Smart Guitar

Alex Paige
Larry Zhao
Henry Tang
Jeff Hanna
What is Smart Guitar ?????
Product Purposes

Smart Guitar

[Images of a wrench, a guitar player, a young girl writing music notes, and a globe]
Mode Overview

- Tuning

- Live Streaming Mode
Easy guitar tab

Mary Had A Little Lamb

Arr. Peter Edvinsson

Traditional

Free guitar tab sheet music at http://www.capotastomusic.com
### Basic Notes

#### Diagram:
- **1st Fret**
- **Middle C**

#### Table:

<table>
<thead>
<tr>
<th>Note</th>
<th>Frequency (Hz)</th>
<th>Wavelength (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₀</td>
<td>16.35</td>
<td>2100.</td>
</tr>
<tr>
<td>C♯₀/D♭₀</td>
<td>17.32</td>
<td>1990.</td>
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<tr>
<td>D₀</td>
<td>18.35</td>
<td>1870.</td>
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<tr>
<td>D♯₀/E♭₀</td>
<td>19.45</td>
<td>1770.</td>
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<tr>
<td>E₀</td>
<td>20.60</td>
<td>1670.</td>
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<tr>
<td>F₀</td>
<td>21.83</td>
<td>1580.</td>
</tr>
<tr>
<td>F♯₀/G♭₀</td>
<td>23.12</td>
<td>1490.</td>
</tr>
<tr>
<td>G₀</td>
<td>24.50</td>
<td>1400.</td>
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<tr>
<td>G♯₀/A♭₀</td>
<td>25.96</td>
<td>1320.</td>
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<td>A₀</td>
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<td>A♯₀/B♭₀</td>
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<td>B₀</td>
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</tr>
<tr>
<td>C₁</td>
<td>32.70</td>
<td>1050.</td>
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<tr>
<td>C♯₁/D♭₁</td>
<td>34.65</td>
<td>996.</td>
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<tr>
<td>D₁</td>
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<td>D♯₁/E♭₁</td>
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<td>E₁</td>
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<td>F₁</td>
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<td>790.</td>
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<td>F♯₁/G♭₁</td>
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<td>746.</td>
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<tr>
<td>G₁</td>
<td>49.00</td>
<td>704.</td>
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</tbody>
</table>
Fourier Transform of a Guitar's A String
The Process

- Analog-Digital Conversion

- Fourier Transform
  - Input: digital sound data
  - Output: top contributing frequencies

- Overtone Prediction
  - Knowledge of overtones is used to confirm fundamental frequency

- Post Processing
  - Stable-sequence detector marks start and end of a note
  - Frequencies are adjusted to the nearest possible notes
The Process

```
float minDiff = 1000;

std::vector<size_t> times = new vector;

for (size_t i = 0; i < times.size(); i++) {
    if (times[i] < 0.001) {
        times[i] = 0.001;
    }
    if (times[i] > 1.0) {
        times[i] = 1.0;
    }
    float diff = abs(times[i] - minDiff);
    if (diff < minDiff) {
        minDiff = diff;
        if (diff < 0.001) {
            // Do something
        }
    }
}
```
The Process
UART for RS232

FFT Algorithm

Look-Up Tables

Mode Operation

Memory Interfacing

SPI for ADC
Problems and Fixes

- Weak signal from Roland device
  - Added Op Amp to boost signal
- Incorrect configuration for Voltage Regulator
  - Flipped the device upside down
- Signal Noise
  - Set a threshold range for frequencies
- SDRAM Connection
  - Software workaround
    Used upper 8 bits
Member Specialties

- Alex Paige
  - Team Leader/Hardware/Music
- Zhiyuan Tang
  - Software Interfacing/Processor
- Jeff Hanna
  - FFT/Music
- Larry Zhao
  - CAD/Hardware
Possible Improvements

- Better FFT algorithm that can handle overtones
- Wireless
- Updated Roland device
- A data save mode
- Integrate with other stringed instruments
- Signal Isolation
Advice to future students

- Start early!!!!
- Be creative in your project selection
- Quadruple check your hardware
- Read every data sheet fully
- Set project goals and deadlines and follow them
- Meet often as a team
- Communicate
Special Thanks to...

Professor John Johnson

Joseph Malcolm

Mentor Graphics

NXP

UC Santa Barbara engineering

Rapid Prototypes Technology & Manufacturing, LLC

Sunstone Circuits

ECE Shop
Questions???

Smart Guitar