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Checkpoint 2

The introduction of gesture based interaction and new input technologies have given rise to many new forms of Human-Computer interaction, including the debut of digital based musical instruments. Electronic music has become an increasingly popular development in the last few decades, though it is not new technology. One early example of electronic music is the Theremin invented in 1919. This instrument was also gesture based as it was played by moving one's hands between two metal antennas to control frequency (pitch) and amplitude (volume). Recent developments in digital musical instruments enjoy increasingly more user interfaces. Touch screen and Virtual Reality devices are just some of the many interfaces that have allowed for advancements in the music industry.

With more sophisticated gesture based technologies, the world of digital musical instruments is also growing. Now, technologies can better emulate playing a real instrument without actually needing one. Devices like Microsoft's Kinect, Nintendo's Wii, and Virtual Reality headsets have opened doors for an even wider range of possibilities. The Nintendo Wii remote's debut in 2006 allowed for many cost effective experiments including, the "Wiiolin" (Miller and Hommond, 2010), a virtual violin that could be played by moving the Wii's sensor bar over the Wii remote. Another example is the ChromaChord, which uses an Oculus Rift headset and Leap Motion controller. This system allows a performer to play single notes and chords (Serafin, Stefania, et al., 2016). Developing virtual reality musical instruments such as the

Wiiolin and the ChromaChord is a challenge, but they are extremely beneficial to the continuous growth of human computer interaction.

Others areas of technology in music have been studied including tempo, latency and precision with instruments. In 2011, as multi-touch surfaces became increasingly popular, Montag, Sullivan, Dickey and Leider, explored the effects of audio latency and how it provided a negative experience to any kind of musical technology using the interface. They then created a multi-touch table that uses a system output that simultaneously drives the audio display and the haptic display, resulting in no latency between audio and haptic feedback systems. Performance context and behavior were also studied in relation to the analysis of digital musical instruments and new interfaces to do so (Malloch, Birnbaum, Sinyor, and Wanderley, 2006).

While many musical technologies have emerged, virtual teaching devices for music are still in the early stages of development. “[M]ost instrument implementations in VR are simple string or tapping based instruments,” (Salz & Azam, 2019). The more complicated an instrument is, the harder it is to develop it as a virtual reality musical instrument. Camera-based motion tracking is a common technology used with musical interfaces and human computer interaction. It utilizes cameras and infrared sensors to “see” a person’s motion (Brown, Dom, et al., 2016). The use of wearable technology, such as data gloves, is another popular way of determining the gestures of humans. It is effective with the detection of joint angles and other orientations of the body (Brown, Dom, et al., 2016).

One combined approach, of camera-based motion and wearable technology, is the Leap Motion tool. The Leap Motion “is a USB peripheral designed to create an invisible air space surrounding a computer screen that can be interacted with,” (Ritter & Aska, 2015). Since its development in 2013, the Leap Motion has contributed a lot to musical interfaces and human computer interaction. Unlike the Xbox Kinect and other similar systems, the Leap Motion is capable of tracking larger movements and more precise gestures. It is a groundbreaking device that is a widespread tool for any interface of musical expression.

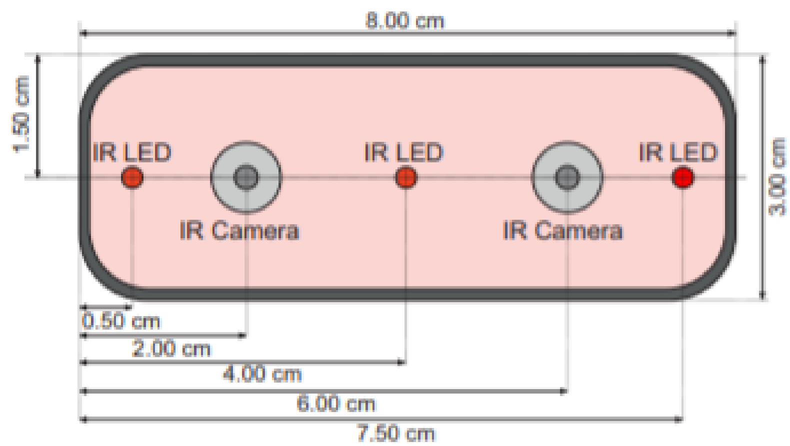

Figure 1. A schematic view of the Leap Motion controller. (Bachmann, Daniel, Weichert, and Rinkenauer, 2018).

The Leap Motion and other technological systems have contributed a lot to the development of virtual reality musical instruments, but they are also important to other human computer interaction activities. However, unlike other activities, "music seems to involve almost aloof the brain," (Holland, Wilkie, Mulholland, and Seago, 2013). It can involve the whole body, not just the mind, which is vital to those suffering from Alzheimer's and other diseases. Music helps people to engage their bodies and minds.

The piano is one musical instrument that has been created into a virtual reality musical instrument many times. Augmented reality has played an important part in the development of piano teaching techniques. "The application of augmented reality technology in teaching has great potential, which can optimize the presentation effect of teaching materials and promote the interaction between teachers and students in class," (Li, 2018).

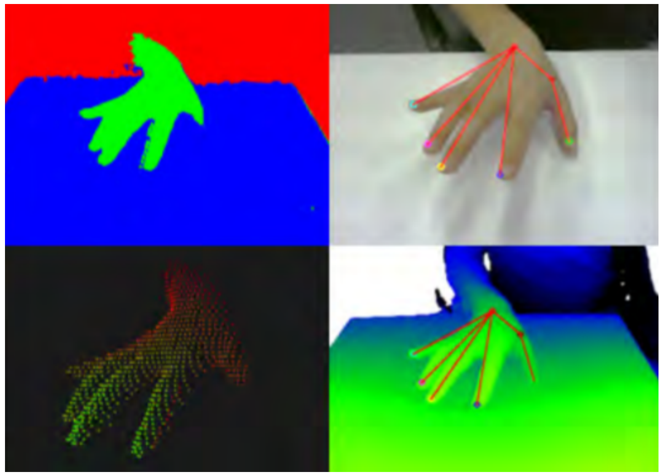

Figure 2. Hand and finger placement recognition. (Liang, Hui, et al., 2017).

Future research regarding virtual reality musical instruments could include the composition of music virtually. There are systems that are able to “compose music reflecting users’ feeling of music,” (Unehara and Onisawa, 2005). This could aim to produce music virtually through the use of systems such as the Leap Motion. Also, virtual reality musical instruments are the future of adaptive music technology. “Adaptive music technology refers to digital technologies allowing people who cannot play traditional musical instruments to engage in musical activities, without external sources assisting in the music making,” (Frid, 2018). Virtual reality musical instruments have played an important part in the development of human computer interaction and have the potential to contribute to adaptive music technology and other developments in the future.

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