CODY'S CORNER: DESIGN & IMPLEMENTATION OF AN ELEMENTARY SCHOOL COMPUTER MUSIC INSTALLATION

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ABSTRACT
In this paper we present the design and implementation of Cody's Corner, an interactive computer music installation targeted at an elementary school. The goal of Cody's Corner is to let children pick up a familiar instrument, in this case a guitar, and play it by using gestures and simple actions they already know. Cody's Corner is fun, interactive and educational, allowing students to explore music without the frustrations and learning curve of a traditional instrument.

1. BACKGROUND
Cody's Corner is an interactive computer music installation at an elementary school in Balgonie, Saskatchewan, Canada. The installation is in honour of a former student, Cody, who passed away from cancer in 2007, one day before turning 9 years old. The space was intended to capture Cody's fun-loving and free spirit, and provide a space for the students to be creative, collaborate and have fun. The project goals were to create a space that incorporated electronics, computers and music, as these were all things the Cody loved. The final design included a custom built digital guitar and drum-loop machine, both connected to a computer, where custom software allows performers to customize their instruments and record their music.

2. DESIGN
Due to the nature of the installation, a few constraints on the instruments needed to be determined. First, the instrument had to be familiar to kids. Secondly, it needed to be easy for elementary school age kids to play. We needed to take into account the size of the kids hands, their dexterity, the size of their bodies and their level of musicality. Third, it had to be robust. The instrument has to withstand everyday use in an elementary school setting. It cannot have small or fragile parts that could break or get lost. It had to be able to take an occasional drop and shaking that might happen when the kids get excited.

Based on these constraints, we decided to create two instruments; a digital guitar and a beat-box. The guitar is the main instrument and will be the focus of Cody's Corner, with the beat-box being used to support the guitar by allowing kids to create beats and rhythms. The instruments conform to the constraints identified in the following ways.

2.1. Design of Digital Guitar
A guitar is a very well known and popular instrument. The gestures are well recognized and imitated through 'Air Guitar' playing. It has also been popularized lately with the development of console games Guitar Hero\(^1\) and Rockband\(^2\). We decided to modify an electric guitar extensively and replace the traditional circuits, strings, pickups and fretboard with digital circuits and sensors.

2.1.1. Finger placement
We decided to mimic the gesture of pressing a string to a fret by replacing the frets and fretboard with touch sensors. We hoped that this would simplify the act of note selection from being very precise finger placement to instead something that required less dexterity and finger control. We also wanted to limit the ambiguity of the available notes. A guitar with 6 strings and 24 frets can produce 36 unique notes using a standard tuning. There are however 144 different places to place a finger on the neck and 6 notes that can be generated by not placing a finger on the neck (an open string). Some notes can be generated using 6 different finger placements on the neck. This introduces a complexity that we wanted to avoid. In our guitar we only allow a relatively small number of touch sensors and only one finger position on the neck to generate the desired note.

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\(^1\) http://www.guitarhero.com/
\(^2\) http://www.rockband.com/
2.1.2. Strumming

The strumming gesture associated with playing the guitar was also transferred over to our digital guitar. An infra-red sensor was embedded in the body of the guitar where the pickups were originally placed and where the strumming hand would pass over it. The sensor can recognize the distance of an object in close proximity and this feature is used to determine when a hand passes over the pickup area of the guitar. We once again aimed at simplifying the traditional gesture in that the performer does not need to worry about making contact with a sub-set of the total number of strings. A strumming motion will produce a note, without the accuracy needed in a traditional guitar.

2.2. Design of Beat-Box

The beat box needed to be a device that would allow the kids to quickly and easily create a rhythmic drum loop. Since we were not using a traditional drum set as a base for the instrument, we didn't feel the need to map traditional drum gestures to our beat-box. Instead we decided to leverage simple percussive gestures such as finger tapping. Tapping a finger to a beat is instinctive to many people. It's not a gesture that needs to be taught or learned.

3. RELATED WORK

3.1. MIDI Guitars

Some digital guitar systems convert the vibration of independent strings into MIDI messages by analysing the signal and using pitch tracking techniques[2]. These systems are available commercially, but in general cannot reproduce all of the nuances of a stringed guitar.

3.2. Digital & Digitally Augmented Guitars

These systems involve using the traditional guitar as the basis of the instrument, but either replacing some of the functionality with digital equivalents, or extending the functionality of the guitar with sensors and digital circuits. The GXtar[1] is such an instrument where FSR sensors have been added to control pitch and a 3 DOF joystick added to control synthesis parameters. This allows for new playing and performance techniques. Ztar[3] a commercially available product also has replaced much of the traditional electric guitar circuits with touch sensors, pressure sensitive sensors as well as buttons and knobs to change synthesis parameters.

3.3. Guitar Gesture Inspired Instruments

These systems use the gestures involved in playing guitar to control synthesizer output, sometimes without a physical instrument at all. The Virtual Air Guitar[4] is one such system that uses the position of the hands and gestures to control a guitar synthesizer. The Mountain Guitar[5] is another system that is based on a guitar, but has been simplified by allowing the performer to control the tone generated by the instrument simply by changing the height of the device. There are also other controls and sensors that augment the device and allow the performer more expressive opportunities.

4. IMPLEMENTATION

4.1. Digital Guitar

We decided that the guitar would use touch sensors to mimic the fretboard finger positioning for note selection. 8 touch sensors replaced the fretboard on the neck of the guitar. We chose 8 to correspond to the number of notes in a western octatonic scale. We removed the strings of the guitar, so to mimic the strumming gesture we employed an IR sensor to detect when an hand or other object passes over the body of the guitar. All of the sensors were connected to a Phidgets[6] Interface Kit and LCD display. The display allowed the performer to see the current MIDI program selected, and there were two buttons to scroll through the possible programs. A number of LEDs were installed in the guitar to provide feedback to the performer.
when a touch sensor was activated or when a strumming gesture was detected. The body and neck of the guitar had to be modified and routed out to make room for the electronics. A thin Lexan covering was fashioned to cover the electronics and replace the original pick guard and fretboard. This ensured that all of the circuits and electronics were protected and contained within the guitar, and couldn't be accidentally damaged in the course of normal use. The only electronics that were not fully contained within the guitar was a single USB cable the exited the body to be plugged into a computer.

4.2. Beat-Box

The beat box is a small device with 3 touch sensors, 3 buttons and 3 LEDs. We used the touch sensors to capture the tapping gesture for the creation of percussive beats. The LEDs provide feedback to the performer and the buttons are used to delete beats from a loop. The idea is the performer is given a blank loop, visualized through software described in the next section, and they can place beats along 3 different tracks. There is a time indicator the scrolls across the tracks and when it passes over a beat, a sound is generated. The electronics for the beat box are also implemented using Phidgets, and the beat box is also self contained and connected to a computer via USB.

4.3. Software

4.3.1. Guitar software

The software employed in Cody's Corner is designed to allow configurability and personalization of the instrument to each performer that plays it. The performer can choose a root note and octave for the first fret, and choose from a number of scales such as Major, Minor and Blues to assign notes to the other 7 frets.

The performer also has the chance to create different behaviours when multiple touch sensors are activated. The performer can assign to the act of holding one to four touch sensors down a number of chords such as Major & Minor Triads, Diminished Sevenths and so on. The root note for the chord is the first touch sensor activated.

The software uses the performer’s configuration and the messages received via the Phidget interface to generate MIDI notes that are in turn sent to a MIDI synthesizer. The MIDI notes can be recorded, played back and written to a file through the software. A third party software program is employed to allow the performers to convert their MIDI files to WAV files that can be played in portable music players or written to a CD. The entire software package is implemented in the Java programming language for portability.

4.3.2. Beat-box software

The software developed for the beat-box is designed to give the performers a visualization of the drum loop they are performing. The visuals consist of 3 horizontal lines representing the three distinct drum tracks as shown in Figure 2. A vertical line is used to indicate the timing, and it scrolls from the left side of the screen to the right and loops back again. When a tap is recognized by the beat-box, a small visual cue will appear on the screen, on the appropriate track to indicate a recorded beat. When the timing line passes over any previously recorded beats, the software will generate a MIDI message for the appropriate track. When the delete button is being held down for a track, the beats are removed from the corresponding track when the timing line passes over them. The performer is allowed to speed up or slow down the timing line to adjust the tempo. The performer also has the opportunity to assign specific percussive instruments to a particular track through the software.

5. CONCLUSION & FUTURE WORK

Cody's Corner was unveiled in a dedication ceremony held on April 15th, 2008. The initial response has been good, with kids picking up the instruments are creating music quickly and easily without frustration. It is hoped that this installation could be used as a music teaching tool in the future, to teach students basic music theory and structure. In the future we plan on completing a case study to understand how the instrument is being used and how it could be leveraged and improved as a teaching device.

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7. REFERENCES

[1] Loic Kessous, Julien Castet and Daniel Arfib. 'Gxtar, an Interface using Guitar Techniques", in Proceedings of the Conference On New Instruments for


