

# DeJong Distortion: An Experimental Composition Tool Using the DeJong Chaotic Attractor to Manipulate Audio Using an AU Plugin Implementation

## ABSTRACT

*The DeJong Distortion is an AU plugin that can be used in any DAW on Mac OS which applies the discrete-time De Jong chaotic attractor equation, first proposed by Peter De Jong, to incoming audio in stereo. The plugin can be used as easily as any other common effect plugin, such as distortion and equalization, with the ability to automate parameters in real-time. The sonic output is captivating, experimental, and diverse.*

## 1. PRIOR WORK

DrawJong 2.0 [1] is a synthesizer and visualizer created by Matthew Hetrick specifically designed to sonify and visualize chaotic attractors.

The reacTable[2] uses control data flows to synthesize audio which includes chaotic and fractal generators.

In [3], the De Jong chaotic attractor was applied to digital waveguides to synthesize audio in real-time.

## 2. DEJONG CHAOTIC ATTRACTOR

The De Jong chaotic attractor is given with the equations[1]:

$$\begin{aligned}x_n &= \sin(a * y_{n-1}) - \cos(b * x_{n-1}) \\y_n &= \sin(c * x_{n-1}) - \cos(d * y_{n-1})\end{aligned}$$

In Hetrick's DrawJong, points are plotted on a two-dimensional graph according to the behavior of the chaotic attractor.  $x_n$  and  $y_n$  equal the next point to be plotted on the respective axis with  $x_{n-1}$  and  $y_{n-1}$  being the previously plotted points. Variables a, b, c, and d are parameters that can be constants or dynamic, but Hetrick's implementation used these variables as constants. The images created by this equation are truly beautiful and can be seen in Hetrick's paper.[1]

In my interpretation of this equation for audio,  $x_n$  is equal to the left channel's output and  $y_n$  equals the right channel's output.  $x_{n-1}$  and  $y_{n-1}$  represent the previous sample in each channel and I used variables a and b in the plugin replacing variable c with variable a and replacing variable d with variable b.

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The significance of using a discrete-time chaotic attractor as an audio plugin is creating a new experimental composition tool that is easy to use inside of any DAW by anyone regardless of how familiar they are with experimental music making techniques.

## 3. THE JUCE FRAMEWORK AND PLUGIN DESIGN

I used the open source Juce framework with C++ to build both the visual component and dsp component of this plugin. [4] In this framework, Juce includes a method that handles all of the plugins dsp called the processBlock which is shown in figure 1. This method iterates through each audio sample coming through the input with a for loop given as:

```
for (int sample = 0; sample < buffer.getNumSamples(); ++sample)
```

```
{
    if (stereo == true)
    {
        prevX = prevX + *varCParameter + inputX[sample];
        prevY = prevY + *varDParameter + inputY[sample];

        auto newXDeJongX = (sin(varA * prevY) - cos(varB * prevX));
        auto newYDeJongY = (sin(varB * prevX) - cos(varA * prevY));

        if (inputX[sample] == 0)
        {
            outBufferOne[sample] = 0;
        }
        else
        {
            outBufferOne[sample] = ((newXDeJongX) * 0.25f) * gain;
        }

        if (inputY[sample] == 0)
        {
            outBufferTwo[sample] = 0;
        }
        else
        {
            outBufferTwo[sample] = ((newYDeJongY) * 0.25f) * gain;
        }

        // Update prevX and prevY so that the next time this for-loop starts, they will have the previous
        // sample value stored in them.
        prevX = newXDeJongX;
        prevY = newYDeJongY;
    }
    else
    {
        channelData[sample] = 0;
    }
}
```

Figure 1. The process block method in Juce.

Before I implemented the equation, I created a way to dynamically access previous samples from the input. I created two variables named prevX and prevY to store the current sample from the input so that after each iteration, the samples contained in prevX and prevY are what came before each iteration through the for loop. This was done by implementing the code:

```
prevX = prevX + *varCParameter + inputX[sample];
prevY = prevY + *varDParameter + inputY[sample];
```

Finally, I implemented the actual De Jong equation for  $x_n$  and  $y_n$  with:

```
prevX = sin(varA * prevY) - cos(varB * prevX);
prevY = sin(varB * prevX) - cos(varA * prevY);
```

This is where I am able to pull from previous samples. One difference that one notices in this implementation is that I am using only variables a and b in place of variables c and d from the original De Jong equation. This is because in my testing, I found that having four variables did not make any sonic difference from having only two variables. Figure 2 shows the user interface I created for the plugin.



**Figure 2.** Current interface for the experimental DeJong distortion plugin.

I named variables a and b as "Color 1" and "Color 2" and prevX and prevY as "Left Portal" and "Right Portal" since they are essentially pulling samples from back in time. Finally, I pass each equation to the left and right output buffer with the code:

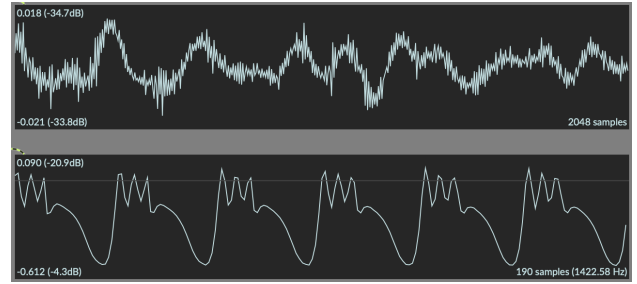
```
outBufferOne[sample] = ((prevX) * 0.25f) * gain;
outBufferTwo[sample] = ((prevY) * 0.25f) * gain;
```

Each side is multiplied by 0.25 to compensate for the volume increase inherent in using this equation. It is also multiplied by a gain parameter that I have not implemented in this demo. This will serve as an output volume in the finished product. Unlike any of the previously cited works, this implementation applies the De Jong chaotic attractor to incoming audio instead of synthesizing audio which makes this plugin dynamic and ideal for a composition tool.

#### 4. SOUND RESULTS

The sonic effect of this plugin and equation in general is captivating and erratic. Figure 3 shows a comparison between a dry drum loop and the same drum loop passing through the plugin using MaxMSP.

The top level is the dry drum loop and the bottom level is the affected drum loop. You can see how the dry drum loop looks fairly asymmetrical and dynamic, but the affected drum loop is so distorted that the waveform looks like perfect copies of itself. In terms of timbre, this plugin turns the signal into a thin, bright fuzz that resembles static and feedback. However, changing the color param-



**Figure 3.** Comparison between a dry drum loop and an affected drum loop.

eters shift the fundamental sound around drastically. The dry signal is still somewhat retained in the affected signal which makes this plugin very dynamic and useful in composition projects.

#### 5. FUTURE WORK AND DESIGN IMPROVEMENTS

In future conceptions I will add an output volume parameter, connecting to the gain variable, to control the volume of the plugin. I will also add a wet/dry control to the plugin to change how much of the wet signal and how much of the dry signal passes through to the outputs which is a common control for most effect plugins. [5]

#### 6. REFERENCES

- [1] M. Hetrick, "DrawJong 2.0," 2011.
- [2] M. Kaltenbrunner, G. Geiger, and S. Jordà, "Dynamic patches for live musical performance," in *Proceedings of the 2004 conference on New interfaces for musical expression*. National University of Singapore, 2004, pp. 19–22.
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- [4] WeAreRoli/Juce, "Juce Framework," <https://github.com/WeAreROLI/JUCE>, 2018.
- [5] V. Goudard and R. Muller, "Real-time audio plugin architectures," *Comparative study. IRCAM-Centre Pompidou. France*, 2003.