# Sprint 6 – Studying fractals and fractal implementation for future using in hydraulic erosion 22/03/2019 – 05/04/2019

# Research

After researching for a few hours, I came across an application named Instant Terra, this is a 3D application made in C++ for Procedural Terrain Generation. I used this application and got an idea in what I should expect from the hydraulic erosion in my terrain (Figure 1, Figure 2 and Figure 3).

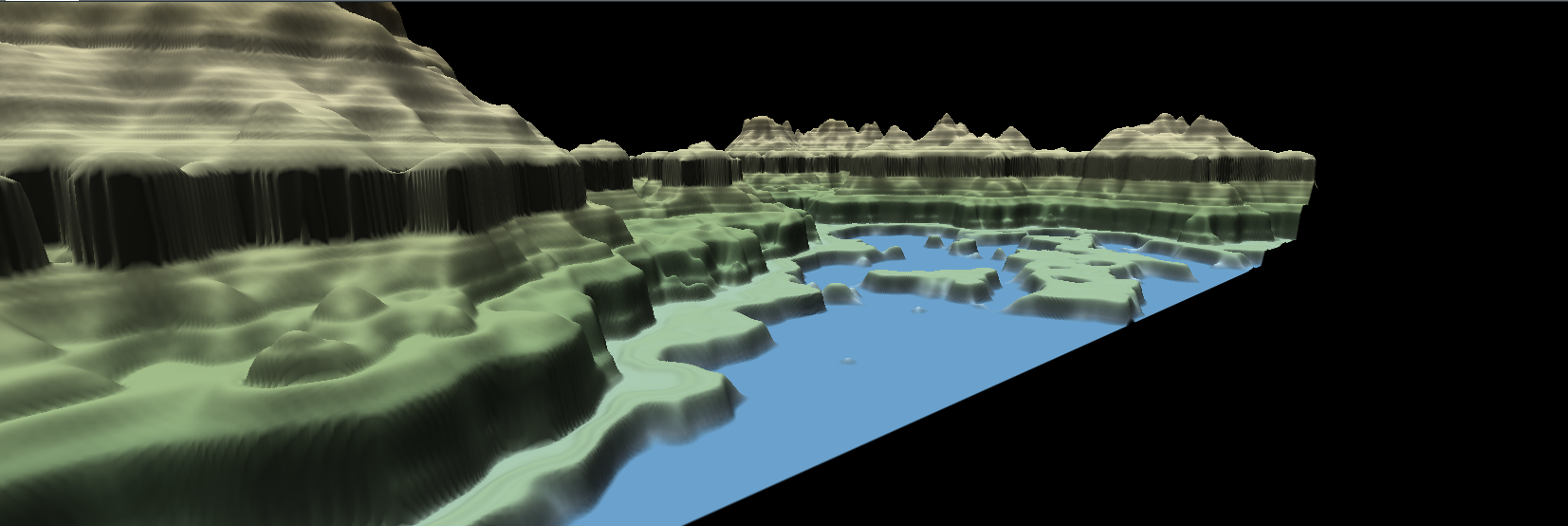


Figure 1 - Instant Terra, terrain without hydraulic erosion

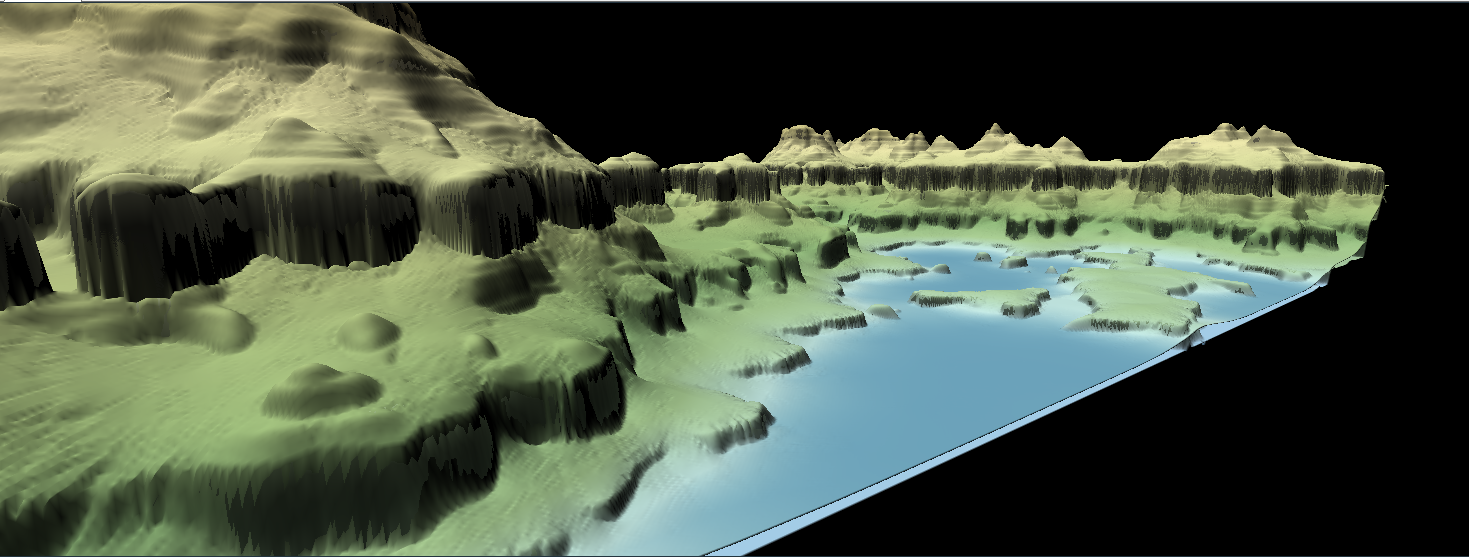


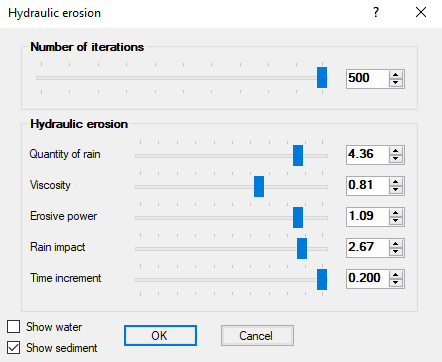
Figure 2 - Instant Terra, terrain with hydraulic erosion

Figure 3 - Instant Terra, hydraulic erosion settings

The first step when reading the journal (Génevaux et al. 2013), I figure out that I needed to learn how to create fractals.

After a quick search, I found that for drawing basic lines I needed to learn how to use the LineRender in unity (Unity School 2016) [Figure 4].

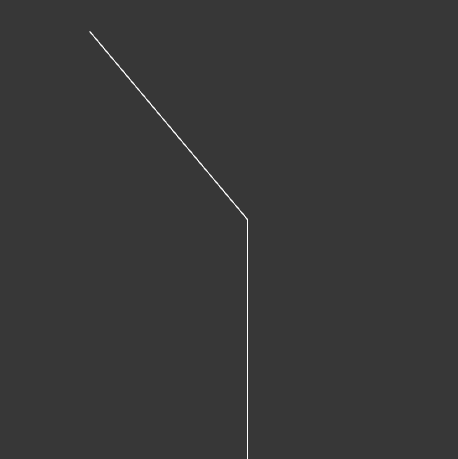


Figure 4 - Fractals Step 1

## Line Class

First, I started creating a Line Class, this class have a method for Drawing a line, each time is called it creates a game object and it stores it inside a list. The struggle here was to draw the line and being able to draw the next line saving the position from the line before and apply a specific rotation if needed. To be able to do this I created two vector 3, variables, a quaternion and a Boolean for checking if this is the first line (Figure 5).

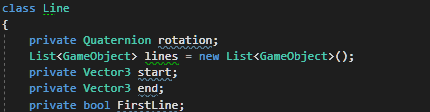


Figure 5 - Line Class Variables

I defined that the game object position is going to be equal to the start position and, in the end, when the line is created, the start position is going to be equals to the end position. When going through the list I had to find a way to check if the line was not drawn yet, for this I did an if statement to check if the game object had the line Renderer component, if not then draw the next line (Figure 6).

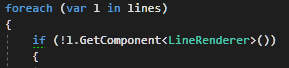


Figure 6 - Check if the line is already drawn

On the branch function the first line draws a line with the length defined in the parameter, the next code sets the rotation for the next line and after draws another line (Figure 4) (Figure 7).

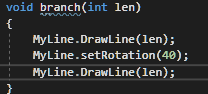


Figure 5 - Line Drawing

When I am trying to call this function recursively, I am getting this strange problem (Figure 8), it seems that I need to find the exact point were the line finishes and apply the translation from that point.

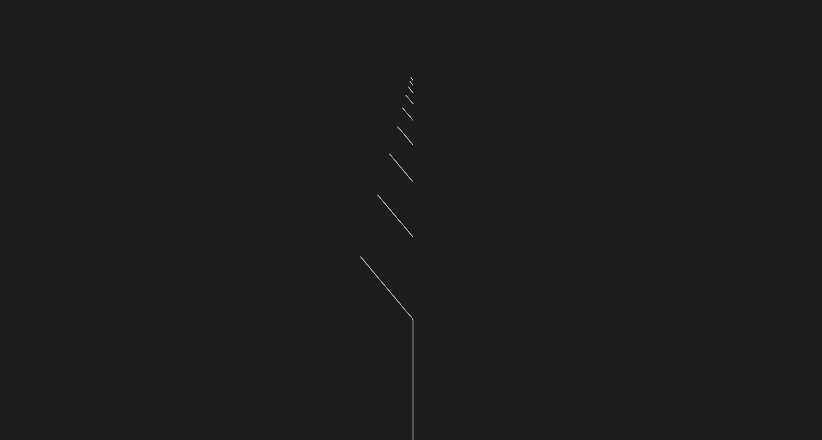


Figure 6 - Error when calling the function with recursion

The problem seems to be on the position for each line, to solve this problem I set the object position equals to the last object position multiplying by the last object rotation.

After many hours spent on the attempt to create a fractal, I ended up with two interesting fractal pattern using only lines in unity (Figure 9)(Figure 10). My end goal is to be able to create different patterns for example a tree, this technique is going to allow me to draw the water paths for the hydraulic erosion.

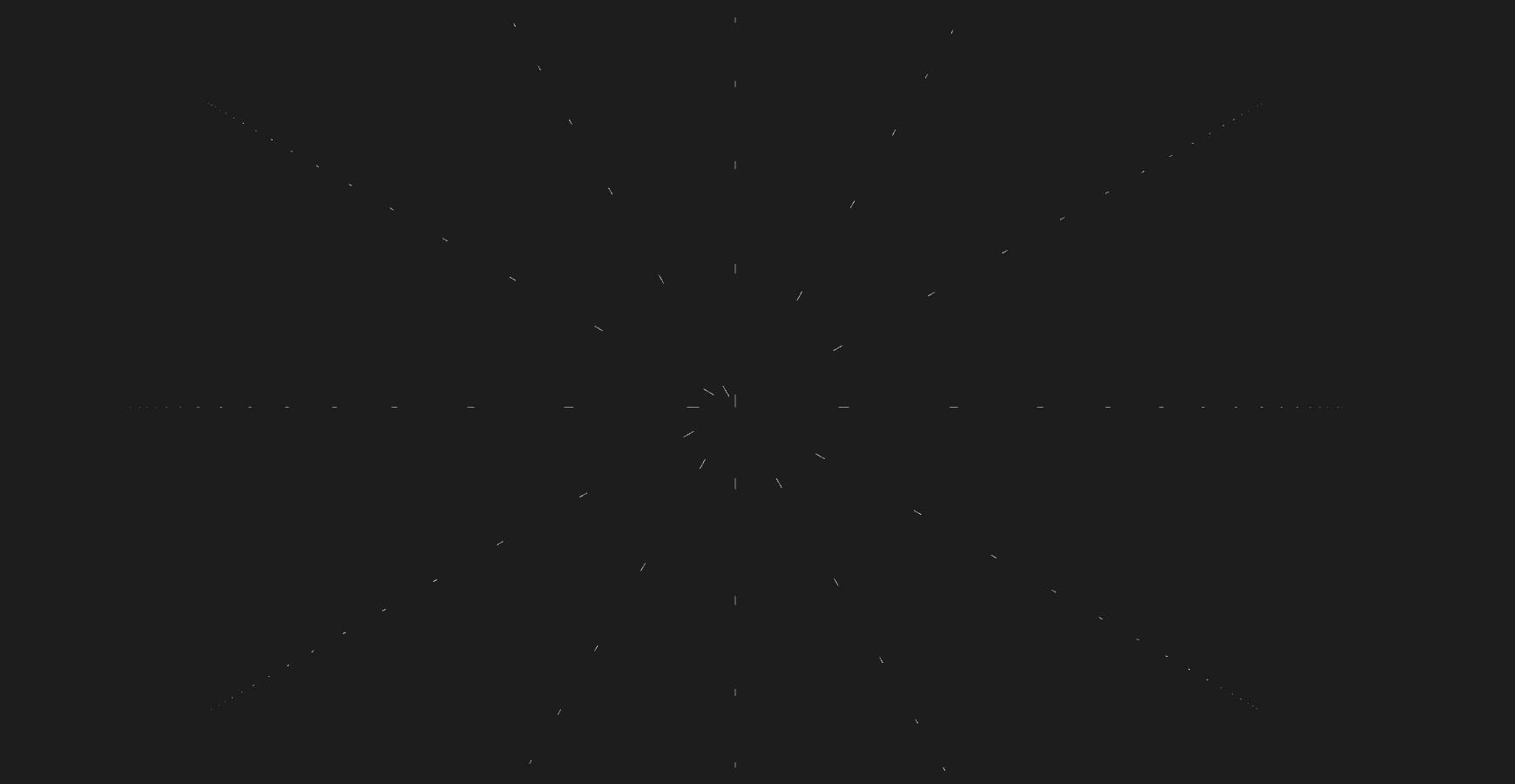


Figure 7 - Random Fractal by Flavio Fiori

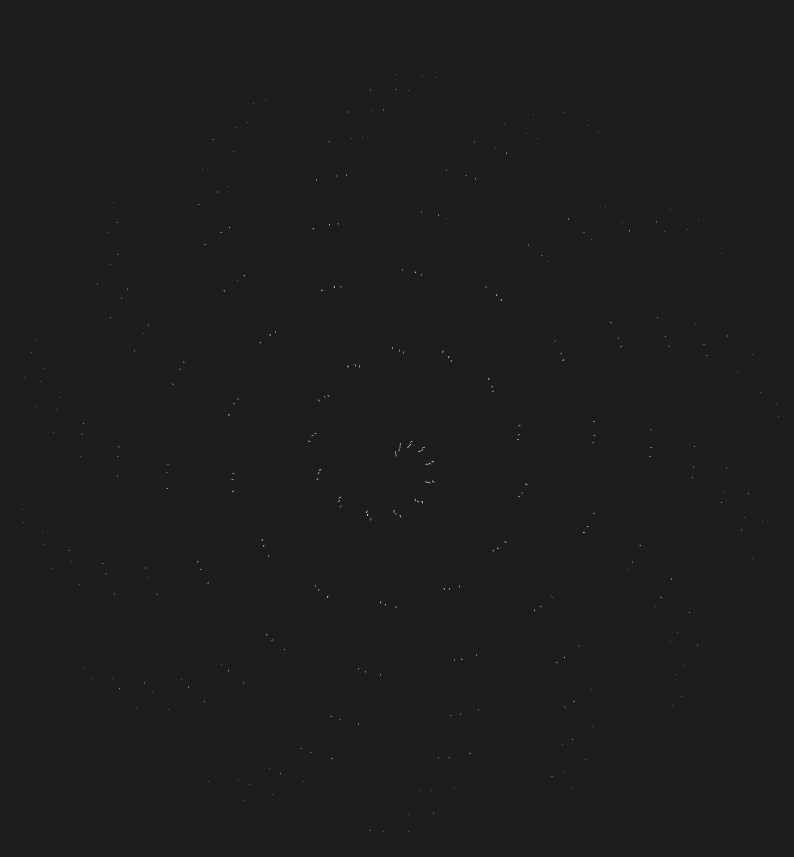


Figure 8 - Random Pattern 2

## Fractal Tree

Not happy with the result from the previous attempt to generate fractals, I took a different approach.

I decided to create an empty game object that is going to have a cube has a child and create a script for the empty game object.

### Fractals Script

This script is responsible for the recursion of the game object, and to achieve this result, different from the previous time where I was using a line renderer, now I just instantiate a copy of the game object itself [Figure 9].

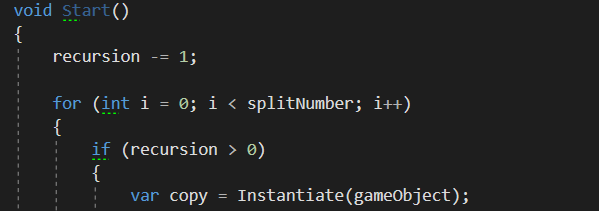


Figure - Recursion for the game object

When the copy variable is created with the game object, the goal is to create another variable to store the script where I am going to use a method named Send Message, this method allows to call any method in a class that derives from MonoBehaviour (Unity 2018) [Figure 10].



Figure 10 - Using Send Message Method()

### Expander Script

This script contains the method that is called from the SendMessage() method that is used on the Fractal Script [Figure 10].

This method is named Created and have a RecursionScript has a parameter, this script is responsible to store the value from “i” in the for loop. For example, let’s say that the splitNumber value is 2, then the “i” can be 0 or 1. When the “i” is 1 then the rotation is positive when the “i” is 0 the rotation is negative due to the fact that multiplying 0 by \* 2 is 0 then subtracting 1 is -1. [Figure 11].

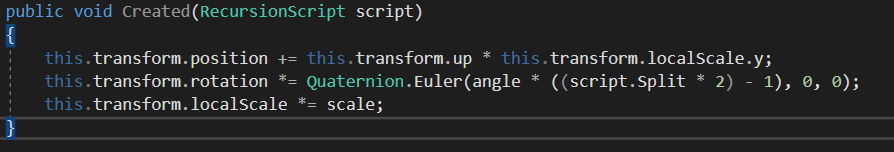


Figure 11 - Created Method

### Recursion Script

This script is only responsible to hold the value from split and then use it to know the direction that is rotating.

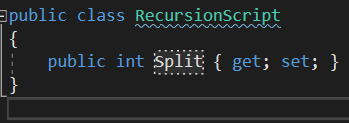


Figure 12 - Recursion Script

### Conclusion

Now that the code was working has intended the result using the cubes started to look like a tree, I called this a fractal cube [Figure 13].

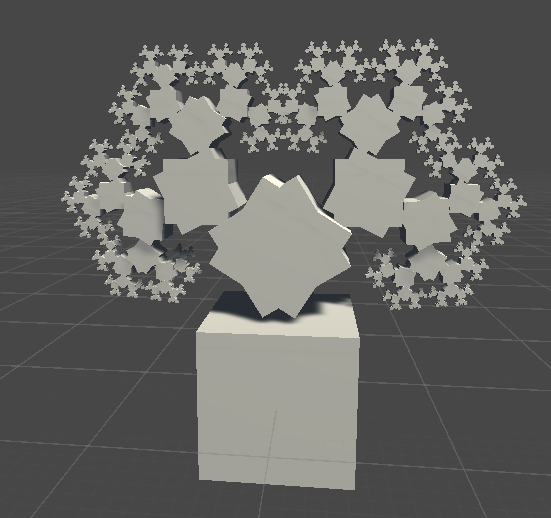


Figure 13 - Fractal Cube

I decided to rescale the cube to look alike a branch from a tree, using the cube scale has follow: x = 0.1, y = 1 and z = 0.1



Figure 14 - Tree Branch

Now that I created the tree branch, I compiled the code once again, the result was far from what I expected [Figure 15].

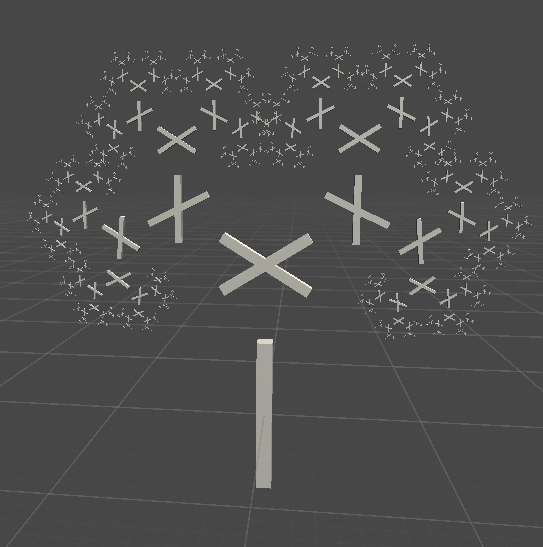


Figure 15 - Tree Generation Failed

After a while looking for a solution, I found that changing the position from the cube inside the parent was improving my results, I changed the Cube Position to Y = 1 [Figure 16].

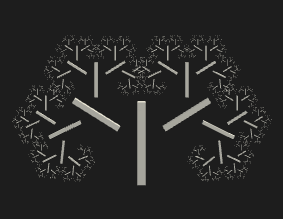
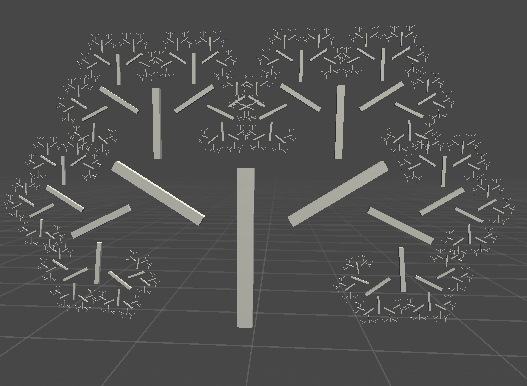


Figure 16 - Cube Y Position changed to 1

Not satisfied with the results, after playing for a while I found that the perfect Position for Y was 0.5, and the result was exactly what I was looking for, the fractal tree [Figure 17].

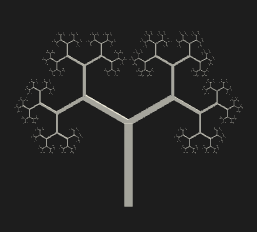
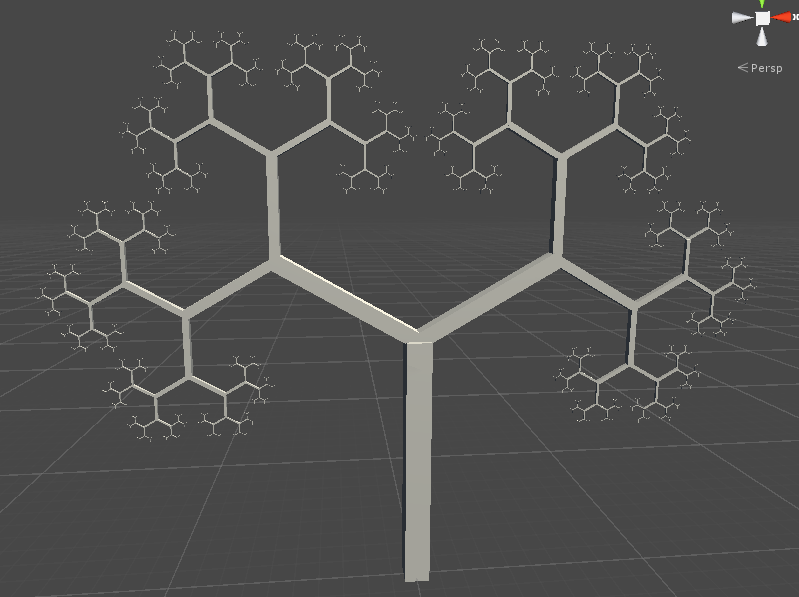


Figure 17 - Fractal tree

# Sprint Review

# WBS

1. Research (60%) (36 hours)
2. Fractal Generation (40%) (24 hours)

# Reading List

Bottom of Form

BEYER, H., 2015. *Implementation of a method for hydraulic  
erosion*, TECHNISCHE UNIVERSITÄT MÜNCHEN

GÉNEVAUX, J.*et al.,* 2013. Terrain generation using procedural models based on hydrology. *ACM Transactions on Graphics (TOG),*32(4), 1-13

GRZEGORZ ROZENBERG and ARTO SALOMAA, 1980. *The Mathematical Theory of L Systems.*US: Academic Press

*Erosion by water,*2012 Directed by Kari KINKEY. Youtube: . 25 Oct,

ROAST, K., 2012. *L-Systems Turtle Graphics Renderer - HTML5 Canvas*[viewed 05/04/ 2019]. Available from: <http://www.kevs3d.co.uk/dev/lsystems/>

ŠT'AVA, O.*et al.,* Jul 7, 2008. Interactive terrain modeling using hydraulic erosion. Eurographics Association, pp.201-210

*8.1: Fractals - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.2: Fractal Recursion - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.3: Fractal Recursion with ArrayList of Objects (Koch Curve) - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.4: Recursion with Transformations - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.5: L-Systems - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*Coding Challenge #14: Fractal Trees - Recursive,*2016 Directed by The Coding Train. Youtube: . May 30,

UNITY, 2018. *GameObject.SendMessage*[viewed 05/04/ 2019]. Available from: <https://docs.unity3d.com/ScriptReference/GameObject.SendMessage.html>

UNITY SCHOOL, 2016. *Drawing Lines with LineRenderer*[viewed 01/04/ 2019]. Available from: <https://unity.grogansoft.com/drawing-lines-with-linerenderer/>

*Generating Fractal Trees in Unity  
,*2016 Directed by World of Zero. Youtube: . 26 Sep,

*How to simulate hydraulic erosion in Instant Terra,*2018 Directed by Wysilab. Youtube: . 7 Mar,

# References

GÉNEVAUX, J.*et al.,* 2013. Terrain generation using procedural models based on hydrology. *ACM Transactions on Graphics (TOG),*32(4), 1-13

UNITY, 2018. *GameObject.SendMessage*[viewed 05/04/ 2019]. Available from: <https://docs.unity3d.com/ScriptReference/GameObject.SendMessage.html>

# Bibliography

BEYER, H., 2015. *Implementation of a method for hydraulic  
erosion*, TECHNISCHE UNIVERSITÄT MÜNCHEN

GÉNEVAUX, J.*et al.,* 2013. Terrain generation using procedural models based on hydrology. *ACM Transactions on Graphics (TOG),*32(4), 1-13

GRZEGORZ ROZENBERG and ARTO SALOMAA, 1980. *The Mathematical Theory of L Systems.*US: Academic Press

*Erosion by water,*2012 Directed by Kari KINKEY. Youtube: . 25 Oct,

ROAST, K., 2012. *L-Systems Turtle Graphics Renderer - HTML5 Canvas*[viewed 05/04/ 2019]. Available from: <http://www.kevs3d.co.uk/dev/lsystems/>

ŠT'AVA, O.*et al.,* Jul 7, 2008. Interactive terrain modeling using hydraulic erosion. Eurographics Association, pp.201-210

*8.1: Fractals - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.2: Fractal Recursion - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.3: Fractal Recursion with ArrayList of Objects (Koch Curve) - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.4: Recursion with Transformations - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*8.5: L-Systems - The Nature of Code,*2015 Directed by The Coding Train. Youtube: . 11 Aug,

*Coding Challenge #14: Fractal Trees - Recursive,*2016 Directed by The Coding Train. Youtube: . May 30,

UNITY, 2018. *GameObject.SendMessage*[viewed 05/04/ 2019]. Available from: <https://docs.unity3d.com/ScriptReference/GameObject.SendMessage.html>

UNITY SCHOOL, 2016. *Drawing Lines with LineRenderer*[viewed 01/04/ 2019]. Available from: <https://unity.grogansoft.com/drawing-lines-with-linerenderer/>

*Generating Fractal Trees in Unity  
,*2016 Directed by World of Zero. Youtube: . 26 Sep,

*How to simulate hydraulic erosion in Instant Terra,*2018 Directed by Wysilab. Youtube: . 7 Mar,