Poster: Evolution of a Theremin-Based 3D-Interface for Music Synthesis

Christian Geiger
University of Appl. Sc. Düsseldorf, Düsseldorf, Germany

Holger Reckter², David Paschke, Florian Schulz
University of Appl. Sc. Harz, Wernigerode, Germany


Additional Keywords: 3D input device, music synthesis, two-handed interaction, Theremin

**ABSTRACT**

The Theremin (including its variants) is the world’s unique instrument that is played without being touched. We present the evolution of a 3D interface for a virtual Theremin, the VRemin. Based on a music synthesizer application we built a number of different 3D interfaces that allow for a contact-free play of the virtual music instrument based on gestures. The variants differ in the size of the interaction space, the use of unimanual and bimanual interaction techniques and the applied IO devices.

**1 INTRODUCTION**

The Theremin was built in 1919 by Prof. Dr. Dr. Lev (Leon) Termen, a Russian professor for physics. It was one of the earliest electronic instruments and unique in that it was the first instrument that was played without being touched. The player stands in front of the instrument and moves her hands in the proximity of two metal antennas. The distance from one antenna determines pitch, and the distance from the other controls volume. The instrument’s circuitry includes two radio frequency oscillators. One is operating at a fixed, the other at a variable frequency that is controlled by the player’s hand distance from the antenna. The hand acts as a grounded plate (connected to the ground via the player’s body) of a variable capacitor in an inductance-capacitance circuit. The difference in frequencies of the oscillators generates an audio signal that is sent to a loudspeaker. The same principle applies to a second antenna to control the volume of the sound. A similar instrument that is played with the full body is the Terpsitone [2]. The artist moves on a plate filled with antennas and plays by dancing. Only a few artists were able to play this instrument and only three samples were built (see figure 1, right).

**2 RELATED WORK AND THE VIRTUAL THEREMIN PROJECT**

New interaction techniques based on tangible computing, VR tracking methods, and the use of experimental IO devices are often applied in a musical context. High level authoring tools like MAX/MSP allow the realistic simulation of existing instruments or to create new effects. Rapid prototyping hardware like Arduino [7] or I-CubeX [4] allows to easily experimenting with different sensors. HW/SW interfaces based on MIDI or OpenSoundControl protocols allow for connecting interface technology with music generation components. For example, the I-CubeX tutorial for interfacing an IR-based distance sensor already motivates a very primitive Theremin-based sound generation [4]. Optical tracking approaches are currently a very prominent approach due to the availability of different software libraries and today’s high performance computers. For example, reactIVision is an open source, multi-platform framework for optical tracking that is often used for experimental music performances [3]. Because the fiducials allow a very robust 2D tracking, the system is often used with table-top interaction. Although a research prototype, it has been successfully used in professional performances like the 2007 “Volta” tour of Björk. Glove-based input is an often used technique for musical interaction. For example, in 1987 Lanier and Zimmermann improved the design of their first VR glove to play a virtual guitar. A Swedish project used optical tracking to develop a virtual guitar and other instruments that are controlled by gestures [5]. R. Helmer from CSIRO, Australia developed a shirt with motion sensors embedded in the shirt sleeves to detect motion when the arm bends - in most cases the left arm chooses a note and the right arm plays it [6]. A similar approach is GypsyMIDI from www.sonalog.com which basically is an exoskeleton that measures “up and down” and “side to side” of wrist, elbow and shoulder for both arms. The motion of the suit generates a continuous MIDI stream. In our “VRemin” project we built a music synthesizer simulation based on the Theremin concept. Developed independently as back-end with a music synthesizer program we provided a MIDI-based interface and developed a set of interaction techniques that can easily be connected to the back end. Main idea is to design and evaluate different interaction spaces that can be used for music generation and to design different two-handed interaction techniques [1].

**3 IMPLEMENTATION OF THE MUSIC GENERATION BACK-END**

The development of the back-end was straight forward. We implemented a small synthesizer application using Native Instruments Reaktor 5, a music software studio that allows for music synthesis, sampling, effect control and sequencing. It features a visual programming environment and a large library of predefined components (e.g. effects, instruments, etc). We implemented a lean MIDI interface that allows selecting a small set of predefined instruments or effects and controlling effect parameters, pitch and volume by MIDI commands. This allows us to develop different variants of input devices and techniques without altering the music generation back-end.

Figure 1. Theremin (1919) and Terpsitone (1923)
We also provide a simple GUI with feedback visualization about note, volume, and effect. For the performer this is simply a sound visualization based on the amplitude modulation similar to an oscilloscope.

4 INTERACTION DEVICES AND TECHNIQUES FOR THE VREMIN

The initial approach for a Theremin-based interaction scenario uses the Wii game controllers for interaction. For the VRemin I, the Wiimote is controlled by the dominant hand (DH, usually right) and the Nunchuck is used by the non-dominant hand (NDH, usually left). Pitch and volume are controlled by the Wiimote acceleration sensor. The buttons are used for switching the current note on and off and permit to interrupt the sound generation. The NDH is used to select the predefined effect with Nunchuck buttons and control the effect parameter with the acceleration sensor (see figure 2). The Wiimote / Nunchuck values are recorded and transformed to midi notes using the DarwinRemote software and a virtual midi device (IAC device driver).

![Figure 2. VRemin I – Wii controller](image1)

The interaction space is determined by each hand’s rotation and thus is the smallest of all variants. The sound generation is designed as an asymmetrical two-handed interaction [1] because both hands perform different tasks and with different gestures / interaction techniques. The second variant interacts within an arm-based space. The VRemin II tracks the X and Y position of the dominant hand and assigns volume level and pitch level based on the assigned position values. We selected optical tracking for monitoring the hand movement. In the current prototype we attached a small fiducial marker at the DH’s wrist and use a web cam to capture the image. The reacTVision software package [3] is used to analyze the image, calculate the position values and sends a MIDI value which controls pitch of the sound to the back end interface. The selection and adjustment of effects is also controlled with the DH. We built a small custom glove-based input device that uses a bend sensor for each finger. The sensors are connected to an I-CubeX midi converter that generates MIDI signals. The poses of all fingers determine an individual combination of effects and their strength. This approach realizes a unimanual interaction technique. The NDH then be used for percussion support, e.g. using the Wiimote as virtual drum stick. We built the VRemin III, a second variant of the arm-based interaction space type. In this approach the NDH’s distance to an obstacle, e.g. a wall or vertical mounted panel is measured using an infrared sensor from the I-CubeX system. Both hands are moved similarly and the distance to the panel determines volume and pitch level. Effect control is realized as in the VRemin II variant. We consider the interaction as a symmetrical two-handed technique because the control gestures for DH and NDH are identical (although NDH and DH tasks are different and effect control is performed by the DH only).

![Figure 3. VRemin II – Hand tracking and glove (prototype)](image2)

The last variant VRemin IV is similar to the Terpsitone approach and uses the complete body for sound generation. A fiducial marker is attached to the upper body and determines pitch and volume levels based on the body position. Effect control is realized by attaching bend sensor to select limb joints, e.g. shoulder, elbow, wrist. This results in an abstract dance when creating sounds (see figure 4)

![Figure 4. VRemin IV – Body tracking version (prototype)](image3)

5 EVALUATION

We prepared a small questionnaire and asked amateur performers and audience to complete it after a demonstration of all variants and, in addition, with an original Theremin instrument. The questionnaire considered the intuitiveness of playing sounds and small melodies, the exertion of performing as well as the fun of playing and fun of watching the performance. We collected positive feedback from our evaluation and most users enjoyed playing or watching our virtual Theremin variants.

REFERENCES


