Design of Artificial Music Intelligence System Based on Fuzzy Perception Learning

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Abstract: The music intelligence of simulated human is of great significance in the research of music informatics. The purpose of this paper is to establish a formal system for describing music intelligence from the perspective of music memory-perception relationship, namely artificial music intelligent system. First, music intelligence is defined as the memory-perception ability of music elements, and a music intelligent system based on music memory mapping and music perception inversion is established by applying the principle of relational mapping-inversion. Secondly, from the perspective of music memory-perception fuzziness, music intelligence index based on fuzzy memory-perception and non-fuzzy memory-perception is proposed, and the solution method is given. Finally, a learning model of music intelligent system is established. Research shows that artificial music intelligence system is a kind of learning system of fuzzy memory-perception, the learning system embodies the basic characteristics of the music nervous system of the human brain, and to establish the artificial music intelligence system to explore people's music intelligence, improve people's music cognitive ability and value of music research has far-reaching significance.

1. Introduction
The concept of "music intelligence" first appeared in the book "intelligent structure" written by Howard Gardner, including people's expressive force, creative ability and appreciation ability to music. The core abilities of music intelligence are the memory-perception ability of music elements such as tone, rhythm, melody and timbre. Only when music memory-perception ability is reached to a certain extent, the ability to express, create and appreciate music can be realized. Multiple intelligences confirm music as the independent existence form of human intelligence, forming people's new understanding of the construction and development of music in individual intelligence. In recent years, in the research fields of music psychology, music informatics and intelligent computing, many research results have emerged around the cognitive problem of music. Among them, the simulation of music intelligent system has become a research hotspot. [1-3]

However, it can be found from the existing literature that the research on music intelligent system is basically psychological model for music cognition, perception simulation of music elements, and neural network model based on music perception and so on. In fact, the core problem of music intelligent system design and research is the learning mechanism of music memory and music perception. In other words, how to simulate the learning mechanism of human brain music memory-perception is the key to solve the problem of artificial music intelligent system. [4] In
addition, the essence of human cognition of music is based on fuzzy memory and fuzzy perception. Only through the learning process of fuzzy memory-perception can people have music intelligence of music performance, music creation and music appreciation to varying degrees.

The purpose of this paper is to build an artificial music intelligent system based on the basic characteristics of human brain's memory and perception of music, and analyze people's music intelligent behavior through this artificial music intelligent system. The main contribution of this paper is to put forward the concept of music intelligence index and establish music fuzzy memory-perception learning model.

The structure of this paper is as follows: section 2 proposes a learning method of artificial music intelligent system based on memory mapping and perception inversion. In section 3, music intelligence index is established by using music perceptual fuzzy set method. Section 4 designs the basic framework of the artificial music intelligent system. Finally, section 5 gives a conclusion and further work.

2. Mapping-Inversion Principle of Music Intelligent System

The main function of the artificial music intelligent system is to simulate the music intelligent behavior of human beings and achieve the satisfactory music intelligence through the learning process of human-computer interaction. Generally speaking, the premise of designing an intelligent system is to use formal methods to describe human's intelligent behavior. [5]In general intelligent system design, knowledge-based reasoning model is a formalized method. The core of music intelligence is the learning ability of music memory and music perception. Therefore, the design of music intelligent system should reflect the learning behavior of memory and perception. In this paper, the principle of relational mapping-inversion is applied to the design of music intelligent system, a novel music intelligent system model is presented. [6]

According to the basic structure of human music cognition, there is a music memory space and a music perception space in human brain. The formation mechanism of music intelligence is the process of mapping and inversion of these two Spaces, namely the mapping from memory space to perception space and the inversion from perception space to memory space. The specific formal expression is:

Let \( S^* = (X^*, R^*) \) be a music memory space, \( S = (X, R) \) be a music perception space, where \( X^* \) and \( X \) are music memory set and music perception set, \( R^* \) and \( R \) are music memory relationship and music perception relationship, there is a memory mapping \( M : x^* \rightarrow x \ (x^* \in X^*, x \in X) \), that is, from memory to perception, through the perceptual learning process, a perceptual inversion \( I : x \rightarrow x^*(x \in X, x^* \in X^*) \) that is, from new perception to memory. This process is called the mapping-inversion principle of music intelligent system. As shown in Fig. 1: [7]

\[
M : x^* \rightarrow x (x^* \in X^*, x \in X) \\
I : x \rightarrow x^*(x \in X, x^* \in X^*)
\]

2. Mapping-Inversion Principle of Music Intelligent System

In Fig. 1, \( P^* \) is the perception based on music memory, and \( P(x^*, x) \) is the perception of music after learning. \( P(x^*, x) = P^*(S^* \rightarrow S) \) is a learning process from memory space to perceptual
space, for example, music learning is a training process of the perception and memory ability of music elements, which promotes the development of music intelligence.[8] In the expression and measurement of music perception ability, fuzziness is the essential feature of music perception. Both music performance and music creation achieve the cognition and utilization of music fuzziness through the fuzzy perception process of music elements. Therefore, the fuzzy expression and measurement of music memory and perception is the key to realize the design of artificial music intelligent system.

3. Learning Models of Music Fuzzy Perception

3.1. Fuzzy perception model of music elements

Person's so-called "perception" is the accumulation of knowledge and experience is the moment of the many complex factors in the many complex changes in the consolidated judgments. Such judgments are based on "fuzzy" [9]. Because it is fuzzy, so simple, people can in a short period of time to conclude. Perception Computation (PC) for people to learn this so-called "perception" thinking for further analysis. Look at the "perception" in the end is how many complex factors; many of the complex changes resulting in an overall comprehensive "grasp" of things at the same time give the mathematical description of science. Only ambiguity is not enough, the only accurate is not enough.

If there is a group of basic music elements, their perception judgment and perception fuzzy degree are designated in advance. Then it is called criterion space. The perception judgment and perception fuzzy degree between any two elements can be calculated by a set of rules inflicted on the memory space. According to perception fuzzy set is presented in the literature [10], we have as follows definition:

**Definition 3.1** [11] Let \( S = (X, R) \) be a perception space of music elements based on memory space of music elements \( S^* = (X^*, R^*) \), where \( P(x^*, x)(x^* \in X^*, x \in X) \) has fuzzy perception and non-fuzzy perception, as well as the degree of the fuzzy perception is \( \mu(x^*, x) \in [0, 1] \), the degree of the non-fuzzy perception is \( v(x^*, x) \in [-1, 0] \), then \( R(p(x^*), p(x)) = R(\mu(x^*, x), v(x^*, x)) = I(x) \) be called a music intelligence index (MII), without loss of generality, we have

\[
I(x^*, x) = \begin{cases} 
1 & \mu(x^*, x) = 1, v(x^*, x) = 0 \\
0 & \mu(x^*, x) = 0, v(x^*, x) = 1 \\
\frac{1}{2} & 0 < \mu(x^*, x) - v(x^*, x) < 1 \\
0 & \mu(x^*, x) = v(x^*, x) 
\end{cases}
\]

The definition with nature comes to following:

1. If \( \mu(x^*, x) = 1, v(x^*, x) = 0 \), then \( S^* = S, P = P^* \), that is, the memory music elements determines the perception of the music elements. In other words, the memory space of the music has complete music knowledge and music experience.

2. If \( 0 < \mu(x^*, x) - v(x^*, x) < 1 \), then \( S \subset S^*, P \subset P^* \), that is, the music perception has some memory music elements. In other words, the memory space of the music perception has incomplete knowledge and experience.

3. If \( \mu(x^*, x) = 0, v(x^*, x) = 1 \), then \( P^* = \emptyset, P = \emptyset \), that is, the music perception have no memory space. In other words, the memory space of the music perception has no relevant music knowledge and experience.

3.2. Music intelligence based on music fuzzy perception

The fuzzy perception model of music provides an effective formalization method for describing and
measuring music intelligence. For a music work, an individual music intelligence index can be obtained through fuzzy perception and non-fuzzy perception measurement of music elements such as tone, rhythm, melody and timbre. In fact, the music cognitive theory focuses on the study of the effect of memory on the perception of music, but does not make an in-depth discussion on the effect of music memory on the perception of music. At the same time, it is also a problem that needs to be studied to improve the memory ability of the relationship between music elements through perceptual learning. Through the fuzzy perception analysis of music elements, the fuzzy perception relationship of music elements can be established, which is realized in the process of mapping and inversion of music memory space and music perception space.[12]

In analysis and evaluation of music intelligence level, both music performance, music creation and music appreciation, in general, music intelligence index \(0 < I(x^*, x) < 1\), namely the music perception from the part of memory space, that is to say, music memory space is an incomplete space, and can't satisfy the music performance, music creation and the need of music appreciation, therefore need to music perception through continuous learning and training to improve the completeness of music memory space, and close to and achieve the \(I(x^*, x) = 1\). When \(I(x^*, x) = 0\), that is, \(P^* = \emptyset, P = \emptyset\), It indicates that the individual does not have music intelligence, so it needs to strengthen music learning and training, so as to make \(I(x^*, x) = 0\) approach \(0 < I(x^*, x) < 1\), that is, to have a certain music intelligence.

4. The Design of Artificial Music Intelligence System
The establishment of artificial music intelligent system is a meaningful subject in the field of AI at present, and it is also the main content of music informatics research. The traditional research models of intelligent systems are all based on the framework of reasoning system, one is rule-based reasoning, and the other is a solution method based on mathematical model. In the design process of artificial music intelligent system, considering that music perception behavior has the characteristics of non-data and fuzziness, the reasoning model of music perception is established from the perspective of intuitionistic fuzzy set. This reasoning model of music perception is a learning process based on memory perception and direct perception.[13]

In general, everyone's fuzzy perception of music elements is different, and the memory structure of music elements is also different. The difference in music memory space determines everyone's music perception. The main function of artificial intelligence system is reflected in the learning mechanism of music intelligence. The reasons for this perceptual learning machine are as follows (See Fig. 2).

(1) Memory structure of human brain music. It has the function of self-organization, which is realized in the process of music perception.

(2) Human-computer interaction function of music elements perception. This human-computer interaction is based on the fuzzy perception of music works and the evaluation of the fuzzy cognition degree of music elements.

In this study, the electone solo "Why Are the Flowers So Red" was selected as an example to analyze the function of the artificial music intelligent system, and the ideal music intelligent training effect was obtained.[14]

5. Conclusions
In this paper, a music intelligent system based on fuzzy perception learning is proposed. The music intelligent index is established to measure the music perceptual ability. At the same time, it is pointed out that the completeness of music memory space is the key to the development of music intelligence. Research shows that different music knowledge and experience determine the perception ability of music elements, and only by improving music fuzzy perception ability can the level of music intelligence be promoted. At the same time, music perception has two effects, one is the impact on music cognitive ability, and on the other hand, it will promote the development of other intelligence.
In fact, artificial music perception system also provides a new research method for music cognitive theory and a new research field for the development of computer music.

![Artificial music perception system based on memory structure of music perception](image)

Fig. 2 Artificial music perception system based on memory structure of music perception

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