Sketch-based 3D Modeling in Virtual Reality

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April 26, 2018

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Introduction

- VR for interactive 3D content

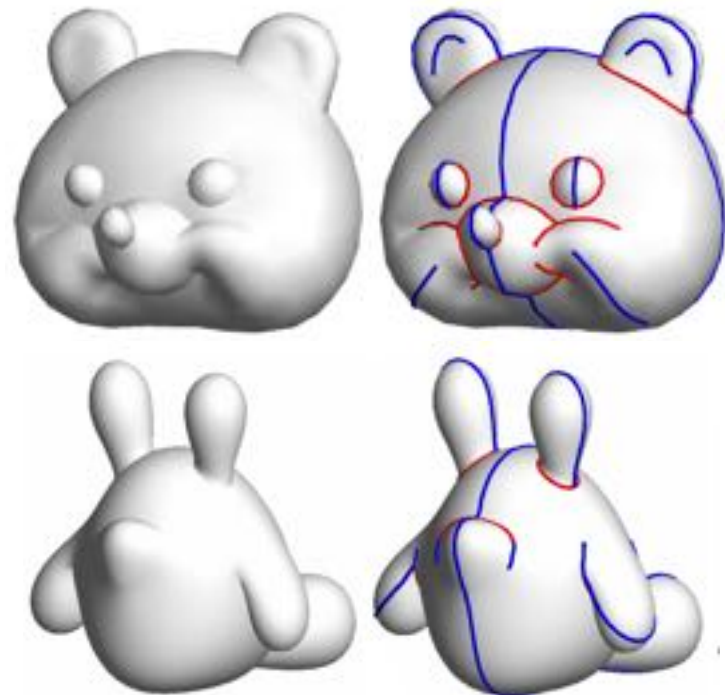- Intuitive sketch-based 3D modeling

- Easy to use for beginners

Related Work

FiberMesh

Nealen A., Igarashi T., Sorkine O., and Alexa M., 2007

- Sketch-based 3D modeling
- Functional optimization
- Drawn curves serve as handles and functional constraints
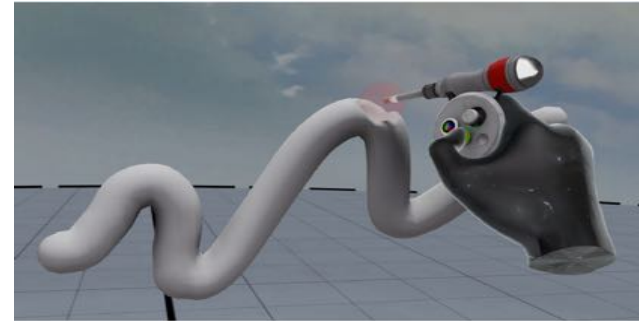- Curve deformation & surface optimization

Google Tilt Brush

- 3D art in virtual reality
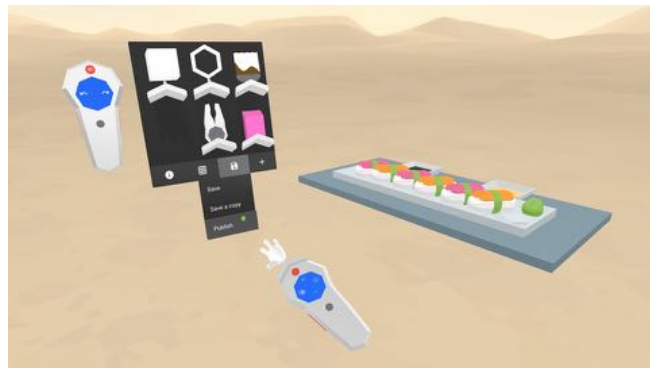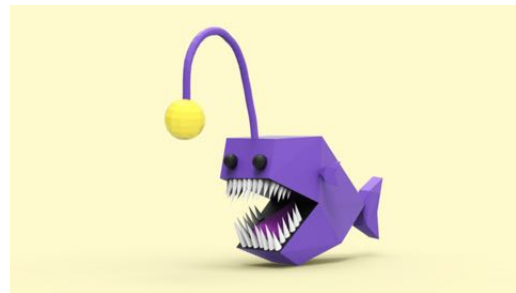- No exporting to 3D model formats

Oculus Medium

- Intuitive clay-like modeling
- Exporting models in .obj format

Google Blocks

- Provides predefined base shapes (spheres, cubes, cones)

- Low-level editing

- Low-poly meshes

- Exporting models in .obj format

Motivation

- Transfer pen-and-paper drawing skills
- Intuitive editing
- Utilizing 3D space
- Real time to avoid motion sickness

SketchMeshVR

System components

- Oculus Rift + Touch controllers

- FiberMesh (Nealen et al. 2007)

- Libigl

- Multithreaded rendering + linear solving

FiberMesh algorithm

- Curve deformation
  - Differential coordinates with co-rotational methods

$$\arg\min_{\mathbf{v},\mathbf{r}} \left\{ \sum_i \left\| \mathbf{L}\left(\mathbf{v}_i\right) - \mathbf{r}_i \mathbf{R}_i \delta_i \right\|^2 + \sum_{i \in C_1} \left\| \mathbf{v}_i - \mathbf{v}'_i \right\|^2 + \sum_{i,j \in E} \left\| \mathbf{r}_i \mathbf{R}_i - \mathbf{r}_j \mathbf{R}_j \right\|_F^2 + \sum_{i \in C_2} \left\| \mathbf{r}_i \mathbf{R}_i - \mathbf{R}'_i \right\|_F^2 \right\}$$

ETH zürich

FiberMesh algorithm

- Surface optimization
  - Geometry-independent linear systems

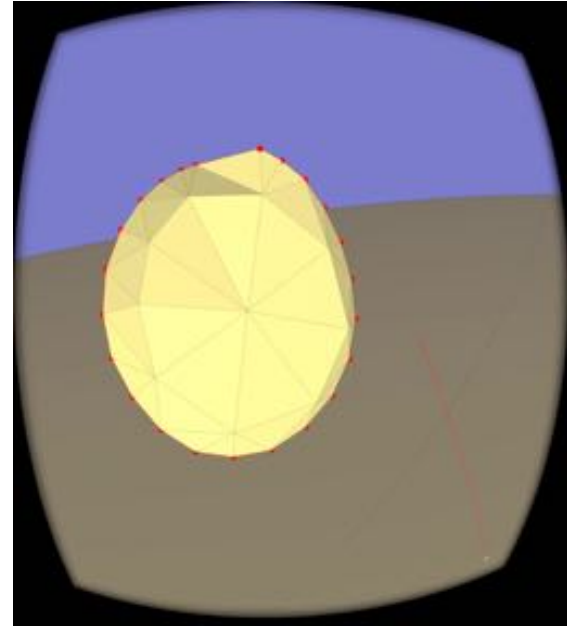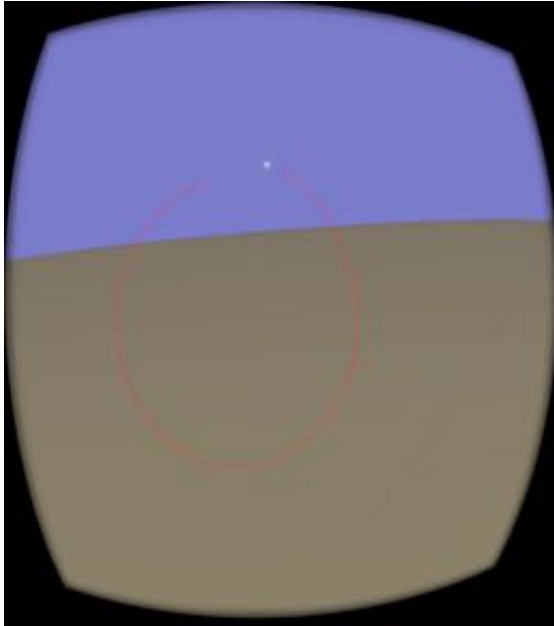$$\arg\min_c \left\{ \sum_i \|\mathbf{L}(c_i)\|^2 + \sum_i \left\| c_i - c_i' \right\|^2 \right\} \qquad \arg\min_e \left\{ \sum_i \|\mathbf{L}(e_i)\|^2 + \sum_i \left\| e_i - e_i' \right\|^2 \right\}$$

$$\eta_{ij} = (e_i + e_j)/2 \cdot (\mathbf{v}_i - \mathbf{v}_j) / \|\mathbf{v}_i - \mathbf{v}_j\|$$

$$\arg\min_{\mathbf{v}} \left\{ \sum_i \|\mathbf{L}(\mathbf{v}_i) - \delta_i\|^2 + \sum_{i \in C} \left\| \mathbf{v}_i - \mathbf{v}_i' \right\|^2 + \sum_{(i,j) \in B} \|\mathbf{v}_i - \mathbf{v}_j - \eta_{ij}\|^2 \right\}$$
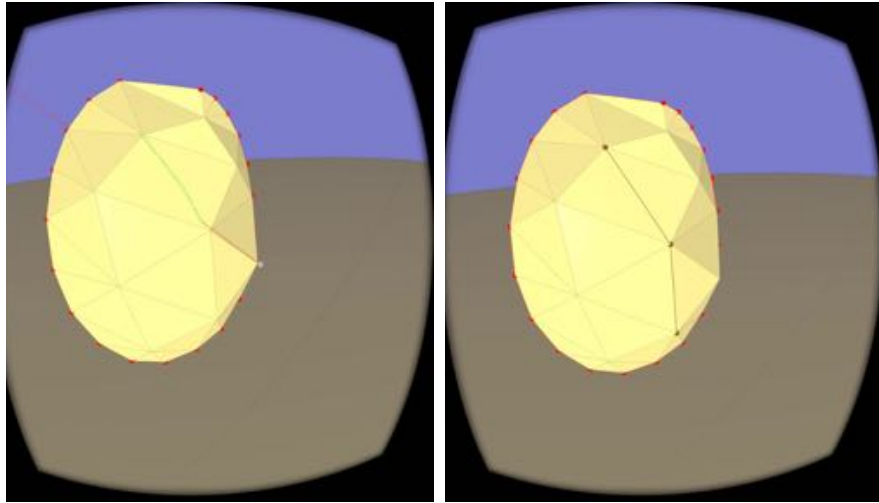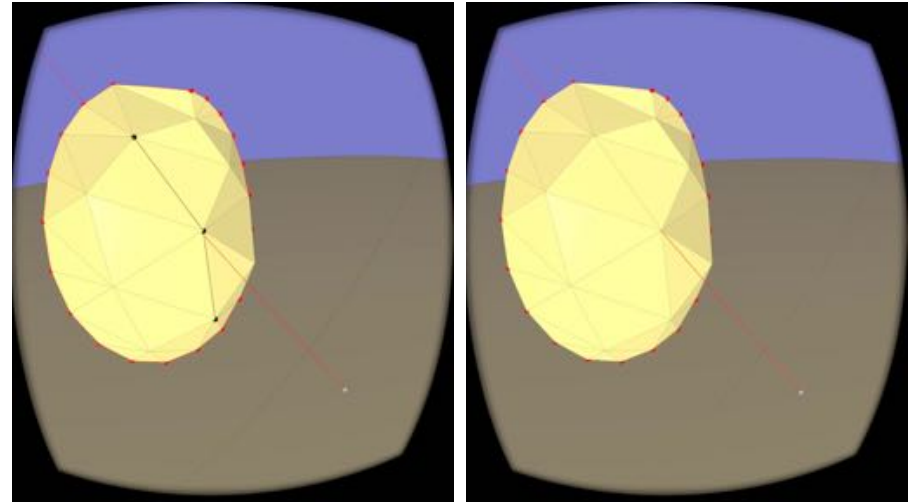
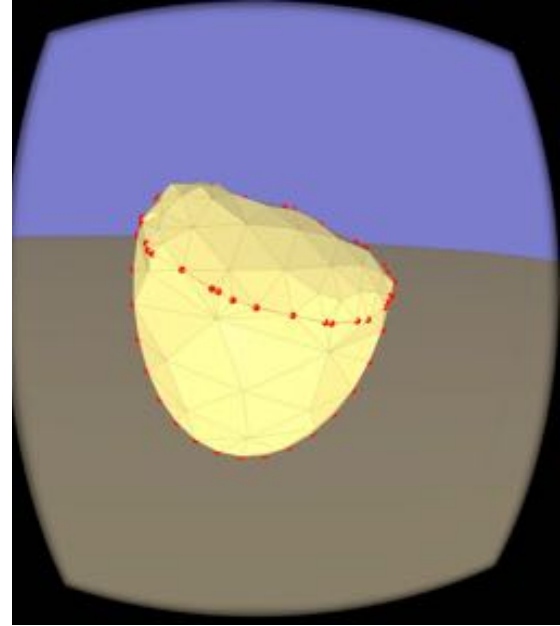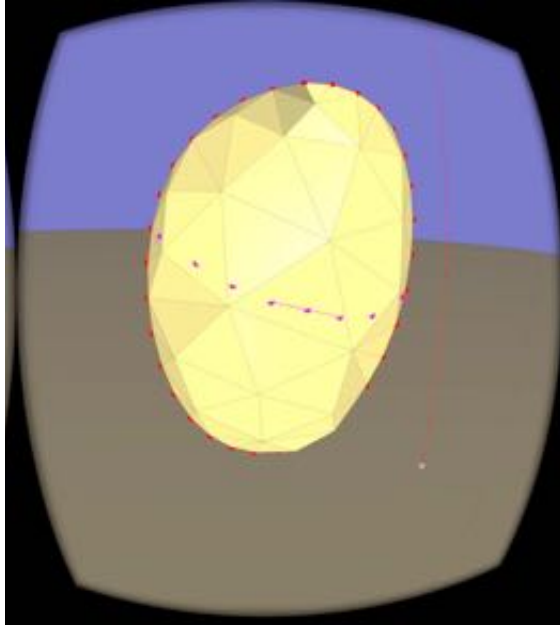**ETH** *zürich*

Drawing

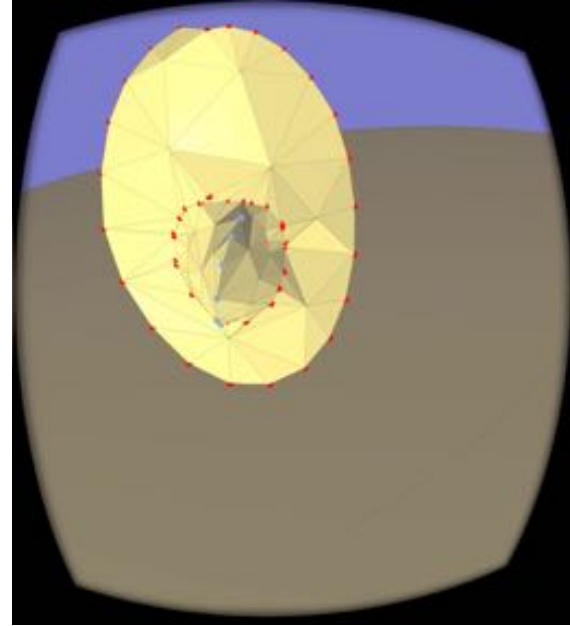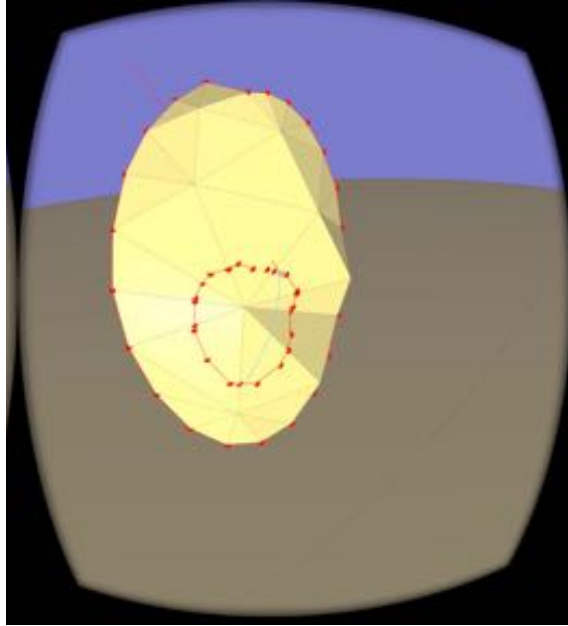Uses hand position

Adding and removing curves

Adding

Removing

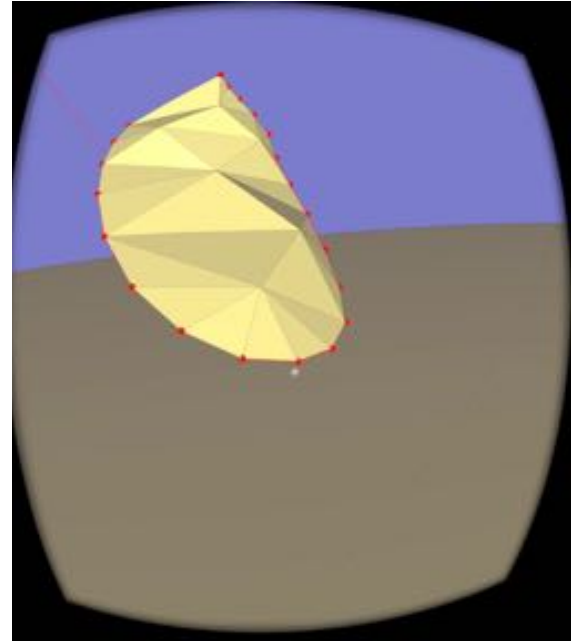

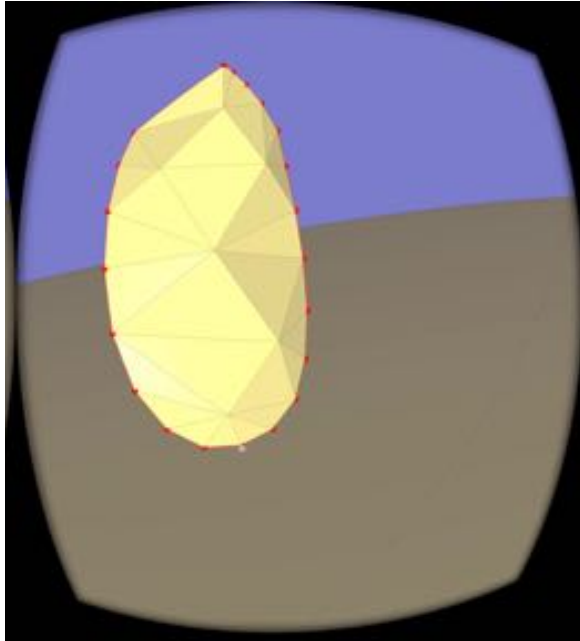Uses ray-mesh intersection

Cutting

Uses ray-mesh intersection

Extrusion

Uses ray-mesh intersection for base and hand position for silhouette
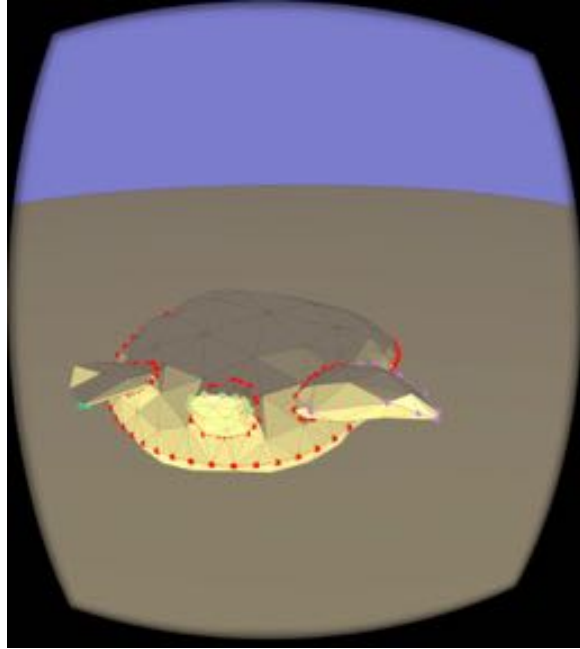
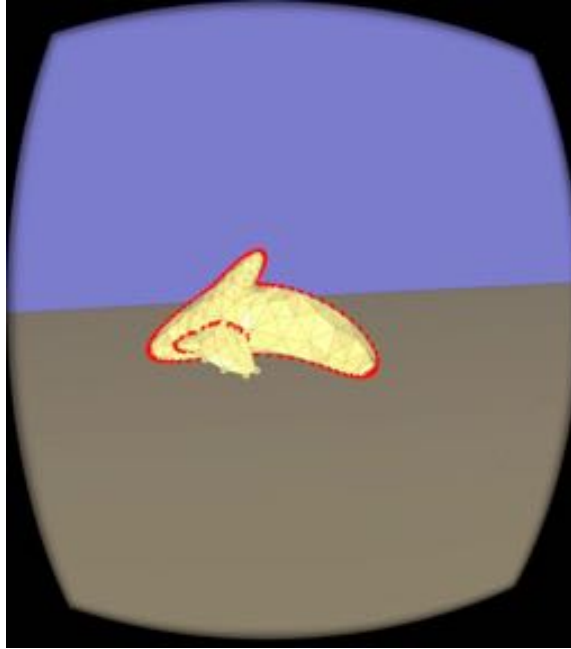# Curve deformation

Uses hand position

Novel contributions

- First silhouette sketch-based method in VR

- Out-of-plane editing
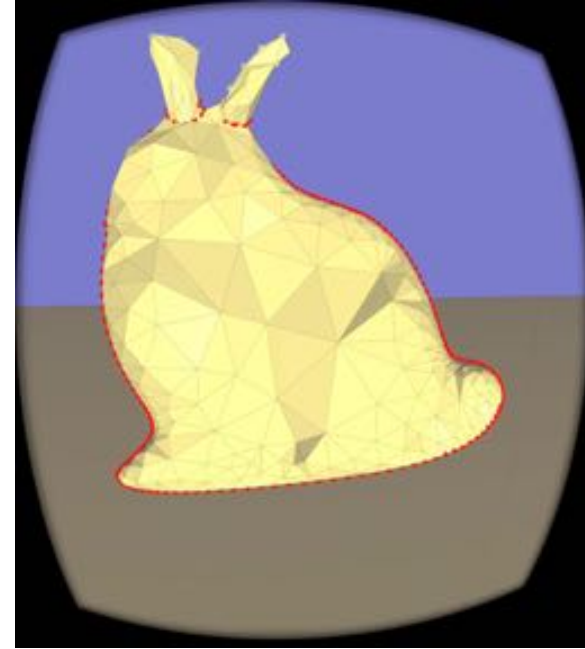 - Curve deformation
  - Diagonal cuts
  - Extrusions

Some results

5 minutes   7 minutes   9 minutes

Evaluation

Advantages

- Out-of-plane editing
- Tactile 3D feedback
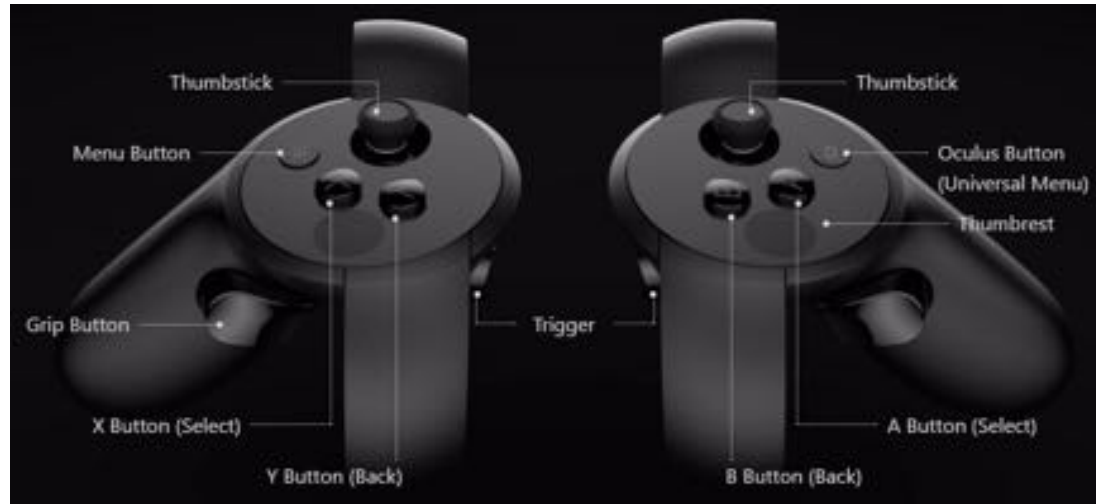- Sense of scale

Disadvantages

- Less precise
- Quicker fatigue
- Requires more space

Current limitations

- No feedback on selected mode
- Mesh navigation in small space
- Sharp curve deformation
- Undo button

Demo

Action button	Toggle button	Actions
Grip	A button	Cut & extrude
Trigger	B button	Add & remove curves
Grip + Trigger	Thumbstick	Draw & pull

Thank You

April 26, 2018