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Violin Musical Tone Analysis using Robot Finger

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Abstract

This paper introduces a study to improve the performance of robot finger for violin fingering. The authors have developed violin-playing robot system. Also, authors have designed robot hand anthropomorphic type for the violin fingering. The violin fingering plays an important role in determining the tone or sound. Whether the performance sound produced when the developed robot finger presses the strings of the violin is identical to when a human violinist presses the strings requires verification. The researchers propose utilizing the precedent sound quality rating system to analyze the performance sound of a human violinist and create the conditions needed to produce the accurate quality sound. On this basis, the researchers compared the performance sound made by the fingering of a robot finger with that of a human violinist and suggest a strategy to make improvements to disadvantages.

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Keywords: violin-playing robot; anthropomorphic robot finger; sound quality rating system;mass-spring-damper model.

1. Introduce

Numerous studies have been conducted on human-robot interaction (HRI) with the aim of developing service robots for personal and private use. In particular, both industry and researchers alike have focused on a variety of entertainment robots that can deliver human-friendly mutual information. Visual, auditory, and touch sensors have been further installed to identify the intended actions of humans. Rapid technological developments of visual and

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touch sensors in the field of entertainment robots have enabled interaction of the robots with humans. However, no suitable sensors and algorithms for recognizing human intent through auditory perception are yet available.

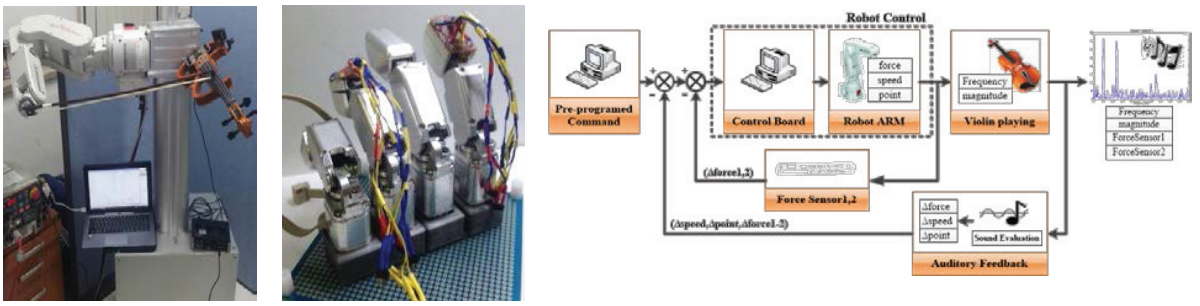
Currently, studies are actively pursuing to recognize a variety of sounds and human voices[1]. However, among the literature, studies specifically investigating auditory feedback are only conducted, to a limited extent, in the medical field[2]. In particular, a self-treating method for people who stutter, which entails listening to their own voice and understanding its state, has been proposed[3]. Determining that this auditory feedback technology is the key element of HRI, the present researchers have accordingly developed a sound quality rating system for improving the existing violin-playing robot by combining this system with auditory feedback[4-6]. The present work introduces a robot hand and a robot finger that perform the role of violin fingering in the violin-playing robot. The rest of this paper is organized is follows. Section 2 briefly introduces the previous work of violin-playing robot system. Section 3 illustrates how violin fingering affects the human violin sound quality and presents a comparison and analysis of the results of sound quality in the case of violin fingering by a human violinist and the proposed robot finger when playing the fourth-octave C-note. Section 4 introduces about mechanical impedance modeling of human finger. Also, in order to find out whether the developed robot finger produces the same performance sound as when a human violinist presses the violin strings, a sound quality-rating test is implemented.

2. Previous Work

This section explains the developed violin playing robot system. We have developed a violin-playing robot with an industrial six-axis vertical robot arm (RV-2SD), as shown in Fig. 1(a), to mimic the appearance of a human violinist. Similar to the arrangement in the case of a human violinist, the violin is fixed at an angle of 30° to the left shoulder. A violin bow is placed at the end of the robot arm, which is equipped with a force sensor in order to measure the pressing force and twisting force[6-7].

Also, authors have developed an anthropomorphic type robot hand for violin-fingering, as shown Fig. 1(b). This robot hand is similar to size of an average male hand for accurately pressing violin string. Also, it operates based on wire-driven and under-actuated for light weight[8].

Auditory feedback is known as a stuttering therapy method in the medical field, where delayed auditory feedback (DAF) is mainly studied[3]. If the auditory feedback is fused with visual feedback and somatosensory feedback, it helps people to talk or sing a song by determining the accuracy of the sound. This process has been utilized in the process of playing music, where in previous work proposes a method that improves the sound quality automatically by using violin robot. Fig. 1(c) shows the framework of auditory feedback system that is used in violin robot. This system is implemented by listening and mimicking the playing technique of violinist to improve the sound quality[6-7].



(a) (b) (c)

Fig. 1. (a) Developed violin-playing robot system; (b) anthropomorphic type robot hand[8]; (c) flow chart of auditory feedback system[6-7].

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