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Research and Application of Artificial Intelligence in Electric Guitar Performance

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Abstract: The article explores the application of artificial intelligence technology in electric guitar playing. It delves into the advantages of artificial intelligence and its seamless integration into electric guitar performance. Additionally, it investigates the application of artificial intelligence technology through an intelligent playing robot. The research aims to offer substantial support for the advancement of artificial intelligence in electric guitar performance.

Keywords: Artificial intelligence technology; Electric guitar playing; Fusion advantage; Guitar-playing robot design

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1. Artificial intelligence and its integration advantages in electric guitar playing

1.1. Overview of artificial intelligence technologies

Artificial intelligence technology, also referred to as AI technology, is a technology designed to learn, study, simulate, and expand human thoughts and behaviors through computer systems and related models, providing ample power for technological innovation. Within the current landscape of AI technology, its primary components encompass image recognition, language recognition, natural language processing, expert systems, and intelligent robots. These technologies have found successful applications in various fields, demonstrating the significant advantages of artificial intelligence.

1.2. Advantages of integrating artificial intelligence technology into electric guitar performance

In contemporary electric guitar performance, the integration of artificial intelligence technology has emerged as a major developmental trend. In this specific integration, the organic fusion of disciplines such as music performance, mechanical design, software engineering, and electronic science enables the electric guitar-playing robot to possess human-like music score recognition abilities and electric guitar-playing skills [1]. Through the cross-fertilization of multiple disciplines and technologies, this integration not only offers robust support for interdisciplinary research in electric guitar music performance but also provides digital and intelligent technical support for modern electric guitar music creation and teaching.

2. The application of artificial intelligence in electric guitar performance research

2.1. Basic overview of electric guitar-playing robots

To rationalize the application of artificial intelligence technology in modern electric guitar playing, this research focuses on studying an electric guitar-playing robot. The primary actuators of the robot responsible for electric guitar playing include the plucking mechanism and the pressing mechanism. Among these, the plucking elements within the plucking mechanism correspond to the number of strings on the electric guitar and operate independently. The plucking strength of each string can be controlled individually. The pressure mechanism comprises a specific number of pressure elements designed to meet the actual pressure requirements of intelligent electric guitar performance. Additionally, the robot is capable of producing the sound of each electric guitar string independently.

2.2. String plucking mechanism design for electric guitar-playing robots

The plucking mechanism of an electric guitar-playing robot consists of two main components.

The first component is the plucked string assembly. Each plectrum assembly comprises a volume control servo, a single plectrum servo, a linkage, a servo arm, and a plectrum swing arm. Specifically designed, the plectrum assembly is configured as a two-by-two counterpart and fixed on the left and right sides of the electric guitar strings. The spacing between each pair of opposing plectrum assemblies should be two strings or more to prevent collisions between the plectrum assembly and the plectrum and pendulum arm. Plucked strings are positioned in the sound hole of the guitar to ensure articulate sound quality. The plectrum swing arm should have functionalities for normal plectrum action, left and right swinging, and servo angle adjustment to achieve optimal sound production, enabling the robot to play a diverse range of electric guitar music [2]. The servo model is set as MG996R, with a supply voltage of 4.8 V and a response speed of 0.17 s per 60° in this mode. For calculating the note duration in music performance, the design follows the formula:

$$t_n = \frac{N}{nT} \qquad (1)$$

$$n = 1,2,4,8,16 \qquad (2)$$

where N represents the duration of each beat in the piece equal to an n-th note, n is the n-th note, and T is the tempo at which the piece is played in T beats/min.

The second component is the volume adjustment mechanism. In this specific design, pulleys and lines are utilized to adjust the volume of the servo connected to the toggle, which sets the spring on the toggle. Through the toggle, the volume of the servo is adjusted by changing the toggle position when the plucked string pendulum arm is in a particular state, ensuring precise control of the intelligent playing volume.

2.3. Design of string presser mechanism for electric guitar-playing robots

In the string press mechanism of the electric guitar-playing robot, the specific design comprises two main components.

The first component is the string press module, consisting of pressure pads, cylinders, and housing. Three pressure modules are incorporated, each comprising six cylinder actuators with pressure pads corresponding to the six strings on the electric guitar. To accommodate the minimum string spacing of approximately 7 mm, the pressing module utilizes 5.5 mm diameter CJIB4 pin-pad single-acting cylinders. These cylinders have a telescoping length of up to 10 mm and a very rapid response time, enabling effective pressing of the electric guitar strings.

The second component is the moving module, consisting of a linear guide, stepping motor, synchronous

belt, slider, and synchronous wheel. Its primary function is to intelligently control the lateral movement of the string presser module on the fingerboard of the electric guitar. Five linear guide rails are employed, with three power guide rails connected to the string presser module and two support rails providing stability. To adapt to the actual playing mode of the electric guitar, the specific design incorporates a 7 mm wide MGN7 miniature guide rail, corresponding to the slide rail MGN7C type slider, a 6 mm wide GT12 synchronous wheel, and a synchronous belt.

To meet the intelligent playing requirements of electric guitars, the designer must ensure that the travel distance of the string presser module, under the condition of the shortest note-playing time, exceeds the length of the longest demanded value of the guitar's moving fret. The formula for calculating the distance of the presser module's travel for the shortest note-playing time is as follows:

$$L = \frac{n\pi dt}{360T} \qquad (3)$$

where n represents the step angle in the operation of the stepper motor, t represents the pulse period, d represents the diameter of the synchronization wheel, and T represents the time taken for the shortest note to be played.

2.4. Control system design for electric guitar-playing robots

In the design of an electric guitar-playing robot, the control system serves as the primary realization mechanism for artificial intelligence technology. It is through the thoughtful design of this system that artificial intelligence technology can fully leverage its application in modern electric guitar playing.

Within this design of an electric guitar-playing robot, the main components of its control system include a controller, computer, stepper motor driver, servo control module, solenoid valve, and relay. The upper computer functions as the computer, while the lower computer serves as the controller. During specific intelligent control operations, the upper computer primarily analyzes music score data, using it as a basis to plan the movements of the intelligent playing robot. Subsequently, the upper computer transmits the planned data code to the lower computer. Upon receiving the data, the lower computer promptly analyzes it and uses the results as a basis to intelligently drive the robot's string plucking mechanism and string pressing mechanism, thereby executing the intelligent electric guitar performance [3].

Taking the aforementioned design ideas for an intelligent electric guitar-playing robot as a foundation, in this design, the designer initially focused on the hardware of the control system, implementing the following measures:

(1) Controller design: To achieve intelligent control of stepper motors, multiple cylinders, and servos, the designer utilized the STM32RCT6 core board as the controller. The core board boasts a maximum main frequency of 72 MHz, a power supply voltage ranging between 2.0–3.6 V, a program buffer capacity of 256 kB, and 51 inputs and outputs, providing support for 2 interpolated coordinate systems.

(2) Servo control module design: To satisfy the need for simultaneous control of the 12 servos in the intelligent performance robot's structure, the designer employed the Lefthand Sol 16-channel servo control module. This module intelligently drives the servos, facilitating precise manipulation of the 12 servos in the robot.

(3) Stepper motor driver design: To meet the intelligent drive requirements for stepper motors in the robot, the designer selected the TB6600 two-phase stepper motor intelligent driver. This driver operates with a DC input voltage of 9–40 V, an output current range of 0.5–4.0 A, and a maximum

power of 160 W. It supports intelligent drive for both 42-step and 57-step two-phase stepping motors.

(4) Solenoid valve design: To fulfill the demand for intelligent control of single-acting needle cylinders in the pressure string mechanism, the designer opted for the 3V110 two-position, three-normally closed solenoid valve, enabling intelligent control of the cylinder.

Next is the control system software design of the intelligent electric guitar-playing robot. In this specific design, to meet the actual requirements of intelligent control and achieve the desired effect of intelligent electric guitar performance, the designer has specially employed the depth-first search model in artificial intelligence technology. In practical application, this model initially selects a path and searches for the target in one direction, intelligently backtracking when reaching the end of the search. It then selects other paths to continue the search until the target is found. This process enables intelligent control of strumming, pressing the strings, and other actions on the electric guitar, in accordance with specific electric guitar sheet music.

Finally, there is the communication design of the control system for this intelligent electric guitar-playing robot. For the serial communication protocol between the upper and lower computer, the designer primarily employed two types of data frame formats. One is the data frame for the string presser module, used for intelligent planning of the robot's string presser module movement during performance. The other is the data frame for the music score, primarily used for intelligent control of the robot's electric guitar music performance. Regarding the communication protocol in the servo control module, the designer establishes serial communication between the controller and the servo control module. **Table 1** illustrates the data frame format in the servo module of the electric guitar-playing robot.

Table 1. Data frame format in the servo module of this electric guitar-playing robot

Serial number	Enterprise	Specification	Serial number	Enterprise	Specification
1	Header	0*550*55	3	Directives	0*03
2	Data length	L	4	Parameters	Prm1-PrmN

3. Conclusion

In summary, within the realm of electric guitar playing, a playing robot represents a quintessential application of artificial intelligence technology. To meet the practical application demands of this technology, the designer must meticulously design the plucking mechanism, pressure mechanism, and control system of the intelligent playing robot. This ensures the incorporation of intelligent music score recognition functionality, enabling the realization of intelligent electric guitar music performance based on the provided music score. This approach aims to achieve a seamless integration between artificial intelligence technology and electric guitar performance.

Disclosure statement

The author declares no conflict of interest.

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