Learning Guitar with an Embedded System

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Abstract

In this paper, we propose an embedded system and a smartphone application that allow guitar students to practice guitar, without music sheet, by lightening LEDs on the corresponding positions at the guitar fretboard. With our smartphone application and a content server, the student can easily search songs and download them to the embedded system of the guitar through Bluetooth. Then, without the smartphone, the student can practice the stored songs with LED guidance. In addition, the user can quickly master a certain song by using efficient practice features such as Rewind, Fast-Forward, and AB Repeat provided in our embedded system.

Keywords: Guitar, learning interfaces, embedded system, smartphone application

1 Introduction

With the popularity of audition programs, musical instruments have attracted the attention of many people. In particular, the demand for learning guitar has increased. The guitar may be one of the easiest instruments to start learning. There are, however, many obstacles that may prevent a beginning guitar player from advancing. The student should first memorize many chord fingerings and should then practice complicated fingerpicking for advanced music. Performing these tasks is more difficult when the student is attempting self-education.

Learning materials for autodidacts include tablature (tab), a form of musical notation indicating instrument fingering rather than musical pitches, and Internet

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video guitar lessons. These have a drawback in that the student must frequently switch focus from the learning material to the fretboard of the guitar. Moreover, a fretboard being shown in video lessons has an opposite view of student's fretboard so that the student may get confused.

Approaches to overcoming these inconveniences mainly focus on displaying fingerings, either by using embedded LEDs or projection, on the fretboard. The portability of these approaches is limited because the guitar must be continuously connected to a PC or a smartphone to control the LEDs or projector. Previous studies only focused on how to represent playing techniques through LED colors or projected image shapes. Few studies of effective learning methods, through which the student can quickly master a certain song, have been conducted.

We are now surrounded with various types of embedded systems such as home media systems, portable players, medical devices, and automotive embedded systems. With the continued trend to convergence of communications and everyday objects in IoT era, we employ an embedded system for guitar lessons. In this paper, we design and implement a new guitar lesson system, GuitarSolo, by combining a traditional guitar with an embedded system that allows the student to practice guitar without peripheral devices. GuitarSolo also provides effective learning features such as Tempo Control and AB Repeat.

The rest of the paper is organized as follows. Section 2 presents the related works and products of the existing educational instruments. Section 3 explains architecture of the guitar educational platform and the user interfaces of GuitarSolo. Detailed features are described in Section 4. Finally, concluding remarks and future work are given in Section 5.

2 Related Works

Prior researches [1, 2, 3, 4, 5, 6] mainly focused on assisting instrument education by providing a guide for fingering or playing technique. In the followings, we explain two approaches that use a projector and LED, respectively.

2.1. Educational instrument using projector

Game of Tones [2] and guitAR [1] use a projector to assist instrument learning as shown in Figure 1. Game of Tones is a system where students can exercise the piano by pressing the correct positions of the keys using images projected onto the projection surface. The guitAR system projects information about fingering onto the fretboard of the guitar using a projector phone mounted on the headstock or a tablet PC with a separate projector.

Game of Tones has a disadvantage in that it is impossible to apply to a piano like a classical piano where the projection surface cannot be placed properly. The guitAR system has several disadvantages. First, the student's fingers may block proper projection of the image since the projection angle is narrow, a result of the projector being mounted on the headstock of the guitar. Second, the sharpness of the projected image will be reduced and the length of the image will be distorted

and elongated as the distance from the projector increases, due to the keystone effect. Third, the fingering image may be projected on more than two frets because the space between guitar frets decreases as the frets get closer to the guitar body. Lastly, the projected images may be difficult to see under bright ambient light conditions.

(a)   (b)

Figure 1. Educational instrument using projector (a) Game of Tones, (b) guitar

2.2. Educational instrument using LED

fretlight [3] and gTar [4] are prior products that use LEDs installed on the fretboard of the guitar and provide a fingering position guide by turning on the LEDs. Figure 2 shows these products. The fretlight system requires the guitar be connected to with a PC by USB cable followed by execution of exclusive software to practice guitar. Thus, the fretlight system does not have good portability. On the other hand, the gTar guitar can dock with the user's smartphone, but can support only certain smartphones which are compatible with the dock installed in the body of gTar. Also, the gTar guitar generates sound via the docked smartphone's speaker so that it will be mixed with the sound created by the strings which may sound off-key.

(a)   (b)

Figure 2. Educational instrument using LED (a) fretlight, (b) gTar

3 GuitarSolo

Previous studies and products can be used only when the guitar is connected to a smartphone or PC as discussed in Section 2. To overcome this inconvenience, we propose the GuitarSolo that can use embedded music files for practicing the guitar. Thus, GuitarSolo helps the user to learn without a smartphone or PC during the practice session. In this section, we explain architecture of our implemented guitar educational platform and prototypes of acoustic guitar and ukulele with an embedded system.

3.1. Architecture of the platform

We propose a guitar educational platform to practice guitar efficiently using GuitarSolo. Figure 3 shows our proposed architecture. The platform consists of an embedded system guitar, smartphone application, and server. We provide a content server, so that students can share each other's music sheets. Students can search a list of songs in the server by using the smartphone application, and transfer songs to the embedded system through a Bluetooth connection. GuitarSolo can be seen as a device in the Internet of Things.
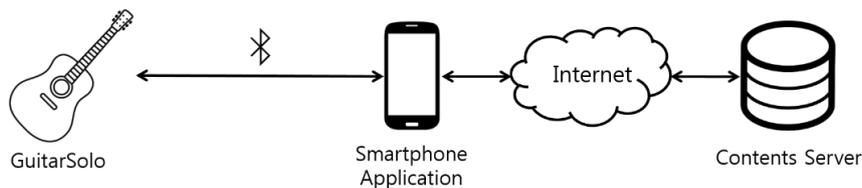

Figure 3. Architecture of guitar educational platform

3.2. Interfaces of GuitarSolo

We implemented an embedded system using an Arduino Mega2560 as a main controller board and an LED fretboard for fingering display as shown in Figure 4. For simple user interfaces, a main controller of GuitarSolo has mainly one rotary switch as an input interface and an OLED display as an output interface.

Figure 4. A prototype of GuitarSolo; A controller (left) and LED fretboard (right)

Students can identify the menu and a list of songs through the OLED display The embedded system has a rotary switch to perform functions such as Power ON/OFF, menu moves, song selection, pause, rewind, fast forward, and tempo control. The embedded system has a built-in battery that can be charged using a USB cable. Thus, students can use GuitarSolo without a separate power supply.

The embedded system can receive song files from a smartphone by using a built-in Bluetooth module. The system has a built-in micro SD card to store received song files. When a student selects a desired song in the list of stored songs on the micro SD card, the system controls the LEDs on the fretboard depending on information about fingering. The LEDs express a variety of playing information according to color changes with three colors (green, red and yellow).

4 Detailed Features

This section introduces the various features of GuitarSolo.

4.1. Music file management

We implemented an embedded system that allows the student to practice guitar using a guitar alone. GuitarSolo with the embedded system does not need to be connected to any other device, such as a smartphone or PC, during practice. A smartphone application provides a feature to select desired songs from the content server, transmit, and save the song files to GuitarSolo. GuitarSolo provides convenience and easy access to guitar learning for the student by allowing repeated practice and mastery of the desired song by looking at the list of song files stored on the embedded system. Figure 5 shows screens of the music list in smartphone application and embedded system.
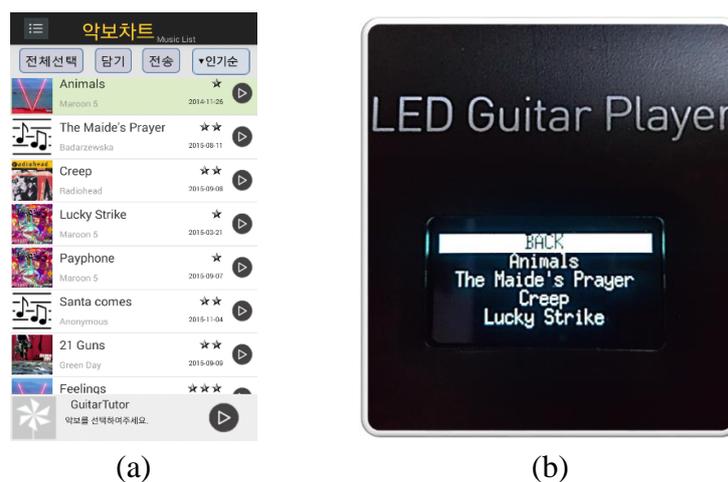

(a)   (b)

Figure 5. Screens of the music list (a) smartphone application, (b) embedded system (controller)

4.2. Learning support

GuitarSolo provides several features to enhance the effectiveness of student learning. A group of features is related to playback speed control. Pause and resume are possible whenever the user presses the rotary-button. The pause menu is depicted in the middle of Figure 6. The student can also seek within the music track by rotating the button either clockwise or counterclockwise. With this feature, the student can either skip an easy part of the music or continue practicing for a difficult part repeatedly. Additionally, tempo of a song can be adjusted in terms of play speed up to 0.1~2.0 times. Figure 6(a) shows a tempo control example. The users are capable of effective learning by controlling the playing speed (intuitively) to suite the pace of their learning. Apart from speed control, another useful learning support feature is AB Repeat, which enhances learning by repeatedly playing a specified part which may be difficult to learn. Figure 6(b) shows the operating state of AB Repeat feature. Both advanced and novice guitar players can quickly master a new song by using these learning support features.
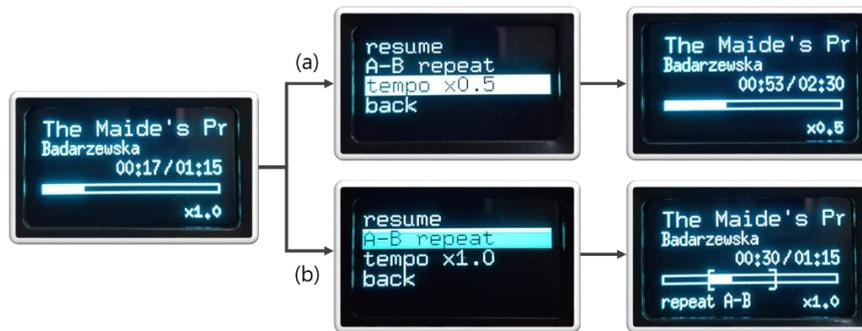

Figure 6. the learning support features (a) tempo control, (b) AB repeat

4.3. Contents sharing

We provide a feature that helps users easily access various content and save this content directly to the guitar. To do this, we built a content server and website. When administrators or members accesses the website and uploads a song file, the file is stored on the content server. All song files stored in server can be checked through the smartphone application, and a student can transmit the file to the guitar directly by searching for a desired song from smartphone application. In addition, users can practice a popular song through the popularity chart, and tailor song choice to ability level through a difficulty level mark for each song.

4.4. Practice the chords

Students should know the fingerings of chords to play a guitar. However, novice players need a lot of time and effort in order to become familiar with many chords. The embedded system stores 49 typical guitar chords. When the user selects

a desired chord to practice from the chord list, the LEDs are turned on in a position corresponding to the fingering of the chord. If GuitarSolo is connected to a smartphone, the user can also identify the fingering and the sound of the selected chord through the smartphone in real time. Figure 7 shows the application screen, the display of the embedded system, and lit LEDs for chord practice.
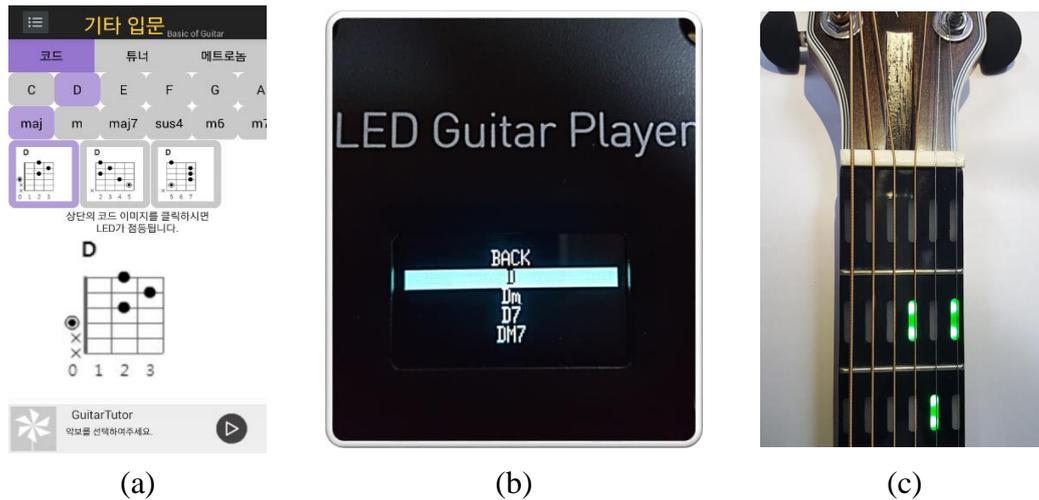

| (a) | (b) | (c) |

Figure 7. the feature for chord practice (a) application screen, (b) display of embedded system, (c) lit LEDs

5 Conclusion and Future Work

We have designed and implemented an embedded system for self-learning guitar, GuitarSolo, together with a guitar educational platform where the student can download music sheets in his guitar and then play them to turn on the LEDs on the fretboard to see fingering positions. GuitarSolo allows guitar practice using a guitar alone. GuitarSolo does not have to be connected to another device such as a smartphone or a PC during the practice session. This portability is one of benefits due to the embedded system. Another benefit is to improve learning effect by using features such as pause, rewind, fast forward, tempo control, and AB repeat. To the best of our knowledge, this is the first trial to apply such features to a musical instrument by making an IoT guitar. Our embedded system and the learning platform provide an enhanced learning solution for user convenience and portability.

In the future work, we plan to develop additional features such as fingering recognition and string stroke recognition, through integrating sensors on the fretboards and strings. The guitar will be able to identify that the user is playing correctly by using the sensing information, and it will also provide feedback. In addition, user tests will be performed using the developed prototype, and both user convenience and the educational effect will be evaluated.

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