# Irregular Incurve

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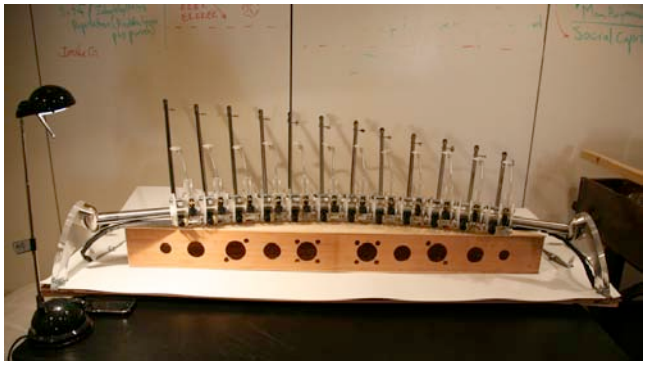

**Figure 1. First Prototype without control interface**

## ABSTRACT

Irregular Incurve is a MIDI controllable robotic string instrument. The twelve independent string-units compose the complete musical scale of 12 units. Each string can be plucked by a motor control guitar pick. A MIDI keyboard is attached to the instrument and serves as an interface for real-time interactions between the instrument and the audience. Irregular Incurve can also play pre-programmed music by itself. This paper presents the design concept and the technical solutions to realizing the functionality of Irregular Incurve. The future features are also discussed.

## Keywords

NIME, Robotics, Acoustic, Interactive, MIDI, Real time Performance, String Instrument, Arduino, Servo, Motor Control

## 1. INTRODUCTION

Most robotic musical instruments, like player pianos, are developed based on the prototype of traditional instruments only for people. Unlike traditional instruments, Irregular Incurve is designed as an acoustic instrument played by a robot. Twelve strings of same thickness but different lengths are laid out on a sound box. The robot operates twelve corresponding guitar picks to pluck each string. The musical scale of this instrument can be potentially expanded through connecting it with more robotic musical instruments of the same type.

The design philosophy behind Irregular Incurve is to visualize and enhance the aesthetic expression of the music generating process. The designer believes that the enjoyment of music appreciation does not only happen at the moment when music reaches the audience, but is also stimulated by watching the visual interactions between the musician and the instrument. Irregular Incurve attempts to enlarge this imagination about music by visually expressing the beauty of mechanical movements.

**Figure 2: Front View of Irregular Incurve**

## 2. DESCRIPTION

### 2.1 Acoustic Sound

Irregular Incurve applies a similar acoustic principle as a traditional acoustic guitar does. Instead of mounting strings on the neck, each string is mounted on an independent steel pipe. The steel pipes are fixed onto a curved shower rod by three pieces acrylic panels. Also mounted on the shower rod are twelve robotic arms, which can pluck twelve strings respectively with guitar picks or mute them with fabric felt. The twelve strings are of the same thickness with different lengths. Each length is


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mathematical calculated to get a complete musical scale. Through a guitar tuner mounted at the end of the steel pipe, the musician can modify the tension of the strings to generate different tones.

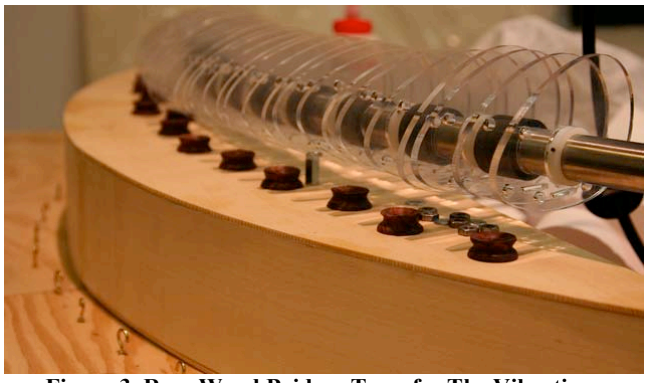

**Figure 3. Rose Wood Bridges Transfer The Vibrations**

A handmade bridge transfers the vibration of the string to a spruce-wood sound box that sits under all the steel pipes. The box is built in an arc shape to get harmonic sound.

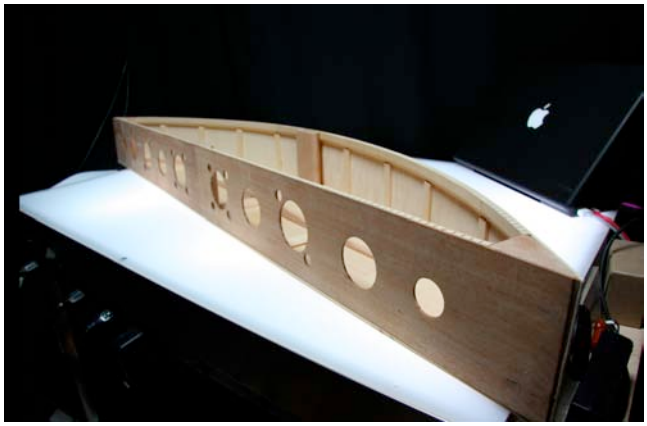

**Figure 4. Sound Box Layout**

## 2.2 Robotic Motor Control

In order to achieve an aesthetic movement of plucking the strings, Irregular Incurve utilizes a combination of two servomotors for each robotic arm.

**Figure 5. Fish Wire Pull Down The Arms**

One motor controls the rotation of the arm; another one controls the up-down movement of the arm. The duplex control system would sacrifice the speed of plucking. However, it enhances the flexibility of the mechanical mechanism and enables the robotic arm to perform more complicated movements of elegance. A piece of fabric felt is attached on each arm as a muting system for each string. The picks are mounted off the axis of the arms to avoid retouching the strings when move back to the original position.

**Figure 6. Picks Are Off The Axis Of Arms**

The servos using in Irregular Incurve are Hitec HS-82MG and Hitec HS-635HB. They both provide enough torque with a relative fast speed. The complete movements of plucking a string are comprised of three steps:

1. Rotate and move down the arm.

2. Raise the arm.

3. Rotate the arm back.

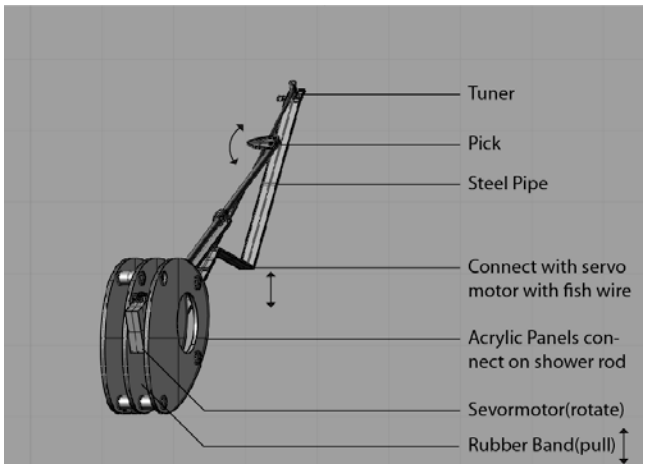


**Figure 7. 3D Rendering of Mechanisms**

The movements of plucking each string can reach a speed of one per second by utilizing the duplex motor system. If financially permitted, a control system composed of multiple high-speed servomotors would be considered to increase the arms' speed to 5~10 per second.

One Arduino Mega and three Pololu micro motor controllers are equipped to program the whole set of twenty-four motors to complete complicated movements. Using Pololu as additional motor controllers allows all servomotors to work simultaneously. In other words, all the strings can be plucked at the same time.

## 2.3 User Interface

Irregular Incurve is MIDI compatible, which makes it potentially a universal performing instrument. The instrument matches the twelve-note information to its twelve strings. 'Note On' message indicates plucking a string. 'Note Off' message indicates damping a string. Because each pluck takes one second to accomplish, a 'Note Off' message will not be performed within that period.

In order to give musicians more control of this instrument, an additional function is added on the keyboard. It is the 'Mute All' key, which will trigger all the arms to damp the strings.

Also, Irregular Incurve can play algorithmic composed music by itself. The instrument contains an Arduino library, which can transformat the stored musical information to corresponding strings.

# 3. INSPIRATION AND RELEVANT BACKGROUND

The aesthetic characters of Irregular Incurve are inspired by a virtual instrument animation (Acoustic Curve) produced by Animusic, and GuitarBots, a robotic guitar instrument that produces rich and unique sounds.

# 4. FUTURE FEATURES

Servo Motors can easily generate noises. Audience feedback indicates the noises can be developed into a feature of Irregular Incurve. The noise can also be controlled in a certain way to cooperate with musicians' performances.

Additionally, interactive light effects can be added in tune with the acoustic sounds produced by Irregular Incurve.

# 5. CONCLUSIONS

Irregular Incurve, as an experimental prototype, achieves its goal of expressing both visual and audio impact of robotic music generation. It is machined in a way for robots to express their own aesthetic characters. It is an experiment that brings a new concept to robot design.

# 6. REFERENCES

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