Overview

- Problem Identification
- Project Goals
- Team Breakdown
- DTW
- Pure Data
- Project Specifications
- Implementation
- Digital Effects
- Schedules
- Summary
Problem Identification

- Guitar effect pedals physically restrain the guitar player
- Effect pedals require presence of mind on the part of the performer
- Analog and digital effects pedals are costly
Project Goals

- Develop a software platform to analyze a time sequence of notes and trigger guitar effects as instructed.
- Trigger on a designated instance that occurs multiple times throughout the song.
- Mitigate the latency between a detected match and the triggering event.
- Process sequences up to 10 note onsets per second.
## Team Breakdown

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bryan Guner</strong></td>
<td>Team Lead - Develop a protocol for digital signal processing of the guitar signal in order to create a time-sequential record of the frequency content of the guitar signal and a comparison between pre recorded songs and live performances.</td>
</tr>
<tr>
<td><strong>Ralph Quinto</strong></td>
<td>Software Engineer - Research for possible programming platforms. Responsible for reading electric guitar signals, creating the signal analysis patches in pure data, and triggering digital guitar effects.</td>
</tr>
<tr>
<td><strong>Haley Scott</strong></td>
<td>Architectural Manager - Responsible for ensuring successful integration of project components, researching system methods, designing digital effects, project and organizational management.</td>
</tr>
</tbody>
</table>
Dynamic Time Warping

- Algorithm for the measurement of similarity between two temporal sequences
- Calculates an optimal match in the form of a distance that is the sum of localized cost functions
The process can be thought of conceptually as arranging the two sequences on the sides of a grid. Each cell within the grid will be filled in with a distance measure comparing the corresponding elements of the two sequences.
How DTW Works

- To find the best path through the grid, we search for a path that minimizes the total distance between them.
- Without optimizations, all possible paths through the grid are calculated and a minimum is selected.
Why DTW?

- DTW is relatively insensitive to time-scale contraction or dilation in either the database or query signals.
- A slightly erroneous performance will register a match as long as the section is the closest match to the database sequence relative to what’s been processed so far.
- The algorithm is commonplace in most speech dictation software and has a wide scope of applications such as gesture recognition.
Basic Dynamic Time Warping
Background (Pure Data)

- Visual programming language (LabView)
  - Objects are linked together to model the flow of control and audio
  - Designed for creating interactive computer music and multimedia works
    - Generate Waveforms
    - Perform Signal Analysis
- Modular code base
  - Externals could be generated using C, C++, Python, Java, and many more
- Open source project listed under a modified BSD License
  - All distributed copies of the source code must contain the BSD license
Project Specs (PD & Physical Components)

- Pure Data Specs
  - Sampling rate of 44,100 Hz
  - Fiddle uses 1024 most recent samples to produce midi data
- Electric Guitar: Ibanez RG5EX1
  - Bridge Pickup: Infinity 4
    - Magnet: Ceramic
    - DC Resistance: 15.6 KΩ
Block Diagram of Simplified PD Patch
Current PD Recording Implementation
Current PD Implementation
Testing and Validation

- Tested different sequences
  - Single Notes
    - Consistent triggering
  - Chords
    - Inconsistent triggering
- Record system clock at input and triggering
  - Took difference to measure latency
    - 1-2 ms
- $44100/1024 = 44$ notes per second
Issues With Approach

- Currently triggers on the first instance of trigger sequence
- Accuracy in chord detection (trigger sequence length)
- Match detection versus actual desired trigger point
- User familiarity with PD / ease of use
Future Improvements

- Subsequence tracking over DTW matching
- Application to control actions other than guitar effects
- Interface kit for analog effect pedals
- User GUI external to PD patch
- Hybrid of other candidate techniques to serve as false trigger fail safe
Reverb Effect

- Creates the sound of a performance in a concert hall
- Mirrors a large number of reflections to build up and then decay
Delay Effect

- Creates the sound of a repeating, decaying echo
- Delwrite block allocates memory for a delay line
- Delread block reads the signal from a delay line
Fuzz Effect

- Creates the sound of a distorted, heavier guitar
- Clip block restricts a signal to lie between two limits
Spectral Delay Effect

- Creates the sound of a repeating echo, with harmonics ringing at different times
- FFT divides frequencies into smaller bins, which each have a different delay applied
### Project Schedule

<table>
<thead>
<tr>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>36</td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
<td>41</td>
<td>42</td>
</tr>
<tr>
<td>41</td>
<td>42</td>
<td>43</td>
<td>44</td>
<td>45</td>
<td>46</td>
<td>47</td>
<td>48</td>
</tr>
<tr>
<td>49</td>
<td>50</td>
<td>51</td>
<td>52</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Current Stage
- Documentation
- Auxiliary Research
- Primary Research
- Candidate Selection
- Software Platform Selection
- Hardware Selection

#### DTW Stage
- Pure Data
- Acquisition
- Hardware

#### Prototyping
- Digitization of Signal
- Counting Implementation

#### DTW Implementation
- Testing and Method Improvement
- Basic Functionality
- Design Specifications
- Adjustments
- Tweaks and GUI

#### Final Project
- Finalize Project

- Presentation Preparation
- Design Reviews
- Final
Time Budget

![Time Budget Chart](image-url)
Spending Budget
Summary

- Created an automatic guitar effect trigger system using DTW
  - Capable of triggering any digital effect
- Design criteria met:
  - Trigger latency of <= 1 second (2 ms)
  - Minimum note onset separation of 10 notes per second
    - 43 notes / sec (detect a new note every 23 ms)
  - Concurrent effects triggering
Questions?