Procedural 3D Modeling using Unity3D

Hyungki Kim

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Me

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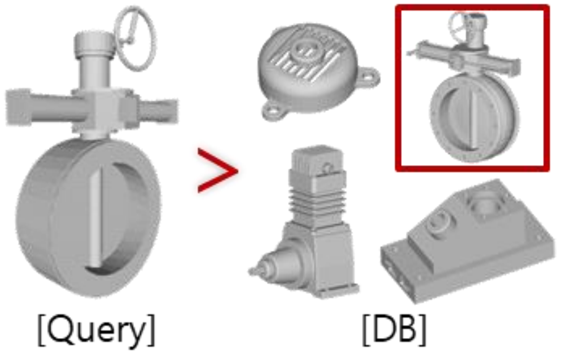
  - https://sites.google.com/site/diskhkme/
  - Ph.D. 2015, iCAD Lab (Adviser : Soonghun Han)

Research field

3D modeling

Visualization

Comp. Geometry



VR / Simulation

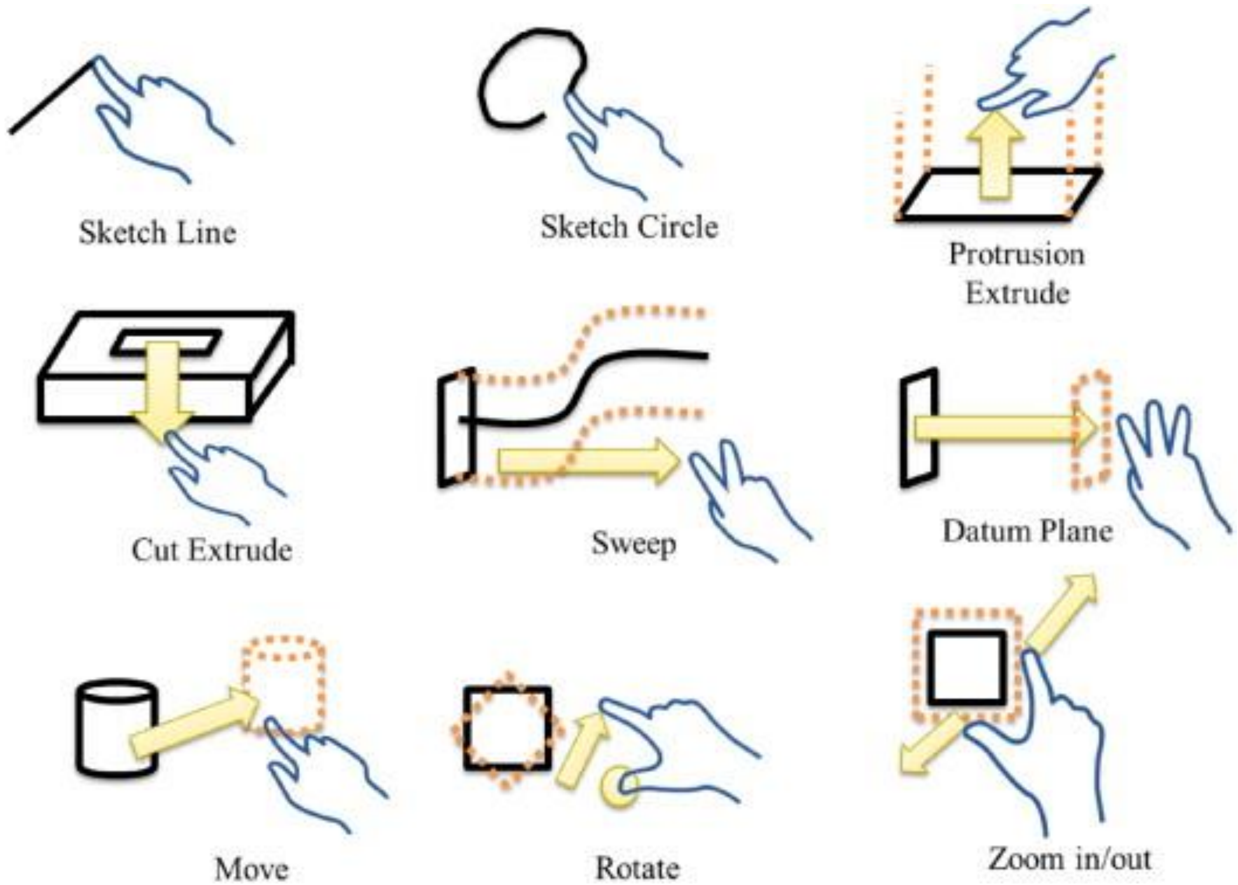
Today's Topic

- Related research
  - Background
  - Geometric modeling kernel
- Mesh generation in Unity3D
  - Extrude operation
  - Sketch feature
- Other approaches

Related Research

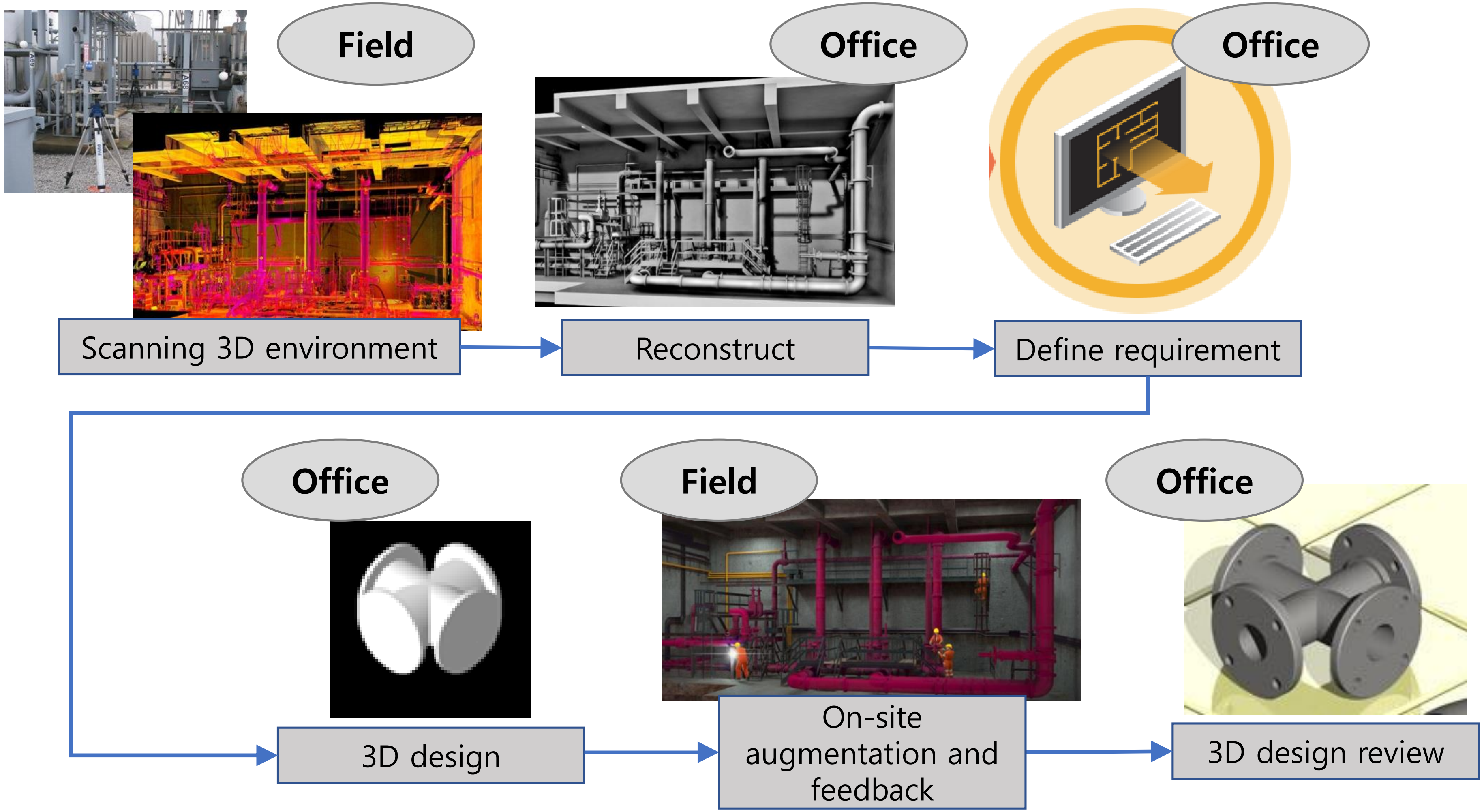
Background

- Yuna Kang, Hyungki Kim, Hiromasa Suzuki, Soonhung Han "Editing 3D Models on Smart Devices", *Computer-Aided Design*, 59, pp.229-238, 2015.02.01



Motivation

- On-site design system using smart device



Field

Scanning 3D environment

Office

Reconstruct

Office

Define requirement

Office

3D design

Field

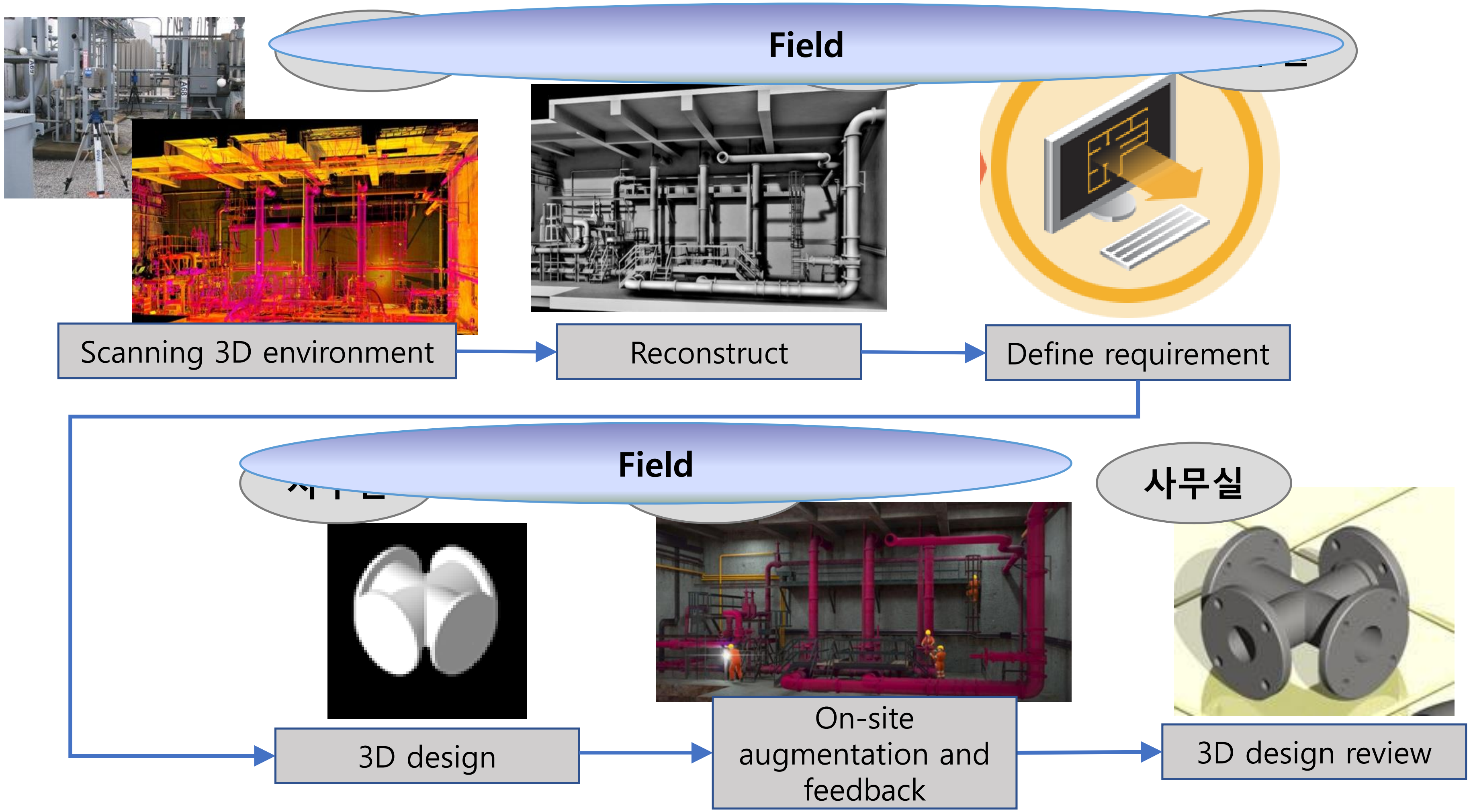
On-site augmentation and feedback

Office

3D design review

Motivation

- On-site design system using smart device



Field

Scanning 3D environment

Reconstruct

Define requirement

Field

사무실

3D design

On-site augmentation and feedback

3D design review

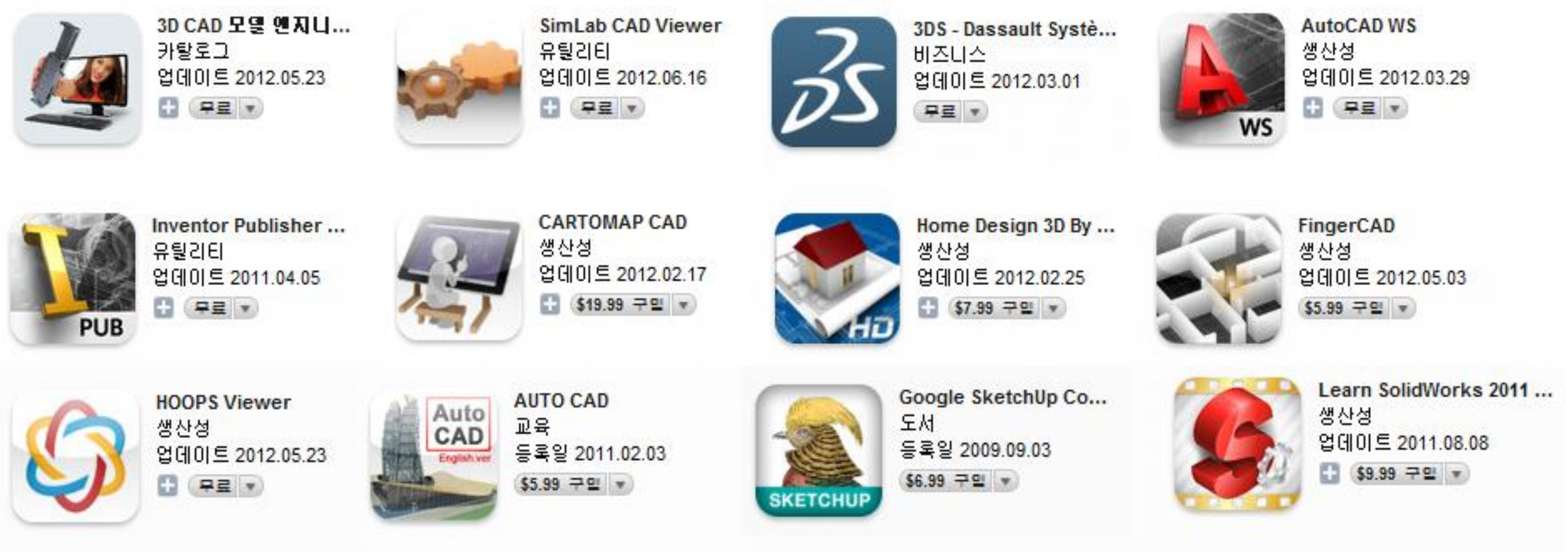
Motivation

- On-site design system using smart device
  - Portability
  - Sensors
  - One of the major platform for augmented reality

  - (Low) Computing power
  - Touch screen input
  - Small screen

Motivation

- (In past) CAD-related application on android
  - CAD viewer
  - Assembly modeling
  - 2D CAD modeling



3D CAD 모델 엔지니...
카탈로그
업데이트 2012.05.23
무료

SimLab CAD Viewer
유틸리티
업데이트 2012.06.16
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3DS - Dassault Systè...
비즈니스
업데이트 2012.03.01
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AutoCAD WS
생산성
업데이트 2012.03.29
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Inventor Publisher ...
유틸리티
업데이트 2011.04.05
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CARTOMAP CAD
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HOOPS Viewer
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AUTO CAD
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Learn SolidWorks 2011 ...
생산성
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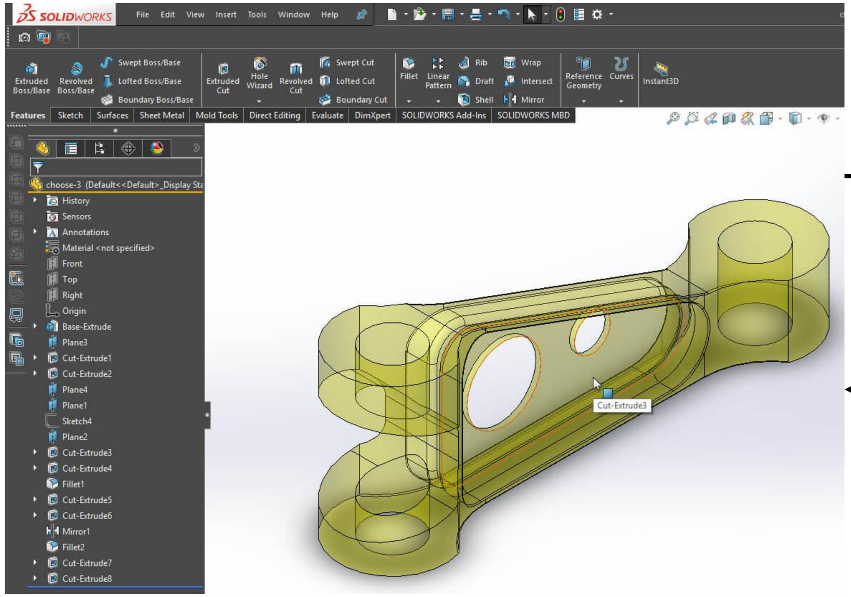
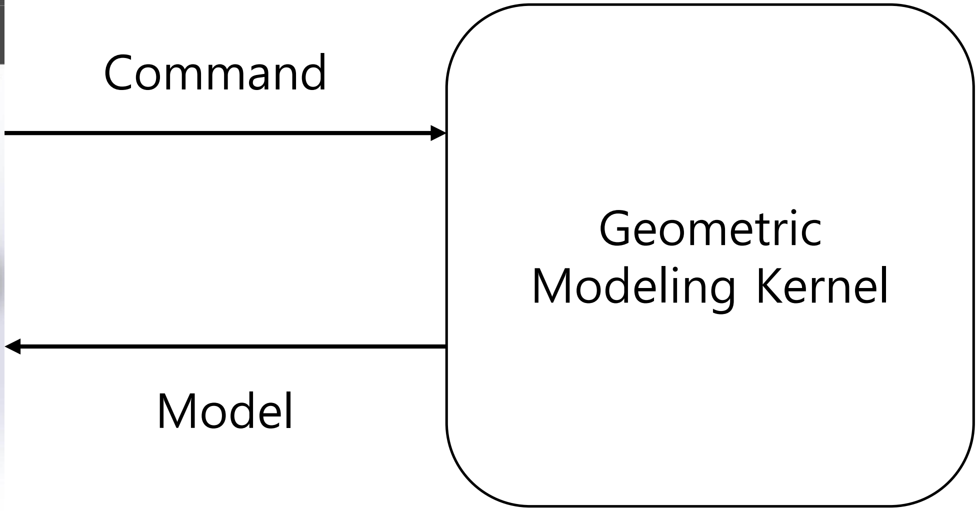
Geometric Modeling Kernel

- Key component of CAD software
  - Other components in CAD : Constraint solver, visualization, GUI and many more…
- Solid(often including high level feature) and surface modeling feature

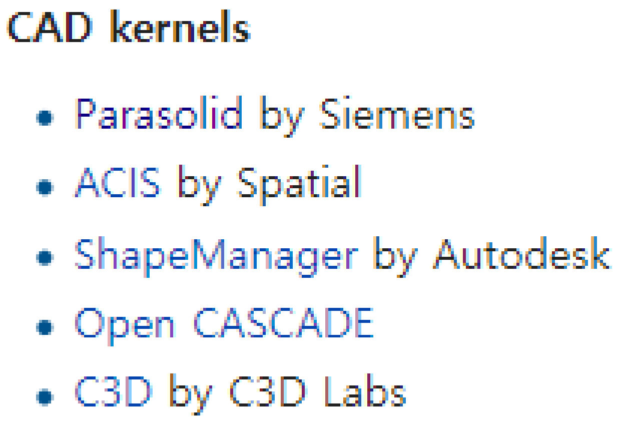




Caution! It's a extremely simplified figure!

Geometric Modeling Kernel

- Existing geometric modeling kernels
  - CAD software and their kernels
    - ➢ https://en.wikipedia.org/wiki/Geometric_modeling_kernel#cite_note-23
  - Introductions on geometric modeling kernels, C3D
    - ➢ https://www.slideshare.net/ssuser389b50/c3d-labs-geometric-modeling-toolkit



CAD kernels

- Parasolid by Siemens
- ACIS by Spatial
- ShapeManager by Autodesk
- Open CASCADE
- C3D by C3D Labs

Problems

- No geometric modeling kernel for android/iOS platform
  - Low computing power
  - Supply and demand…
- Touch screen cannot handle precise input
  - Low productivity
  - Compared with keyboard + mouse input

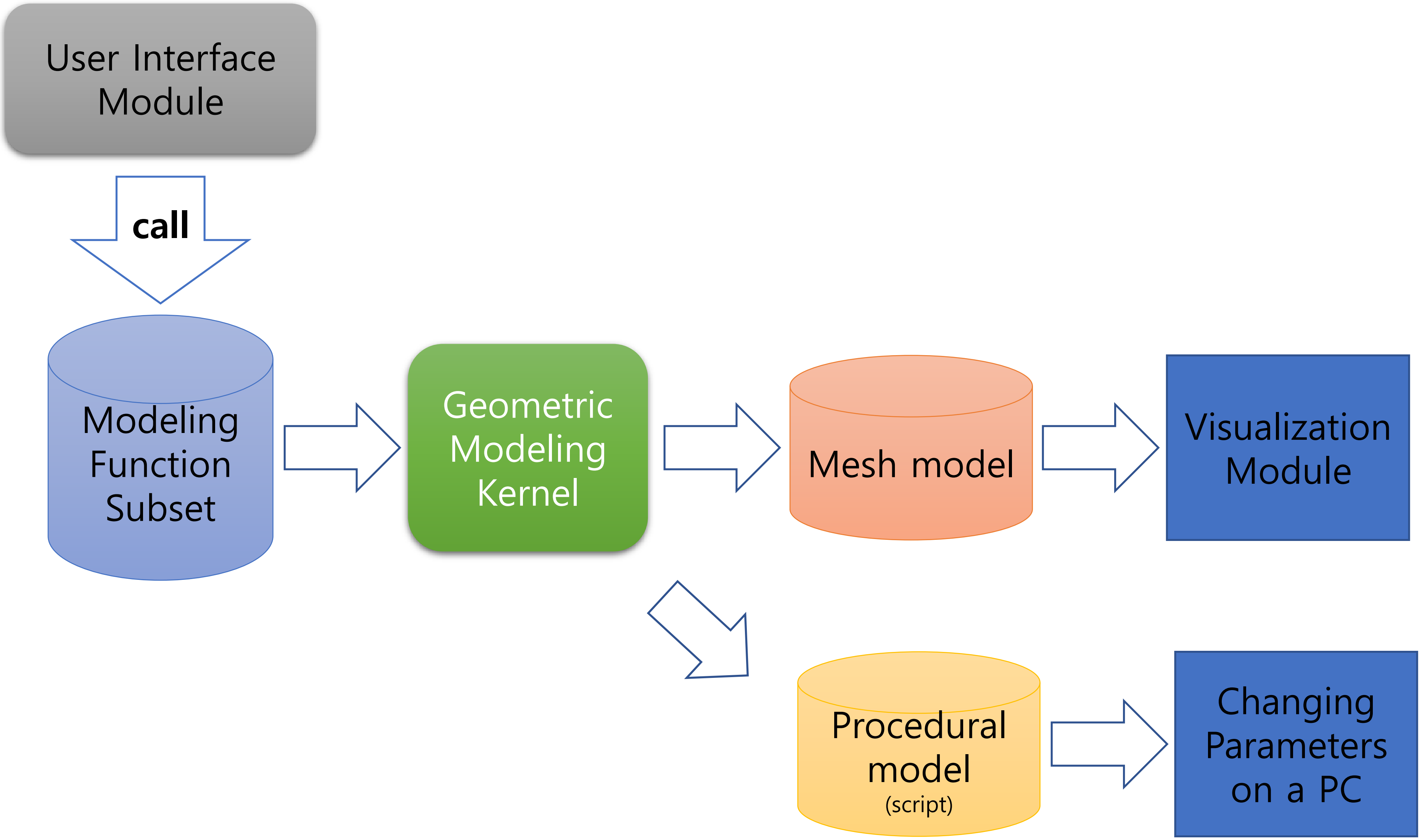
Proposed method

- No geometric modeling kernel for android/iOS platform
  - Define subset of modeling feature
  - Small modeling kernel based on mesh
  - Store modeling command / post-editing on PC CAD
- Touch screen cannot handle precise input
  - Design UI using multi-touch input and sensor

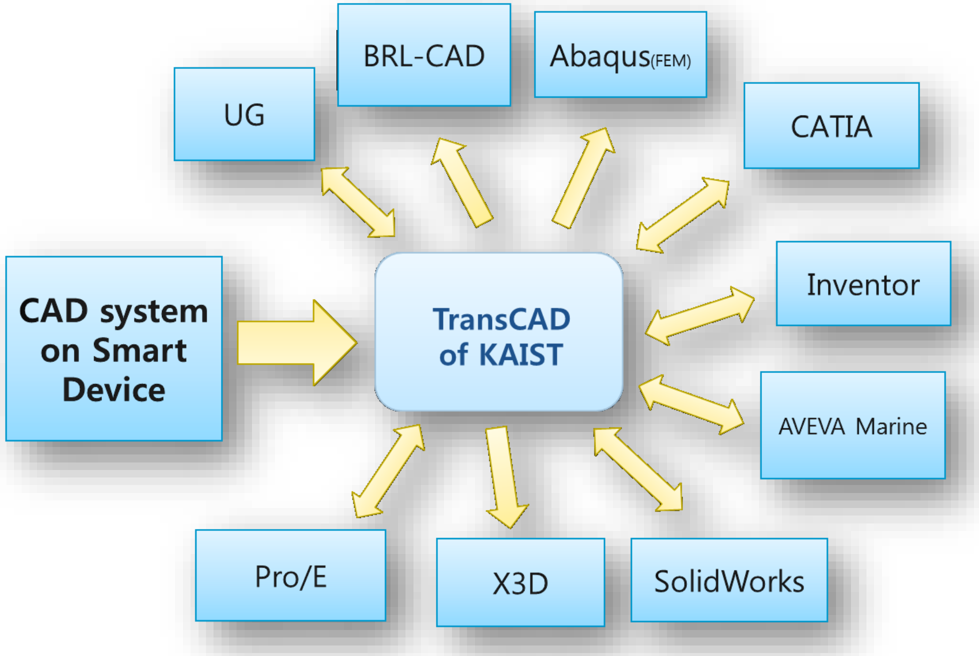
Proposed method

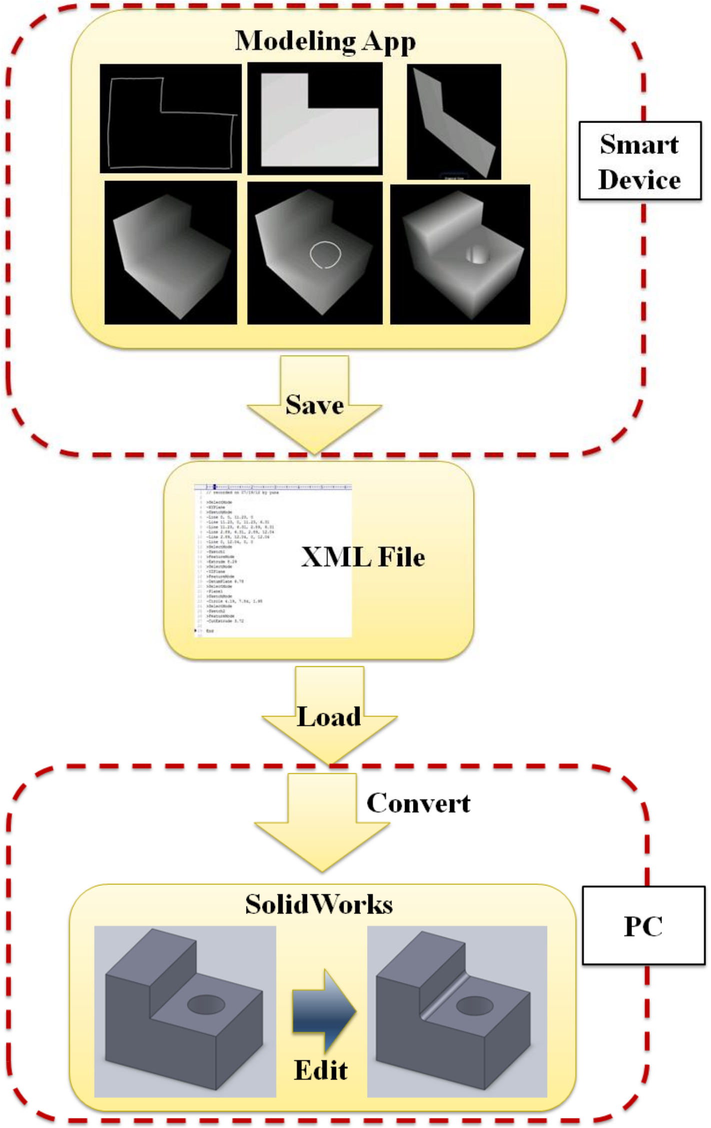
- No geometric modeling kernel for android/iOS platform
  - Define subset of modeling feature
  - **Small modeling kernel based on mesh ← Today's topic**
  - Store modeling command / post-editing on PC CAD
- Touch screen cannot handle precise input
  - Design UI using multi-touch input and sensor

Proposed System

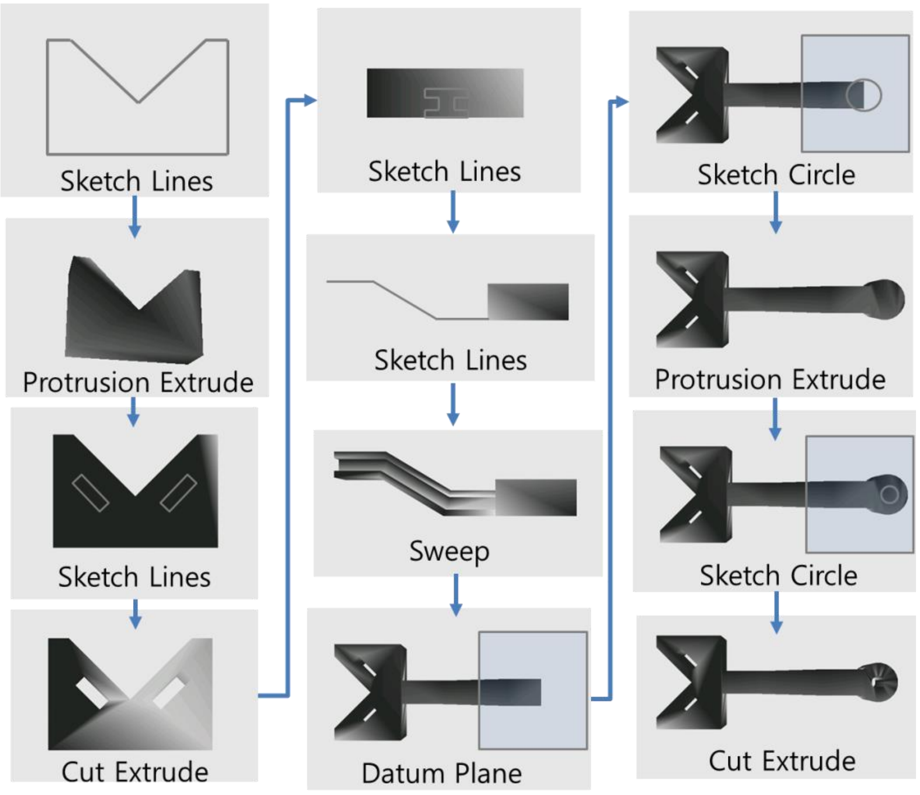


Proposed System

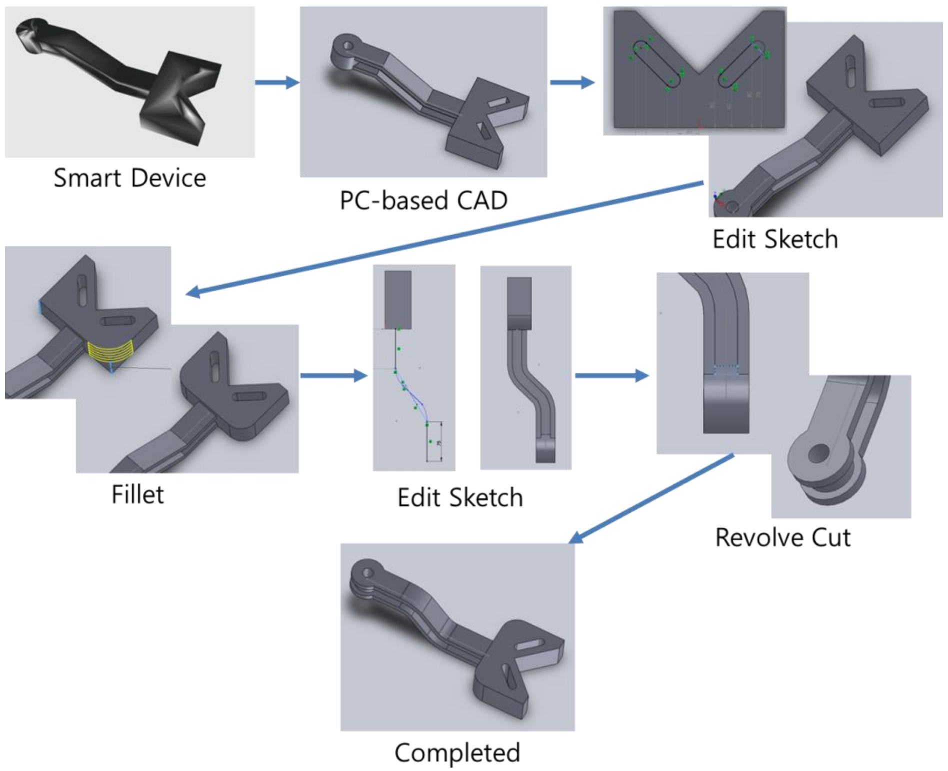




Proposed System



Modeling on a smart device

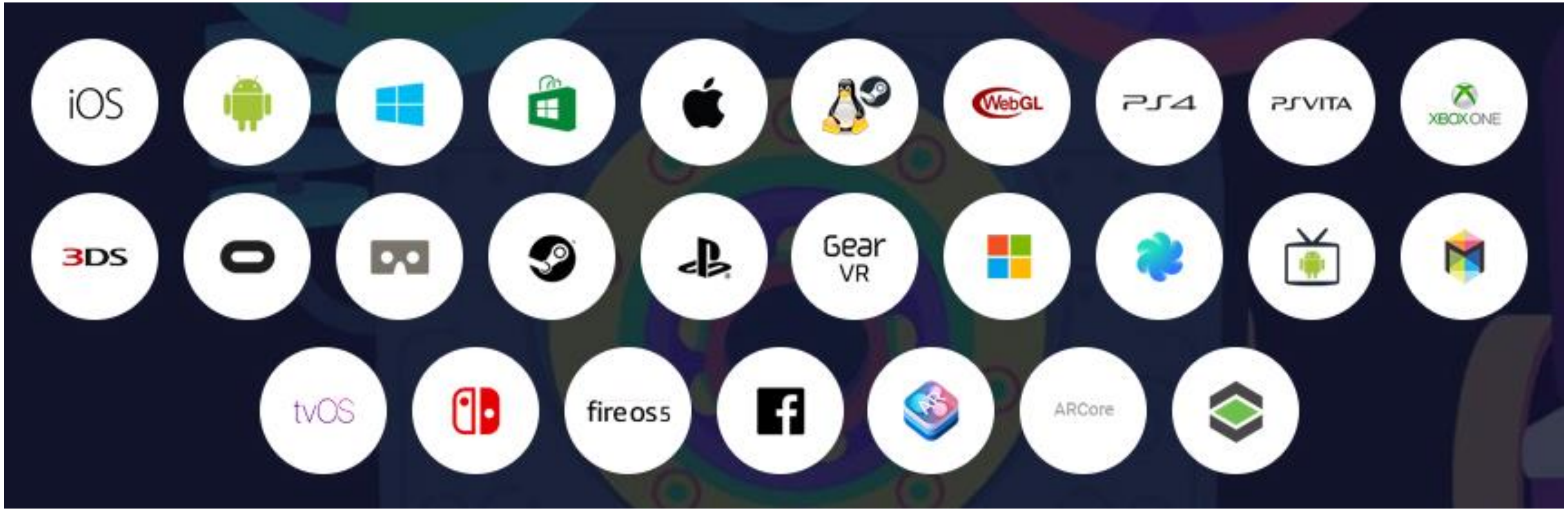


Editing parameters on a PC

Mesh Generation in Unity3D

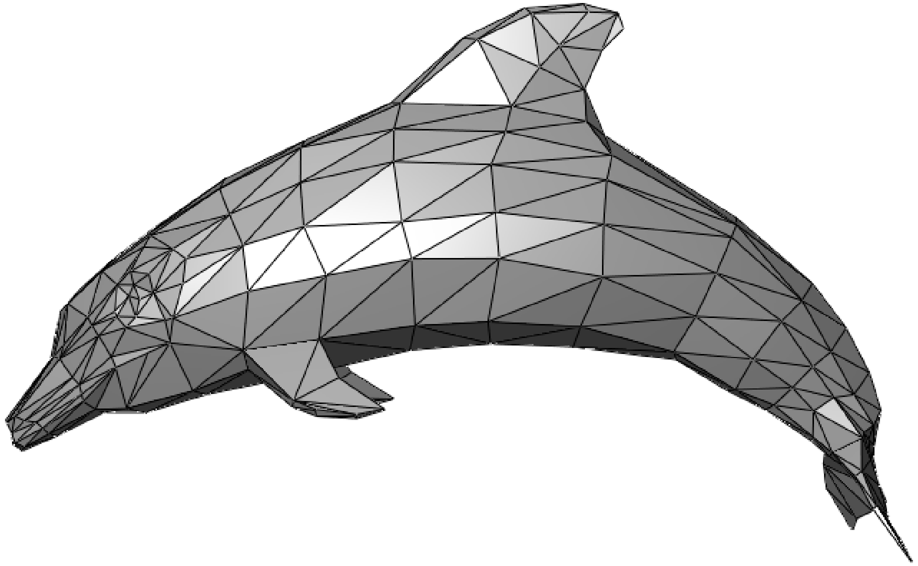
Unity3D

- Game engine
  - Authoring tool for 2D/3D game
  - Rendering engine + Physics engine + networking + input handling + sound + AI + etc
  - Multi-platform release



Mesh data structure

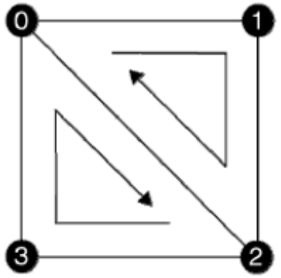
- Most common data structure in computer graphics field, to represent surface of 3D geometry
- Triangular mesh is most efficient data structure to visualize 3D surface using computer
- Triangle face is defined from vertices and their connections(edge)

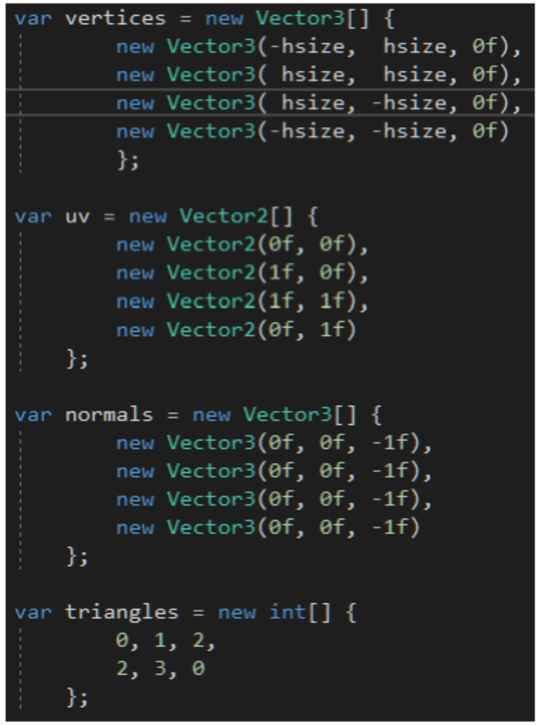


Mesh data structure

User-customizable primitives

- Quad.cs
  - Set of Vertex
  - Two Triangles = One quad
  - Order is important

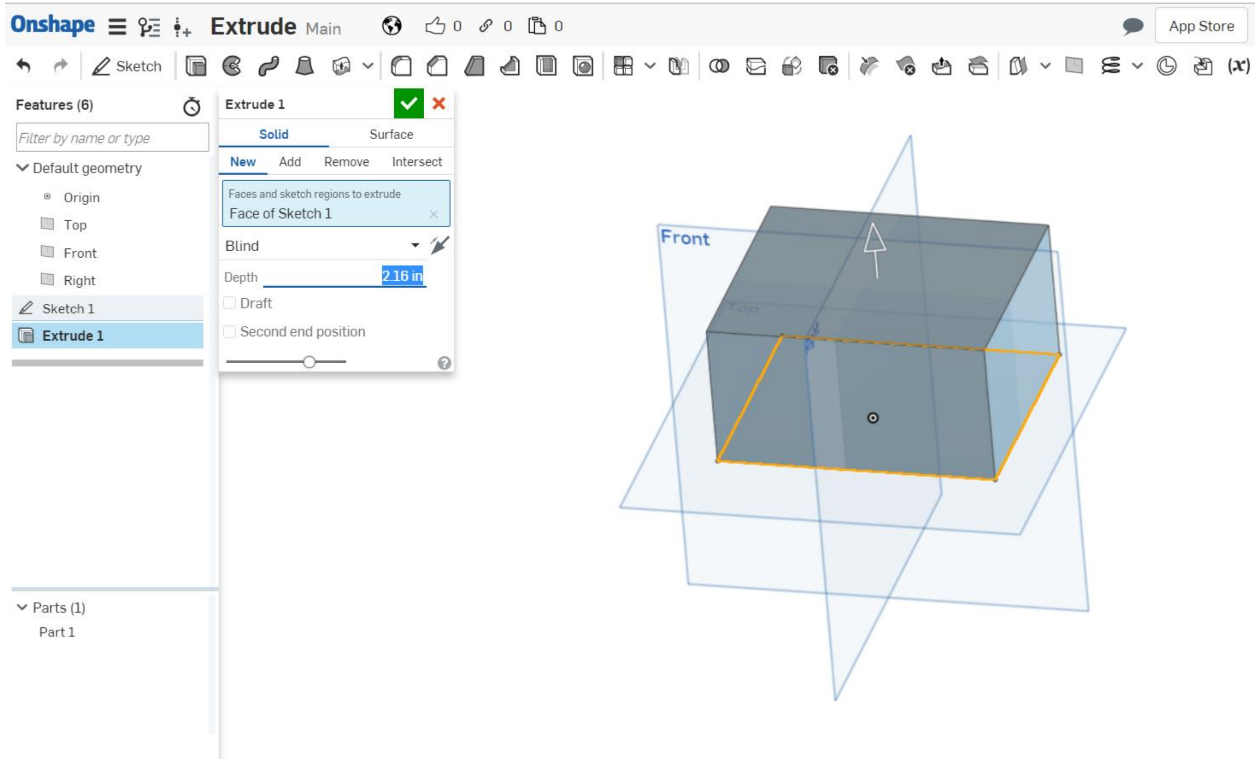




```
var vertices = new Vector3[] {
        new Vector3(-hsize,  hsize, 0f),
        new Vector3( hsize,  hsize, 0f),
        new Vector3( hsize, -hsize, 0f),
        new Vector3(-hsize, -hsize, 0f)
        };

var uv = new Vector2[] {
        new Vector2(0f, 0f),
        new Vector2(1f, 0f),
        new Vector2(1f, 1f),
        new Vector2(0f, 1f)
    };

var normals = new Vector3[] {
        new Vector3(0f, 0f, -1f),
        new Vector3(0f, 0f, -1f),
        new Vector3(0f, 0f, -1f),
        new Vector3(0f, 0f, -1f)
    };

var triangles = new int[] {
        0, 1, 2,
        2, 3, 0
    };
```

Extrude Operation

- Generate solid from profile



Extrude 1

Solid

New

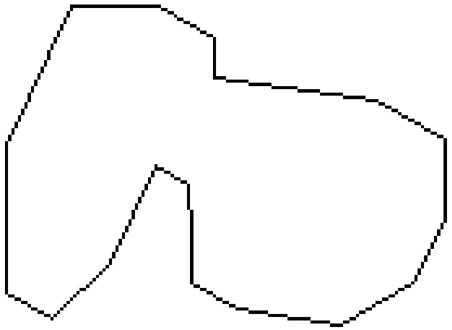
Faces and sketch regions to extrude: Face of Sketch 1

Blind

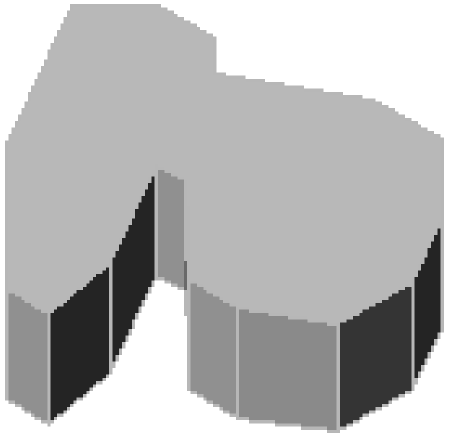
Depth 2.16 in

□ Draft

□ Second end position



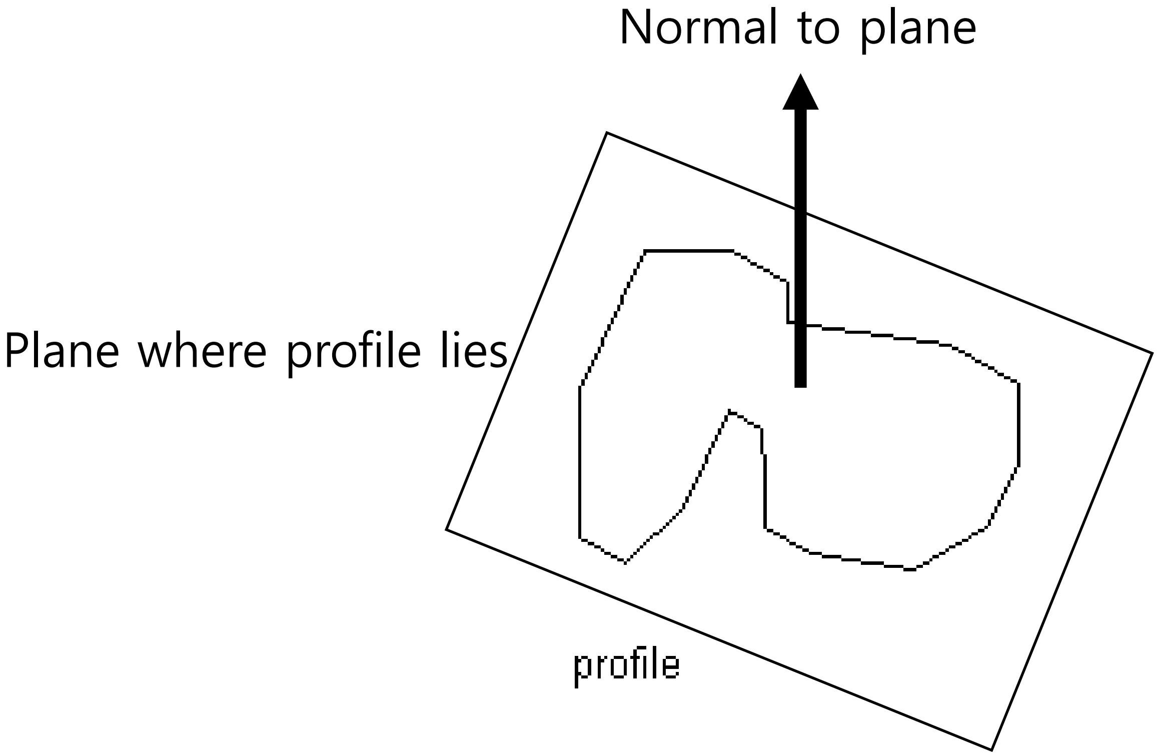
profile

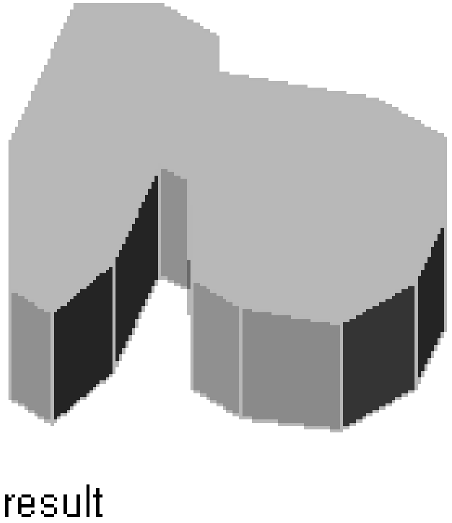


result

Basic Extrude Operation

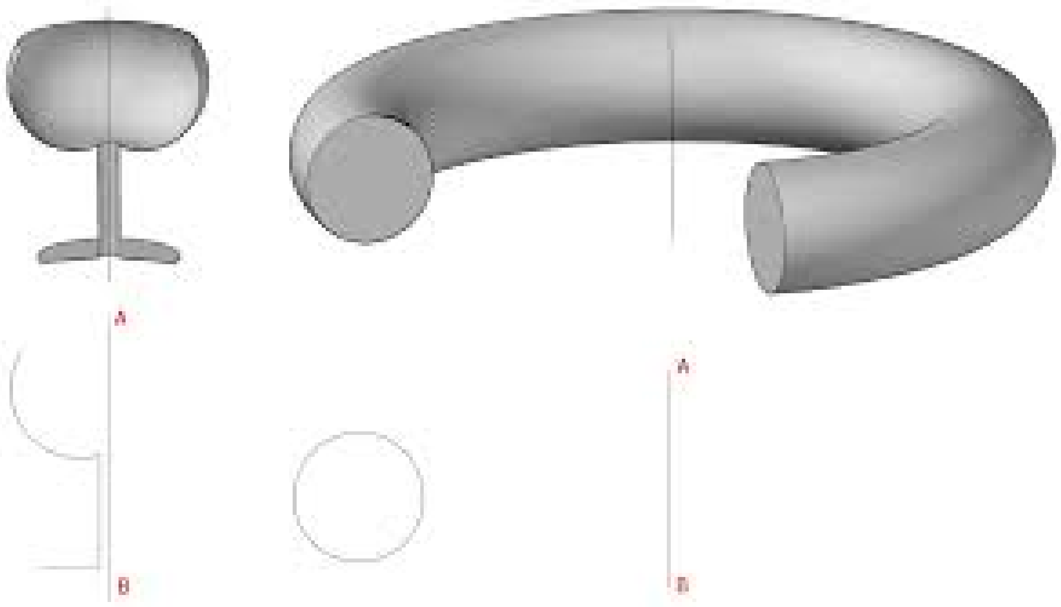
- Planar profile + extrude along normal to plane

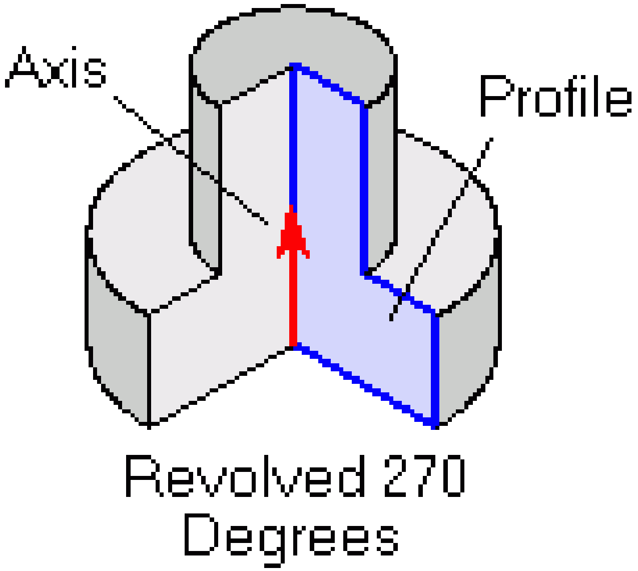




Extended Operation, Revolve

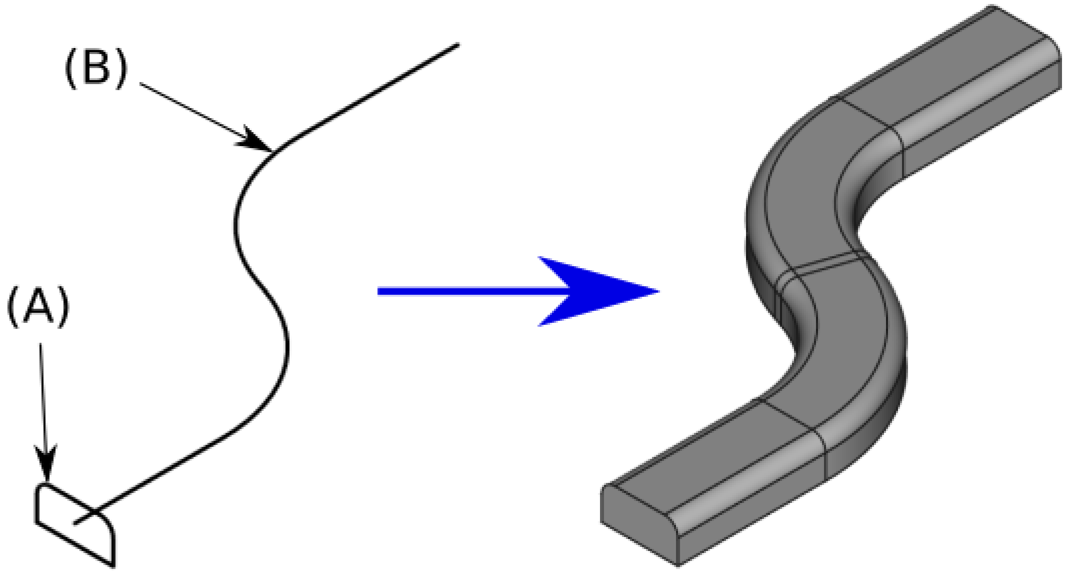
- Planar profile + circular path defined by axis

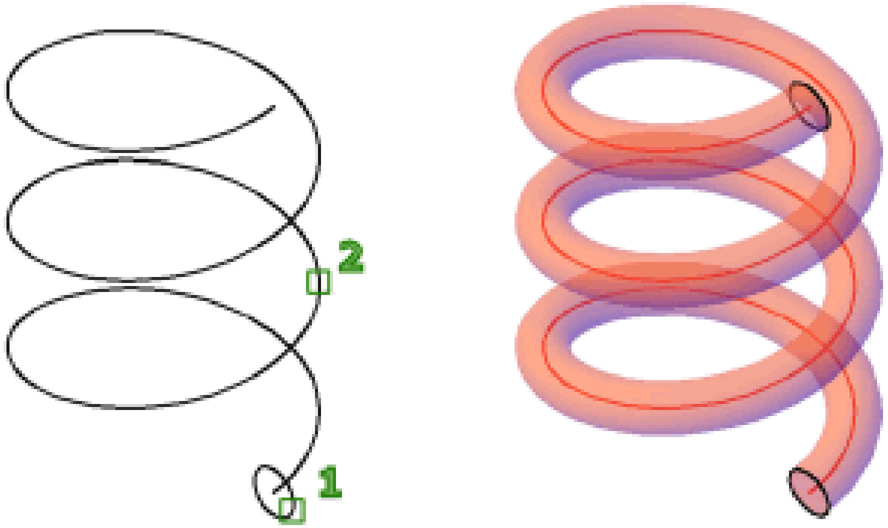




Extended Operation, Sweep

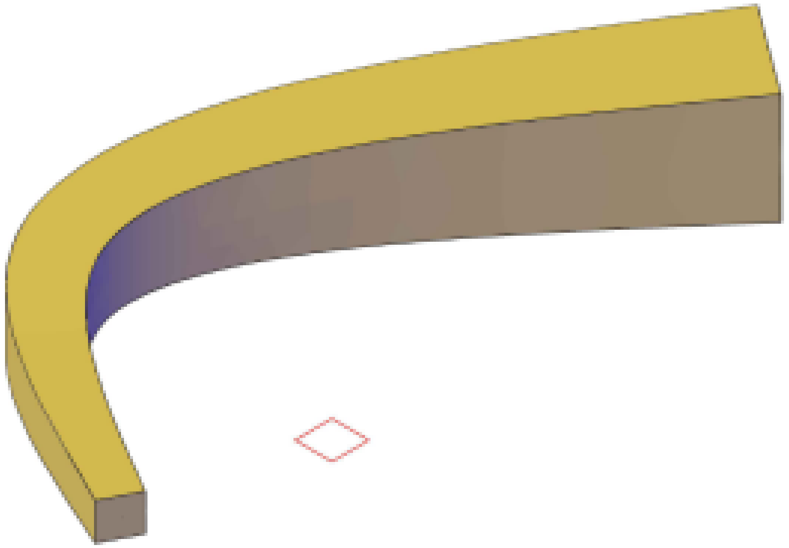
- Planar profile + path

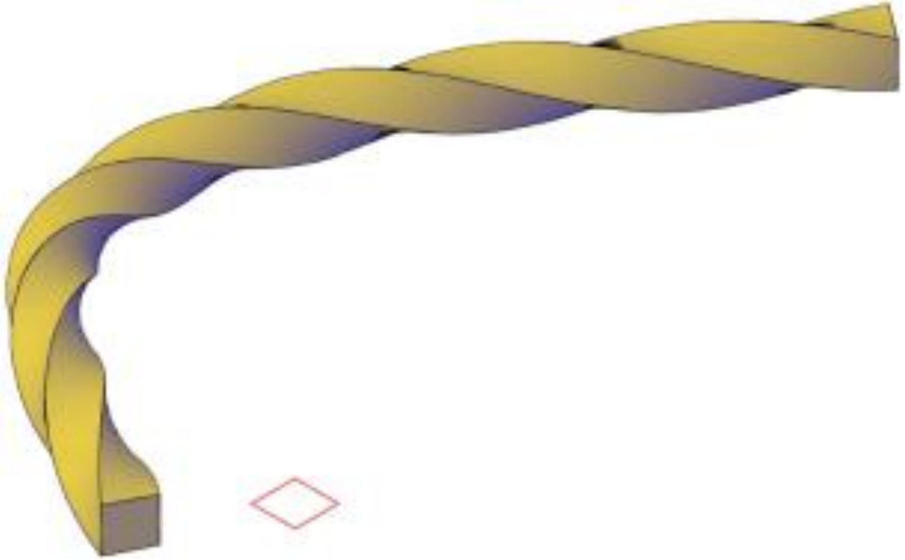




Extended Operation, Advanced Sweep

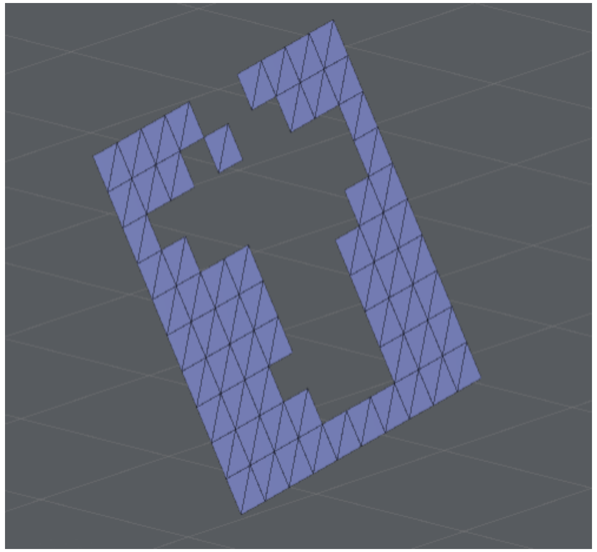
- (Planar) variable profile + path with angle property, etc…

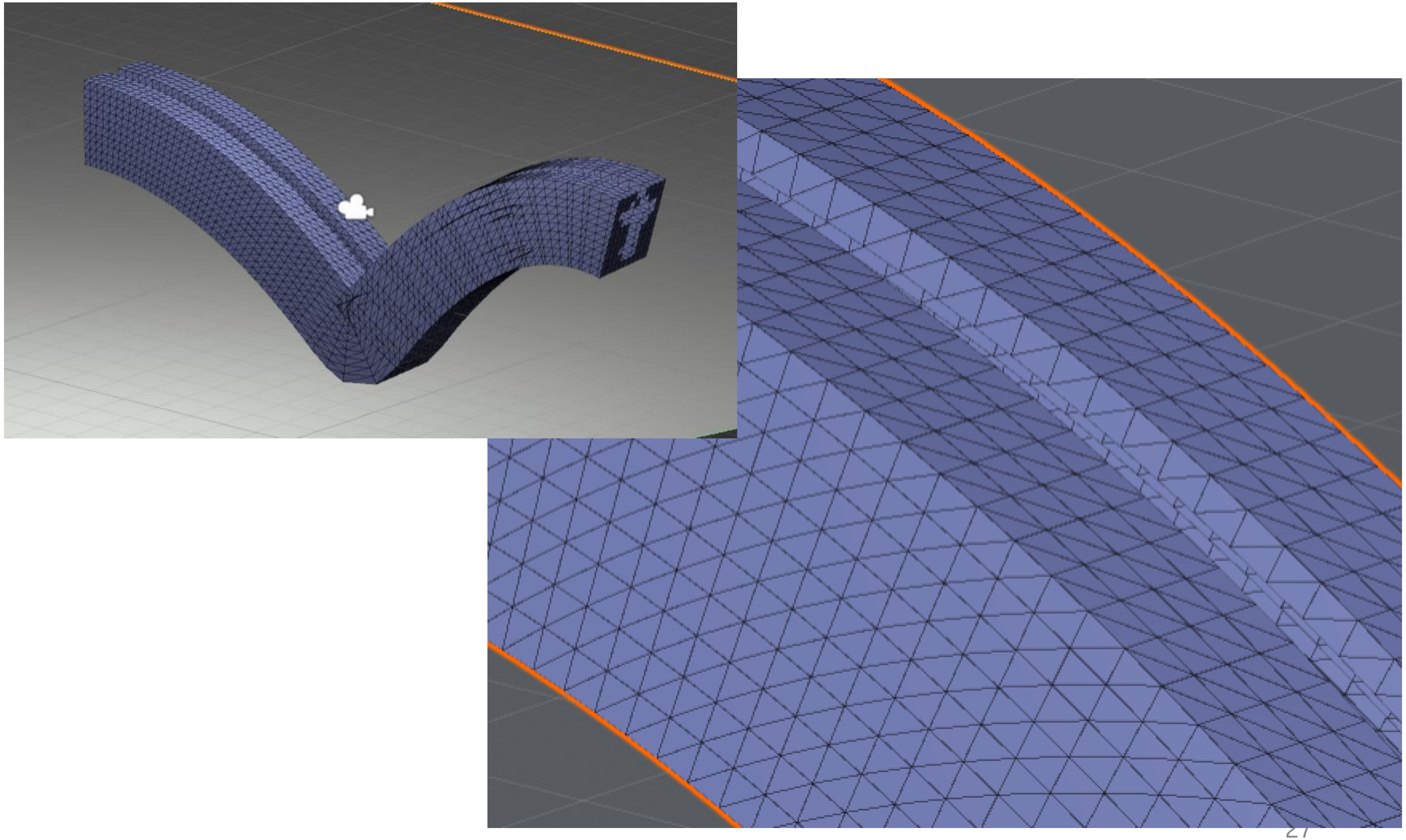




Extrude Example in Unity3D

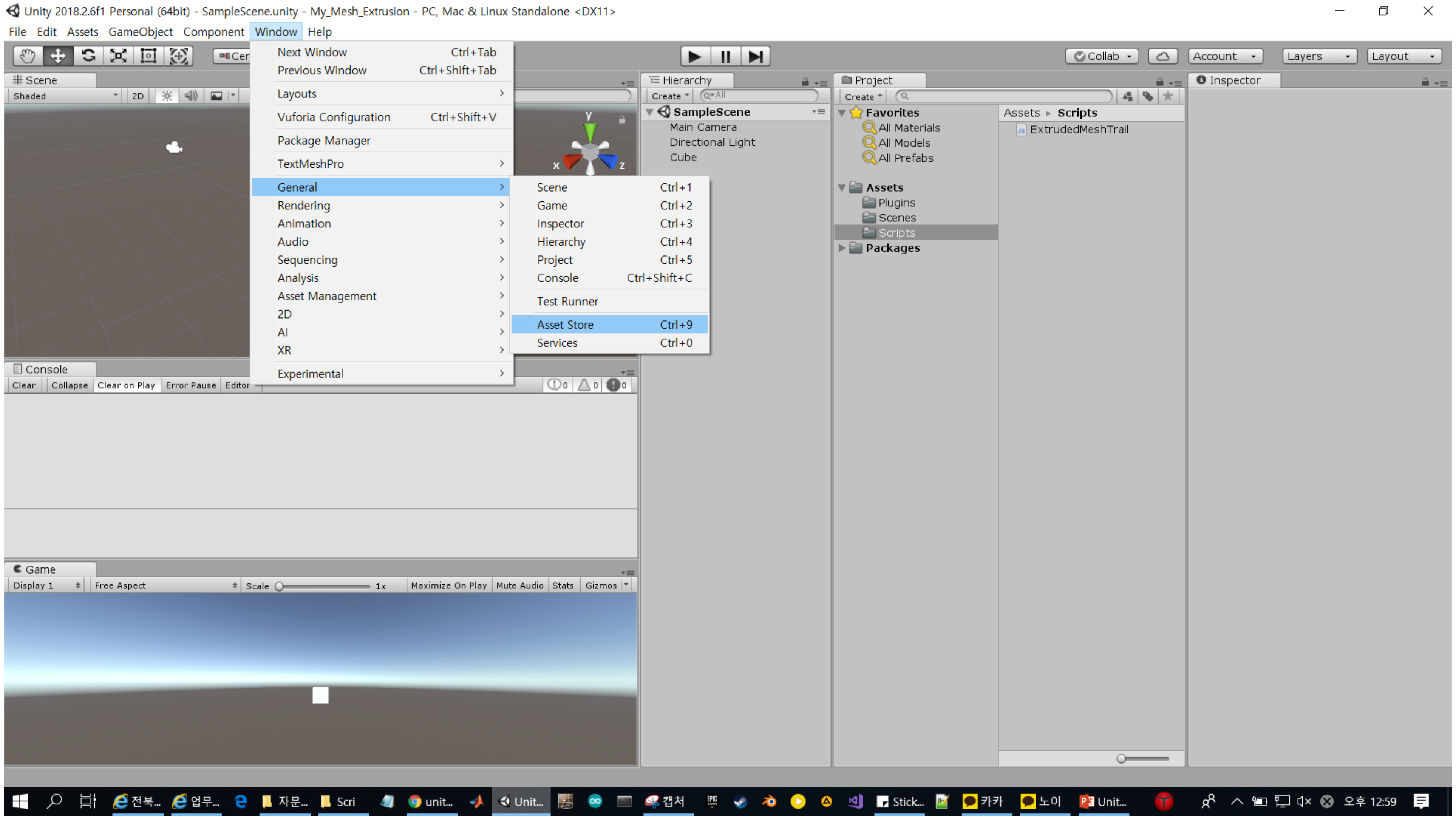
- Triangular mesh generation from set of rotated profiles and path sections





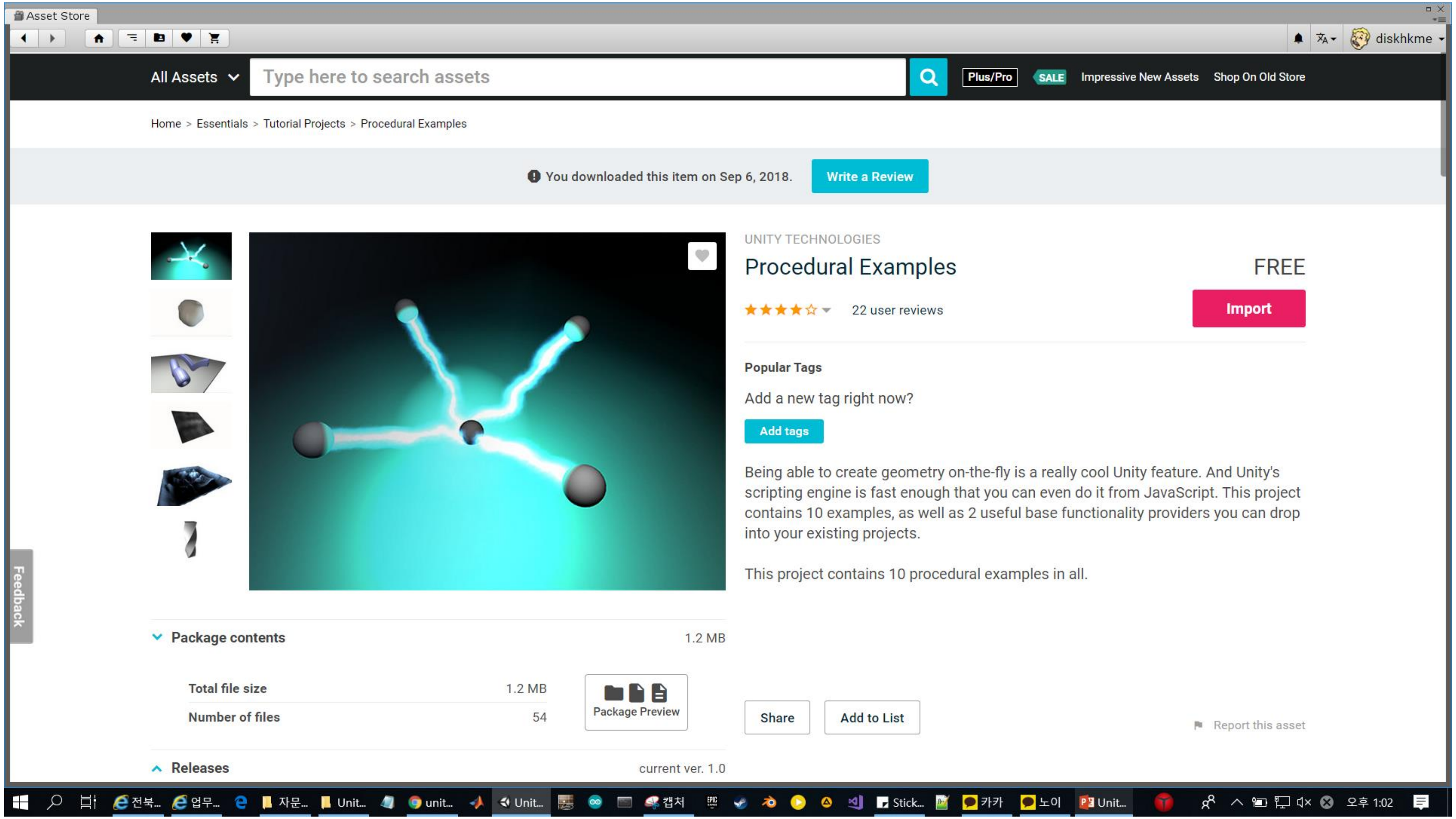
Source Asset Download

- Windows → General → Asset Store



Source Asset Download

- Search “procedural examples” and import



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Being able to create geometry on-the-fly is a really cool Unity feature. And Unity's scripting engine is fast enough that you can even do it from JavaScript. This project contains 10 examples, as well as 2 useful base functionality providers you can drop into your existing projects.

This project contains 10 procedural examples in all.

Package contents 1.2 MB

Total file size 1.2 MB

Number of files 54

Releases current ver. 1.0

Source Asset Download

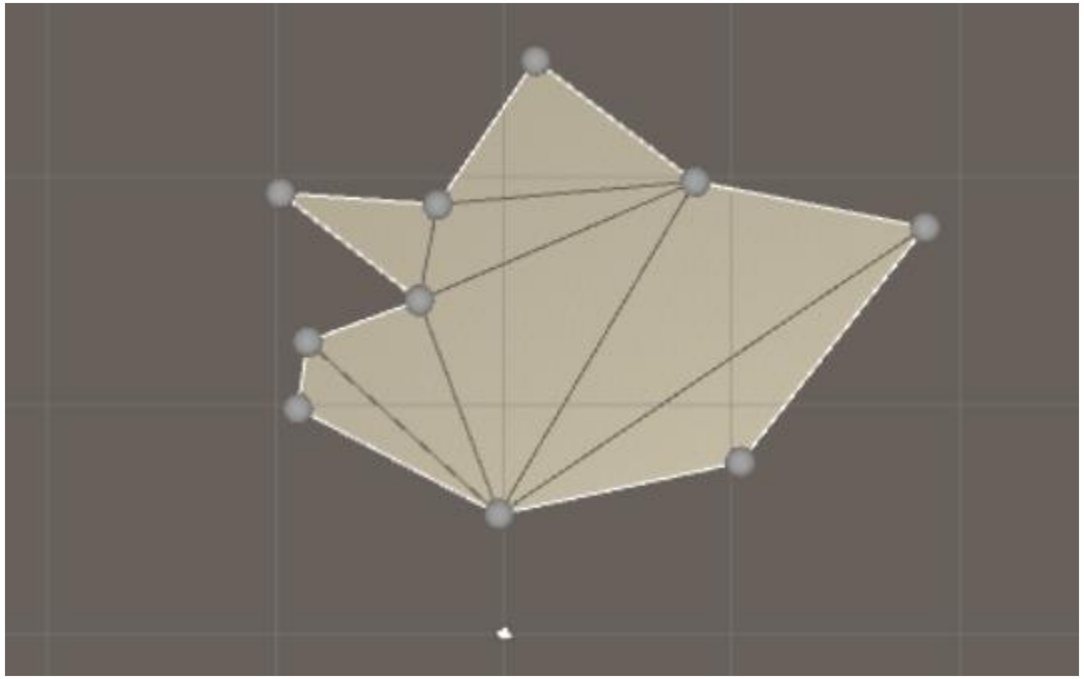
- In imported project folder, we need only two scripts to start
  - **Assets/Plugins/MeshExtrusion.cs**
    - Mesh generation from data
  - *Assets/Sources/ExtrudedMeshTrail.js*
    - Feed data from gameobject

- We will replace second script with our implementation

Simple Live Explanation on MeshExtrusion.cs

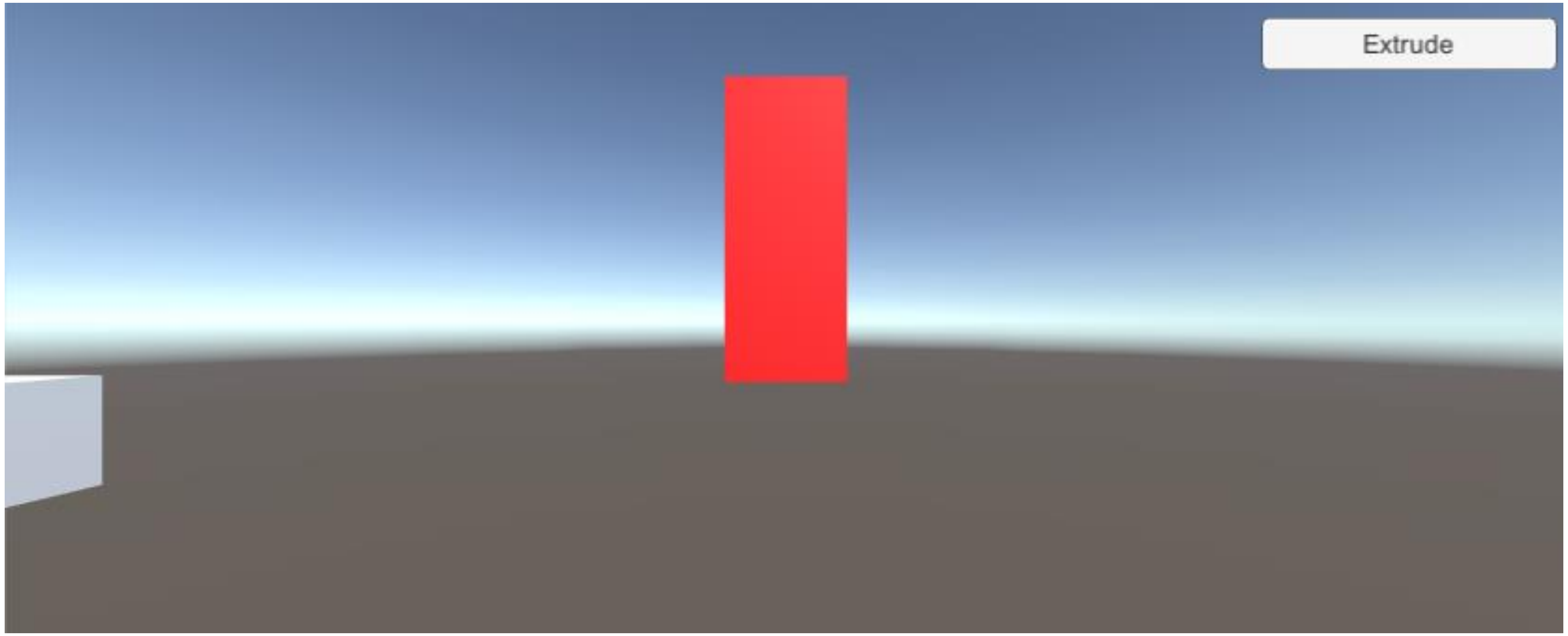
Triangulator.cs

- To reuse MeshExtrusion script without modification, we need triangulator
  - http://wiki.unity3d.com/index.php/Triangulator
  - Vertices to planar mesh



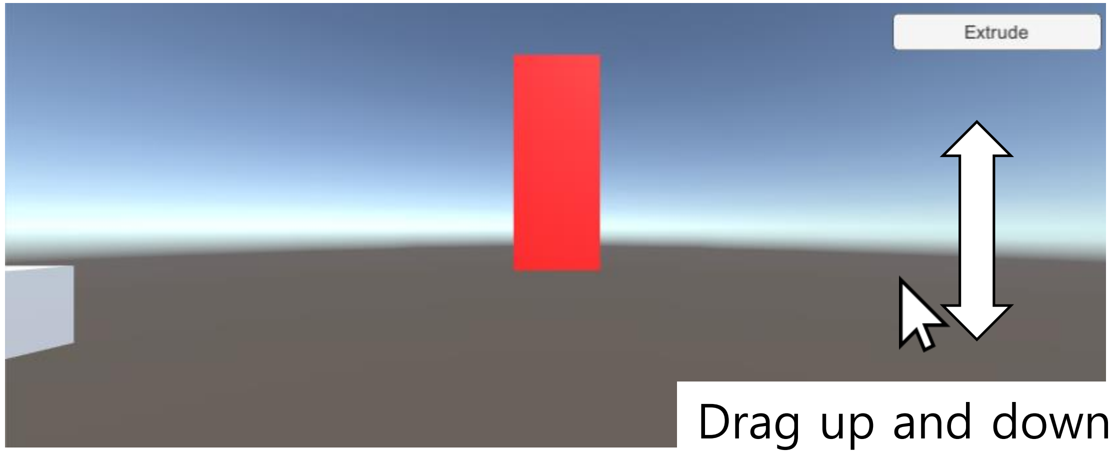
BuildMesh.cs

- From the start of the application, extrude mesh from planar rectangle sketch to generate cube in the scene
  - Start() function

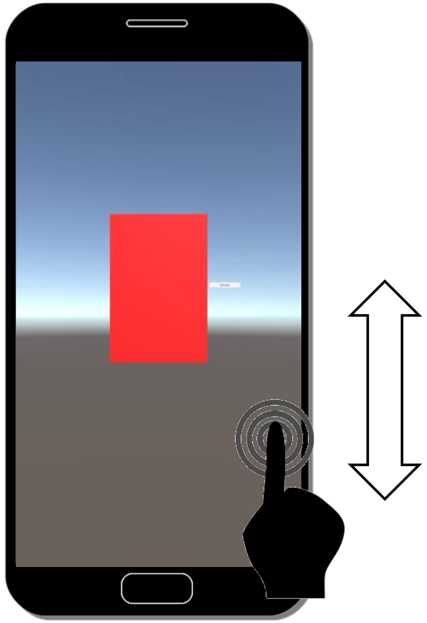


BuildMesh_Variable_Length.cs

- Extrude mesh from planar rectangle to certain length along user input
  - Platform dependent compilation
  - Update() function



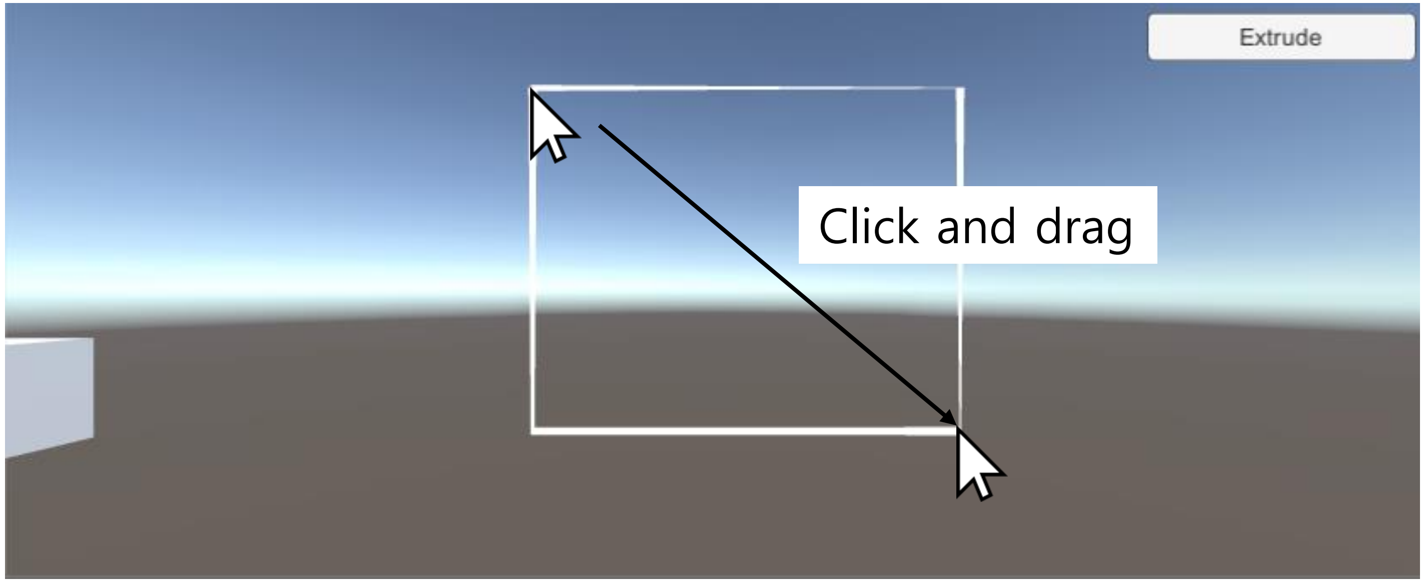
Drag up and down to adjust extrude length



Slide up and down to adjust extrude length

DrawRectangle.cs

- Indicate 2D rectangle sketch from user input
  - Line renderer



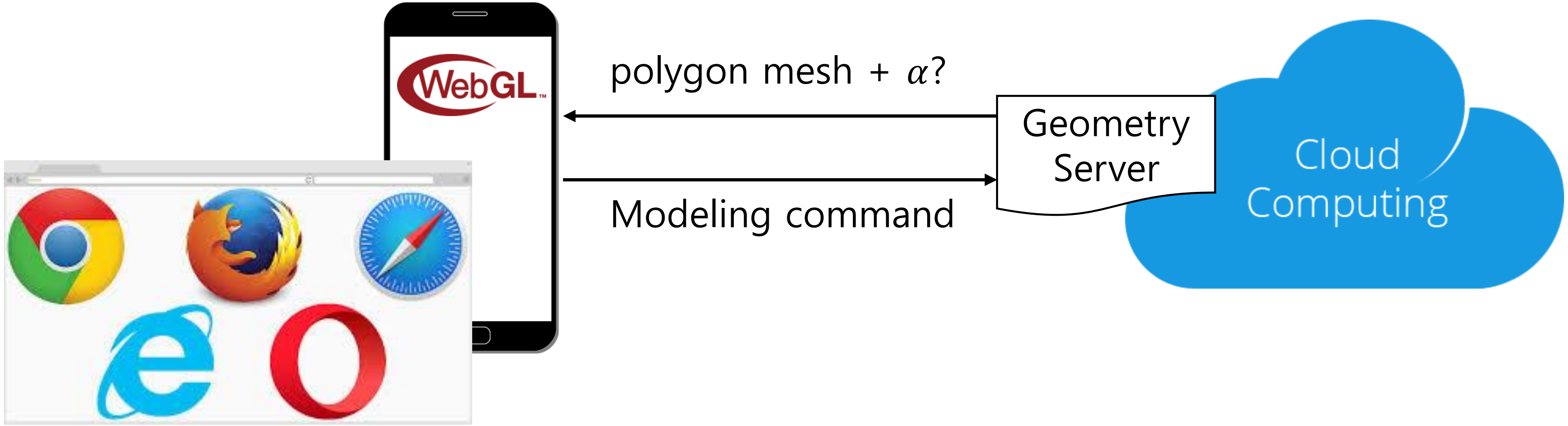
Make your own implementation

- Throughout this course, you may learn several theory behind geometrical modeling
- You can refer/modify my sample code to visualize your own implementation
- Or, make your own application from the scratch to make some innovative result!

Other approaches

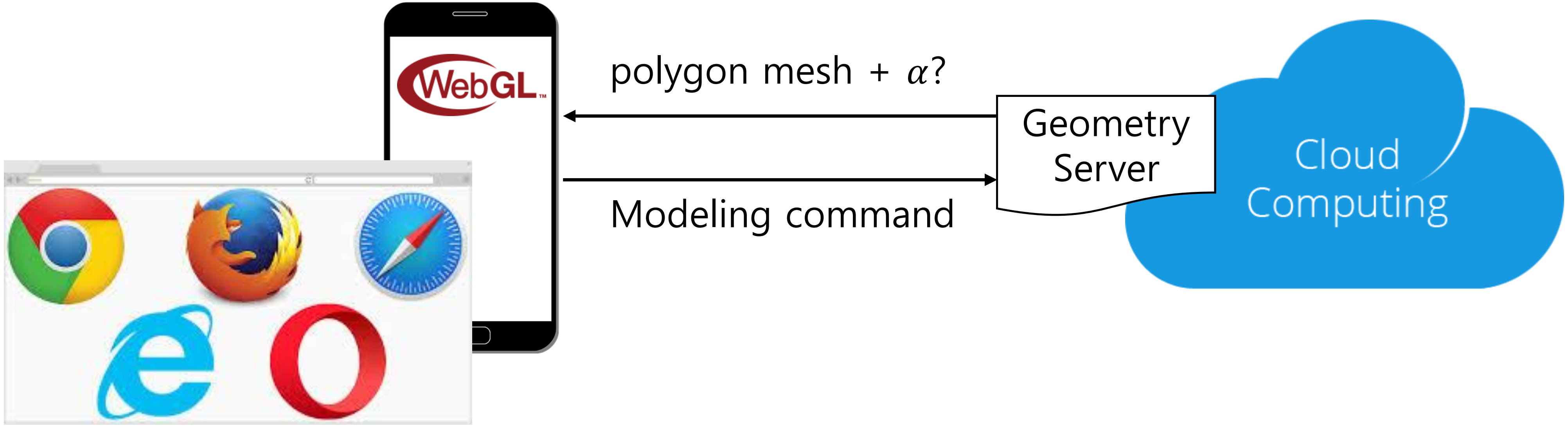
OnShape

- CAD system you can use via Web / Mobile platform
  - https://www.onshape.com/
- How OnShape Works?
  - https://www.onshape.com/cad-blog/under-the-hood-how-does-onshape-really-work



OnShape

- SaaS (Software as a service) model
  - Software & data is hosted from server/data center/cloud
  - User connects service from client (often, web browsers)
  - Powerful when connected, not available in isolated environment


WebGL
polygon mesh + α?
Modeling command
Geometry Server
Cloud Computing