Jack Watson

Student ID:16008335

Department of Computer Science and Creative Technologies

University of the West of England

Coldharbour Lane

Bristol, UK

[jack2.watson@live.uwe.ac.uk](mailto:jack2.watson@live.uwe.ac.uk)

# Abstract

The Project aims to create a built into Unity tool for creating destructive environments. This tool will select the type of material that will be simulated and then dynamically create said terrain / object.

# Introduction

In older games destruction involved destroying either pixels of a wall (Figure 3) or hitting a crate sprite until it shows a shattered sprite and then left the screen after a delay.

Some games in the last decade have made leaps in this field such as the Dragon Ball Z Budokai Tenkaichi series with entire rocks being destroyed on impact or holes being created such as in figure 2 (though these were scripted events).

The Red Faction series also included huge amounts of dynamic destruction in game.



Figure 1 A house after being destroyed by manually placed explosives from the player.

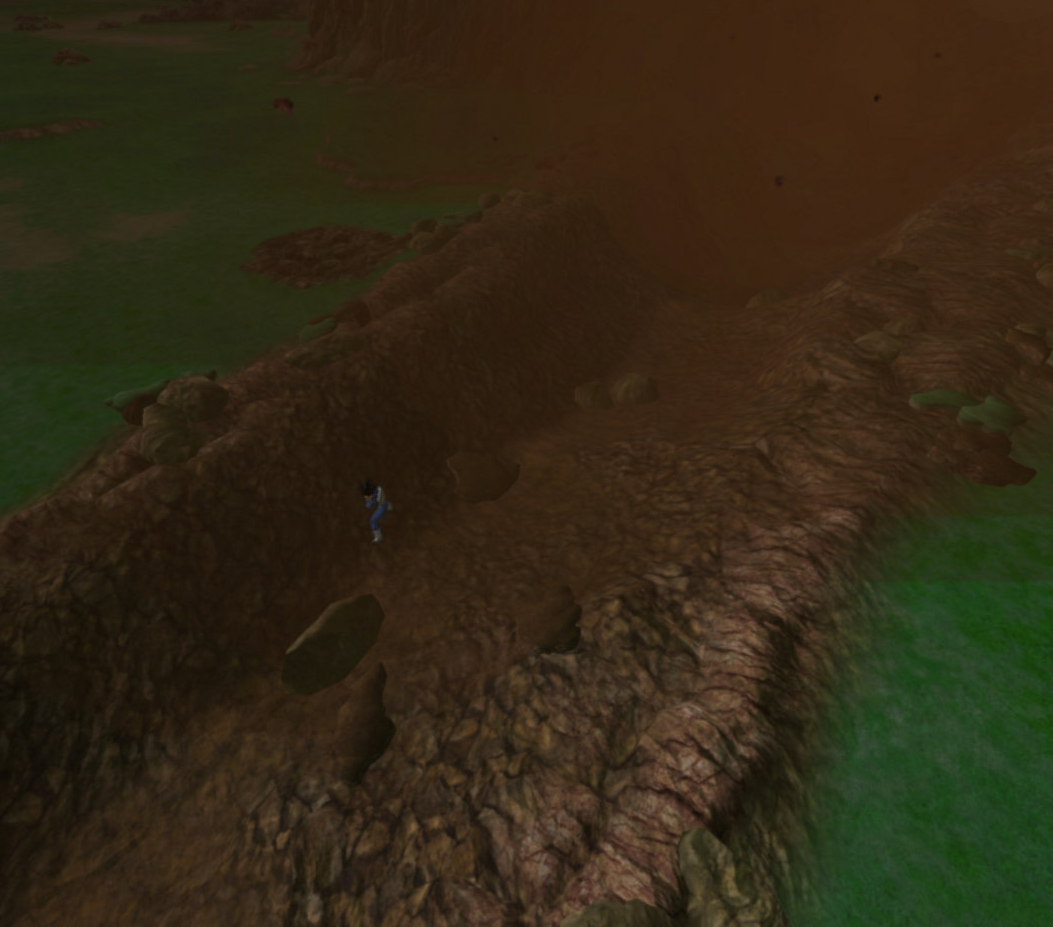


Figure 2

Destructive environments involve terrain or objects in a virtual world being interacted by the player with enough force to cause damage like in the real world e.g. if a ceramic vase fell from 10 meters it would shatter.

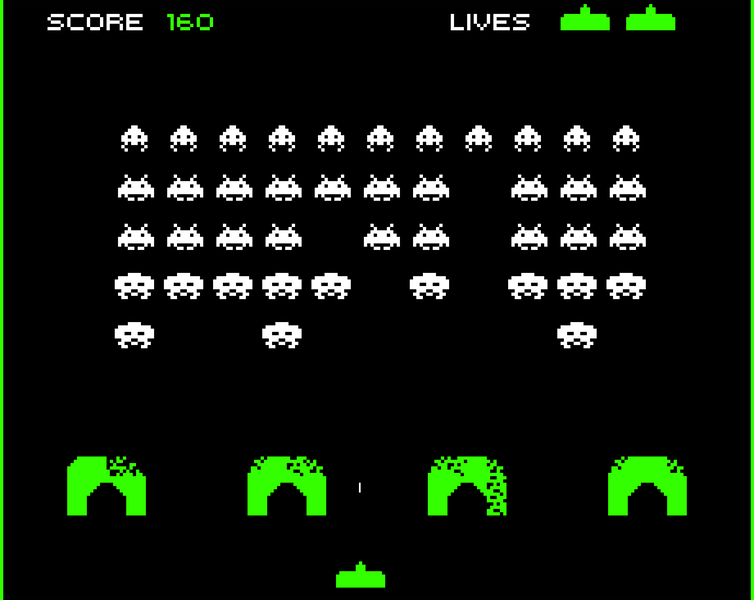


Figure 3

A tool will be devised allowing dynamic destruction via the unity pipeline, quickly creating destructible objects. Done efficiently, memory would be saved allowing the tool to be used in active environments such as in video games.

In a professional context this would allow creators to add the script to an object and destroy it in Unity without need for an editor like Maya or Blender. A tool of convenience.

Initial development of the solution will be covered, completion of the software will not be.

Preliminary work for the project will aim to discover and implement the destruction of a virtual environment. Individual objects made up of different materials such as: Wood, Glass and Stone will be created with unique variations of destruction.

# Background Research

## **Research Aims/Questions:**

* How does basic destruction operate?
* How shattering works in software like blender?
* The Structures of different materials?
* Can destruction be computationally efficient?
* How do meshes operate in Unity?

## **Research methods**

Qualitative research for this tool would be inefficient as each user would be tested on their opinion of destructive detail.

Instead an iterative process used in the industry will be employed. A case study will be conducted investigating the realism of destruction in a real and digital environment. Each study will observe how destruction functions with different materials and contexts.

Accuracy of physical destruction will be simulated, developing an understanding of basic physics and makeup of objects in a digital space.

Software’s (like blender) will be studied for how shattering is done, as this is needed for the unity pipeline.

The internet is primarily used to find Unity specific documentation and tutorial aids.

# Research Findings

## **How does shattering work in Blender?**

A tutorial by (DanielFilms, 2017) gave insight towards destroying objects in a conventional manor. The technique involving the replacement of an object with a “shattered” variant.

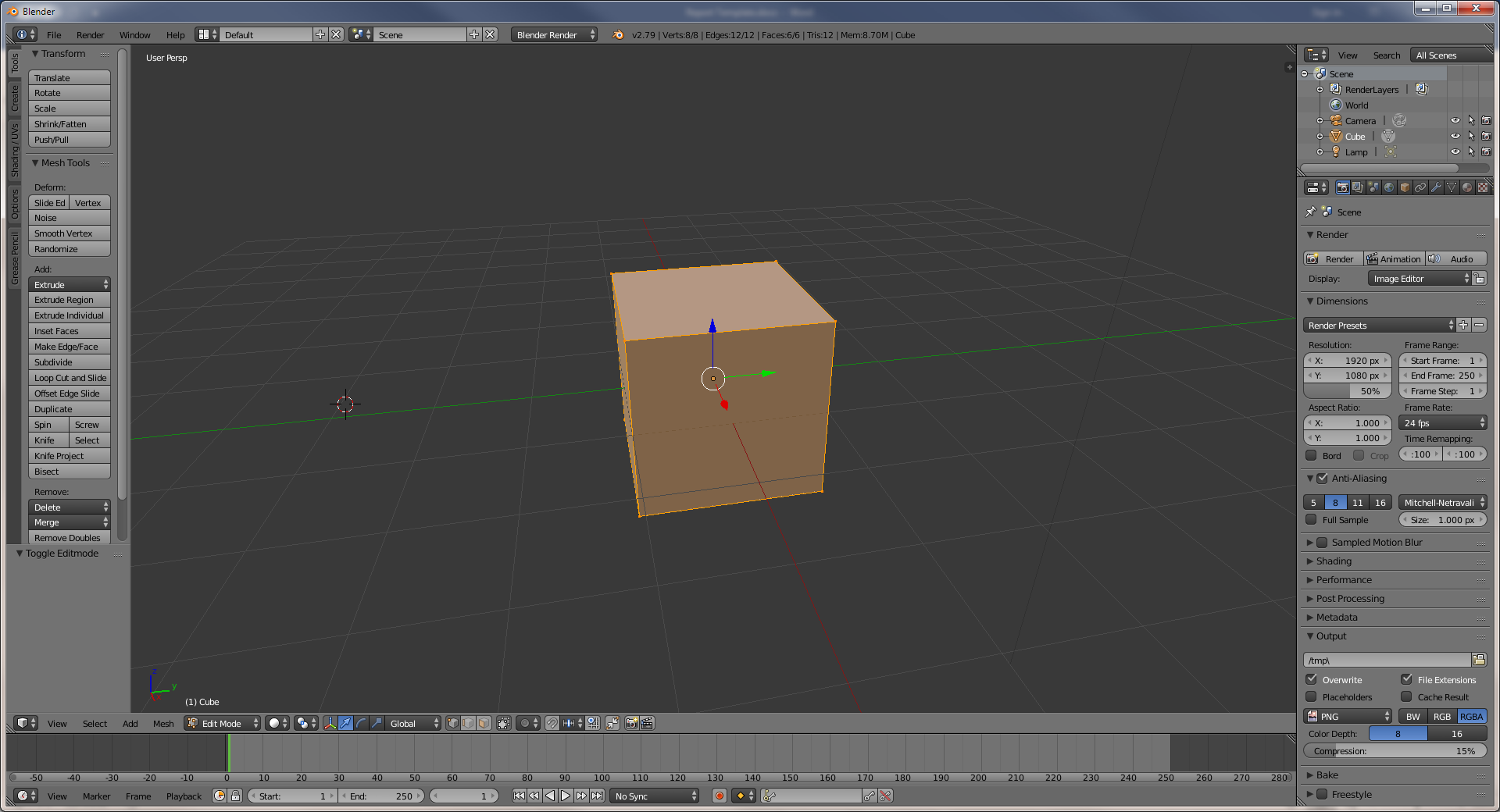


Figure 4 And some basic code from (Brackeys, 2017)

Figure 1

A cube in blender

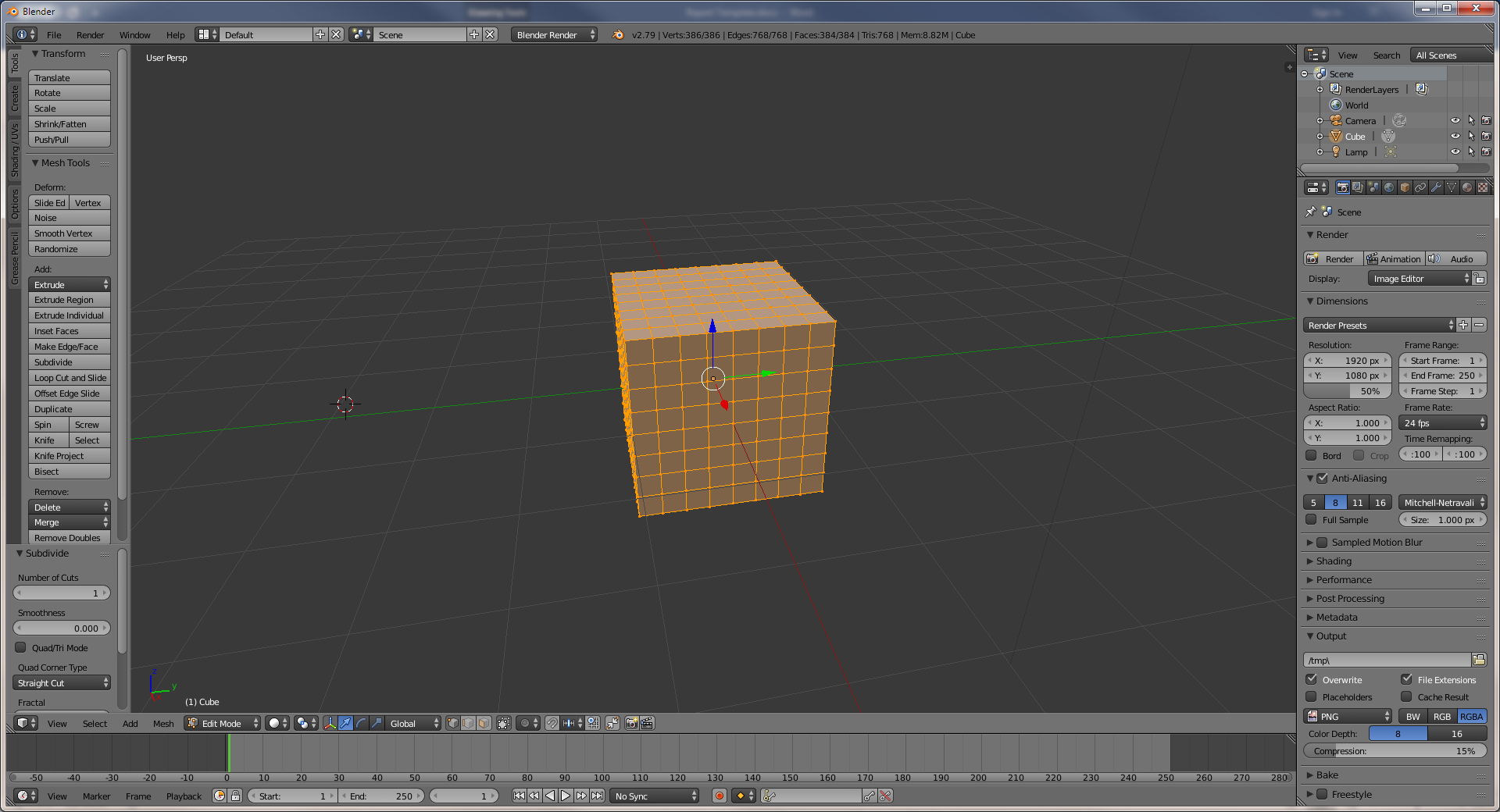


Figure 2 After applying multiple subdivisions

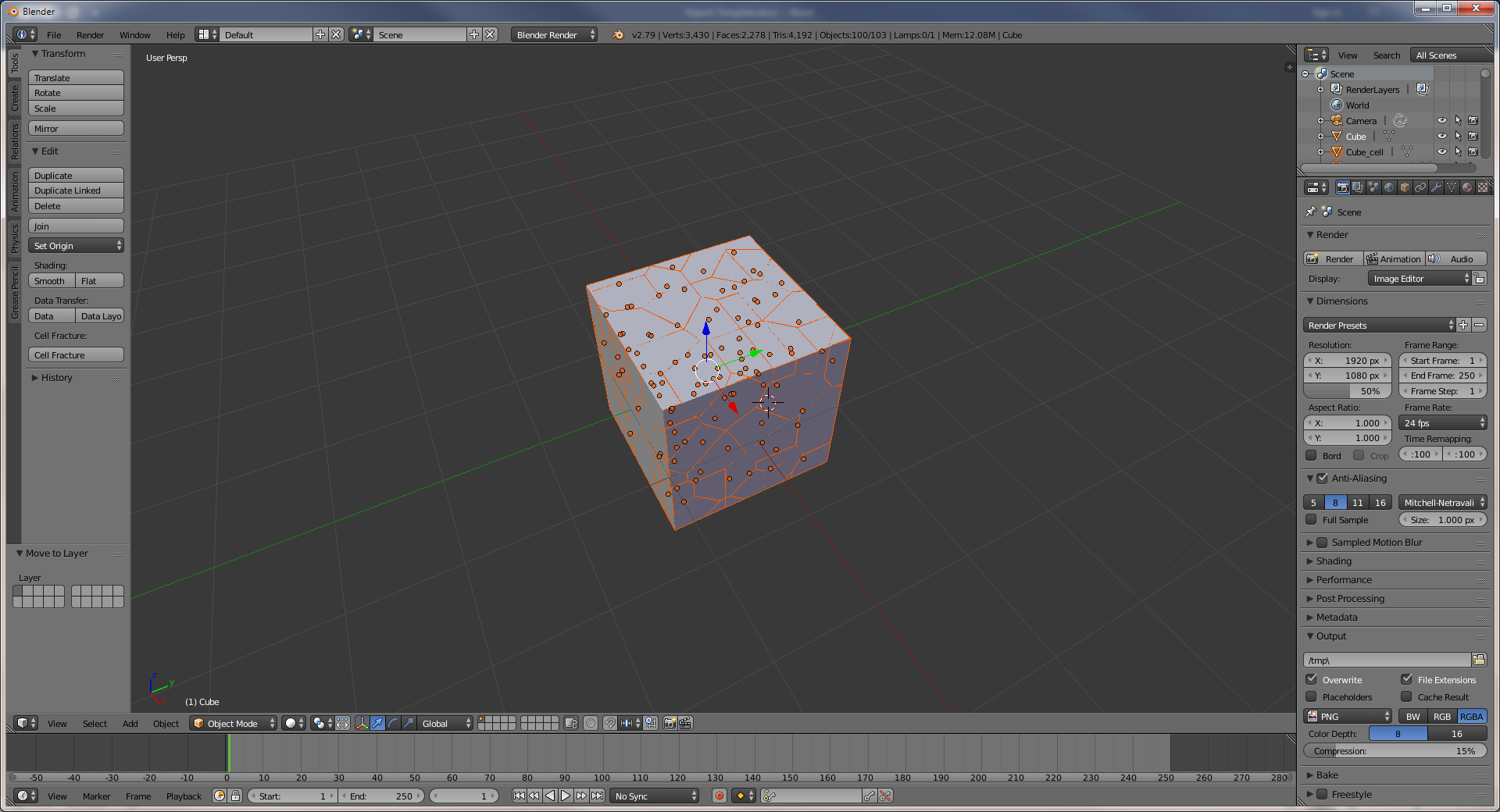
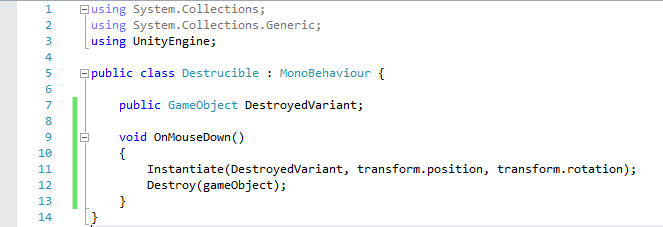


Figure 3 Using the cell fracture addon mentioned in (DanielFilms, 2017).

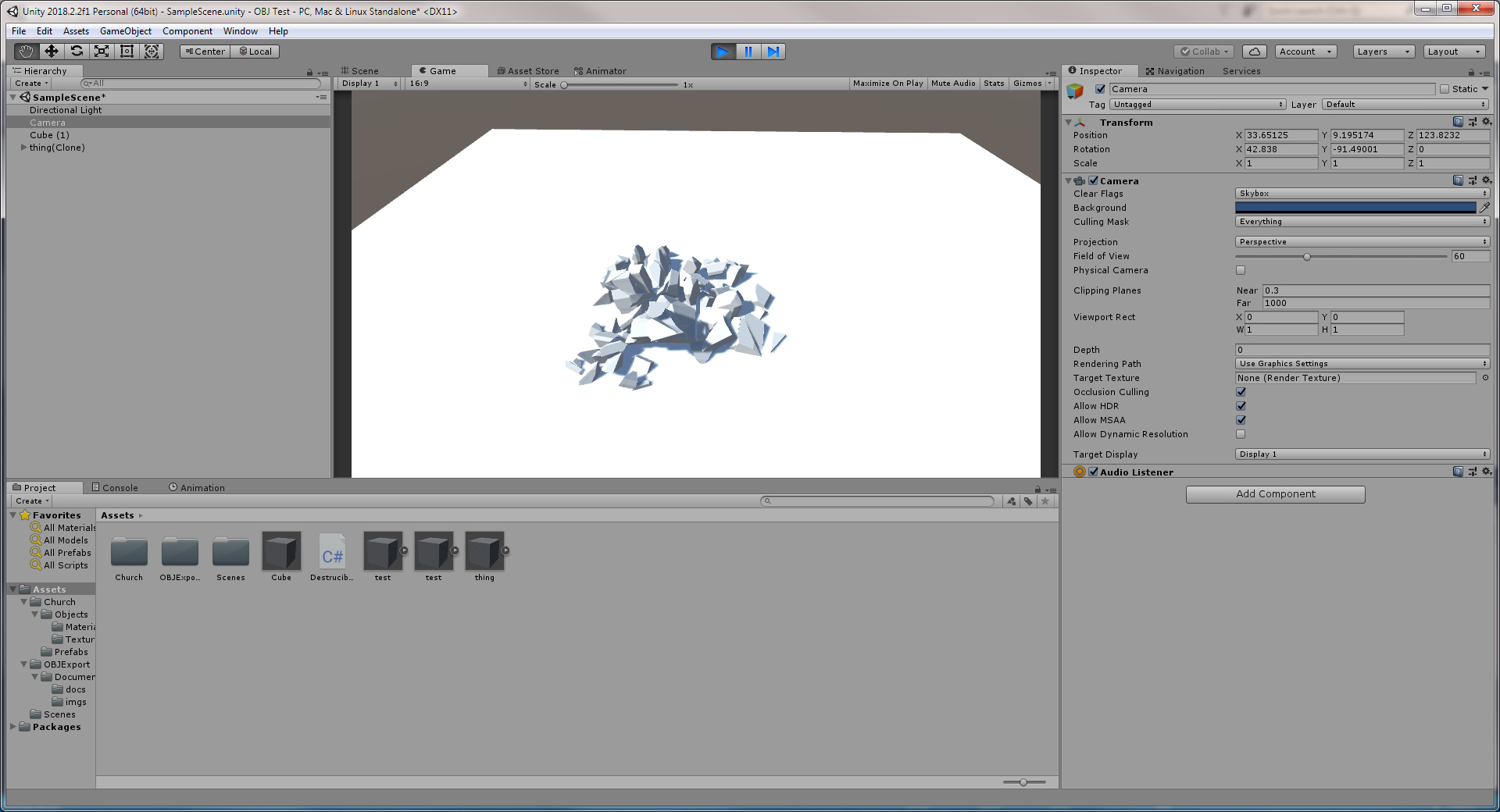


Figure 5 A simple cube shattering from gravity after being clicked on.

While the shatter (as seen in figure 5) is detailed for a rock like destruction, it does not reflect that of glass shatter or wood splinter effect.

Blender does incorporate a surface shatter which for flat objects yields a glass effect. It is not applied throughout the whole object.

## **How to shatter in Unity?**

Afterwards a premade tool allowing objects to be cut was discovered.

This being essential, as objects that shatter are required to break into pieces, this is covered in a simple manor with mesh alteration in the cut.

(BLINDED-AM-ME, 2018)’s MeshCut and MeshMaker class were downloaded and implemented using an array of game objects that stored the output.

**Pseudocode**

IF (Button pressed Cut desired object at entered angle)

FOR (Each piece generated from the cut)

Give each piece a rigid body and collider

ENDFOR

END IF

**Inside Cut**

FOR (Each submesh in cut object)

Copy the mesh vertices, UV’s, normals and tangents over to the correct side of the cut based on where the object and blade are positioned.

IF (Object vertices no longer form a triangle cut the triangle of the object)

Move onto next face

ENDIF

ENDFOR

Copy materials from original object to new ones.

Add a cap to fill the missing side between objects.

Create new objects.

END

All the code below the cut adds a collider, gives the objects physics and prevents falling through the floor via gravity.

Figure 4 This cube upon the click of the mouse

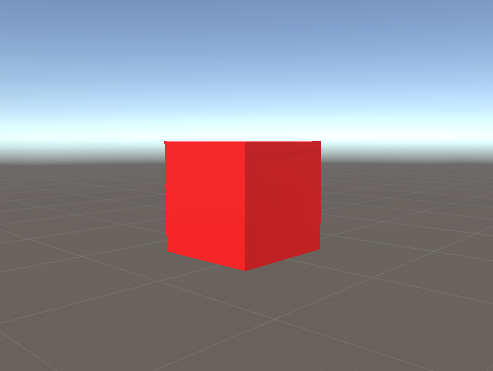


Figure 5 Is cut in two

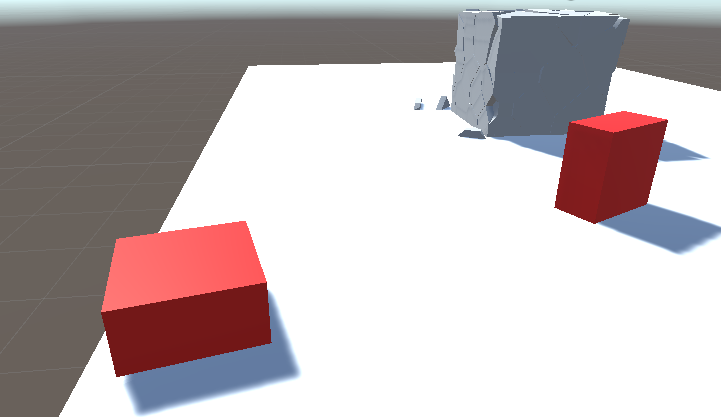
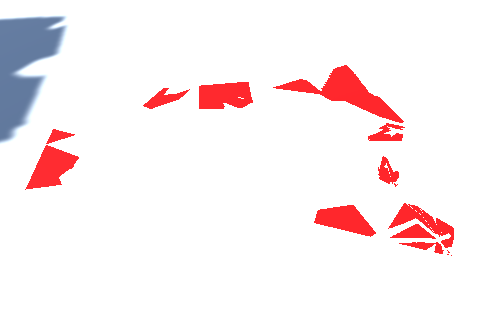


Figure 6 Although, multiple clicks results in only shaving triangles of the object.



However, with the code provided in the classes used, gives insight into the mesh logic and can be extracted.

A copy of the scripts object mesh is made. A “blades” position is established based on the script’s gameobject and inverted direction passed into the function.

The second class, Mesh Maker, is then used to instantiate two objects representing the new objects that will be made as a result of the cut.

Mesh Maker includes all core data for a mesh such as vertices, normal and UV’s (as well as tangents) of the two new objects.

A main function being AddTriangle which creates a new face for the shape using passed core data mentioned above.

The victims mesh is used to create the new one. The new triangles are added to the mesh maker objects Vector arrays containing core information.

The new meshes created are based on the modified mesh maker values.

The original victim is used for the left side. For the right side, a new object is created using the modified right half mesh maker object.

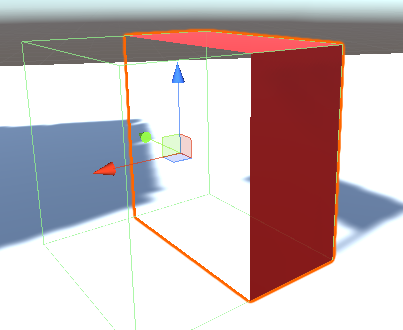
If the triangle sides detected by the blade are not on the same side of a plane as each other, then the triangle at the core is cut.

This means as the information is fed into the leftSide and rightSide vectors the original object is deleted face by face as the counter is incremented.

The materials are copied from the original and then allocated to the new objects.

A function called Capping is run. This recreates the face at the cut to connect all the other faces, forming the original shape.

i.e. without this function a 5 sided cube is produced.



Capping copied the vertices from the initial cut.

The ‘cap’ is filled. The blades normal is used for producing the faces normal.

UV’s use the centre, which is divided by the number of vertices total

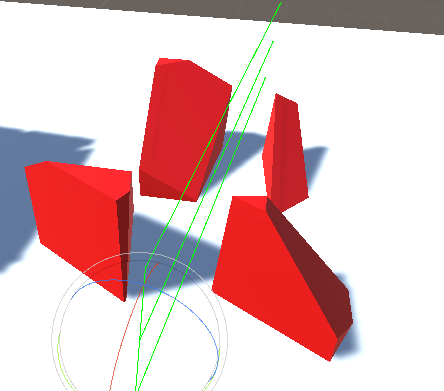
Displacement uses the centre and the combination of vectors displacement and direction inside of Dot to create the UV vector.

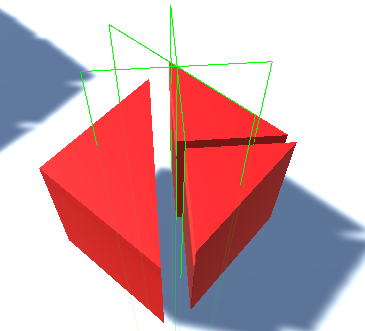
This function flips the caps depending on what side is capped. This is done by swapping vertices, normals and tangents around.

The add triangle function is used again to fill cap vertex

When the blade is used from (W., 2015), the coordinates are more detailed than a mouse’s position.

This removed the issue before where vertices would disappear and thin slices of cube were removed after the initial cut.

This resulted in:  


With multiple blades in formation, they could be made to create different combinations of destruction.  
  
However, in testing this proved difficult.  
  


This combination should have produced six pieces, but only produced three.

# Evaluation

Currently, using logic from the (BLINDED-AM-ME, 2018) code base allows some of the desired effects, as shattering an object includes effectively cutting it into multiple pieces. However, the tool only supports cutting the first object hit by the ray cast.

For the demo, pieces should be produced by multiple blades simultaneously to allow a shatter like the Blender cube shattered prior.

The ordering of the blades based on the material selected will be the final goal.

This will likely involve storing all blades in an array and processing each one gradually in one key press

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| --- | --- | --- | --- |
| 16008335,  Jack Watson | Destructive Environments | | |
| 07/11/2018 | Look into basic logic for destruction | Looked into industry tools such as Maya and Blender and created a shattered cube using. This was then imported and destroyed in unity | How does Blender create the shattered cube?  How will this operate in Unity? |
| 15/11/2018 | Creating examples of aims in other editors  such as Maya or Blender, then observing the structures of the meshes in Unity | Documentation for how Blender Cell Fracture could not be found. Instead a Cut tool in Unity was discovered. | How do meshes wok in Unity? |
| 21/11/2018 | Looking into Unity script further that cuts game objects in two.  Logic for altering meshes could be reverse engineered and used. | Tool is very intricate and barebones, refining it would be inefficient as the bare minimum required to perform a cut has been established, code cannot be shortened lightly.  Instead base blade logic will be used and how and where the cut occurs will determine the output. | How to use the blade for different materials destruction? |
| 11/12/2018 | Add support for multiple blades and patterns.  Adding final touches to report. | Code replaced with pseudocode to generalise and shorten the algorithm before an in depth description is presented.  The blades do not work separately and simultaneously. Resulting in only 4 pieces when there should be six.  A different approach using the blades will be need for the demo. | How to create a “cookie cutter” blade formation to procedurally generate a new shattered object?  Should the objects have a shattered prefab outputted by the code or be instantiated in runtime? |

# Bibliography

BLINDED-AM-ME. (2018, April 15). *Unity Assets*. Retrieved November 18, 2018, from Github[online]: https://github.com/BLINDED-AM-ME/UnityAssets

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DanielFilms. (2017, April). *How to make objects shatter in blender*[online]. Retrieved October 29, 2018, from Youtube: https://www.youtube.com/watch?v=SlJEInN\_Els

Games, B. t. (2016, September 15). *Procedural Mesh Tutorial, Part 4: All About Vertices* [online]. Retrieved December 06, 2018, from Youtube: https://www.youtube.com/watch?v=IJ9Tla\_Q4gk

W., D. (2015, September 13). *Unity simple Mesh cutting Code* [online]. Retrieved December 07, 2018, from Youtube: https://youtu.be/xgoUmrhXyYE