Universal Access to Participatory Musical Experiences for People with Disabilities

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Abstract. Participating in music is a promising way to provide therapy for people with neurological and developmental disabilities. Unfortunately people are often unable to participate in music because of cognitive or physical impairment, and the steep learning curve of playing an instrument. We developed the Sensor to MIDI Interface (SMIDI) controller in order to provide a common platform to create MIDI-based musical instruments that are appropriate for people with disabilities. In this paper we discuss the SMIDI controller and three unique applications that use the system. The first is the MusicGlove, a musical instrument that motivates use of the hand through practicing functional gripping movements. The second is a fabric-based sensor technology that can be cut into any size or shape and connects with SMIDI to turn ordinary objects into a musical instrument. The third is a sensor laden stuffed animal that elicits sounds through bending and squeezing various appendages. Through the SMIDI system we hope to make music participation an accessible and enjoyable medium for therapy.

Keywords: music therapy, participation in music, physical disability, musical instruments, stroke, spinal cord injury, autism.

1 Introduction

1.1 Background

Music is a promising avenue for improving mental, physical, and emotional health in individuals with neurological and developmental disabilities [1]. Participating in music through playing a musical instrument, Therapeutic Instrumental Music Performance (TIMP), is one common method for employing music therapy and is most commonly used to exercise and emulate functional movements for motor rehabilitation [2], [3]. Previous studies have shown significant improvement in motor function of a paretic upper extremity in people with stroke through this approach [2], [4], [5]. Unfortunately, people are often unable to participate in music because of cognitive or

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physical impairment, and the steep learning curve of playing traditional instruments. TIMP programs commonly use musical instruments intended for able-bodied users and are therefore limited to using instruments that do not require fine motor coordination—such as percussion instruments—or require a trained therapist to physically assist the patient in using an instrument [4]. In this paper, we discuss a platform that enables people with disabilities—such as stroke, spinal cord injury, multiple sclerosis, traumatic brain injury, muscular dystrophies, cerebral palsy and autism—to participate in music regardless of prior musical background or level of disability, and we discuss three music based devices which were developed specifically for disabled populations.

1.2 SMIDI Platform

We developed a Sensor to Musical Instrument Digital Interface (SMIDI) system which interfaces with a plurality of sensors and communicates with a computer through a USB-MIDI protocol (Fig. 1). MIDI is an industry standard protocol that enables electronic instruments to communicate with computers and other MIDI instruments. Using MIDI, commercially available digital audio workstations (DAW), such as Reason or Garage Band (Fig. 2) can communicate with SMIDI. This allows the user to choose a variety of different instrumental sounds that are mapped to specific notes on the SMIDI instrument. Moreover, the SMIDI system has pre-installed musical scales that allow an individual with no musical background to play along with a prerecorded song, with a trained musician, or with another individual that is using the SMIDI system.

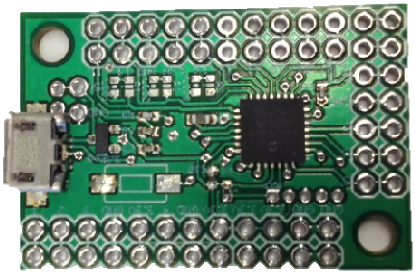

Fig. 1. The SMIDI controller allows for the development of MIDI-based musical instruments that accommodate all levels of physical disability

The SMIDI controller size is 1.5 inches by 1.0 inches, and uses a PIC24FJ64GB002 microcontroller to sample sensor data, convert the data to MIDI commands, and communicates to a computer via a USB-MIDI protocol. A USB 2.0 A-Male to Micro-B Male cable powers the controller and enables data communication and between the SMIDI controller and computer. The controller supports up to 15 I/O channels, 7 ADC channels with 12 bit resolution, and can interface with sensors using SPI, UART, or I2C communication protocols.

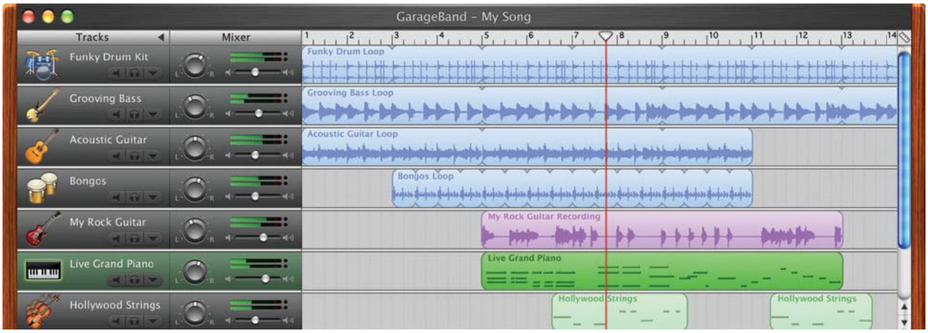

Fig. 2. GarageBand is one example of a digital audio workstation (DAW) that can interface with SMIDI instruments. Users select from a large database of instrument sounds (left) that are mapped to specific notes on the SMIDI instrument. Users can also compose music using a SMIDI instrument and a DAW (right).

2 SMIDI Instruments

We discuss three devices that use the SMIDI controller to provide a music-based participatory experience for people with physical disability.

2.1 MusicGlove

The MusicGlove is a device designed to train functional hand movements through music participation (fig. 3). It is a sensorized glove which contains six fabric-based contact sensors situated at the distal section of each digit and one on the proximal interphalangeal joint on the lateral aspect of the finger. To create a musical note, the user must touch the sensor on the thumb to any of the other five sensors. By doing so, the user practices important hand postures such as pincer grasp, key-pinch grip, and thumb opposition.

Fig. 3. MusicGlove is a sensorized glove designed to train functional hand movements

In a usability study with 10 participants with chronic stroke, we found that the MusicGlove could be used by individuals ranging from severe to mild hand impairment (Box and Block assessment > 2) [6] and can accurately measure clinical hand impairment level. We also found that chronic stroke patients who trained with the MusicGlove significantly improved their hand function as measured by an established clinical scale [7].

2.2 Fabric-Based Music Pads

We developed fabric-based touch and pressure sensors in order to provide easy to create custom instruments (Fig. 4). These fabric-based sensors can be cut into any shape or size and connect to the SMIDI system via a standardized 0.100'' pitch IDC cable connector. This particular approach allows any surface to become a musical instrument and allows a person to use any appendage to play an instrument—not just the hand. The instrument can therefore be specifically designed to fit the need of the participants with physical disabilities. Figure 4 shows a fabric-based touch piano intended for individuals with mild impairment.

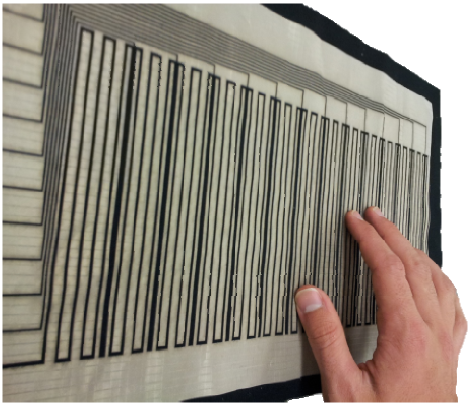

Fig. 4. Fabric-based music pads that can be cut into any size or shape to accommodate a specific level of impairment

2.3 Instrumented Stuffed Animal

The SMIDI platform enables anything to become a musical instrument—even UCI's stuffed animal mascot (Fig. 5). In this example, Peter the Anteater is instrumented with a number of commercially available bend and pressure sensors. Squeezing different sections of the mascot's body elicits a unique note in a pentatonic scale. Pushing upward on the nose elicits a MIDI note that increments in a pentatonic scale, pushing up on the tail increments the octave. This instrument can be integrated into a music therapy program for a child with a developmental disability such as autism [8–10].

Fig. 5. A musical instrument stuffed animal may be used for children with disabilities. Pushing and bending various sections produces unique sounds.

3 Discussion

We developed a platform which facilitates the process of creating custom, music-based technologies that are appropriate for the target disabled population. The three musical instruments presented are each geared towards specific affected populations ranging from stroke to autism. These unique examples are a testament to the flexible and easy-to-use nature of the SMIDI system.

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