Strumming with Stringpots: A Novel Guitar Controller Designed for a Person with Limited Sensorimotor Skills

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ABSTRACT

People with motor disabilities often have difficulties in playing common musical instruments. Strumming with Stringpots (abbr. StrumPot) is a guitar MIDI controller, designed for a person that suffers from tetraparesis with Brown-Sequard syndrome. The controller has been built by modifying the gaming device "Guitar Hero". An Arduino microcontroller board is used in order to manage all the data from all the sensors and send MIDI messages. Two string potentiometers mounted on the guitar are used for tracking the 2D-position of the right hand of the user in front of the guitar. Six virtual strings are placed on the guitar. When the hand of the user crosses each of them, a midi note-on message is sent with the corresponding note number. On the neck of the guitar the already built in buttons of the Guitar Hero device are used for changing the chords. The device is easy to use, low-weight and easy to transport anywhere.

INTRODUCTION

Assistive Technologies (AT) allow people with disabilities to do activities that normally would not be able to perform. An extensive study on access technology from 1996 till 2006 is available by Tai, Blain & Chau [1]. A commonly used low-cost AT is the Camera Mouse [2], invented by James Gips and Margrit Betke (Boston College) and commercialized on April 2007. Using a common web camera the user is able to control the mouse pointer of a computer.

A Digital Musical Instrument (DMI) is an instrument that consists of a control surface unit (or gestural controller) and a sound generation unit [3], both of them independent and related by mapping strategies (see figure 1). The Gestural Controller unit is the physical interface where the gestures of the performer are translated to specific commands. These commands are mapped to trigger events in Sound Production unit. The big variety of available sensors for capturing input gestures and the flexibility in mapping these gestures to sound events, make possible the design of DMIs highly adapted to the specific needs of individuals with limited sensorimotor skills.

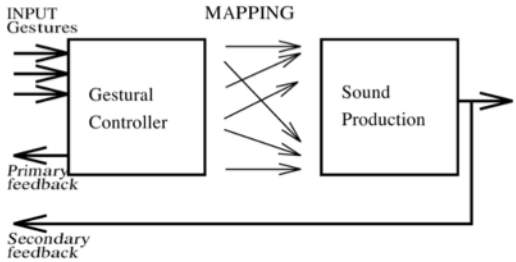

Figure 1. A Digital Musical Interface scheme.

MIDIcreator [4] developed by Kirk, Abbotson, Hunt & Cleaton, was one of the first commercial devices on the AMT field. It is a device that can be connected with a wide range of sensors or switches and then converts its signals into MIDI data. Nowadays, a toolkit called Apollo Ensemble[5] does a similar function. The Ensemble software can be connected with Ensemble device for working with other assistive and mainstream technologies like Xbox games controllers, MIDI instruments, etc. Another project targeted for poeple with sensorimotor disabilities is the EyeHarp [6]. It is a gaze-controlled musical interface. It can be used by people that maintain precise control over their eye movements, even

if the rest of their body is paralysed (locked-in syndrome state).

There are a few DMIs that emulate a guitar. The Yamaha EZ-AG is a MIDI guitar controller released in 2004, composed by six strings and on its neck, instead of strings it has 72 buttons that allows you to play any note or chord. Other similar MIDI guitar controllers are available on the market. They are mainly expensive, but the Yamaha device seems to be the cheapest one with a cost around the 180€. All these products are not targeted for people with motor disabilities.

The goal of the current study is to implement a guitar midi controller for a 37 years old woman that suffers from tetraparesis with Brown-Sequard syndrome. The left part of her body, below the neck she has no sense of touch or temperature. Furthermore, she is incapable of moving the fingers on her right hand. Four years ago she was diagnosed with intramedullary spinal tumour and was operated. Before her illness, she used to play the conventional guitar without any problem.

MATERIALS AND METHODS

The design of the StrumPot is the most important and difficult phase in assistive technology. The final prorotype should be adapted to a specific person person, taking into account his/her special motor skills and limitations. The patient has mostly been present through the development of the project. Before ending up in the current design of the StrumPot a few more prototypes were implemented and rejected.

For building the structure of the instrument, after many attempts we decided to use the guitar of the game Guitar Hero III: Legends of Rock. This device made of plastic, has a similar form of a guitar, but smaller. It has already some buttons that we used for building the final instrument.

The ability to perform strumming with the StrumPot is one of the main goals of the device. Analyzing this process on a conventional guitar, we can observe that each hand has a special function: the right hand is responsible of playing the strings and to do the strumming movement, and the left hand is in charge of fretting notes. It is a proper idea to apply this concept to our device, considering that with her right hand she cannot move their fingers while she can with her left hand.

For building the strumming part, we have used two stringpots and four little pulleys. A string potentiometer also known as stringpot, is a sensor composed by a thread and a potentiometer used to measure linear position. Normally, these sensors are used in fields such as robotics, medical equipment or industrial testing, among others. However, to the best of our knowledge they have never been used so far in music performance scenarios. Commonly, the cost of a stringpot is around 130€ -500€. Thanks to 3D printing technology, we were able to construct two strigpots that costed 10€ each. The 3D sketches and construction for building them were found online[1]. An adjustable potentiometer of 10 turns and 5 Koh was used for each stringpot. Each stringpot was located inside the body of the guitar. Then, the pulleys were strategically collocated in order to conduct the threads to the front of the body(see Figure 2).

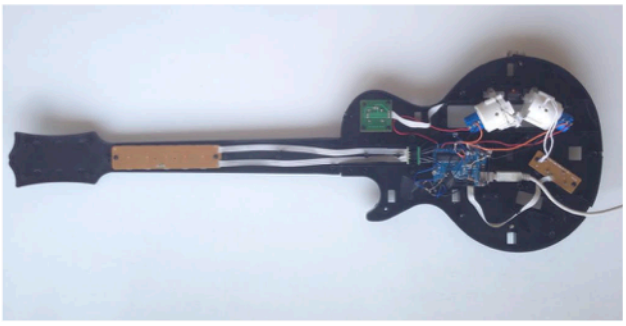

Figure 2: Placing the Arduino and the two stringpots inside the Guitar Hero.

About the left part of the device we had to consider that she has no sense of thouch and on the left hand and she can only do satisfactory movements with three of her fingers: the index, middle and ring finger. In the current version of the prototype each of the five buttons is mapped to the following cords: F, C, G, Dm, Am. The next step would be to map combinations of

[1] http://www.andymark.com/product-p/am-2618.htm. Last accessed on 28/4/2015.

pressed buttons to chords. This would increse the number of available chords. The buttons of the Guitar Hero are big enough, and our user was in general able to quickly access them.

An Arduino Uno is used for retrieving the data of all the sensors and controllers, and send them to the computer via USB. The two stringpots provide the distance of the user's hand to each of them. When the two threads of each stringpot are tied together on a ring placed in the thumb of the user (see Figure 3) the coordinates x and y of the ring relative to the body of the guitar are given by the following equations:

$$x = \frac{a^2+c^2-b^2}{2\cdot c} \qquad y = \sqrt{a^2 - \left(\frac{a^2+c^2-b^2}{2\cdot c}\right)^2}$$

, where a and b are the distances between the ring and edges of the guitar and c is the guitar's width.

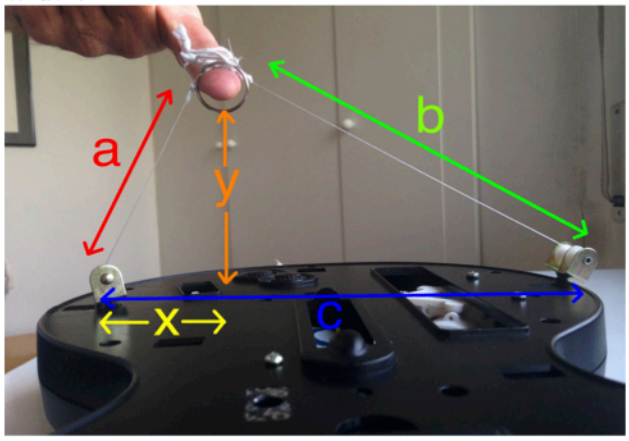

Figure 3. Computing x and y when a,b and c are given.

Six virtual strings were placed close to the body of the guitar. For playing each of virtual strings, we consider the coordinates x and y of two consecutive frames. If between these frames the ring crosses any of the virtual strings, the corresponding midi note-on message is triggered. For each string the following simple algorithm is applied:

IF ($y_{current} <$ threshold)
AND $((x_{previous} - S_x)*(x_{current} - S_x) \leq 0)$
THEN send corresponfing midi-on message.

, where S_x is the position in the x-axis of a virtual string.

As seen in the equation above, each string would only sound only if the ring is close to the guitar's body. This allows applying strumming techniques used in normal guitars. As mentioned before, the five buttons on the neck of the guitar allow the user select one of the 5 chords while strumming the instrument.

The Arduino Shield processes all the data information and sends midi messages to any Virtual Instrument. In order to send midi messages the hiduino firmware [7] is utilized.

EVALUATION

The target-user has been present during the development of the project. So, the evaluation has been constant in all the phases of the project. Before ending up in the current design of the StrumPot a few more prototypes were implemented and rejected.
For a preliminary evaluation of the StrumPot inetrface, the target-user was asked to do some strumming rhythms changing the chords and the results were successful. However, she obviously needed to take practice, like learning a new instrument to gain confidence and play more fluid. Also, she had some problems with the position of the threads of the stringpots that will be solved in the future. A short video demo can be found online at `https://vid.me/zBPk`.

CONCLUSIONS AND FUTURE WORK

This paper has presented StrumPot, a DMI for a person with motor disabilities. Although this project doesn't attempt to improve something existent or discover something new, a novelty has been presented. The use of stringpots in the music field can be very powerful. They are robust and exact, and with its combination, very potent devices or interfaces can be built. However, StrumPot has some limitations that need to be solved in the future development of the instrument. The lack of control over the volume of each string or the noise produced by the stringpots when the threads are pulled are factors to consider when improving the instrument.

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