TOWARDS CREATING AN AUGMENTED HANDPAN USING LEAP MOTION

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ABSTRACT

In the last years handpans have gained more and more popularity and evolved to an idol of the public. They provide the possibility to produce tones and beautiful melodies rather then only transient sounds, like most other easy-to-use percussive instruments. Considering the assumption that instruments with very simple interfaces offer a particularly suitable introduction to making music, it follows that handpans could also be used in early musical education. However, their interface itself is still abstract and not very informative about the kind of sounds it produces. For this reason, in this paper we present the concept and first prototype for an augmented digital handpan. In our concept we use Leap Motion to capture strokes on a plexiglass dome and give additional visual information for advices and learning instructions by augmentation with the help of projections on the surface.

1. MOTIVATION & GOALS

In the past we already dealt with innovative musical instruments to be used for early music education and in this context we assumed that an instrument for early childhood education should have a simple and highly intuitive interface. To this purpose we built a NIME [1] and evaluated it at various stages of development with groups of children at different ages. We were able to show that our assumptions were correct but we also found out that some of the functionalities were not automatically understood by the children solely through acoustic feedback [2]. For this reason we supplemented the prototype with visual feedback, which was intended to serve both as motivation and guidance [3]. It then became clear though that the simplicity and limited functionality of the interface itself, in this case a standard digital drum pad, was not a big incentive in the long run [2]. Thus, we now deduce that a combination of visual feedback with a simple interface, which offers rewarding functionalities, could solve this issue. As a result, we infer the necessity of developing a prototype for an augmented handpan. The use of hardware components should provide a similar physical playing experience to that of the classic instrument, unlike in the purely virtual approaches that exist so far (e.g. [4]). In addition, virtual components should complement this haptic feedback with visual information, which will be used to support the learning process.

2. THE INSTRUMENT

A handpan is a musical instrument made from steel, which basically consists of two hemispherical segments glued together. On the upper half-shell there are several sound fields hammered into the metal sheet. The sound fields usually have a flat and elliptical shape with an oval bulge in the middle and the highest point on the upper side of a handpan represents the bass note (called: *ding*). It is built up like the other sound fields, only the middle is not turned inwards but outwards. Usually there are eight or nine sound fields plus the bass note. Furthermore, on the bottom there is a hole, which is called *Gu* [5, p.5]. Tuning and scale of each individual handpan are freely configurable when building the instrument, but cannot be changed afterwards, since they are defined by the field sizes and their gaps. When playing, the instrument is usually held horizontally on the lap and slapped with fingers and hands.

3. RELATED WORK

There are many research projects existing so far following a similar approach and confirming our assumptions. An application developed for Leap Motion and Oculus Rift, in which the user can play a virtual handpan, is particularly relevant. The application is freely available in the Leap Motion developer portal [6], the interface is designed aesthetically appealing (although it seems to use only a two-dimensional representation of a handpan) and the software runs smoothly and error-free. When playing this purely virtual instrument, however, it is noticeable that a haptic feedback is missing, which leads to difficult handling. Thus this example demonstrates the need for further development, but also indicates that our approach for stroke detection with Leap Motion should be technically viable. Furthermore the 'Drum On' [7] project should be mentioned in this context, in which Bae et al. work on the issue that some instruments may occasionally tend to get boring. As we did, they worked with digital drum pads and added visual feedback to them. They use a short-range projector to project images onto the drum surface [7]. A by now relatively well known and successful system was developed in 2012 by Christos Michalakos [8] and has since

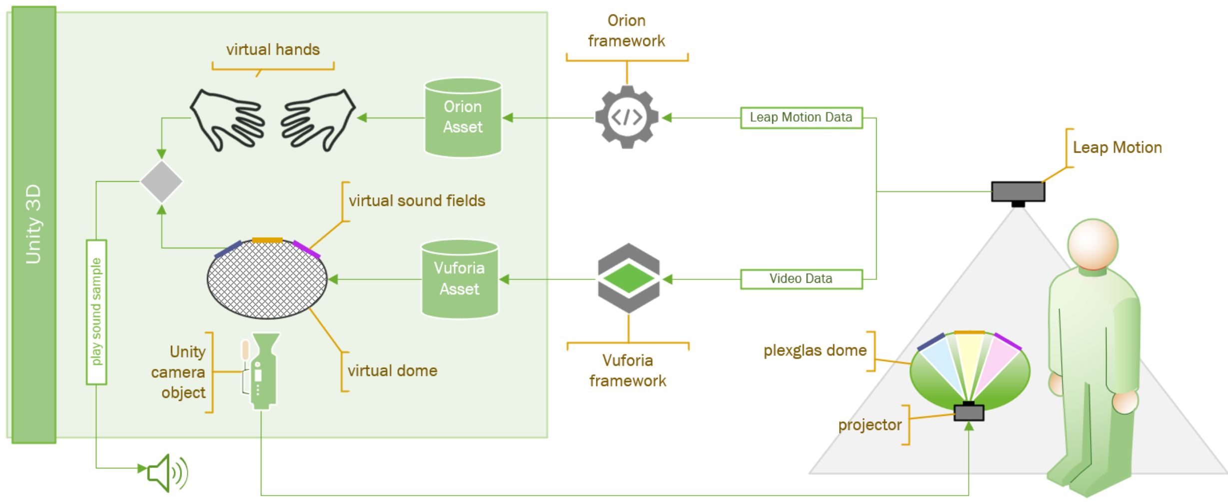

Figure 1. Virtual dome with colored trigger panels and virtual hands within Unity

then been presented repeatedly at conferences and exhibitions with different pieces and performances, for example in the play 'Torrrque' [9] or the performance-game 'Pathfinder' [10]. Michalakos uses a traditional drum kit and augments it with colored light. There are also some projects, which focus on young people (e.g. [11, 12]) or people with disabilities (e.g. [13]). The study by Matthieu and Dominique, who compare the benefits of different artificial instructors (virtual and robotic) and use them to teach the fundamentals of drumming to children is also noteworthy. They found that younger children had some difficulties following the instructions of the robot and preferred virtual instructors [14].

4. IMPLEMENTATION

In general we use a combination of different technical systems: the main components are represented by a Leap Motion system in combination with the Unity3D development environment and various frameworks such as Vuforia (for Augmented Reality) and FMOD (for sound output). In addition to the software components two connected acrylic glass domes are used as hardware components, in the lower half of which a small projector is mounted.

4.1 Strike Recognition

The upper dome is not equipped with sensors to detect the drum impacts, but is rather used as a placeholder only and provides haptic feedback while offering a projection surface for visualization purposes. The strokes on the drum, on the contrary, are captured visually. To do so the position and size of the real dome is internally mapped to a virtual drum, which was modeled in Unity. This mapping is implemented with the help of the augmented reality framework "Vuforia" [1], which simplifies the creation of augmented reality applications significantly. The virtual object is supplied with several panels that produce a sound associated with them when they collide with other virtual objects (see figure 1). For this purpose, the Leap Motion captures the position of the hands. These, on the other hand, are mapped virtually with the help of the Leap Motion framework "Orion" [2], whereby a collision of virtual fingers with the virtual surfaces of the drum can be detected. This can be implemented relatively effortlessly by integrating the corresponding Unity Asset.

4.2 Sound Generation

The sound generation, which is triggered by this collision, is realized with the use of FMOD because it can be integrated easily to the application and at the same time it offers a multitude of possible future enhancements and adjustments. Currently it is only used to play different samples which are available as .wav files. In later versions, however, the system could also be expandable with regard to a greater variety of sounds. The currently used samples are recordings of a real Hang Drum and therefore offer an exceptionally authentic sound, which can of course be beneficial for immersion. To enhance the realistic experience, samples of different volume levels are used and played when the Leap Motion framework measures higher or lower stroke acceleration.

4.3 Visualization and Augmented Reality

As discussed earlier, the plexiglass dome is supposed to provide both haptic feedback as well as a projection surface. For this purpose, we chose a especially small projector using LED technology, which is wireless and supplied with data via WiFi. It is mounted inside the two interconnected domes in the lower section and projects the image upwards. (see figure **??**) In order to achieve a sufficiently large projection at this short distance, a lens is additionally mounted in order to spread the image. Furthermore, the usually crystal-clear acrylic glass surface is frosted to ensure that the projections on it become visible.

[1] https://developer.vuforia.com/

[2] https://developer.leapmotion.com/orion/

The image created by the projector is generated at runtime in Unity. For this purpose, a camera object [3] is directed at the virtual dome model and its trigger panels. These panels are then colored dynamically according to the current mode. Since the virtual dome is mapped with the real dome, in this way the corresponding areas of the real dome can be augmented at the correct position. In addition to the projected information, the musician should also be shown further details. For instance, as a guideline it would be reasonable to also show the note values to be played. In the simplest possible scenario, this may be realized using an additional display. Alternatively, the user can also choose to wear a pair of VR-glasses. With the help of video pass-through those can be used like AR-glasses. The video is provided by the Leap Motion system, which is attached to the VR glasses (in our case the Oculus Rift). With the help of the Vuforia framework, the video is then displayed inside the glasses conveying the impression that the glasses are transparent. At the same time, the virtual objects, are rendered on top of this video. An additional implementation for regular AR-glasses is planned for the future development.

4.4 Settings and Controls

To configure and control the different functions, we developed a special menu, which is based on an already existing sample application [15] from the Leap Motion framework. When the user turns the inside of his left palm upwards (or the right palm for a left-handed musician), the menu will automatically pop up next to his hand. The user can then use the other hand to make various settings there (see figure 2).

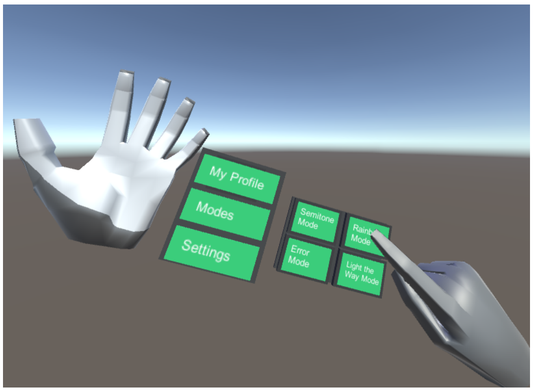

Figure 2. The settings menu in virtual reality

In particular, this menu is used to show training catalog and select a mode, to get an overview on the learning progress or to change color settings (only for certain modes). However, further additional functionalities are intended to be controlled there in the future: Among other things, recordings should be managed with this menu and also the size, tuning and other parameters of the handpan should be adjustable.

[3] https://docs.unity3d.com/Manual/class-Camera.html

5. AUGMENTATION MODES AND TEACHING SYSTEM

The augmentation by projecting colours onto the surfaces of the drum is supposed to serve both the musician (feedback to the played sound, etc.) and the audience (at a performance, concerts, etc.). Therefore we implement several different modes:

5.1 Semitone and Fulltone Mode

Keyboards and Pianos distinguish between semitones and fulltones using different colors: all fulltone keys are bigger and white and the semitone keys in between are smaller and black. Based on this concept, in this mode, fields with fulltones are augmented in a different colors than fields with semitones (see figure 3). When the particular fields are being played, the corresponding area will be highlighted by brighter illumination. This could be used to practise the C major scale with or without chromatic extensions and to learn the placement of fulltone and semitone fields.

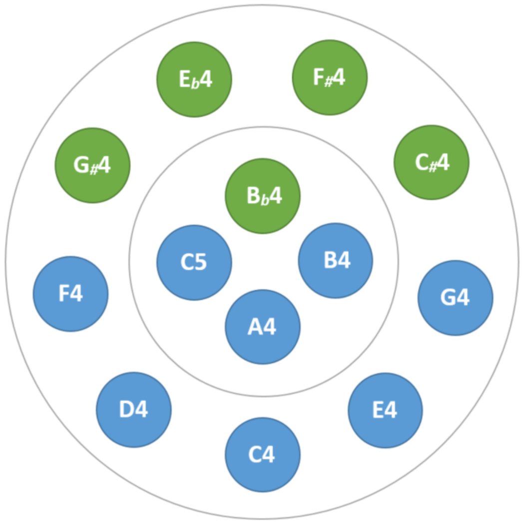

Figure 3. Semitone and Fulltone Mode

5.2 Rainbow Mode

Goethe's theory of colors [16] states that some colors are perceived more cheerfully than others. For example, bright, luminous colors such as orange, yellow and light green are usually associated with something positive, whereas colors such as dark red, violet and dark blue are perceived more as dark or mysterious. It therefore seems logical to assign the color values to the tones in such a way that basic concepts such as "cheerful key = major" and "sad key = minor" can be explained. This allows for example to practice music scales and note values. Furthermore, in this mode, the fields can be augmented according to their note values with different colors, which are based on the pattern of a rainbow and thus the brightness of the color increases with higher tones.

5.3 'Light the Way' Mode

With 'Andante' Xiao et al. developed a visualization concept that is to be used to learn how to play the piano. Their visualization consists of small figures running from one key to another, which are projected onto the keyboard cover [17]. We chose a similar approach in our' Light the Way' mode. This mode can be used to learn a new melody and help playing unfamiliar songs. Therefore, the next tone to be played is highlighted by colored light. Additionally the light intensity is dimmed a little bit and then augmented brighter when the right sound is actually played.

5.4 Error Mode

This mode is mainly used to learn how to master a given sequence of notes or melody. For example, if a melody is to be played, the played field is augmented green whenever the correct notes are hit. Fields that were hit incorrectly are illuminated with red light. Furthermore, in case of an error, the field that should have been played is simultaneously marked with yellow light. Similar methods were used and validated in various other learning systems, such as the work published by Kumaki et al. [18], which however includes a further difficulty level in which false-positive and false-negative augmentation occurs.

5.5 Teaching System

The system is designed to support several stages of learning and different user groups. On the one hand very young children and toddlers can be introduced to basic concepts of making music with this augmented handpan, for instance by using Rainbow Mode or 'Light the Way' mode. In this case the colored augmentation both serves as an incentive, motivation and support. On the other hand, more experienced children or adult musicians are also able to use this instrument for systematic learning. The users will start with simple, predetermined pieces and depending on their success, more difficult pieces are offered gradually. As an alternative, the difficulty of already known pieces can also be adjusted. The personal performance of each individual user is then recorded over time and presented to the user in the form of progression diagrams or other visualizations. In an enhanced version, which is planned for future work, individual deficits should be detected automatically, highlighted to the user, and special training sessions will be provided.

6. CONCLUSIONS AND FUTURE WORK

In this paper we outlined the concept and prototypical development of a digital augmented handpan built by a combination of several hardware and software components: we used an acrylic glass dome for haptical feedback and realized the user inputs with gesture recognition via Leap Motion. We added visual feedback for both musician and audience by installing a small projector inside the plexiglass dome. As expected, the software engineering process went smoothly, as the use of existing frameworks eliminated the need to develop basic functionalities. Thus in conclusion it can be said that the technologies Unity, FMOD, Leap Motion, Vuforia and Oculus Rift in combination are well suited to create prototypical NIMEs, since the implementation is rapidly realized. Furthermore, our first functional tests have clearly shown the practicability of the resulting system, even though not all parameters have as yet been investigated and further tests have to be done. Especially our system lacks of a proper latency test and a preliminary user study. Before introducing it in any music classroom, response latency should be evaluated as one of the most critical factors affecting virtual percussion instruments. After this the evaluation with groups of children is one of the next steps we will take. In addition, we plan to improve the system to eliminate existing problems and add more functionality. For instance, with the next version it should be possible to use different sized plexiglass domes and arrange individual acoustic sweet spots.

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