The Art of Dance from the Perspective of Artificial Intelligence

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Abstract. With the continuous improvement of artificial intelligence application level, computer data processing technology has gradually become the main and classic auxiliary technology application method in the daily work and life of the majority of society members. This article is based on artificial intelligence technology, using computer animation technology, combining artificial intelligence, computer music and graphics disciplines, to show the musical image in the virtual dance of characters, involving the analysis and recognition of musical elements, the establishment of character models, and motion control and other issues. This paper explores the Hidden Markov Model (HMM, HiddenMarkovModel) model characteristics and algorithm training methods, and proposes an improved HMM training method model algorithm to identify common dance movement models and the control and synthesis of basic dance gestures. This system uses animation as a virtual dance character to show more dance artistic movements for the issues related to the display and scoring of dance movements. Based on the dance movement recognition algorithm and other related algorithms (such as score and error judgment algorithm, error reduction algorithm, etc.), this paper constructs a set of dance movement technical feature statistics and dance movement training. This system realizes the technical statistics and dance training of dance competitions. Two major functions. The above research solves the technical problems of software and hardware engineering from data collection to algorithm programming, and provides a functional platform for intelligent analysis and auxiliary training of dance art, which can be promoted and applied to more professional dancers and dance teachers, thereby accumulating a large amount of data and refining Produce more technical index parameters in line with the rules of dance art, and finally form a set of professional products for dance art intelligence analysis and auxiliary training.

Keywords: Artificial Intelligence, Dance Movement, Simulation Learning, Hidden Markov Model

1. Introduction
Modern artificial intelligence is a new and very comprehensive discipline developed by the intersection of computer science, simulation, big data and other disciplines; artificial intelligence is
also related to understanding the internal mechanism of human intelligence, and is based on machines. Science to be realized; it is a science about understanding the internal mechanism of human intelligence and implementing it on machines [1]. Machine learning is the main content of artificial intelligence research, and its applications have spread across all branches of artificial intelligence, such as natural language understanding, pattern recognition, computer vision, intelligent robots and other fields [2]. Entering the 21st century, machine learning has become more mature applications in various fields. iFLYTEK’s powerful real-time speech recognition technology, human-computer interaction is a robot dedicated to understanding, manufacturing and evaluating being used by or around humans. field. As the word interaction itself implies, interaction means communication between humans and robots. The communication between humans and robots can be achieved in many different ways, and these methods will be affected by the interaction distance between humans and robots [3-4].

Action recognition extraction based on machine learning-related theories is a very important topic in artificial intelligence research. In recent years, many researchers have conducted in-depth research on action recognition based on human vision or non-visual sensors. Human action recognition based on visual sensors is a research hotspot in the field of computer vision, and it is widely used in the fields of virtual and augmented reality, video surveillance, and human-computer intelligent interaction [5-6]. The same non-visual sensors based on the human body also have a wide range of research and applications in behavior and action recognition. The topics of these studies are mainly distributed in the recognition of human daily behavior and actions, the detection of abnormal falls of the human body, and dance action recognition and training [7].

In recent years, due to the rapid growth of artificial intelligence and machine learning, and the continuous iteration of artificial intelligence technology, the application of artificial intelligence in various fields has increased sharply, forming a new industrial revolution wave of "artificial intelligence +" [8]. Among them, artificial intelligence began to appear in the field of art. Taking the popular dance art as an example, some data analysis and intelligent products have also appeared, which initially demonstrated the charm of artificial intelligence technology applied to traditional dance. The improvement of the dancer's own level largely depends on the professional level of the teacher, and there is no more detailed quantitative analysis standard for the advantages and shortcomings of the dancers' technical level. Therefore, it is necessary for the dancers to exert their individual advantages and make up for their own shortcomings. Targeted training appears to be lacking [9]. This article uses machine learning related algorithms to collect the data of each dancer's training or performance, through pattern recognition and data analysis, lists the detailed reports of the dancers' technical statistics during the dance, and quantitatively analyzes and compares the skills of the dancers. The difference in level is to propose a targeted dance training program for dancers to achieve digital, intelligent and efficient training, to achieve the effect of quickly improving the comprehensive technical level of dancers, and to deepen the application of artificial intelligence in the art of dance. Dancer training efficiency is of great significance [10].

2. Algorithm Optimization

2.1. Forward Algorithm

The first is to define a forward probability. In the model $\lambda = (A, B, \pi)$, the probability of the partial observation sequence at time $t$ is defined as the forward probability $o_1, o_2...o_t$, denoted as

$$\alpha(i) = P(o_1, o_2...o_t, i = q_t | \lambda)$$  \hspace{1cm} (2.1)

The probability of the observation sequence can be obtained by the following steps $P(O | \lambda)$.

(1) Initial value

$$\alpha_0(i) = \pi_i b_i(o_1), i = 1,2,..., N$$  \hspace{1cm} (2.2)
(2) Recursion, for \( t=1,2,\ldots,T-1 \)

\[
\alpha_{t+1}(i) = \sum_{j=1}^{N} \alpha_t(j) a_{ji} b_t(o_{t+1}), \quad i = 1,2,\ldots,N
\]

(3) End

\[
P(O \mid \lambda) = \sum_{i=1}^{N} \alpha_T(i)
\]

### 2.2. Backward Algorithm

For backward algorithms, we still need to define a backward probability. In the model \( \lambda = (A, B, \pi) \), the probability of the partial observation sequence \( q_i \) from \( t+1 \) to \( T \) is the backward probability \( o_{t+1} \ldots o_T \), denoted as

\[
\beta_t(i) = P(o_{t+1}, o_{t+2}, \ldots, o_T \mid i_t = q_t, \lambda)
\]

The probability of the observation sequence can be obtained by the following steps \( P(O \mid \lambda) \)

(1) Initial value

\[
\beta_T(i) = 1, \quad i = 1,2,\ldots,N
\]

(2) Recursion, for \( t=T-1,\ldots,2,1 \)

\[
\beta_t(i) = \sum_{j=1}^{N} a_{ji} b_t(o_{t+1}) \beta_{t+1}(j), \quad i = 1,2,\ldots,N
\]

(3) End

\[
P(O \mid \lambda) = \sum_{i=1}^{N} \pi_i b_1(o_1) \beta_1(i)
\]

In fact, the backward algorithm is the reverse form of the forward algorithm. Through the above steps, the corresponding backward probability and the final observation sequence probability can be calculated. The principle is basically the same as that of the forward algorithm, so I won't elaborate on it here.

Baum-Welch is a non-supervised training algorithm and model learning. Assuming that a given training data value contains \( S \) observation sequences of length \( T \), select the peak-to-peak value and average value of the two features with the highest cluster feature value as the element The feature quantity of the action, so each meta-action can be characterized as a 6-dimensional feature vector containing the peak-to-peak value and average information of the \( X, Y, \) and \( Z \) axes. The feature vector of each meta-action is vector quantized, and the clustering algorithm of unsupervised learning is adopted, that is, a secondary clustering operation is performed, and all the meta-actions of the sample are vector quantized.

\( A \) is the state transition probability matrix

\[
A = [a_{ij}]_{M \times N}, \quad a_{ij} = P(i_{t+1} = q_j \mid i_t = q_i), \quad i = 1,2,\ldots,N; \quad j = 1,2,\ldots,N
\]
It is the probability of transitioning \( q_j \) to the state at time \( t+1 \) under the condition of being in the state at time \( T \). \( B \) is the observation matrix:

\[
B = [b_j(k)]_{N \times M}
\]

where

\[
b_j(k) = P(o_j = v_k \mid i_j = q_j), k = 1, 2, \ldots, M; j = 1, 2, \ldots, N
\]

\( \pi \) is the probability \( q_j \) of generating an observation under the condition \( v_k \) of being in the state at time \( t \).

Is the initial state probability vector \( \pi = (\pi_i) \) where

\[
\pi_i = P(i_t = q_i), i = 1, 2, \ldots, N
\]

It is the probability \( q_i \) of being in the state at time \( t=1 \). Hence the hidden Markov model \( \lambda = (A, B, \pi) \).

2.3. Signal Denoising

Wavelet transform is a kind of local systematic analysis based on time and frequency. This method is to refine the signal step by step in many aspects through the expansion and translation operation, and finally it can reach a time subdivision at high frequency and frequency at low frequency. Subdivision, it can automatically analyze time-frequency signals. Therefore, we will use wavelet transform to denoise the signal. By performing wavelet transform on the signal received in real time, the decomposed low-frequency signal and high-frequency signal can be decomposed by the expansion and translation operation. Here, multiple wavelet transforms are used to approximate the low frequency. The signal is decomposed iteratively to get more and better effective signal waveforms. Wavelet transform and Fourier transform are different, the variable is only frequency, and wavelet transform has two variables, scale \( a \) and translation. Scale \( a \) controls the expansion and contraction of the wavelet function, corresponding to frequency; the amount of translation controls the translation of the wavelet function, corresponding to time.

3. Establishment of Early Warning System

3.1. Build a System Model

Hidden Markov model is a kind of probability model related to time series, which describes the random sequence of unobservable states randomly generated by a hidden Markov chain, and then generates an observation from each state to generate a random sequence of observations \( \lambda = (A, B, \pi) \) and observation sequence \( O = (o_1, o_2, \ldots, o_T) \) calculate the probability of the observation sequence \( P(O \mid \lambda) \) Equation (2.3) \( \alpha_i(j)\alpha_{ij} \) represents \( O = (o_1, o_2, \ldots, o_T) \) the joint probability \( q_i \) that the observation at time \( t \) is \( (o_1, o_2, \ldots, o_T) \), and the state is at, and the state is at time \( t+1 \). The result of summing all possible \( N \) states of the joint probability at time \( t \) \( q_i \) is The previous probability that the observation is at time \( t \) and the state is at time \( t=T \) has

\[
\alpha_i(i) = P(o_1, o_2 \ldots o_t, i_t = q_i \mid \lambda)
\]

(3.1)

Therefore, the probability of obtaining the final observation sequence is

\[
P(O \mid \lambda) = \sum_{i=1}^{N} \alpha_i(i)
\]

(3.2)

In this place, the hidden Markov model is determined by the initial probability distribution, state probability distribution \( A \), and observation probability distribution \( B \).
The highlight of the forward algorithm is that by calculating a part of the forward probability and using the model path structure to infer the forward probability out of the entire system, to obtain the desired probability), each recursion directly refers $P(O \mid \lambda)$ to the calculation result of the previous moment, avoiding repeated calculations. Reduce the algorithm time complexity from $O(TN^2)$ to $O(N^2T)$.

4. Comparative Analysis of Results

4.1. System Application

In this section, various functions of the dance technique training system designed in this paper have been tested on the host computer platform. The test details are shown in Table 1 below.

| Function number | function name          | Condition test | Test Results |
|-----------------|------------------------|----------------|--------------|
| 1               | Bluetooth connection   | 99%            | excellent    |
| 2               | data storage           | 97.7%          | excellent    |
| 3               | Real-time waveform display | 98.9%      | excellent    |
| 4               | Dance action recognition | 99.2%        | excellent    |
| 5               | Scores and turnovers    | 97%            | excellent    |
| 6               | Mistake Recovery       | 96%            | excellent    |

It can be seen from Table 1 that after many tests, it is concluded that the system has certain effectiveness.

![Figure 1. Application of data evaluation in sensor testing](image)

When the user gave a demonstration action, the program successfully recognized the user's action, executed the corresponding action, and completed the scoring task. The learned nonlinear model successfully reproduced the demonstration action. The dance movement information of the dancers is recorded through the video taken by the camera, the key frames of the beginning and ending moments of the dance movement in the video are extracted, grid division and coordinate calibration are performed, and the displacement size and difficulty coefficient score of each dance movement are measured. The gap between the non-professional dancers and the professional dancers can be clearly distinguished in the scores of the non-professional dancers and professional dancers. The gap between the dancers is basically the same as the gap in the above figure 1.
Aiming at the dancer's actual dance practice, this article uses two acceleration sensors to be placed directly in front and behind the dancer. The surface of the floor used has data used to capture the dancer's foothold. Create an effective scoring system based on dance judgment standards. Difficult moves get high scores, so you can know the dancer's level only by checking the scores of all the moves in the dance. At the same time, a set of actions to improve the dancer's level will be generated based on the dancer's previous action level. The decision process algorithm is shown in Figure 2:

![Flow chart of artificial intelligence work](image)

**Figure 2.** Flow chart of artificial intelligence work

The process of the evaluation algorithm requires that the evaluation of each dance movement has a very high accuracy rate, and is highly dependent on the recognition of the dancer's movement and music. Therefore, the undetected dance movement or the unrecognized music will cause the algorithm to fail to detect the confrontation. The end signal. This article collects data from 3 sets of dance moves, each set uses a 10-point system, and uses the upper computer application level to calculate and count the scores and errors of each set in real time. The scores and errors of various dance moves can be judged manually. Watch the game for actual statistics and measurement. As shown below, Table 2 shows the program calculation results and actual measurement results of the dancers' scores and errors in several aspects of the three sets of movements.

**Table 2.** Artificial Intelligence Score Table

| Compared                | Monitoring items | Dance coordination (50 points) | Action difficulty factor (50 points) | Total score |
|-------------------------|------------------|-------------------------------|------------------------------------|-------------|
| "The Wizard of Oz"      | A                | 10                            | 10                                 | 85          |
|                         | B                | 9                             | 11                                 |             |
|                         | C                | 12.5                          | 10                                 |             |
|                         | D                | 12.5                          | 10                                 |             |
| "Walk with Me"         | A                | 9                             | 10.5                               | 87.5        |
|                         | B                | 9.5                           | 11.5                               |             |
|                         | C                | 12.5                          | 11                                 |             |
|                         | D                | 12.5                          | 10                                 |             |
| "Song in"              | A                | 12.5                          | 12.5                               | 95          |
|                         | B                | 10                            | 12                                 |             |
In the three sets of dances, the average absolute error of score and error judgment in each game is 1.2 times, and the relative error is 4.63%. It can be seen that the comprehensive accuracy rate of the score and error judgment algorithm is more than 95%, and this function can be better used in dance technical statistics. In the actual dance competition or training, through the dance coordination feature extraction, the difficulty coefficient calculation algorithm, the score and error judgment algorithm and the dance action recognition algorithm, the technical statistics of the dance competition are finally obtained. The average recognition rate of the system based on the same dancer can reach 97.3%, and the average recognition rate of the system based on different dancers can reach 94%. That is to say, mixing the data of different dancers for training and recognition will have a certain recognition rate of the system. The impact will reduce the average recognition rate of the system by about 3.3%. Therefore, in the future, we can consider extending the current work to a large-scale motion data model, which has more practical significance for practical applications.

5. Result
In summary, with the continuous improvement of living standards, people's attention to physical health and dance art is also increasing. As an important art loved by the people, dance will develop in the direction of intelligent training and popularization of technology in the future. The dance application system constructed in this article focuses on solving software and hardware engineering technical problems from data collection to algorithm programming, and provides a functional platform for dance intelligent analysis and auxiliary training. However, to obtain good training results, more dancers and dances are needed. The teacher's participation has accumulated a large amount of data, and refined technical indicators that are more in line with the rules of dance art. Another application of the dance movement recognition algorithm based on this article is to combine virtual reality and augmented reality technology to study dance games or intelligent training systems. Through inertial sensors, data gloves, VR boxes, virtual helmets, smart cameras and locators and other tools, a human-computer interaction dance somatosensory game is realized. Combining VR and AR technology allows users to experience the live and fun of the dance competition more realistically. At the same time, combining this article and improving the intelligent training algorithm of this article, to achieve the effect of technology improvement and dance art fun.

References
[1] Rahamifard H, Plaksina T. Application of artificial intelligence techniques in the petroleum industry: a review [J]. Artificial Intelligence Review, 2018(5):1-24.
[2] Simon, Heeke, Hervé, et al. [The age of artificial intelligence in lung cancer pathology: Between hope, gloom and perspectives] [J]. Annales de pathologie, 2019, 39(2):130-136.
[3] Liu, Yin. [Application of artificial intelligence in precision cardiovascular medicine].[J]. Zhonghua xin xue guan bing za zhi, 2019, 47(2):153-156.
[4] Miao Z. Investigation on human rights ethics in artificial intelligence researches with library literature analysis method[J]. The Electronic Library, 2019, 37(5):914-926.
[5] Gruenigen S V. Artificial intelligence in spinning mills[J]. Melliand international, 2019, 25(1):28-28.
[6] Resch M, Kaminski A . The Epistemic Importance of Technology in Computer Simulation and Machine Learning [J]. Minds and Machines, 2019, 29(1): 9-17.
[7] Valiev T, Morgan H M. Simulation-based learning of invasive procedures skills: A critical appraisal of its organization in undergraduate medical education [J]. International Journal of Healthcare Management, 2019(2):1-8.
[8] Tavanaei A, Maida A S. Training a Hidden Markov Model with a Bayesian Spiking Neural Network [J]. Journal of Signal Processing Systems, 2018, 90(2):211-220.
[9] Li X, Liu Y, Chen P, et al. [Novel type of unperturbed sleep monitoring scheme under pillow based on hidden Markov model][J]. Sheng Wu Yi Xue Gong Cheng Xue Za Zhi, 2018, 35(2):280-289.

[10] Faridee A Z M, Ramamurthy S R, Roy N. HappyFeet: Challenges in Building an Automated Dance Recognition and Assessment Tool [J]. Mobile computing and communications review, 2018, 22(3):10-16.