guitAR – Supporting Guitar Learning through Mobile Projection

Abstract
The guitar is one of the most widespread instruments amongst autodidacts, but even though a huge amount of learning material exists, it is still hard to learn especially without a guitar teacher. In this paper we propose an Augmented Reality application called guitAR that assists guitar students mastering their instrument using a projector phone. With the projector phone mounted at the headstock of the guitar, the fret board and the strings of the guitar are in the field of projection of the phone. By projecting instructions directly onto the strings of the guitar the user is easily able to realize where the fingers have to be placed on the fretboard (fingering) to play a certain chord or a tone sequence correctly.

Keywords
Guitar, mobile projection, projector phone, learning interfaces

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. K3.1 Computer uses in education: Computer-assisted instruction (CAI)
Introduction

Even though the guitar is one of the most popular musical instruments beyond autodidacts it is still hard and for many frustrating to learn. Even in times where learning material is widespread and video lessons are easily accessible through the Internet many people leave the instrument solitary in the corner caused by the absence of the feeling of success. Instead of playing a real instrument, many music enthusiasts prefer an easy to learn virtual instrument that can be found in video games like Activisions Guitar Hero or Electronic Arts Rock Band.

The most popular information source of learning materials for autodidacts is the Internet. Due to increasing popularity of video-sharing portals like Youtube guitar video lessons are becoming widespread. Besides the lack of interaction and feedback, the big disadvantage of video clips is that the fingering in the video is inverted based on the frontal view on the instructor. Guitar teachers report that the different point of view is a big problem for almost all novices. Furthermore the student has to switch his focus from the screen to the fretboard of the guitar frequently. Guitar teachers are facing the same problem but they are able to react and give instructions that help overcoming the individual problems of the student.

With the increasing miniaturization of projection units the integration of such units into mobile phones is now possible. These so-called projector phones have the ability to project large-scale information onto any surface. Projector phones can enhance the design space for Augmented Reality (AR) applications. In this paper we propose an AR system for projector phones called guitAR that can overcome the problems that auto-didactic guitar students have to face. With a projector phone mounted at the headstock of a guitar, it is possible to project instructions directly onto the appropriate position of the fretboard. The projected information includes fingering and phrasing instructions for chords and melody sequences.

Related Work

Prior HCI approaches to alleviate the learning of the guitar mainly focused on using AR displays overlaying a camera image with the instructions on how to play a distinct chord or which notes to play next [2, 5]. These approaches, which are based on optical markers, have the same disadvantages as video lessons: the student sees the instructions in an inverted view and has to switch his view permanently between the display and the guitar. Besides this, the student has to manage to keep the optical marker, which is attached to the guitar, inside the video image. This retrenches the student further since he is not free to move the guitar. Even though these markers can be replaced by a markerless tracking - since guitar-necks normally provide a rich amount of features that could be tracked - still the area in which the student can move the guitar around would be limited. The approach presented in this paper lets the students move their guitar freely and the instructions that are given are presented directly on the fretboard of the guitar in such a way that the student`s focus of attention can stay on the guitar the whole time.

The usage of stereo cameras to track the fingers of students was presented by Kerdvibulvech [4]. Burns et al. created a system that tracks the fingering with just a normal Webcam using a circular Hough transformation [1]. Both approaches where able to...
determine the position and check if a chord was played right but not able to give any instructions. These techniques could be integrated into guitAR as well to provide feedback and to get a personalized guitar teaching application.

Another approach is the use of commercially available guitars that are especially made for learning, such as the Yamaha AZ EG\(^1\). This guitar is a MIDI guitar without real strings, where a button, which can change its color, replaces every note. Using color patterns the students can learn chords and songs. The Yamaha AZ EG has several disadvantages. First of all it is a special guitar that does not provide the flexibility and the feel of a real guitar. Once the student has learned to master this instrument he has to start again getting used to real strings. Secondly, the guitar is expensive compared to cheaper normal beginner instruments. Besides the Yamaha AZ EG, there is Fretlight\(^2\), a fretboard with an integrated LED for each note that can be controlled via a computer. Fretlight has several disadvantages, it is not applicable on a standard guitar, the guitar needs to be connected to computer and the content for Fretlight is not freely available. GuitAR on the contrary can be used with every guitar even the students fathers 1959 Gibson Les Paul without changing or damaging the instrument. With emerging projector phones in sight it would be a cheap alternative as well since the only additionally equipment one would need is the headstock mounting.

Other output modalities to ease the learning of a music instrument were investigated by Johnson et al. [3].

Their prototype – MusicJacket – was able to give vibrotactile feedback to the arms to indicate to a novice player how to correctly hold the violin and how to bow in a straight manner. This approach on the contrary would need a huge amount of instrumentalization for the player. Furthermore it would not be feasible to instrumentalize the student’s fingers since it would influence the playing too much.

Since battery-powered mobile projection units become available, more and more research has focused on how these projector units can be utilized in AR application scenarios. Basic research on the augmentation of objects using a hand-held projector was conducted by Raskar et al. with the RFIG-lamps [8]. While they used active RFID-tags, Schöning et al. relayed on computer vision approaches to augment a paper map using a hand-held projector phone prototype [10]. Mistry et al. showed how a body worn camera-projector-unit could be utilized in different everyday life situations with their SixthSence application [6]. For example they augmented products in a supermarket with additional projected information. Projected instructions in general were shown by Rosenthal et al. [9] to be very useful for many tasks. In their study, they focused on everyday activities like folding paper or modeling a specific sculpture with Play Doh and found evidence that micro projected instructions can improve speed and reduce errors for a variety of task-components present in manual tasks. With guitAR we want to expand their approach for instructions on how to play the guitar.

**guitAR - Concept**

The idea of guitAR is to project information about fingering of chords or songs directly onto the fretboard of the guitar using a mobile projector. We propose two

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\(^1\) [http://tinyurl.com/yamahaazeg](http://tinyurl.com/yamahaazeg)

\(^2\) [http://fretlight.com](http://fretlight.com)
different approaches. The first utilizes a projector phone mounted at the headstock of the guitar (see Figure 1 left) and the second is based on a tablet computer with integrated projector (see Figure 1 right). The first approach would allow the student to move freely around and would only need the mount. But the mount could also constrain the approach to only be able to use a part of the fretboard since the angle between the fretboard and the projector is really low and with that some frets are not in the field of projection. Furthermore the fingers can block the projection for notes that lay behind them. With the Yamaha AZ EG and Fretlight the problem is analog because the fingers cover the light that shows the position of the note on the fretboard. When using a tablet with integrated projector and project from the front onto the fretboard the light would only be blocked if the angle between the tablet and the guitar is precipitous. Otherwise, the instructions would simply be projected onto the fingers and the student could estimate the exact position. But to enable such a projection first of all a technique that is able to track the guitar neck with high precision has to be established for the tablet. This again would limit the radius of movement to make sure that the guitar’s neck is in the field of projection as well as in the camera image if a computer vision based approach is used. An advantage of the table approach would be the ability to show the sheet of music on the screen as well as further instructions or notes.

The most important factor of guitAR is the visualization. The visualization is not limited to projection of finger positions but can also be used to display more complex playing techniques like string bending’s. To indicate which finger the student should use our first idea was to project a number on the string. This turned out to be impossible to read since the space on the fretboard is limited, thus why we choose to use different colors for different fingers. Generally detailed symbols or characters are hardly recognizable on the fretboard. That is why we choose to use basic shapes like circles or squares that are distinguishable when being projected on the fretboard.

When a single note has to be played a colored dot is projected on the fret. If more than one note has to be played at the same time different colors indicate which finger the student should use to play which note. Such information is normally not contained in guitar tabs. Since musicians typically are more concerned about which notes or chords they have to play next than what they are playing at the moment upcoming notes have to be visualized as well. We choose to fade out the color to visualize this, so that the next notes are the brightest and the following are fading out slowly (compare Figure 2 [a]). The student can adjust how many notes are shown. To visualize that a string has to be bend, a triangle is projected on the fret and the size indicates the pitch to which the string has to be bended. The direction of the head of the triangle indicates if an up- or down-bending should be performed (Figure 2 [b]). A slide from one note to another - which is performed on only one string - is indicated with an arrow on the fretboard. The origin of the arrow indicates the note on which the sliding starts and the arrowhead indicates the destination note to which the student has to slide to with his finger (Figure 2 [c]). To indicate a Hammer-On or Pull-Of, a dotted arrow is projected again with the arrowhead indicating the destination note (Figure 2 [d]). A finger
Tremolo on a specific note is visualized through a curled line (Figure 2 [e]).

These visualizations where exemplarily demonstrated to three advanced guitar players and one beginner. They all rated the visualization as straight forward and easy to learn. First tests with our prototype – that is introduced in the next section - showed that the different shapes and colors are easily distinguishable and referable to the strings they should belong to.

**guitAR - Prototype**

We created a prototype of *guitAR* using a Microvision ShowWX laser projector that is mounted on the headstock of an Epiphone SG guitar (see Figure 3). The mount consists of a Joby Gorillapod to which a small metal board is attached. On top of the metal board we installed the ShowWX using cable straps. With this mount, all guitar tuners are accessible and normally functional while at the same time the projector is easily adjustable. The price for the mount - which is the only additional part that would be needed with projector phones becoming ubiquitous - was under 25$ and would even be much cheaper in mass production. The projector weighs 122 grammes and including the mount the whole prototype weight 210 grammes. Mounted to the headstock there is no adverse effect on the playability of the guitar.

To control the projection we implemented a Qt application running on an Apple MacBook. This application is capable of projecting 25 different chords and also able to read tabs for complete songs in ASCII format and project the notes onto the fretboard. When projecting a complete song the tempo in which the notes are shown can be adjusted individually to the learning speed of the student. The calibration of the projected image to the fretboard was done by hand. And also there is no correction to the distortion of the projection, with the chosen visualization techniques the different symbols are easily distinguishable on the fretboard. With Qt, the portability to mobile devices (Symbian/MeeGo) is also given. But up to now, no device features the possibility to show different content.
on the devices screen and on the TV-Out. When the application gets ported to a mobile device, the screen of the projector phone will show additional instructions on how to correctly fret the projected notes.

**Future Work and Conclusion**

For future work we want to carry out extensive user studies and compare different visualization methods for different fingers and strings as well as upcoming notes. Additionally we want to integrate the microphone of the mobile phone to automatically detect if the student played the right note and with that be able to give feedback immediately. Furthermore the calibration for the fretboard should be done automatically using the camera of the mobile device to detect the frets.

**References**


