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A systematic review of integrated machine learning in posture recognition

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Abstract

Introduction: Posture detection is used in various situations such as medical care, surveillance, virtual environment, indoor monitoring, virtual reality for animations and entertainment. The concept of machine learning has experienced great progress in the last two decades, from a curiosity started in the laboratory to a widespread practical technology for commercial use.

Objective: The aim of this paper is to review the literature on the use of machine learning algorithms in the medical field for posture recognition.

Material and method: Articles were collected from the following databases: Google Scholar, Science Direct, PubMed and Research Gate. We included only articles that were written in English, those that were available for download in full text, published after 2010, the year in which the industrialization of the idea of artificial learning began. Articles that did not assess or recognize the posture deficiencies were excluded.

Results: A total of 55 articles were eligible for the study. Following the inclusion criteria, and after sorting, using the exclusion criteria, a number of 16 articles remained to be analyzed, presented and discussed.

Conclusions: After the analysis of the articles included in this study, it can be concluded that using machine learning we can obtain very good results with high accuracy for posture recognition.

***Key words**: machine learning, posture recognition, artificial intelligence, deep learning.*

Rezumat

Introducere: Detectarea posturii este utilizată în diferite situaţii cum ar fi îngrijire medicală, supraveghere, mediul virtual, monitorizare în interiorul încăperii, realitate virtuală pentru animaţii şi divertisment. Conceptul de învăţare automată a resimţit un progres foarte mare în ultimele două decenii, de la o curiozitate pornită în laborator la o tehnologie practică răspândită cu uz comercial.

Obiectiv: Scopul acestei lucrări este acela de a face o revizuire a literaturii în ceea ce priveşte utilizarea algoritmilor de învăţare automată în domeniul medical, în recunoaşterea posturii şi evaluarea acesteia.

Material si metoda: S-au adunat articole din următoarele baze de date: Google Scholar, Science Direct, PubMed and Research Gate. Au fost incluse în studiu doar articolele care erau scrise în limba engleză, cele care erau disponibile pentru a fi descărcate în full-text, să fie publicate după 2010, anul în care a început industrializarea ideii de învăţare artificială. Au fost excluse articolele care nu au urmărit evaluarea sau recunoaşterea posturii.

Rezultate si discutii: În studiul de faţă, în urma aplicării criteriilor de includere au fost eligibile un număr total de 55 articole, iar în urma trierii, folosind criteriile de excludere, au rămas un număr de 16 articole pentru a fi analizate, prezentate şi discutate.

Concluzii: În urma analizei articolelor incluse în acest studiu se poate concluziona faptul că învăţarea automată oferă rezultate foarte bune, cu o acurateţe ridicată.

***Cuvinte cheie**: învăţare automată, recunoaşterea posturii, inteligenţă artificială, învăţare profundă.*

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Introduction

Posture detection is used in various situations such as medical care, surveillance, virtual environment, monitoring inside the room, virtual reality for animations and entertainment. In addition, posture detection can be used in a familiar setting. With the growing number of the elderly population and limited home health care resources, it is important to use technology that can support remote monitoring of the elderly and vulnerable in order to have a more independent life [1]. Maintaining a correct posture is important to live a healthy life, reducing the chances of musculoskeletal deficiencies. The posture refers to the way in which people maintain the position of their body, but also of their upper and lower limbs [2].

Posture is a broader concept, which can be defined differently depending on the state we are in: static, dynamic, walking and various activities [3].

With the advancement in technology, man has moved from an active lifestyle to a predominantly sedentary lifestyle, which leads to less physical activity and movement. The long period spent at work or to study leads to a decrease in muscle strength, as they are not activated regularly. Sedentary lifestyle has a negative impact on the human body, without caring about approaching a correct posture or the fact that poor posture can cause pain in the neck, back, shoulders and other segments. Postural deficiencies are one of the most popular and yet underestimated health problems due to the subsequent complications they can cause [4]. Therefore, it is important to correct ourselves and pay attention to what posture we adopt in order to maintain our health and prevent possible deficiencies that may occur due to the long time spent in the office.

Machine learning is the scientific study of the algorithms and statistical models that computer systems use to perform specific tasks without being explicitly programmed [5]. It is a discipline that is part of the field of artificial intelligence (Fig. 1.) and is focused on two interdependent questions: "How can a computer system automatically improve through experience?" and "What are the fundamental laws that govern all learning systems, including computers, people, and organizations?" [6].

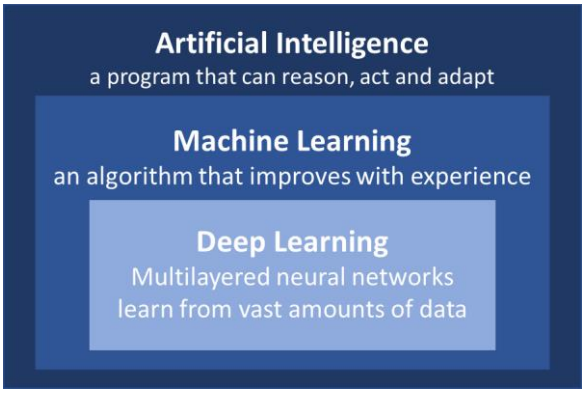


Fig. 1. Machine learning, part of artificial intelligence [7]

The working principle of machine learning: a computer program learns from experience (E) about some tasks (T) and measured performance (P), if performance on tasks in T, measured by P, improve at once with experience E [8]:

- E: the experience of performing many times
- T: tasks or objectives pursued
- P: the ratio between successful tasks and total tasks.

The concept of machine learning has experienced great progress in the last two decades, from a curiosity started in the laboratory to a widespread practical technology for commercial use. In artificial intelligence (AI), machine learning has emerged as a method of choice for the development of computer vision software, speech recognition, natural language processing, robot control and other applications [6].

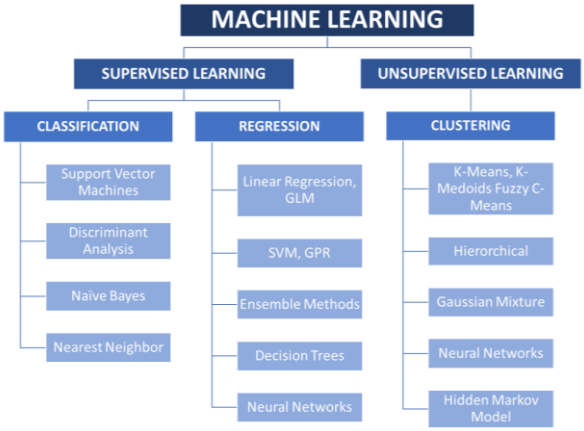


Fig. 2. Types of machine learning

Objective

The aim of this paper is to review the literature on the use of machine learning algorithms in the medical field for posture recognition.

Material and method

In order to complete the present study and to fulfill the proposed objective, articles from the following databases were collected: Google Scholar, Science Direct, PubMed and Research Gate. The collection of articles was done using the following keywords: machine learning, posture recognition, artificial intelligence, deep learning. Included in the study were only articles that were written in English, those that were available for download in full-text, to be published after 2010, the year in which the industrialization of the idea of artificial learning began. Articles that did not seek to assess or recognize the posture were excluded.

Results

In the present study, following the inclusion criteria, a total number of 55 articles were eligible, and after applying the exclusion criteria, a number of 16 articles remained to be analyzed, presented and discussed.

In 2013 Saha examined seven different deficiencies that cause pain in different parts of the body, having as subjects people over 40 years. The proposed machine learning algorithm is validated using ten subjects. The author stated that the performance of the neural network had an accuracy of 91.9% [9].

Another research uses Microsoft® Kinect to capture 3D data of joint positions and uses the Gaussian Mixture Model (GMM) and Hidden Markov Model (HMM) to generate whole-body gestures. The author proposes an algorithm for recognizing gestures by segmenting them from the real-time data stream and recognizing predefined gestures for the whole body in real time. This proposed method offers a high recognition rate of 94.36% [10].

Zhang introduced the idea of machine learning into his study, being a technology based on a data-driven strategy, such as support vector machine (SVM), which allows machine learning and automatic recognition of complicated patterns in Cartesian space. It has been shown that this method is feasible to recognize different stations from the information taken from the Kinect sensor, finally having an average accuracy of 99.14% [11].

An article aimed to identify the posture from the sitting position using as a way to collect data, a chair equipped with weight sensors and an accelerometer. Data analysis was performed using five different machine learning methods (Support Vector Machines, Multinomial Regression, Boosting, Neural Networks, and Random Forest). Forty-one subjects participated and were seated four times in seven different positions (a total of 1148 samples). The best performance was obtained using the Random Forest algorithm with an average accuracy of 90.9% [12].

Zerrouki presented a study to detect people who fell by comparing some of the most popular machine learning approaches (Naïve bayes, K nearest neighbor, neural network, and support vector machine (SVM)). The experiments performed revealed the superiority of the SVM approach, where it offered the greatest sensitivity, specificity and precision in distinguishing falls from failures [13].

In Ma's paper, it was proposed to use an Arduino-based pressure cushion to detect the seated positions of wheelchair users and a method of selecting sensors to obtain the most optimal variant. Experiments were performed on a diverse sample of subjects (in terms of BMI category) having different habits in terms of chair position. Using the data set obtained, they compared five different machine learning approaches (Decision Tree, Support Vector Machines (SVM), Multilayer Perceptron (MLP), Naive Bayes, and k-Nearest Neighbor (k-NN)) and selected the most efficient implementation of the sensor between possible configurations. They evaluated seven different classifiers to recognize five positions in the sitting position. The results showed that the Decision Tree algorithm can be used efficiently and accurately (99.47%) to recognize the posture of wheelchair users [14].

The sedentary lifestyle in the society in which we live is predominant. Among sedentary behaviors, sitting in a chair is a routine behavior of office workers and students in their work environment. Kim, in his article published in 2018, aimed to classify children's positions in the sitting position by conventional algorithms and algorithms based on

deep learning that analyze data on the distribution of body pressure obtained using pressure sensors positioned inside a chair. The machine learning algorithms used in this study are: convolutional neural network (CNN) (part of deep learning), Naïve Bayes classifier (NB), decision tree (DT), neural network (NN), multinomial logistic regression (MLR), and support vector machine (SVM). The accuracy of DT was 0.794, this being the lowest of the applied models. The performance of NB and MLR was 0.871 and 0.845, respectively. The CNN, NN and SVM algorithms performed the classification with an accuracy of over 90%, and the CNN algorithm showed the highest accuracy in terms of classifying the positions adopted by the children in the sitting position. The classification accuracy using the SVM algorithm was 0.942, which is about 1% lower than CNN [15].

Another study developed a system that evaluates a total of six positions in the sitting position, including the position to which a load was applied to the backrest plate, with four load cells mounted only on the seat plate. Various machine learning algorithms have been applied to identify the method that accurately classified the actual posture of the seated person. After data collection, the average accuracy is 97.20%, obtained from nine subjects, the results being statistically significant compared to the results obtained using other classifiers [16].

One paper presents an intelligent real-time information system about the posture approached when using a wheelchair. The system is based on a network of pressure sensors built into the seat cushion and backrest, used to obtain position-related variables. The data were filtered by performing a selection procedure using the Condensed Nearest Neighbors (CNN) machine learning algorithm, obtaining an accuracy of 88% in position recognition [17].

In 2019, a study aimed to detect key positions in Indian classical dance. For this, 2 machine learning algorithms and 1 deep learning algorithm were used. Using the Gaussian Mixture Model, an accuracy of 83.04% was obtained, while the use of the support vector machine algorithm, an accuracy of 97.95% was observed. The best result was obtained using the Convolutional Neural Network deep learning algorithm with an accuracy of 99.12% in posture recognition [18].

Koubâa, in his article published in 2019, raised the issue of correct posture during prayer. To address this issue, the author aims to develop an artificial intelligence assistant to guide believers to assess the correctness of their prayer positions. This paper addresses the problem of recognizing the basic gestures of Islamic prayer using Convolutional Neural Networks (CNN), which is a method of deep learning. Experimental results show that the average accuracy reaches 85% by analyzing a number of 764 images of different positions [19].

Yoga has its origins in ancient India and is a group exercise associated with mental, physical and spiritual strength. Yoga should be done under the guidance of an authorized person, but this is not accessible to every person. Data collection and interpretation techniques have been used to build the AI software that works as a guide. This software provides feedback on the accuracy with which Yoga positions are performed. Agrawal in 2020, used machine learning on a large number of data sets collected from images containing 10 yoga positions. Six machine learning classification models were used in this article; the yoga position is detected based on the joint angles extracted from the skeleton model. The average accuracy in which Yoga positions were recognized was 94.28% using machine learning algorithms. The author concluded that the Random Forest model offers the best recognition accuracy of all models [20].

One study proposes a multisensor-based posture recognition system using the LoRa (Long Range) technology. LoRa is an extended low power network, which has the advantages of low power consumption and very long signal transmission. The theoretical coverage of LoRa is 15 km for rural areas and 5 km for urban areas. In the experiment, the data collected from the sensors are used to be analyzed by six machine learning algorithms to extract the best method of posture recognition. The results show that the Random Forest algorithm has the best performance with an accuracy of 95.06% [21].

An article studied the difference between posture recognition using the conventional machine learning algorithm and the deep learning algorithm. Deep learning is part of machine learning that uses multiple neural layers. The accuracy of recognizing the squat position using conventional machine

learning was 75.4%, while the accuracy using deep learning was 91.7%. Thus, the author concluded that the results obtained through deep learning were superior to those obtained using conventional machine learning [22].

Ahmad J. conducted a study in which he set out to detect the posture of people in wheelchairs. Position recognition was performed for four positions in the sitting position: tilted to the right, left, forward and backward using as machine learning algorithms k-nearest neighbors (k-NN), support vector machines (SVM), random forest (RF), decision tree (DT) and LightGBM. As a result, a posture classification accuracy of up to 99.03 percent was observed [23].

Kumar S. compared the performance of different classifiers in detecting 3 positions, sitting, standing and lying down, using the Microsoft Kinect sensor for data collection. The Machine Learning classifiers used included the Support Vector Classifier, Naive Bayes, Logistic Regression, K-Nearest Neighbors, and Random Forests. The Deep Learning ones included the standard Multi-Layer Perceptron, Convolutional Neural Networks (CNN), and Long Short Term Memory Networks (LSTM). It was found that Deep Learning methods were more efficient than machine learning and that CNN's algorithm achieved the best performance with an accuracy of 93.45% [24].

Discussions

Of the 16 articles that were studied, a number of 7 articles analyzed the use of machine learning technology in recognizing the sitting position, this technology proved to have an accuracy of over 88%. Of these articles, two showed that the best results were obtained using the Random Forest algorithm [12,14], one demonstrated that the most efficient would be to support vector machines [13], and two other articles showed that the Convolutional Neural Networks algorithm is part of deep learning which would get the most accurate results [15,17].

A study was conducted to detect posture in Indian dance. The author concluded that using machine learning achieves very good results with high accuracy. Comparing three different algorithms, it was observed that deep learning, part of machine learning, obtains data with the highest accuracy [18]. The same conclusion was reached by another author who studied the posture during prayer for people of Islamic ethnicity [19].

Another article aimed to study the precision of recognizing the Yoga positions. Several conventional machine learning algorithms have been compared in this article. Of these, with an accuracy of 94.28%, the Random Forest method proved to be the most effective [20]. The same conclusion was reached by another author who obtained an accuracy of 95.06%, comparing the Random Forest algorithm with 5 other machine learning algorithms [21].

Two articles aimed to compare machine learning with deep learning, the latter winning each time, achieving results of over 90% in terms of posture recognition [22,24].

Of the studied articles, 3 used the Kinect optical sensor to detect posture, which proved that it is possible to integrate the machine learning algorithm in association with the Kinect device [10,11,24].

Conclusion

Following the analysis of the articles included in this study, it can be concluded that machine learning offers very good results with high accuracy. Among the conventional machine learning algorithms, it can be stated that Random Forest has the highest accuracy. However, it has been proven that deep learning through the Convolutional Neural Networks algorithm offers the best results, being the closest to having 100% accuracy.

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