tasks in fitness, coaching, rehabilitation, surveillance, or even some AR applications like virtual fitting rooms. The most basic form of Human pose estimation is 2D point extraction. This entails a model that will only take into account 2D space and generally brings poor accuracy because there is no depth perception. A more widespread approach is 3D pose estimation models, which are generally quite accurate at tracking given there are decent light conditions. Both methods are often used in conjunction, because the 2D approach is faster at detecting actual key points, while 3D grants accuracy and correct perception of the space.

A Review on: Body Posture Detection and Motion Tracking using AI for Exercise: One of the most significant and popular types of exercise for health is weight training. Exercises that focus on particular muscles can be used to treat certain disorders. On the flip side, if done poorly or without help, free exercise can be frightening for novices and physically taxing. Even with the exciting and high-risk activities, not much is done to leverage technology to assist new students in learning new material. Conventional exercise instruction frequently depends on subjective visual cues, which are prone to error and ambiguity. AI, on the other hand, provides an objective, data-driven method, assessing your body's motions with astounding accuracy. This review covers a variety of AI and technologies used in the context of the body to detect and track movement from advanced machine learning to good ideas. Our objective is to develop an intuitive interface technology that aids in the recovery of users who require exercise or who can recover on their own without the assistance of a professional. Its functions include calculating reps, keeping track of grades, alerting users to their time, and showcasing improved and novel exercises performed under medical supervision. In addition, this review aims to identify research gaps and provide guidance for future studies. Last but not least, offering advice on how to posture yourself better for the best possible workout results as well as keeping track of your past workouts to get historical data on your daily, weekly, and monthly exercise routines

IV.MAIN RECOGNITION TECHNIQUES

Sensor-Based Recognition: The sensor-based posture recognition requires the target to wear a variety of sensors or optical symbols and collect the action information of the target object based on this. The research on sensor-based human posture recognition algorithms started earlier. As early as the 1950s, some people used gravity sensors to recognize human posture [10]. In daily human posture recognition research, sensors have been used to distinguish standing, walking, running, sitting, and other stable human posture. The common classification methods of posture recognition sensors are as follows. According to the position of the sensor, it can be divided into lower limbs, waist, arm, neck, wrist, etc. Sensors can also be classified according to the number of sensors, which can be divided into single-sensor and multi-sensor. Compared with the method of single-sensor signal processing, the multi-sensor system can obtain more information about the measured target and environment effectively [13,14]. Whether or not the sensor is installed on the user can be divided into wearable and fixed sensors.

Wearable devices are a representative example of sensor-based human activity recognition (HAR) The sensor's type of data output can be divided into array time domain signal, image matrix data, vector data, or strap-down matrix data. Common wearable sensors include inertial sensors (such as accelerometers and gyroscopes), physiological sensors (such as EEG, ECG, GSR, EMG), pressure sensors (such as FSR, bending sensors, barometric pressure sensors, textile-based capacitive pressure sensors), vision wearable sensors (such as WVS), flexible sensors [2]. To avoid physical discomfort and system instability caused by workers on construction sites wearing invasive sensors or attaching multiple sensors to the body, Antwi-Afari et al. [1] utilized the network based on deep learning as well as wearable insole sensor data to automatically identify and classify various postures presented by workers during construction.

Hong et al. [3] designed a system using multi-sensors and a collaborative AI-IoT-based approach and proposed multi-pose recognition (MPR) and cascade-ada boosting-cart (CACT) posture recognition algorithms to further improve the effect of human posture recognition. The various squeezed convolutional gated attention (SCGA) model to recognize basketball shooting postures fused by various sensors. Sardar et al. [3] proposed a mobile sensor-based human physical activity recognition platform for COVID-19-related physical activity recognition, such as hand washing, hand disinfection, nose-eye contact, and handshake, as well as contact tracing, to minimize the spread of COVID-19.

Vision-Based Recognition

The vision-based method extracts the information of the key node and skeleton by analyzing the position of each joint point of the target object in the image data. In vision-based methods, cameras are usually used to obtain images or videos that require posture recognition and can be used in a non-contact environment. Therefore, this method does not affect the comfort of motion and has low acquisition costs. Obtaining human skeleton keypoints from two-dimensional (2D) images or depth images through posture estimation is the basis of vision-based posture recognition. There are inherent limitations when 2D images are used to model three-dimensional (3D) postures, so RGB-D-based methods are ineffective in practical applications. In addition to RGB images and depth maps, skeletons have become a widely used data modality for posture recognition, where skeleton data are used to construct high-level features that characterize 3D configurations of postures [22]. The general process of vision-based posture recognition includes the following: image data acquisition, preprocessing, feature extraction, and feature classification, as shown in Fig. 2.

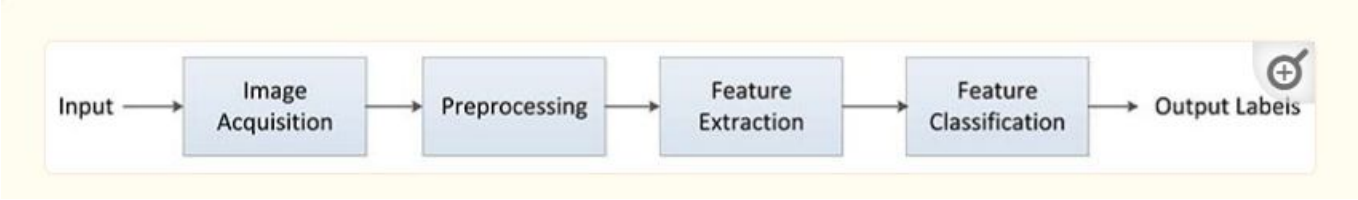


Fig:2 Procedure of vision-based posture recognition

Currently, video-based methods mainly use deep neural networks to learn relevant features from video images for posture recognition directly. For example, when convolutional neural networks identify and classify different categories of human poses (such as sitting, lying, and standing) in the available frames, also fused the probabilistic information of 3D human posture with the multi-stage CNN architecture to achieve 3D posture estimation of the original images. The designed a visual teleoperation framework based on a deep neural network structure and posture mapping method. They applied a multi-level network structure to increase the flexibility of visual teleoperation network training and use. It shows that integration of six independent deep neural architectures based on genetic algorithms to improve the driver's performance on the distraction classification problem to assist the existing driver-to-pose recognition technology. When proposed a computer vision-based label-free motion capture method that combines the discriminative method of posture estimation with morphological constraints to improve the accuracy and robustness of posture estimation.

RF-Based Recognition:-

In some specific posture recognition situations, the target object cannot wear the sensing device, and radio frequency (RF)-based technology can solve this problem. Due to their non-contact nature, various radio frequency-based technologies are finding applications in human activity recognition. Yao et al. [8] used radio frequency identification (RFID) technology to build a posture recognition system to identify the posture of the elderly, who do not need to wear equipment at this time. The RFID and machine learning algorithms to decipher signal fluctuations to identify activities. It proposed a sleep monitoring system based on passive RFID tags, which combined hierarchical recognition, image processing, and polynomial fitting to identify body posture through changes caused by backscattered signals from tags. Radio frequency signals are extremely sensitive to environmental changes, and changes caused by human movements or activities can be easily captured. Radio frequency signals are absorbed, reflected, and scattered by the body, which will cause changes in the signals. Human activities will cause different changes in the radio frequency signal so that human activities can be identified by analyzing the changes in the signals. The most typically used radio frequency technologies are radar, WiFi, and RFID.

V. CONCLUSION

This study is to make sure about the feasibility and accuracy of digital enhancement of images through various image processing techniques, applications, tools that helps to extract complex features of an image. Image processing works on a single-dimensional image to multidimensional a sees what actually in the image is. Image processing is the real core of many developing technologies in the real-time aspect. This paper discusses the overview of development, implementation of operations required for quality image production, and also discusses image processing applications, tools, and techniques.

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