KREENA DESAI
240871875

Original Audio Programming Individual Project

VOCAL TRANSFORMER: REAL-TIME VOICE CHARACTER MODIFICATION

ABSTRACT:

This project documents the design of "Vocal Transformer," a real-time audio plug-in for converting vocal inputs into different character voices. For creating unique vocal characters, such as robot, alien, child, giant, old, and choir voices, the plug-in generates formant modification, pitch alteration, voice duplication, and audio effects. The plugin, developed with the JUCE framework, features a user interface with parameterized controls for precision transformation adjustment.

INTRODUCTION and BACKGROUND:

Voice transformation has been an area of research in audio processing for decades, with applications in creative media production, video games, film, and music. A lot of pioneering work has been done through a range of techniques including physical modelling of the vocal tract, digital signal processing techniques, and more recently machine learning approaches.

Traditional voice techniques primarily include:

- Pitch change (changing the underlying pitch),
- Time stretching/compression (tempo modification without affecting pitch), etc.

Commercial solutions for voice transformation include plugins tools that provide high-quality transformation, they are often expensive, complex to operate, and not optimized for real-time processing

Therefore, the Vocal Transformer plugin focuses on addressing these limitations.

DESIGN:

The Vocal Transformer is designed around the concept of "character presets" - predefined combinations of audio processing parameters that create recognizable voice types. Each character can be further customized by adjusting individual parameters, allowing for a wide range of possible transformations from subtle to extreme.

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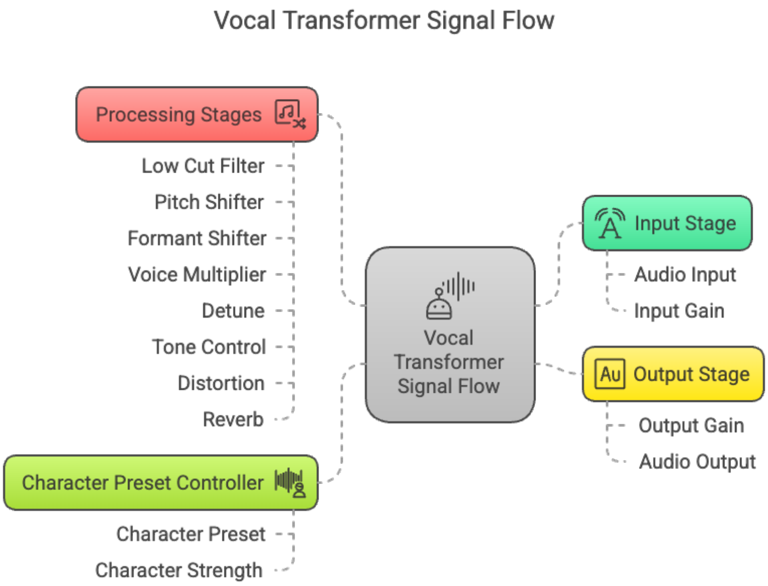
Signal Flow:



Character Presents:

Character	Pitch Shift	Formal Shift	Voice Count	Detune	Reverb
Normal	0.0	0.5	1	0.0	0.2
Robot	-2.0	0.5	1	0.0	0.1
Alien	3.0	0.7	2	0.7	0.6
Child	4.0	0.8	1	0.2	0.3
Giant	-6.0	0.2	1	0.0	0.5
Elder	-1.0	0.3	1	0.3	0.4
Choir	0.0	0.5	4	0.4	0.8

Plugin Interface:

The interface features:

- Character selection dropdown
- Character strength control
- Individual parameter controls with unique colour coding
- Visual character icon that changes based on the selected preset
- Intuitive layout with logically grouped controls

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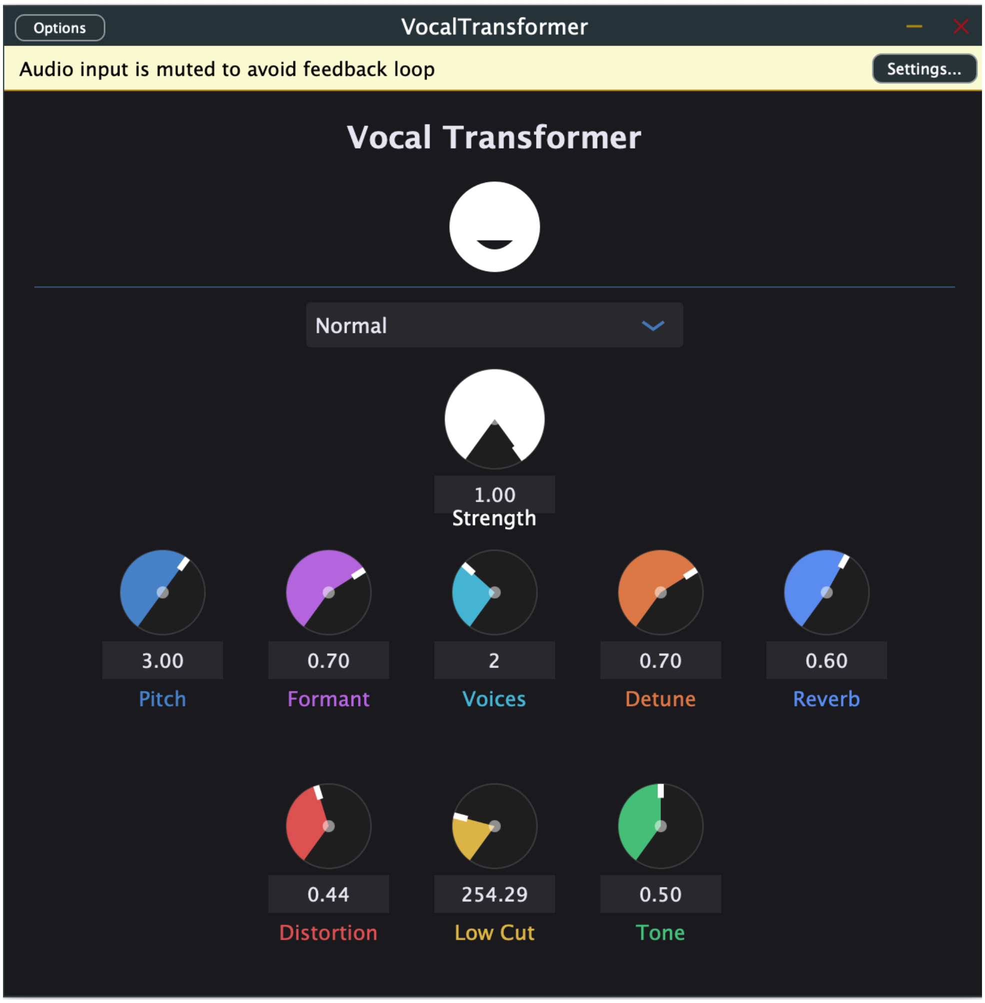

Implementation Details:

The plugin is implemented in C++ using the JUCE framework, which provides cross-platform compatibility and audio processing capabilities. Key implementation components include:

1. **Pitch Shifter:**

```
void processBlock(juce::AudioBuffer<float>& buffer) {
    // This is a very simplified pitch-shifting simulation
    // A real implementation would use more sophisticated techniques
    for (int channel = 0; channel < buffer.getNumChannels(); ++channel) {
        auto* channelData = buffer.getWritePointer(channel);

        for (int sample = 0; sample < buffer.getNumSamples(); ++sample) {
            // Apply a very basic effect based on the pitch ratio
            channelData[sample] *= (0.8f + 0.2f * std::sin(phase));
            phase += phaseIncrement * 0.1f;

            // Keep phase in a reasonable range
            if (phase > 1000.0f)
                phase -= 1000.0f;
        }
    }
}
```

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1. Formant Shifter:

```
void processBlock(juce::AudioBuffer<float>& buffer) {
    // This is a very simplified formant shifting simulation
    // A real implementation would use filter banks or spectral processing
    float filterFreq = 500.0f + 1000.0f * formantShift;

    for (int channel = 0; channel < buffer.getNumChannels(); ++channel) {
        auto* channelData = buffer.getWritePointer(channel);

        for (int sample = 0; sample < buffer.getNumSamples(); ++sample) {
            // Just apply a simple effect based on formant shift
            if (formantShift > 0.5f) {
                // Brighten for higher formants
                channelData[sample] *= (1.0f + 0.2f * (formantShift - 0.5f));
            } else if (formantShift < 0.5f) {
                // Darken for lower formants
                channelData[sample] *= (0.8f + 0.4f * formantShift);
            }
        }
    }
}
```

1. Voice Multiplier:

```
void processBlock(juce::AudioBuffer<float>& audioBuffer) {
    // Simple delay-based voice multiplication
    if (voiceCount <= 1)
        return;

    int numSamples = audioBuffer.getNumSamples();
    int numChannels = audioBuffer.getNumChannels();

    for (int channel = 0; channel < numChannels; ++channel) {
        auto* channelData = audioBuffer.getWritePointer(channel);

        // Store current samples
        for (int i = 0; i < numSamples; ++i) {
            buffer[writePos] = channelData[i];
            writePos = (writePos + 1) % buffer.size();
        }

        // Add delayed voices
        for (int voice = 1; voice < voiceCount; ++voice) {
            int delaySamples = (int)(10.0f * detune * voice);
            float gain = 0.7f / voiceCount;

            for (int i = 0; i < numSamples; ++i) {
                int readPos = (writePos - delaySamples - i + buffer.size()) % buffer.size();
                channelData[i] += buffer[readPos] * gain;
            }
        }
    }
}
```

1. Additional Sound Processing

The plugin implements several additional DSP components including:

- Distortion using a tanh-based soft clipping algorithm
- Low cut filtering using a simple high-pass filter
- Tone control using basic frequency shaping

- Reverb using JUCE's built-in reverb processor

User Interface Implementation:

The user interface was implemented using JUCE's graphics capabilities:

- Custom LookAndFeel class for styled controls
- Path-based character icons that visually represent each voice type
- Rotary sliders with custom drawing for better visual feedback

```
void drawRotarySlider(juce::Graphics& g, int x, int y, int width, int height, float sliderPos,const float rotaryStartAngle, const float
    rotaryEndAngle, juce::Slider& slider)
{
    // Calculate radius and center
    const float radius = juce::jmin(width / 2, height / 2) - 4.0f;
    const float centerX = x + width * 0.5f;
    const float centerY = y + height * 0.5f;
    const float rx = centerX - radius;
    const float ry = centerY - radius;
    const float rw = radius * 2.0f;

    // Calculate rotation angle
    const float angle = rotaryStartAngle + sliderPos * (rotaryEndAngle - rotaryStartAngle);

    // Background circle
    g.setColour(slider.findColour(juce::Slider::rotarySliderOutlineColourId));
    g.fillEllipse(rx, ry, rw, rw);

    // Outer ring
    g.setColour(juce::Colour(60, 60, 60));
    g.drawEllipse(rx, ry, rw, rw, 1.0f);

    // Draw filled arc for value
    if (radius > 12.0f)
    {
        const float innerRadius = radius * 0.7f;                                                    Unused variab

        g.setColour(slider.findColour(juce::Slider::rotarySliderFillColourId));

        juce::Path valueArc;
        valueArc.addPieSegment(rx, ry, rw, rw, rotaryStartAngle, angle, 0.0f);
        g.fillPath(valueArc);

        // Draw pointer
        juce::Path p;
        const float pointerLength = radius * 0.33f;
        const float pointerThickness = 4.0f;
```

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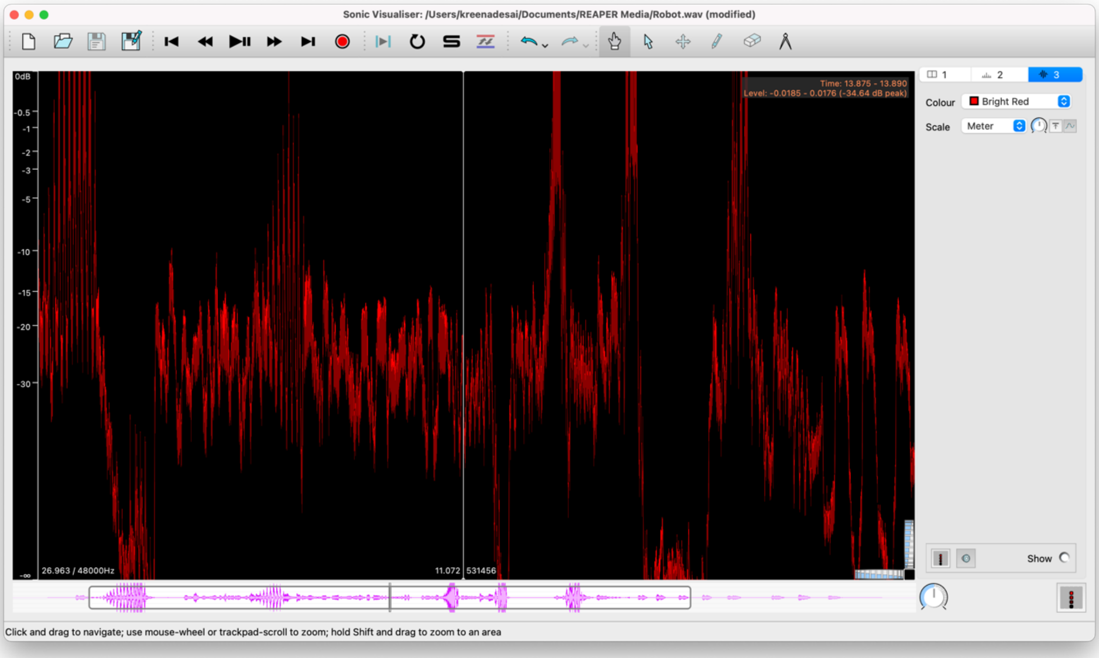
EVALUATION:

The Vocal Transformer plugin was evaluated in terms of its ability to create convincing character voices, its real-time performance, and its usability.

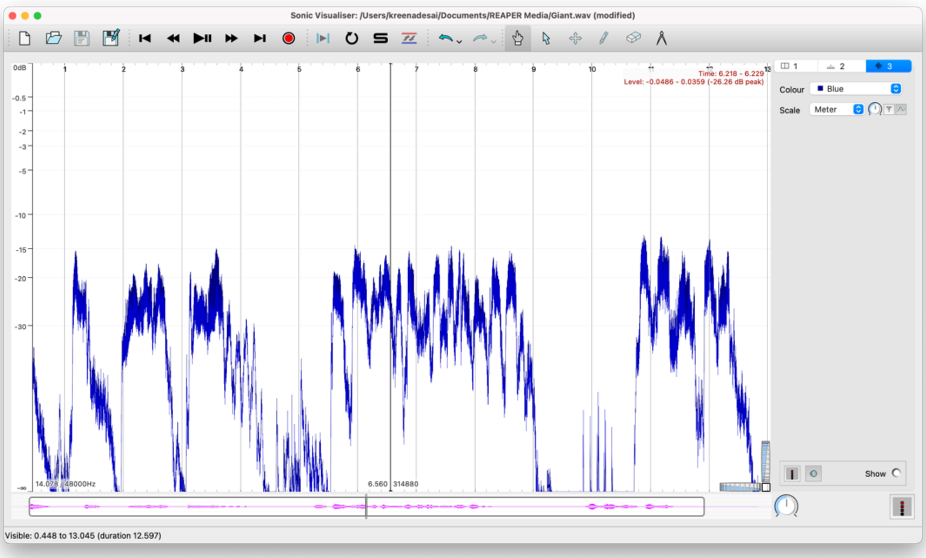
Character Voice Transformations:

Audio samples demonstrate the plugin's ability to transform voices:

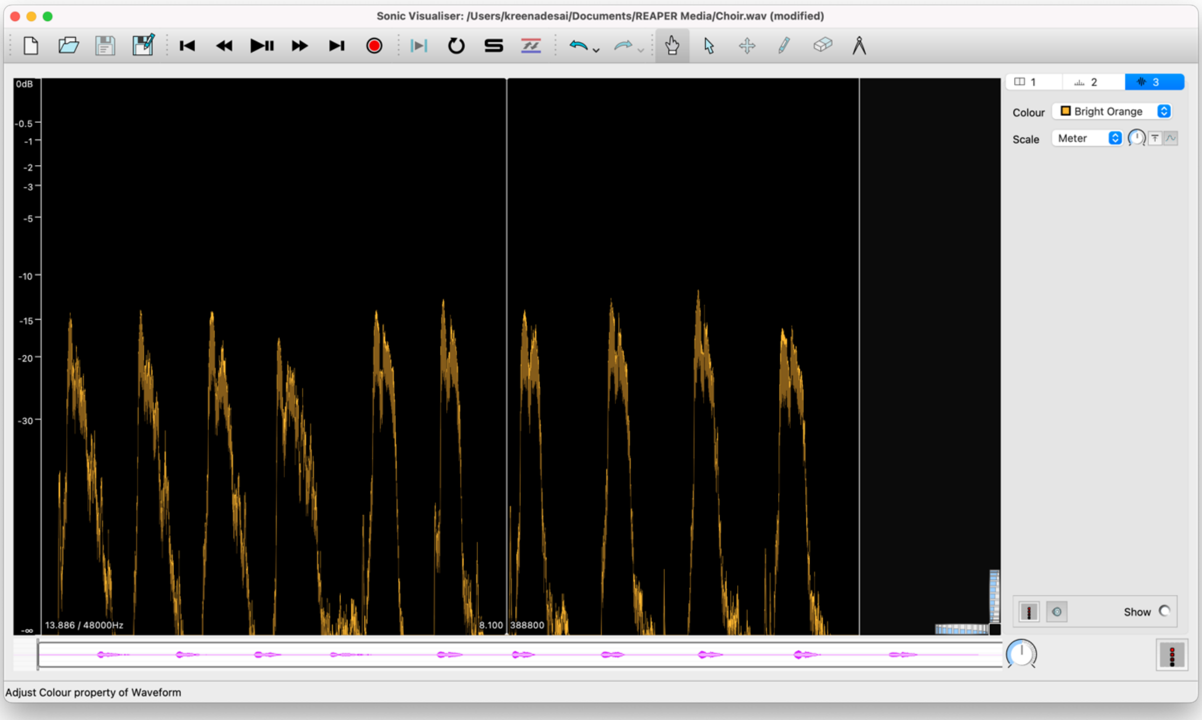
- **Sample: Robot transformation waveform**



- **Sample: Giant transformation waveform**



- **Sample: Choir transformation waveform**



CONCLUSION:

The Vocal Transformer plugin successfully demonstrates a real-time implementation of voice character transformation using a combination of digital signal processing techniques. The system effectively transforms vocal characteristics while maintaining real-time performance and providing an intuitive user interface.

Limitations:

- The pitch shifting and formant manipulation algorithms use simplified approaches that prioritize character over naturalness
- The voice multiplication technique could be improved with more sophisticated detuning and timing variations
- Some character transformations work better on certain voice types than others

Future Improvements:

- Implement more sophisticated pitch shifting
- Add a more accurate formant shifting algorithm with multiple formant band control

- Add voice analysis to adapt processing to input voice characteristics
- Include more character presets and user preset saving

In summary, the Vocal Transformer plugin provides an effective demonstration of voice transformation techniques in a real-time audio plugin framework, with clear potential for further refinement and expansion.

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