Support System for Guitar Playing using Augmented Reality Display

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ABSTRACT

Learning to play the guitar is difficult. We proposed a system that assists people learning to play the guitar using augmented reality. This system shows a learner how to correctly hold the strings by overlaying a virtual hand model and lines onto a real guitar. The player learning to play the guitar can easily understand the required position by overlapping their hand on a visual guide. An important issue for this system to address is the accurate registration between the visual guide and the guitar, therefore we need to track the pose and the position of the guitar. We also proposed a method to track the guitar with a visual marker and natural features of the guitar. Since we used marker information and edge information as natural features, the system could continually track the guitar. Accordingly, our system can constantly display visual guides at the required position to enable a player to learn to play the guitar in a natural manner.

CR Categories: I.4.9 [Image Processing and Computer Vision]: Applications

Keywords: Augmented Reality, Support System for Guitar Playing, Accurate Registration, Vision Marker, Model based Tracking

1 INTRODUCTION

The guitar is a very popular musical instrument. However, beginners experience great difficultly when learning to play the guitar because of the complex and unfamiliar hand positions required to produce music. Some musical instruments with keyboards have recently been commercially produced that assist a player, who is learning to play music, by showing a visual guide (lighting up the keyboard which a player should push). Such visual guides, however, are difficult to provide for stringed musical instruments, such as guitars, because of their structure.

To solve this problem, we proposed a system that assists people learning to play the guitar in which a visual guide is displayed onto a guitar using augmented reality (AR) technology. There are many advantages to using an AR technique when providing visual guides on musical instruments. We do not have to recreate the musical instrument as the visual guide can be displayed directly onto the actual musical instrument. Moreover, since the visual guide can be shown via a display, the system can help a player by showing various types of information (For example, displaying a model manual form to hold the strings, in the case of the guitar).

An important problem to be addressed when constructing such a learning tool using AR is accurate registration between the visual guide and the guitar. Cakmakci *etal*.[1] used only an AR Toolkit's marker[2] to estimate the pose and the position of the guitar. However, the system was unable to always accurately track the guitar when only information provided from the marker was used, which was often incorrectly detected in the real environment. Moreover, the marker was unable be detected even when a part of it was occluded. To solve this problem, we used the edge[3, 4] of the neck of the guitar as a natural feature to track the pose and the position of the guitar when the system was unable to detect the marker. The use of the marker and this natural feature for tracking the guitar enabled us to create a user-friendly system for assisting people learning to play the guitar with just a USB camera and a PC display.

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2 SYSTEM CONFIGURATION

Figure 1 shows the system configuration. The system consists of a USB camera and a display connected to a PC.

As shown in this figure, the USB camera captures the player. The captured image is then displayed so that the player can watch themselves playing the guitar as if they were looking at a mirror. The system tracks the movement of the guitar so that the visual guide is displayed to the player for learning purposes. The system displays a computer-generated model of a playing hand to show the correct finger placement and lines to show the correct holding position of the string. The player can immediately see the information required to correctly play the guitar on the PC display as the body of the actual guitar is displayed as is while the visual guide is simultaneously displayed at the correct position on the body of the guitar. The player can easily understand how to hold the strings of the guitar by simply overlapping their hand on a virtual hand model. Although the user is a beginner, they can easily play the guitar.

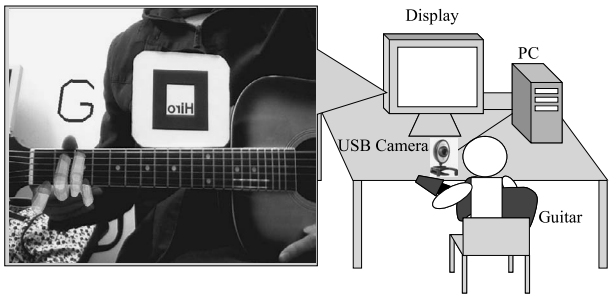

Figure 1: Proposed system.

3 ONLINE GUITAR TRACKING

If the system accurately tracks the pose and the position of the guitar, the system can project the visual guide at the required position so that the player can see the visual guide in a natural manner. To estimate the pose and the position of the guitar, we used the AR toolkit function. We attached a square-shaped planar marker with particular pattern to the guitar beforehand and tracked it using an online process. Unfortunately, the system was often unable to track the marker because of occlusion or was unable to detect the marker. To solve this problem, we used the edges of the neck of the guitar when the system was unable to detect the marker.

Using edge based tracking, we computed the pose and position of the guitar by minimizing the projection error between the edges projected using the predicted pose and position (estimated at the previous frame) and the corresponding points in the image captured with the USB camera.

For determining correspondence points, we sampled points along the projection of the edge, E_i, on a 3D model. The gradient of the image intensity, ΔI, for each point sampled was checked

on the search line in a direction perpendicular to the projection of the edge. A point, $e_{i,j}$, where ΔI exceeded a threshold was chosen as the corresponding point. Once the correspondence points were made between the edges of the 3D model and the points on the input image, we could compute the projection error. Then, by minimizing the projection error, we could compute the pose, $\boldsymbol{R}$, and the position,$\boldsymbol{T}$, of the guitar (as shown in Figure 2). The problem can be determined using the equation:

$$\min_{R,T} \sum_i \sum_j \Delta(E_i, e_{i,j}) \tag{1}$$

where $\Delta(E_i, e_{i,j})$ is the squared distance between the 2D point $e_{i,j}$ and the 3D edge E_i projected on the image plane.

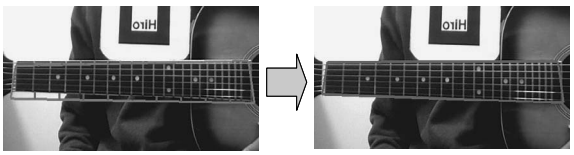

Figure 2: Edge based tracking method.

4 Tracking Results

To determine the efficacy of our method, we evaluated the accuracy and the performance of our system by projecting a virtual hand model onto a guitar. As shown in Figure 3, a virtual hand model was projected at the required position even when the player moved their hand considerably. Furthermore, our system could correctly track the guitar in frames where tracking had failed even though the system was only using marker based tracking, as shown in Figure 4.

Whereas, the tracking error accumulated over the frames when only the natural feature (edges) were used for tracking. As a result, tracking could not be continually performed for long periods of time. The combined use of the marker and the natural feature was important for achieving a user-friendly system.

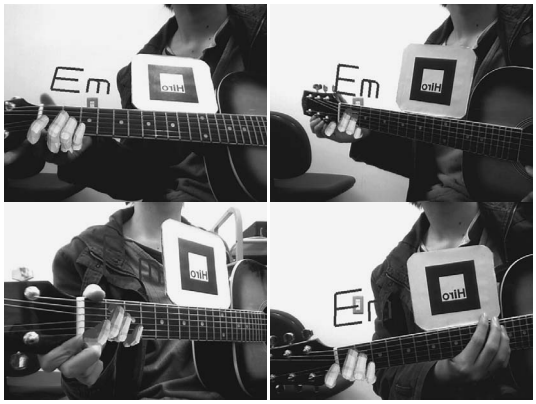

Figure 3: Images of projected virtual hand model using our method.

5 Application

Figure 5 shows scenes when a user used our proposed method. As the musical score information had previously been entered into the system, all necessary information for playing the music was shown on the PC display. This enabled the user to easily play the required music by just moving their hand on the basis of the displayed information.

We presented a live demonstration of our application for several hundred people at a domestic conference in March 2006. Some people who used this system gave positive comments, such as it was useful for learning to play the guitar. However, some people indicated that it was difficult to use because of the way the information was displayed. They expected the system to have displayed

(a)Marker based tracking only.

(b)Marker and edge based tracking.

Figure 4: Comparing proposed tracking method with marker tracking only.

the required positions from not only the front but also from other angles, such as the top or the side.

Results from the demonstration experience indicated that the displaying of visual guides strongly affects the user-friendliness of the system. We consider that it is important to display visual guides from different perspectives so that users can choose their preferred way to play the guitar.

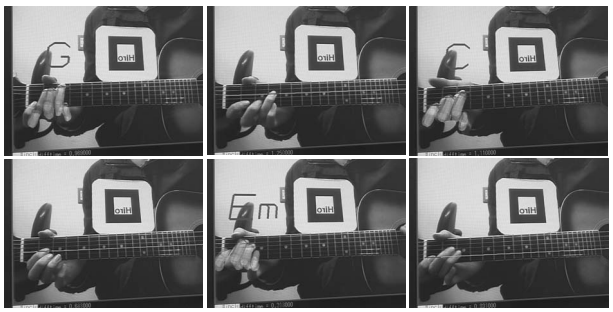

Figure 5: Images when user uses our application.

6 Conclusion

We proposed a system to assist people learning to play the guitar playing using visual guides displayed on a PC. Furthermore, we described a guitar tracking method using AR Toolkit's marker information and the edges of a guitar. By incorporating our tracking method into the proposed system, we created a user-friendly system that enabled a user to easily understand the required hand positions for playing a guitar.

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