Electrical Musical Instrument Design

Musical Shoes

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Overview

The Musical Shoes were created from an old pair of New Balance running shoes. Most of the sensors with and all of the wiring were concealed beneath the insole of the sneaker so that they were padded from the force applied from the person performing in the musical device. Inside each shoe there were 3 force sensing resistors(FSRs) and one infrared distance sensor. The right shoe had an additional 2-axis accelerometer where 1 axis was used, and the left shoe had 3 Reed switches to be used to switch patches in Reason, however due to an unexpected glitch they were not operational.

The shoes were connected to the Doepfer Box via ribbon cable using the continuous controllers and the MIDI data was manipulated in MAX. Each FSR was set to create a different MIDI note-on message when a threshold was reached. The threshold used was when the person's weight was concentrated on the FSR for the sensors underneath the foot for our performer, Jacob Fromer. Jumping would also create a large enough force on the sensors to trigger a note-on. For the FSRs in the toe, the threshold was reached when the toe of the shoe was stepped on. The IR sensor in the right foot controlled the filter frequency, which a higher distance from the ground causing a higher filter frequency. The IR sensor in the left foot controlled the modulation wheel, where a higher distance from the ground caused the mod wheel to be turned up. Lastly, the accelerometer controlled volume, with the shoe tilted up correlating to a higher volume and the shoe tilted down correlating to a lesser volume.

The sounds were created using 3 patches in Reason. Originally those 3 patches were to be selected by closing the corresponding reed switch on the left foot with a magnet on the right foot, however since the reed switches were not operational this was done manually in MAX. The first patch was of a bunch of percussion sounds and a loop of music from Drumline in an NN19 module. The mod wheel in this patch controlled the filter resonance. The second patch had spring sounds triggered from the FSR in the heel of each shoe and rustling leaves samples triggered from the FSR in the ball of each shoe in an NN19 module. The last patch was a Subtractor module with a Scream module attached that created an amorphous space-like sound with each FSR being a different pitch. The mod wheel in this patch controlled the LFO rate.

Hardware

To create the shoes, first a slit was drilled in the side of the shoe for the ribbon cable and holes were drilled for the IR sensor and reed switches. Next, the insole was removed and 2 wires were laid on the bottom of the shoe, one on each side, on top of electrical tape. One wire was connected to the voltage source ribbon cable wire to and the other was connected to the ground ribbon cable wire. These were used to supply power to all of the sensors.

The FSRs were placed beneath the heel, beneath the ball, and above the toe of the shoe. The heel and ball FSRs were glued into the inside of the shoe using an all-purpose glue and were soldered to the voltage source wire and to their data wire from the ribbon cable.

The toe FSRs were attached to the top of the inside of the shoe using duct tape and were soldered to the voltage source wire and their data wire on the ribbon cable. The lead from the FSR in the toe was looped under the insole in toe end of the shoe to reduce the chance of the FSR being ripped out of place by the performer.

The IR sensor in each shoe was attached to the back of the shoe approximate 1 inch above the ground. This allowed the sensor to be in its operational range of 1" to 12" when the performers feet are on the ground. A hole was cut in the back of the shoe for the wires to pass through to connect to the voltage source, ground, and data line for the sensor on the ribbon cable. The IR sensor was affixed to the shoe using hot glue.

The accelerometer was placed in a hole cut out of the base of the sneaker so that it would not be crushed and the wires soldered to it could not become dislocated from the forces applied by the performer. The wires from the accelerometer were then soldered to the voltage source, ground, and data lines and the accelerometer was covered with electrical tape to secure it in place. Due to the difficulty in being able to solder wires onto the accelerometer leads, only 1 axis of the accelerometer was functional. This could not be fixed because of the limited time to work on the project and the chip had already been coated in epoxy to prevent the wires from breaking off of the chip when this problem occurred.

The end result of the right shoe with the insole removed can be seen below in Figure 1.

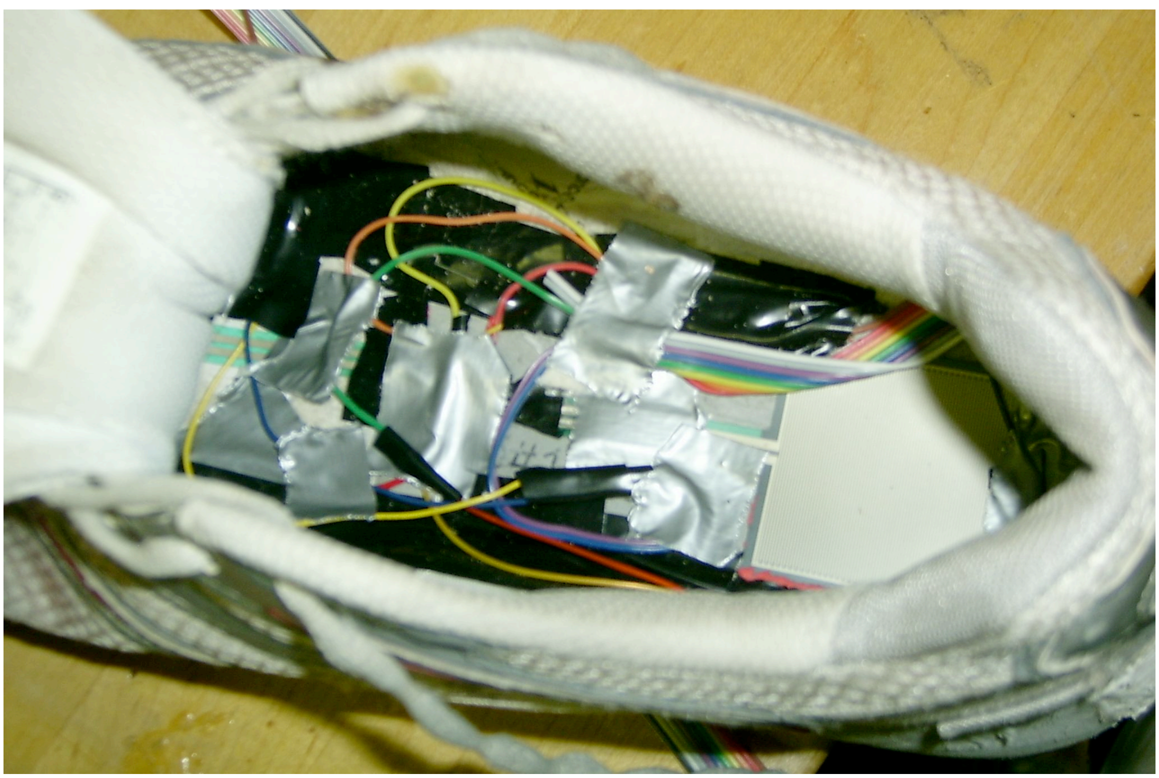

Figure 1: Right Shoe with Insole Removed

On the other end of the ribbon cable, the data lines of the FSRs were used to create the voltage divider circuit below in Figure 2 to generate data using the Doepfer box. These circuits were created in a solderless breadboard so that the resistors could be changed easily in testing. The R_{BIAS} resistance value was chosen to reduce noise and provide as large a range as possible for the uses of each FSR. For the heel and ball FSRs, a resistance of 250Ohms was used. For the FSRs in the toe of each shoe, a 5kOhm resistor was used.

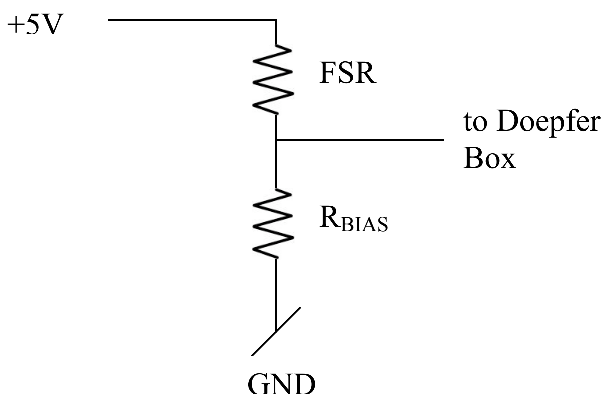

Figure 2: Voltage Divider Circuit

The remaining connections were wired directly to the continuous controllers on the Doepfer box. The connections setup can be seen below in Figure 3.

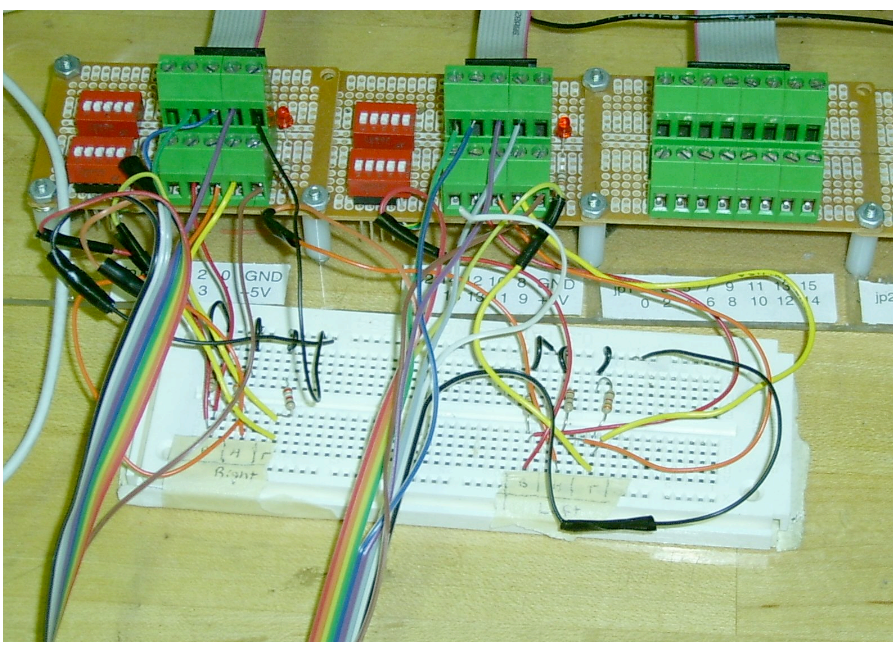

Figure 3