AR-based Guitar Strumming Learning Support System that Provides Audio Feedback by Hand Tracking

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Abstract. In this study, the author developed an augmented reality (AR) system to assist beginners in learning guitar strumming. This system offers support that allow users to practice strumming anywhere using a smartphone, without the need for a physical guitar. This system utilizes hand tracking to capture the hand's coordinates and angles, effectively supporting strumming practice in the manner of a music game.

Keywords: Augmented reality, guitar strumming, hand tracking

1 Introduction

Mastering the guitar is challenging for beginners due to the need for distinct hand techniques. The technique of strumming involves plucking the strings with the fingers and requires proper adjustment of relaxation, timing, angle, and force. According to Hosoi and Matsushita [1], skilled guitarists have been found to exhibit faster wrist rotations during strumming compared to beginners.

To practice the guitar, one needs to have a physical guitar, which can sometimes pose a limitation. This study aims to enable beginners to practice strumming even in the absence of a physical guitar. According to Fujioka [2], practicing 'air guitar' in the absence of a physical guitar is an effective means for beginners to acquire 'strumming' skills. However, the lack of feedback in air guitar poses a significant challenge when attempting to correct movements. Therefore, the proposed system conducts visual feedback in the style of a music game and analyzes hand movements to allow beginners to practice guitar strumming while enjoying the process.

Motogawa and Saito proposed a system that displays information on a display to assist in playing an actual guitar, supporting the user in playing intuitively [3]. We utilize both a vision marker and the natural features of the guitar for tracking, enabling the constant projection of support information to the appropriate position. This study focuses on fretting, but the scope of use is limited due to the use of various hardware.

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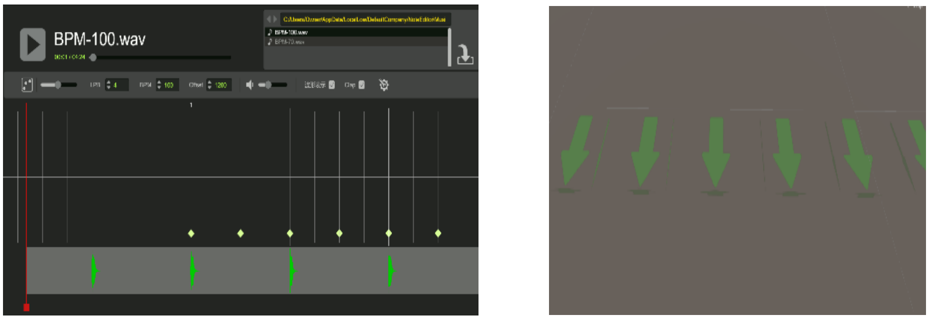

Fig. 1 NotesEditor for creating a chart (left). arrow-shaped notes (right).

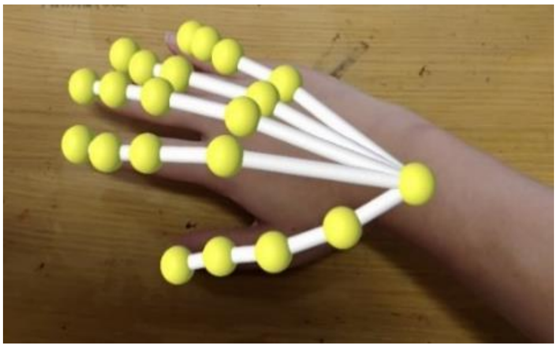

Fig. 2 The hand tracking process enabled by ToF AR.

Kashiwagi and Ochi [4] proposed a method using Kinect to detect guitar picking; however, due to the absence of real-time feedback, it is insufficient for supporting practice. This system improves right-hand strumming through AR and hand tracking, eliminating the need for a physical guitar. With the goal of providing intuitive interaction between virtualn objects, musical scores, and the user's hand, we develop an AR smartphone system equipped with hand-tracking functionally for guitar strumming practice. Through hand tracking, the system displays the user's own hand movements on the UI, providing visual feedback by showing finger coordinates and wrist angle. Futhermore, its usability on smartphones renders it an excellent practice support tool for beginners.

2 Development of a Guitar Stroke Learning Support System

We have employed Unity and C# in the development of the proposed system, integrating ARToolKit for AR development and utilizing ToF AR for precise hand tracking. Our main challenge is to enhance the strumming techniques of the user without the physical guitar, and to address this, we have developed a game-style AR practice system.

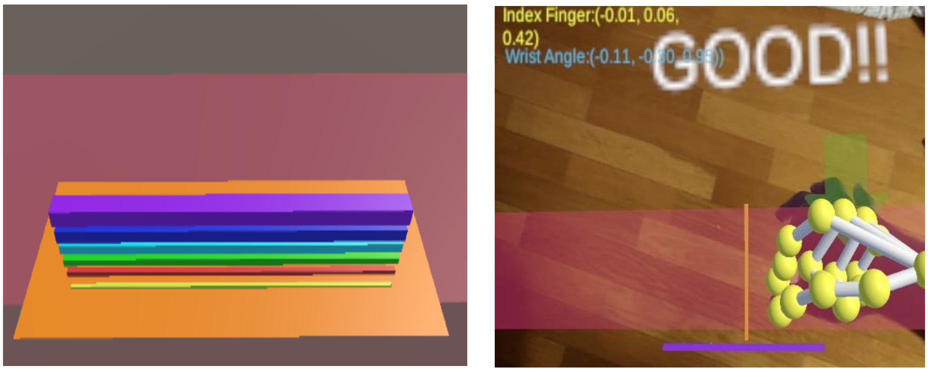

Fig. 3 The strings and judgement line (left), the system screen (right).

In this system, we use arrow-shaped notes created with NotesEditor. As these notes flow at a tempo of 100 BPM (beats per minute), they indicate the direction of strumming, enabling a user to move their hands in accordance and evaluate their own accuracy and timing (Fig. 1).

For hand-tracking, we utilize depth information from the ToF sensor integrated into smartphones to detect a hand within the camera's field of view (Fig. 2).

Fig. 3 shows the string object displayed on the smartphone, along with the orange judgment line used to measure the timing of strumming. As shown on the left of Fig.3, our system displays six elongated rectangular objects in different colors, representing the guitar strings. While holding the smartphone in the left hand, a user can produce the sound of an open string on an acoustic guitar by interacting with the string object using the right hand for strumming.

Fig.3 right shows the screen during the system's execution. The guitar string objects (Fig. 3 left), are displayed from a top-down perspective, similar to actual guitar strings. Upon executing the system, arrow-shaped notes flow in sync with the metronome sound set at BPM 100, and the user strums in accordance with them. When the user's hand touches the strings at the correct timing, the word "GOOD" appears.

Additionally, in the top-left corner of the screen, the user's finger coordinates and wrist angles are displayed. The wrist angle is calculated based on vector calculations using the coordinates.

3 Discussion

As challenges of this system, it currently has limitations in terms of the available practice tempo and stroke patterns, lacks tactile feedback, and does not possess a comparative feature for assessing hand movements against the correct reference. To address these constraints, the plan for the future is to first introduce various tempos and a range of stroke patterns for practice. For example, we plan to create multiple scores in the NotesEditor that correspond to various stroke patterns, allowing the user to freely select their preferred tempo and stroke pattern.

Currently, this system is designed to be used while holding a smartphone in one hand. In the future, we are considering the use of AR headsets to enable the use of both hands freely. Utilizing an AR headset allows for the user's non strumming hand to function as a substitute for the strings, enabling the provision of tactile feedback during strumming.

Furthermore, we plan to create 3D models that demonstrate the correct strumming motions as a reference, allowing the user to visually compare their own movements with the correct one. Additionally, in the future, we plan to implement features that provide the user with advice based on the data obtained through hand tracking.

4 Conclusion

In this study, we developed a guitar strumming learning support system that utilizes AR and hand tracking to provide audio feedback. We utilized Unity for the system development, supporting user's strumming practice through hand tracking technology and gamification. This gamification is achieved through interactive objects that generate guitar string sounds and arrow-shaped notes representing strumming directions. These notes appear synchronized with a metronome sound set to a specific tempo, enabling the user to practice their strumming while assessing their timing accuracy.

Through hand tracking, we visualized the user's hand movements and quantified finger coordinates and angles. Our future plans include expanding the options for tempo and strumming patterns to facilitate more versatile practice sessions. Additionally, The challenges that we plan to address and improve upon in the future include limitations in terms of tempo and stroke patterns, the absence of tactile feedback, and the lack of a feature that enables users to visually compare their hand movements. We plan to conduct evaluations of the system in the future.

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