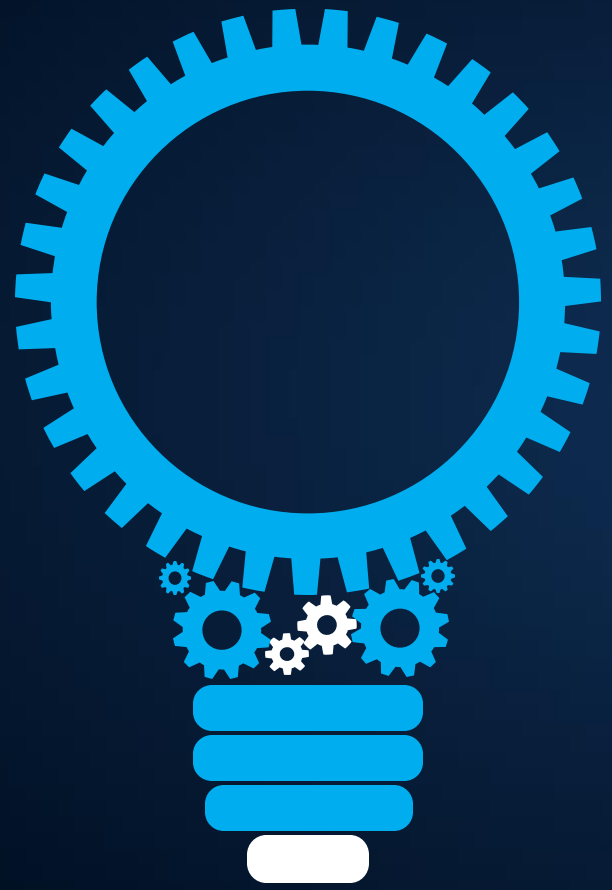
17th International Conference on BioInformatics and BioEngineering



A Feature Preserved Mesh Subdivison Framework

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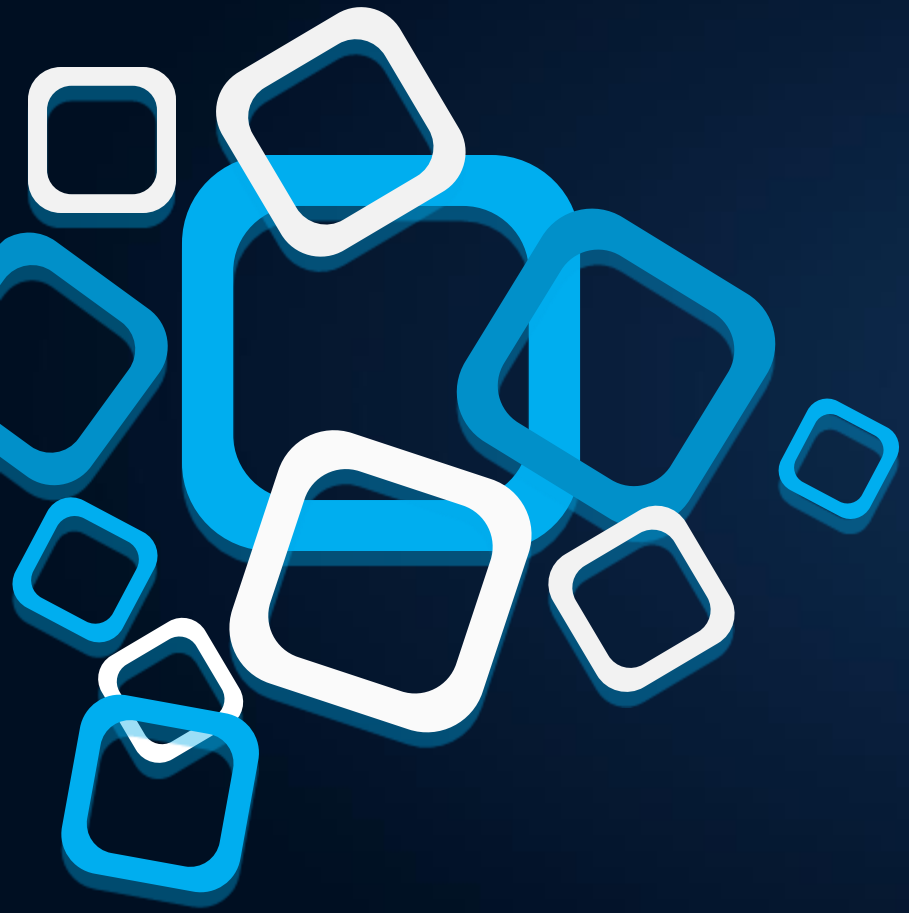
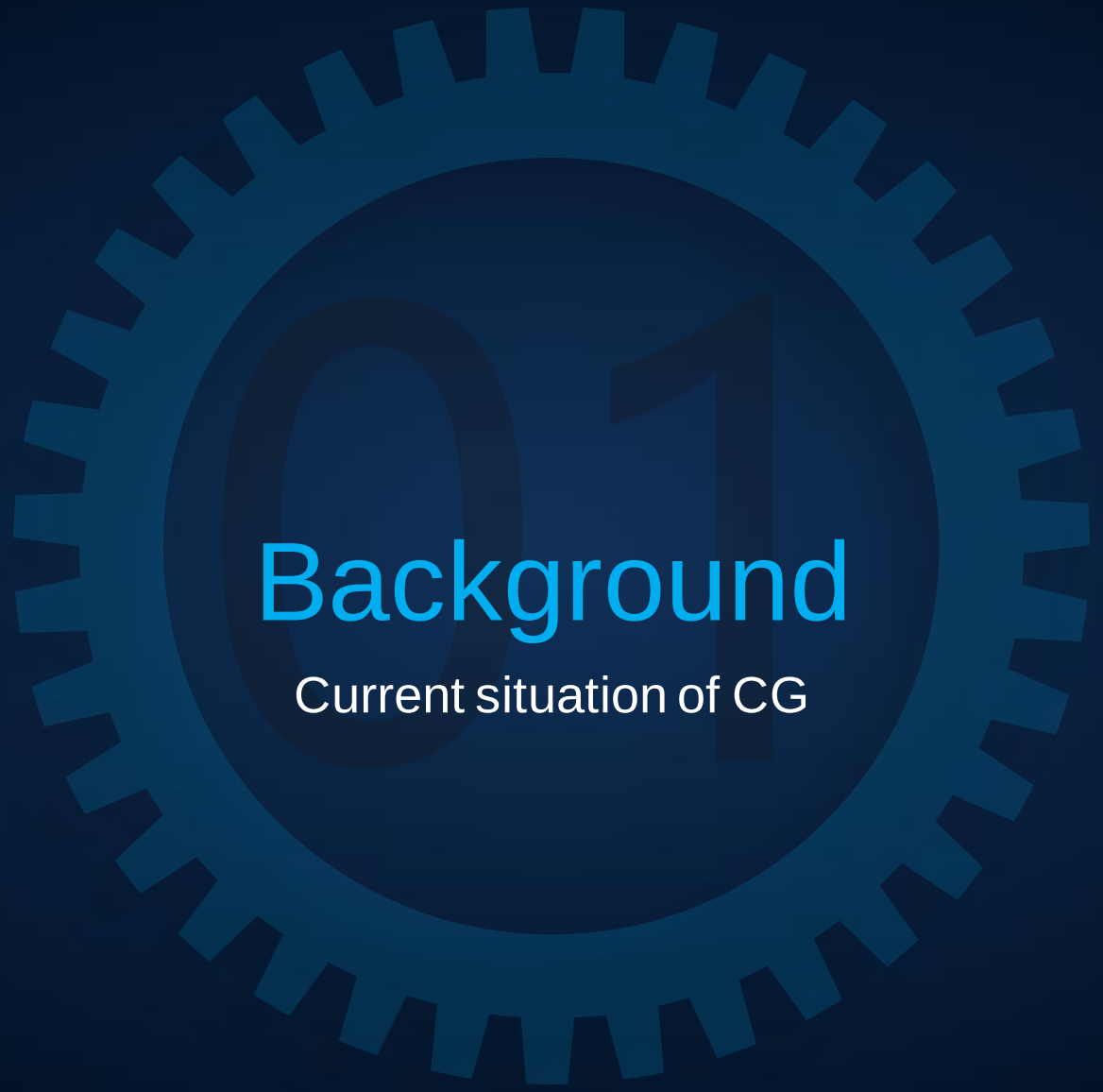
CONTENT



1. BACKGROUND
2. 3D GEOMETRIC ALGORITHM
3. BIOMEDICAL UTILITIES



Background

Current situation of CG

CG - Biomedical Assistants

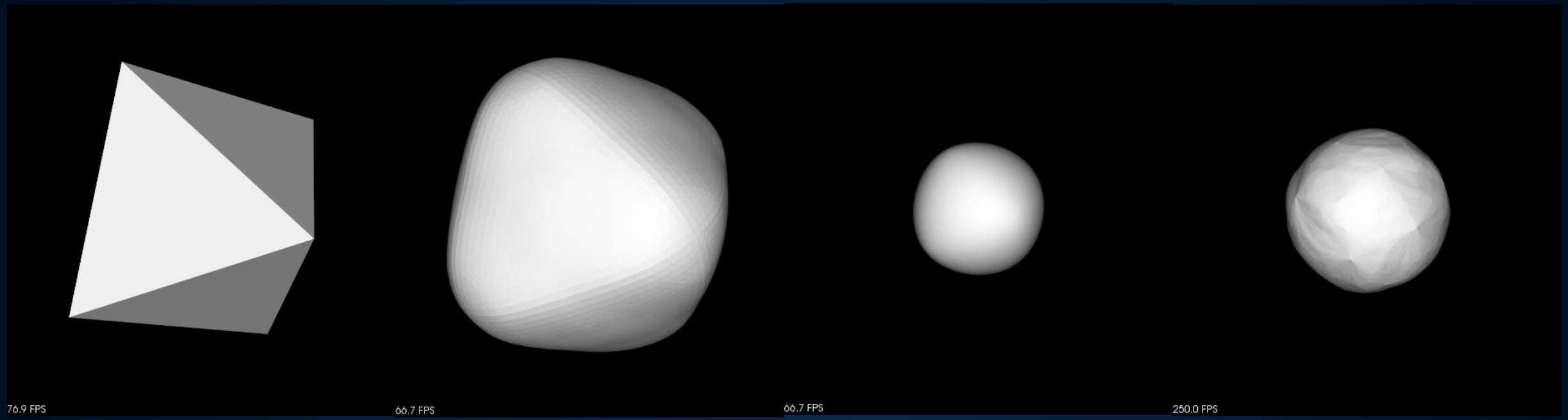
- Recent years, 3D computer graphics technology works as biomedical assistants, including utilization of 3D CT reconstructions, presentations of skeletons and tissues, comparison of genome, etc., due to its visual obviousness.

- The technique is widely used for presenting facial bones and their connections, confirmation of borderline or size of diseased tissues and their relation to the adjacent tissues.

Pros and Cons

- The pros of using Computer Graphics including 3D spatial and triangular meshes to expose nicety of bioinformation has created an ever-titanic amount of spatial data, which requires efficient and accurate process and analysis consequently.
- Restrained by the calculation performance of physical devices, medical detailed expression and accuracy of biomedical data is circumstanced.
- The contradiction of biomedical precision and data optimization will generate as model precision shrinking.
- Hence, one of the solutions is using Mesh Subdivision.

Subdivision Problem



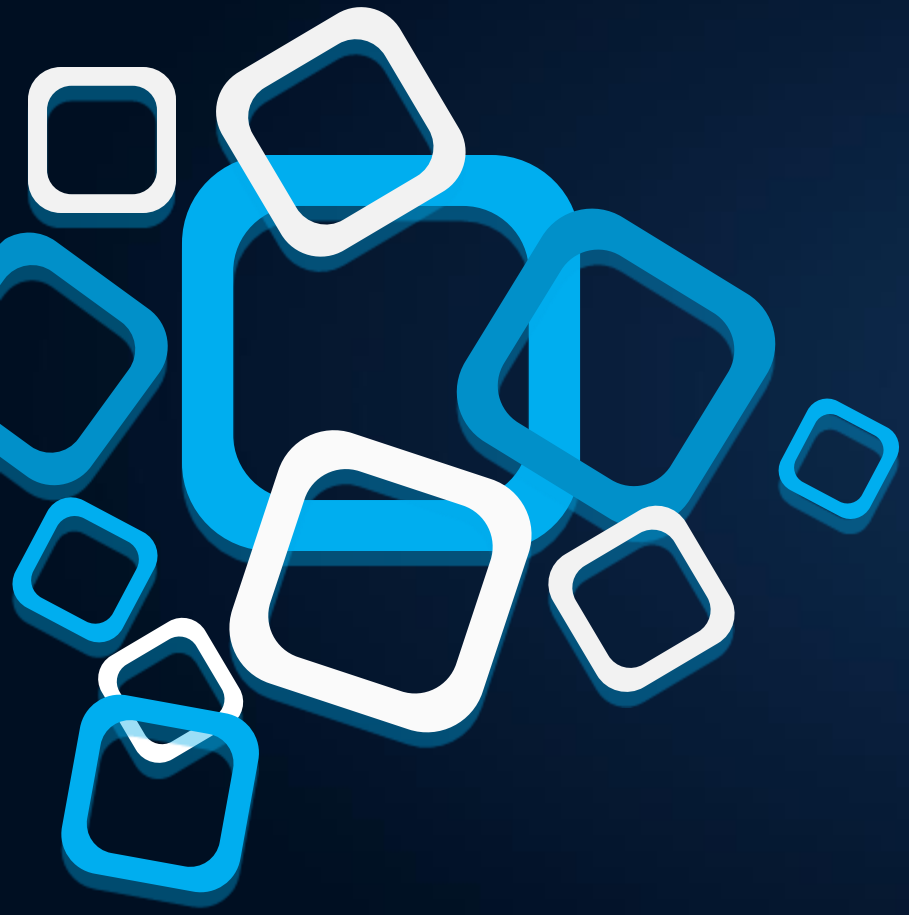
Left 1) Original. Left 2) Butterfly Subdivision. Left 3) Loop Method. Left 4) Catmull Method

Current smoothing methods for each subdivision algorithm will moderate edge and vertex geometric features.

3D Geometric Algorithm

A feature preserved mesh subdivision framework

FRAMEWORK

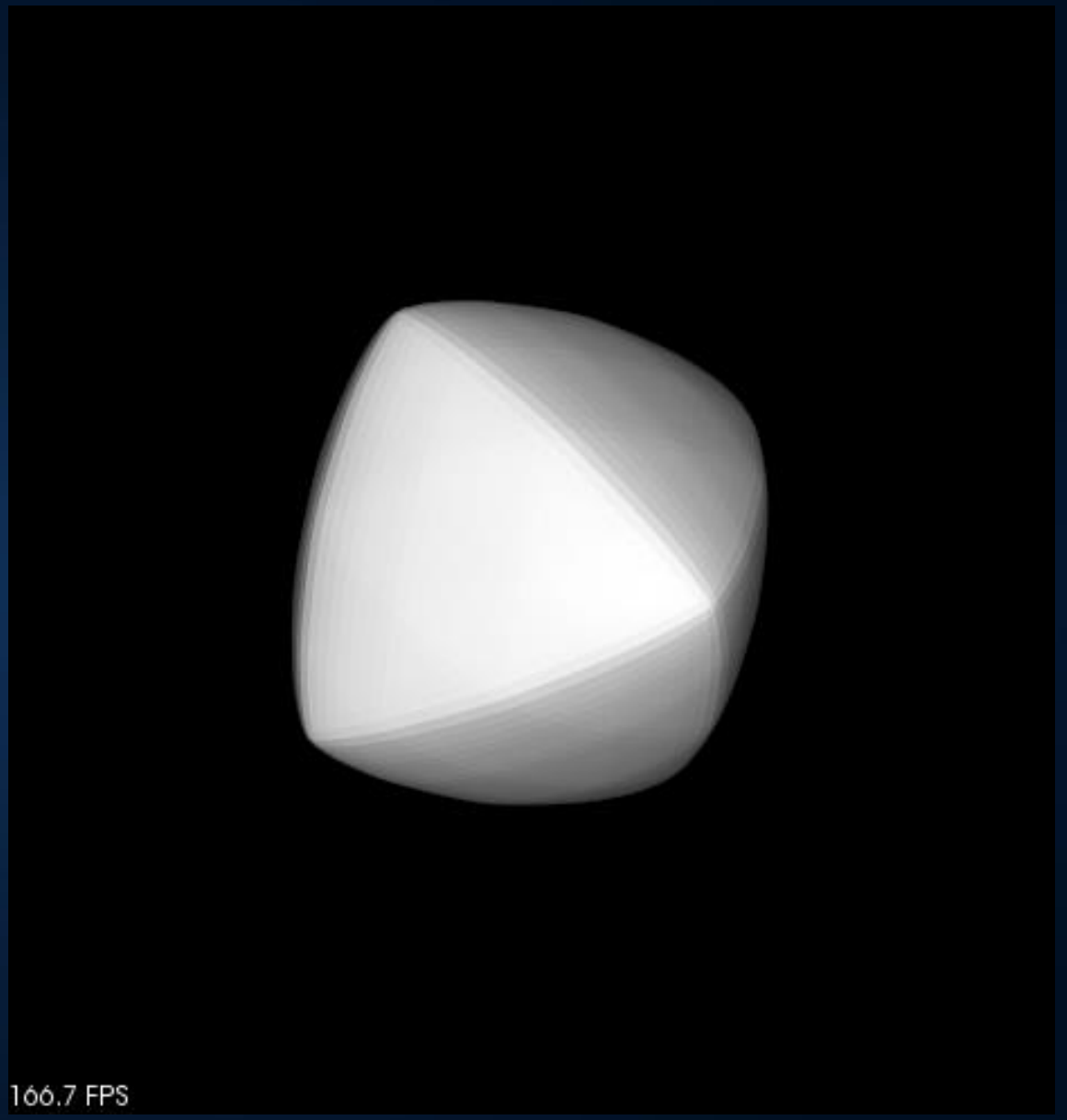


1. Edge Feature Preserved Mesh Subdivision
2. Wavelike Noise Elimination
3. Imbalanced Keypoint Detection

Edge Feature Preserved Mesh Subdivision

As the time of subivision methods iterated increasing, the performance of different algorithm is becoming easier to differentiate.

Obviously, our method accomplished an edge feature remaining and smooth result.



Edge Feature Preserved Subdivision

Input and Output

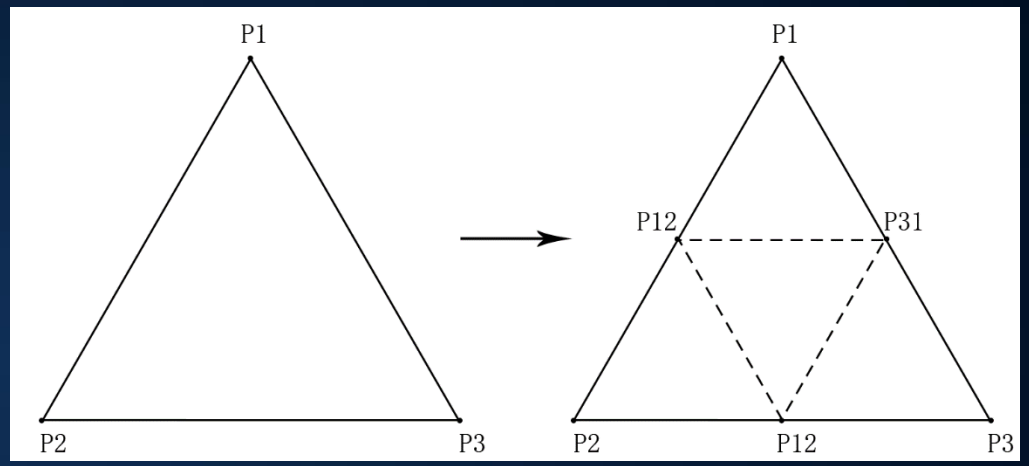
- Input: Original Mesh M_i
- Output: Subdivided Mesh M_{i+1}

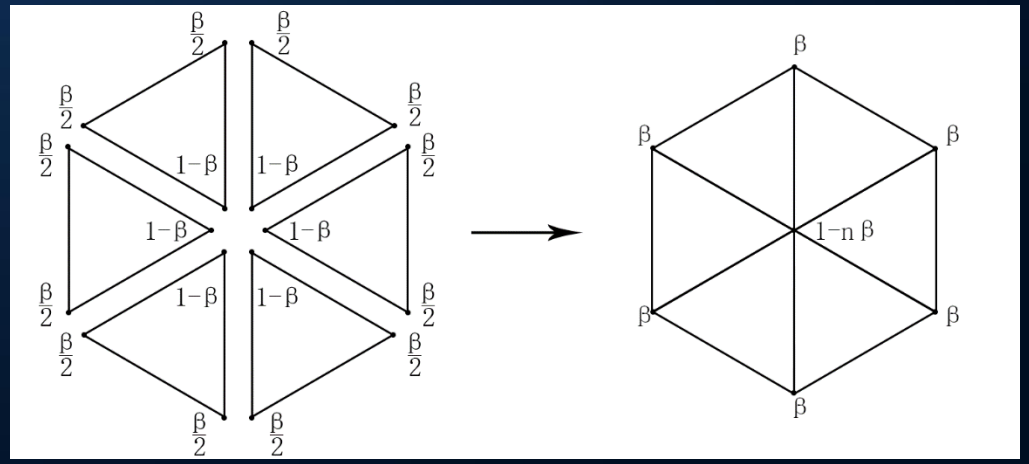
One to Four Subdivision

- for each triangular face f_i in M_i do
  - get 3 edge point on edges of f_i
  - generate 4 subfaces anticlockwise
- end for

Smoothness

- for each vertex v_i on M_{i+1}do
  - $N(v_i)$ =1-ring neighbors on M_{i+1}
  - v_i = neighbor weighted centroid method on v_i
- end for





Model-dependent Wavelike Noise

By using the method, an edge and vertex aware result is generated. But the method will generate model-depent wavelike noise on the mesh.

Wavelike Noise Elimination

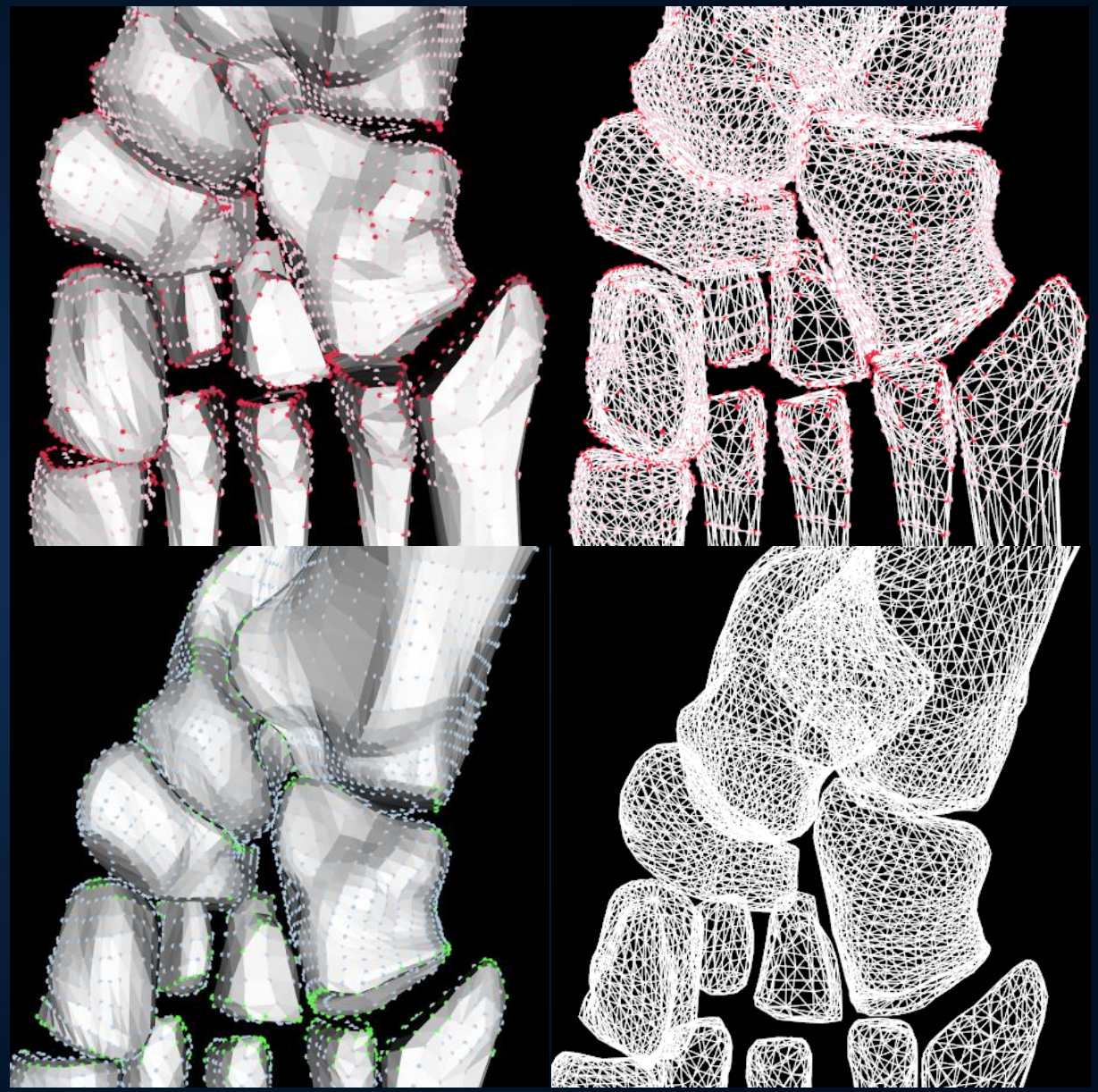
A combination of Edge Feature Preserved Mesh Subdivision and Smooth-based Mesh Subdivision. The noise problem is eliminated.

Smooth-based Mesh Subdivision has the same algorithm structure. Difference is about the smoothing part.

Neighbor vertices for smoothing method depends on previous one-ring vertices on M_i, but not newly generated vertices on M_{i+1}.

Imbalanced Keypoint Detection

We propose a geometric feature-based vertex operator, which is a three-dimensional implementation of key-points detection, to pick up imbalanced keypoints.

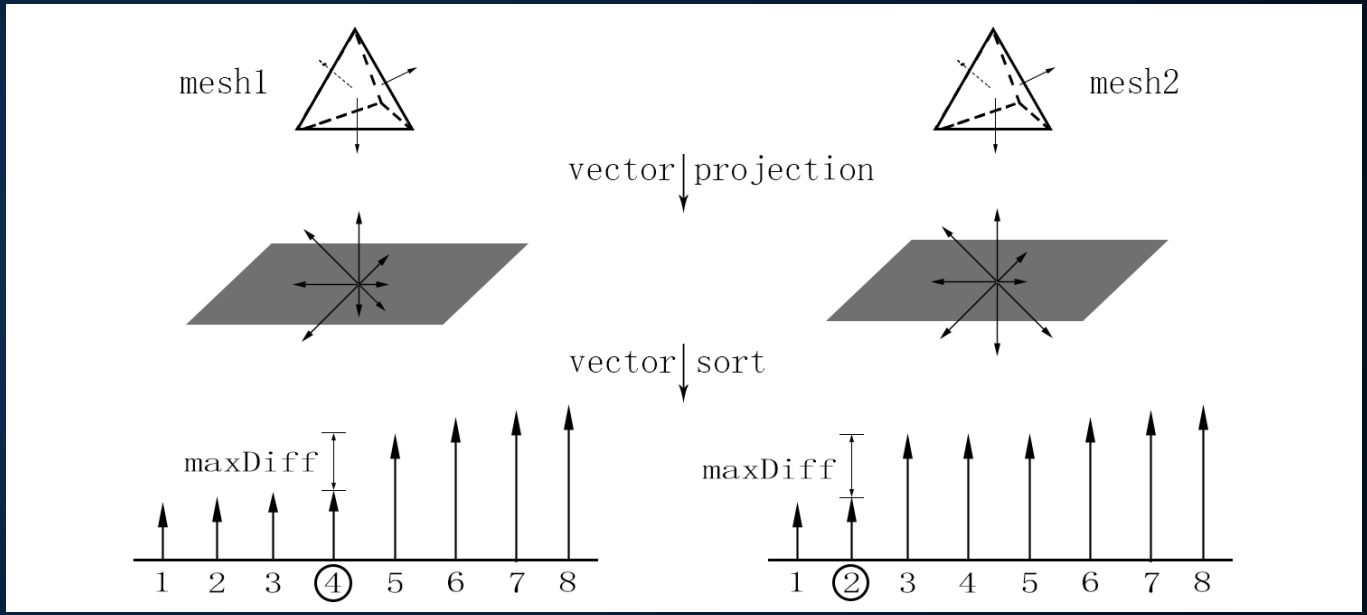


Basic Idea of Keypoint Detection

Basic idea is using normal vectors around the vertex as an identification, using sort and threshold to define if the vertex is a keypoint or not.

After projecting face normals around any vertex on its tangent plane, arrows (suppose 8) are sorted in terms of their magnitudes.

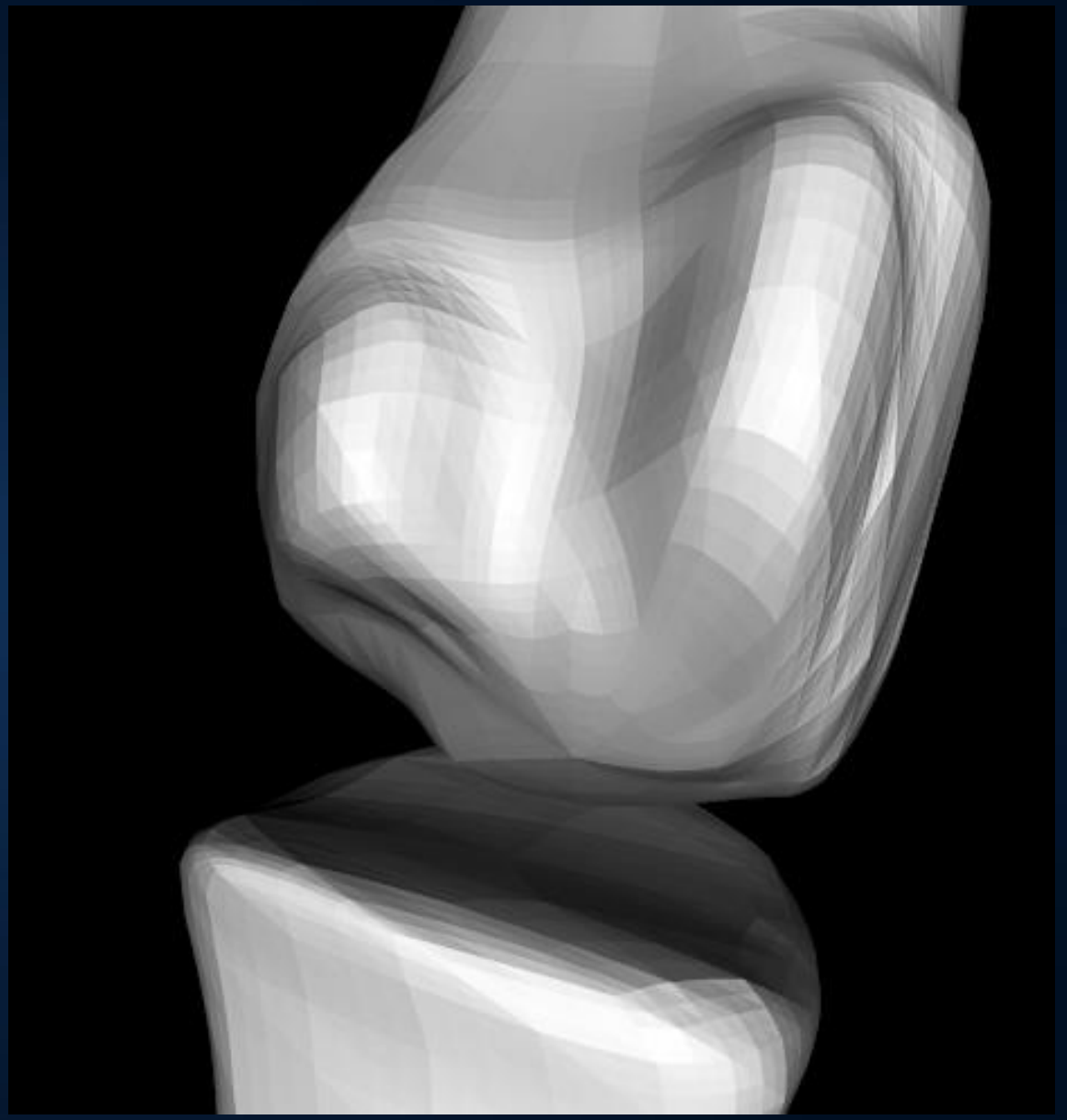
According to the index, a vertex can be classified into balanced point or not.



Feature Preserved Mesh Subdivision Framework

The big picture of our framework is using detected points to guide subdivision procedures.

Based on imbalanced keypoint detection, all the vertices are classified into two categories and keypoints are distributed mainly at the boundaries and detailed parts, which should be remained after subdivision but slightly adjusted with its neighbors.

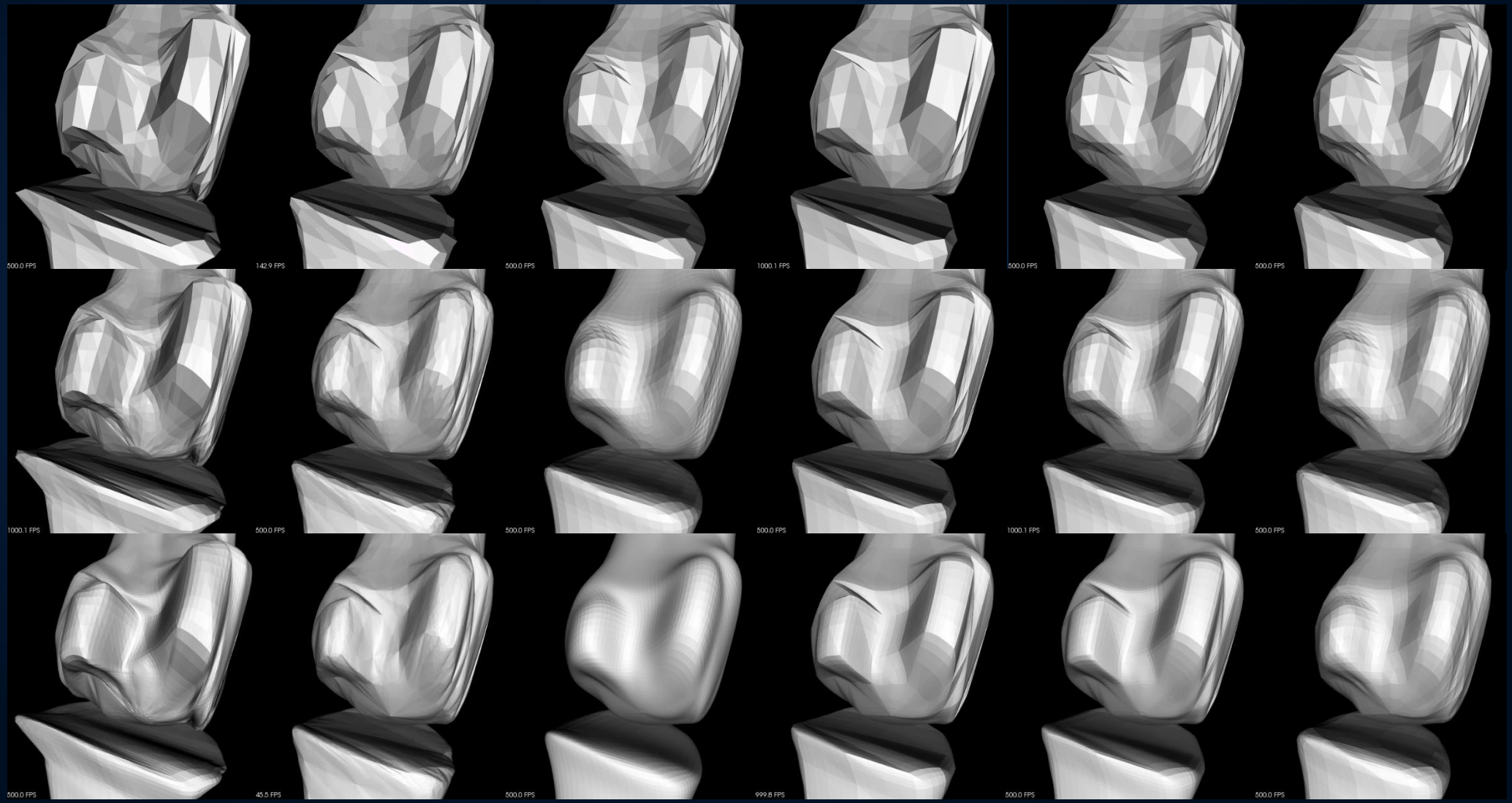


Biomedical Utilities

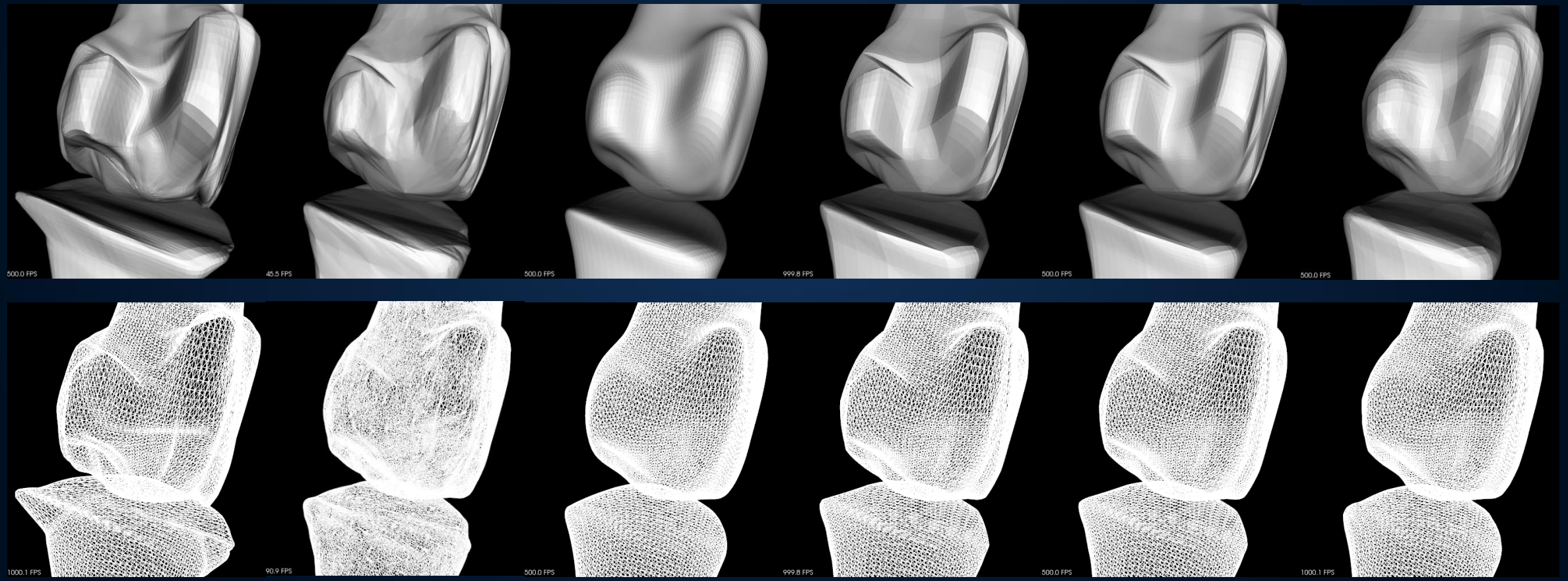
For biomedical meshes

Subdivision Comparison on Phalangeal

- Iteration 3
- Iteration 4
- Iteration 5



Subdivision Comparison on Phalangeal



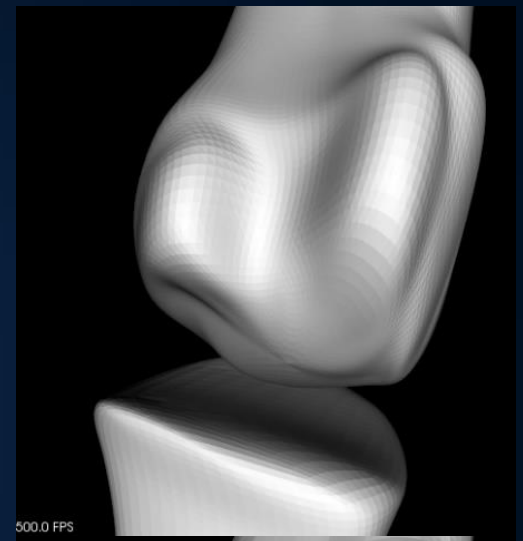
- Butterfly
- Catmull
- Loop
- EFPMS
- SMS
- FPMS

Subdivision Comparison on Phalangeal

- Butterfly

- Catmull

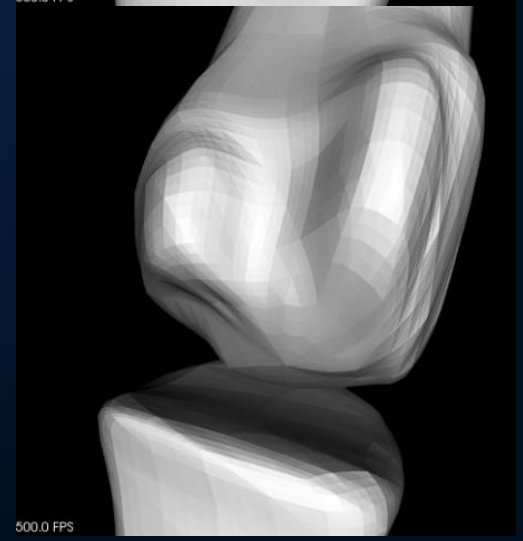
- Loop



- EFPMS

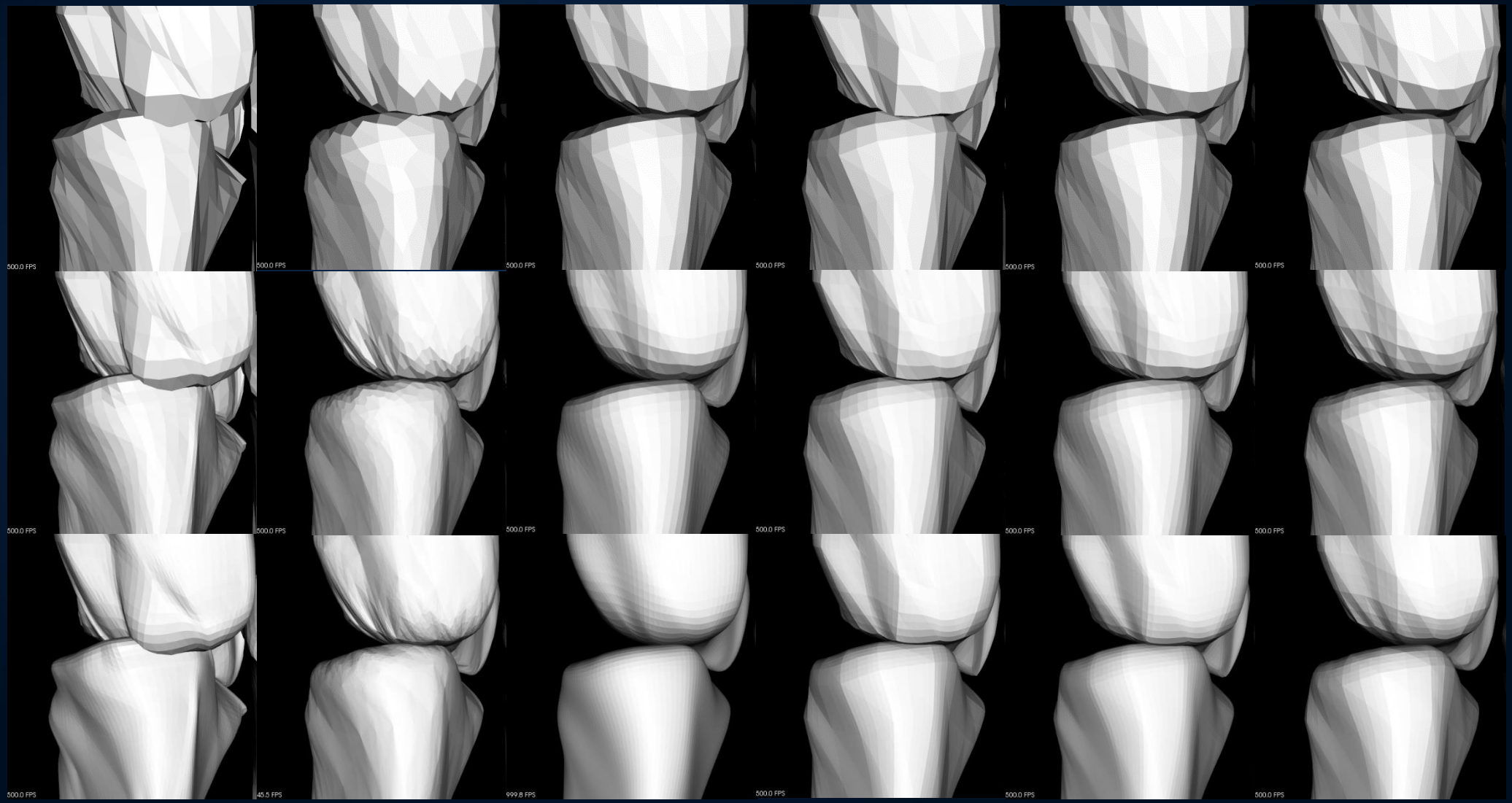
- SMS

- FPMS



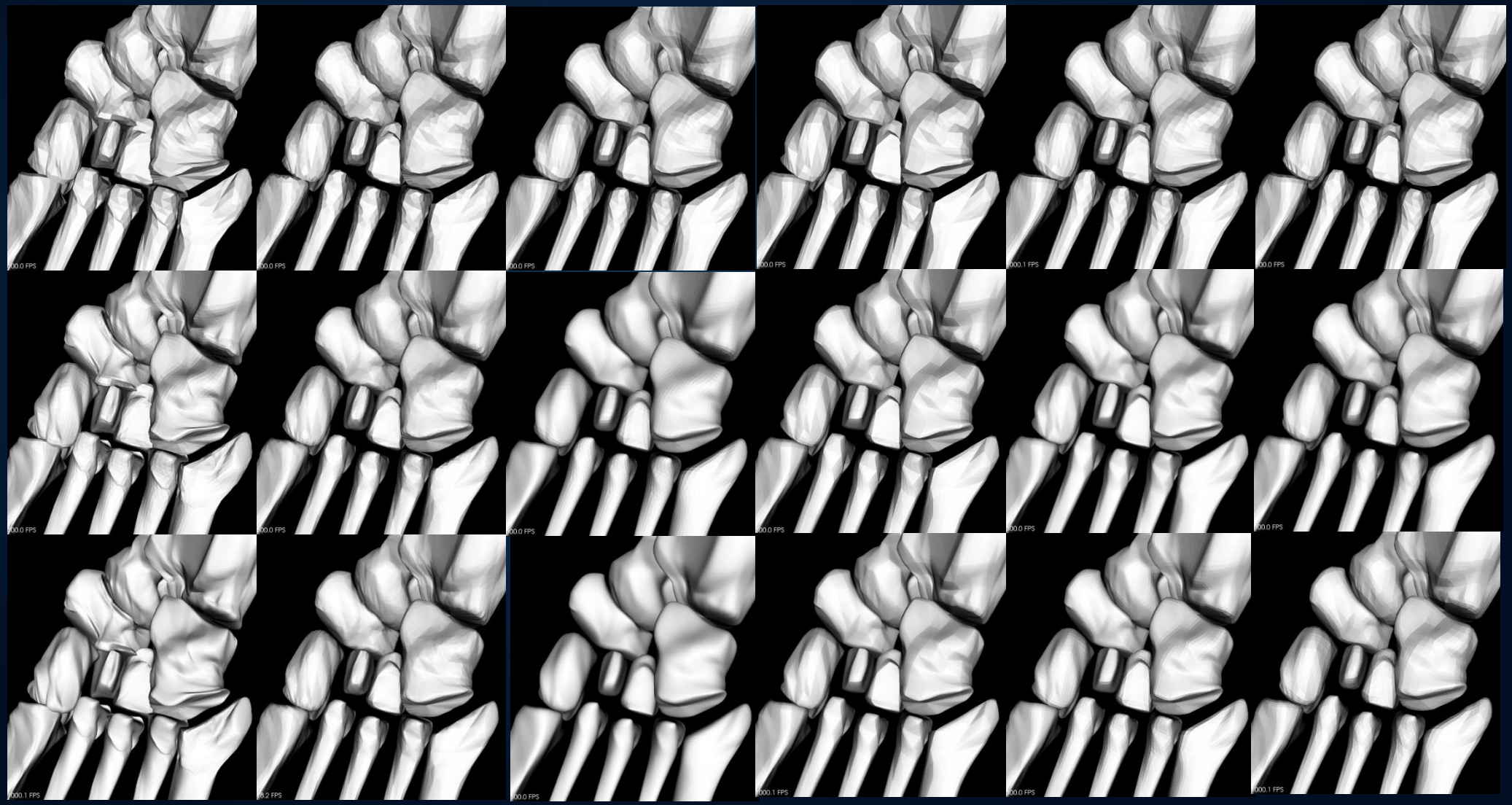
Subdivision Comparison on Metatarsal

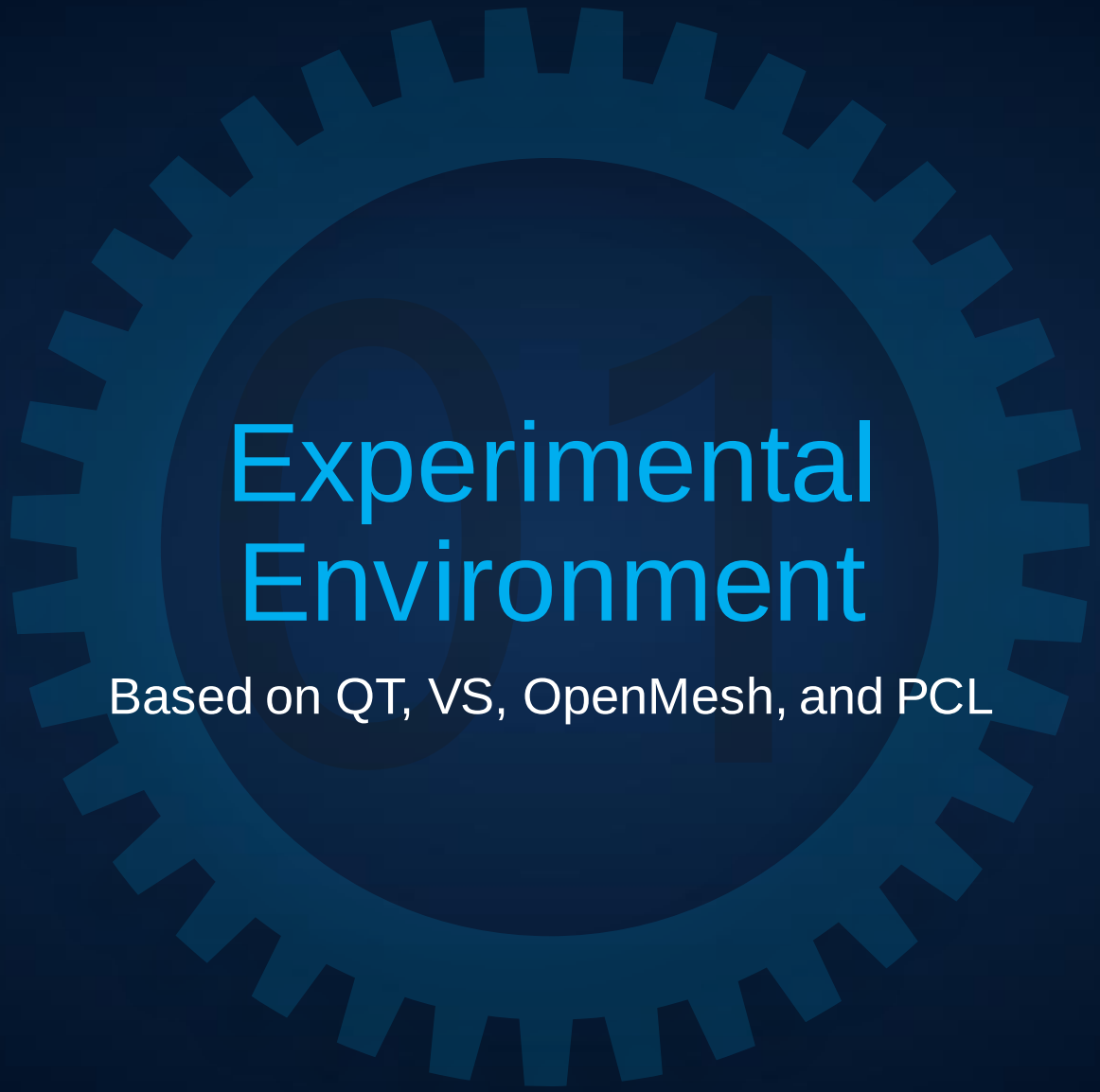
- Iteration 3
- Iteration 4
- Iteration 5



Subdivision Comparison on Footbone

- Iteration 3
- Iteration 4
- Iteration 5

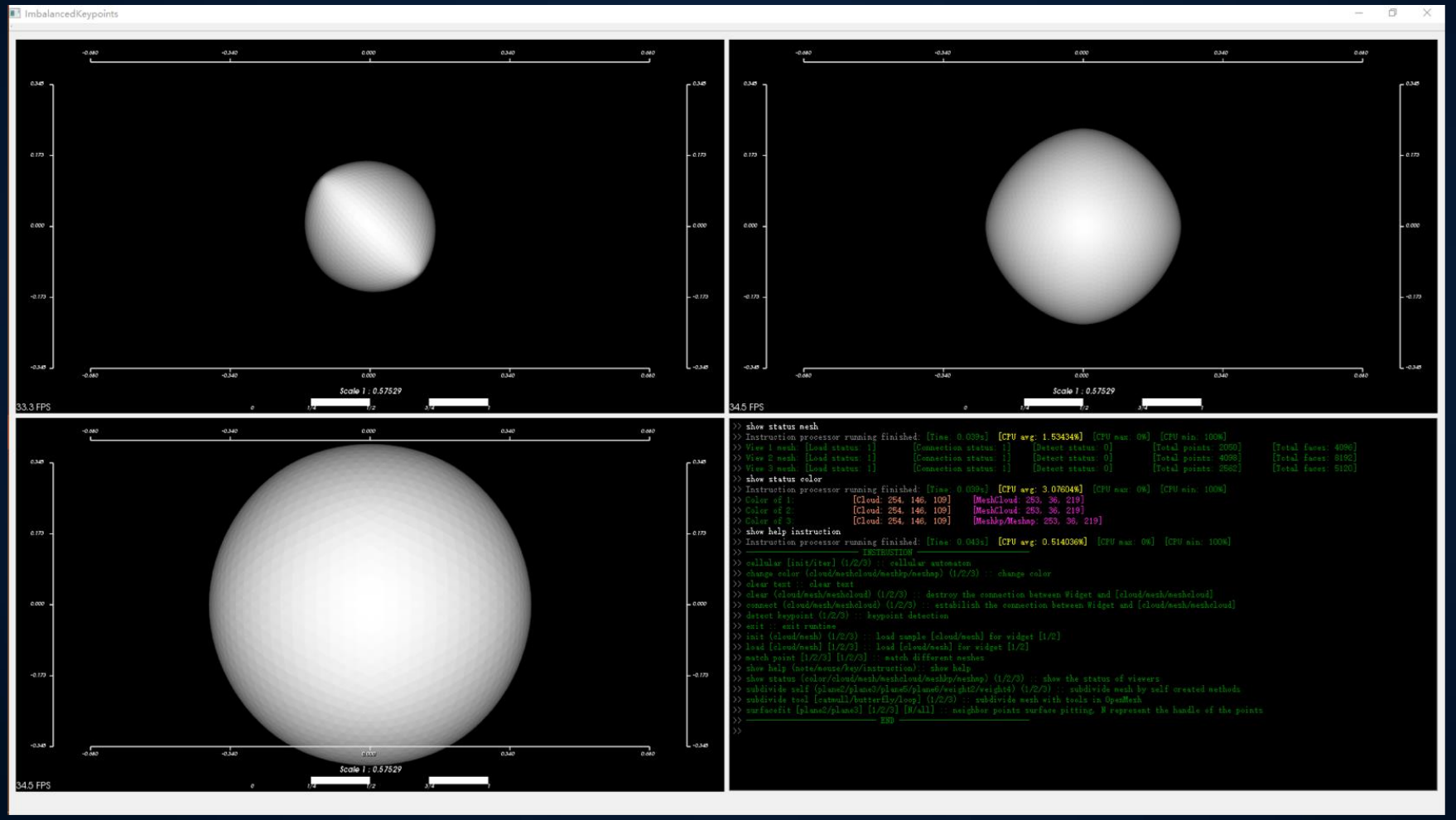


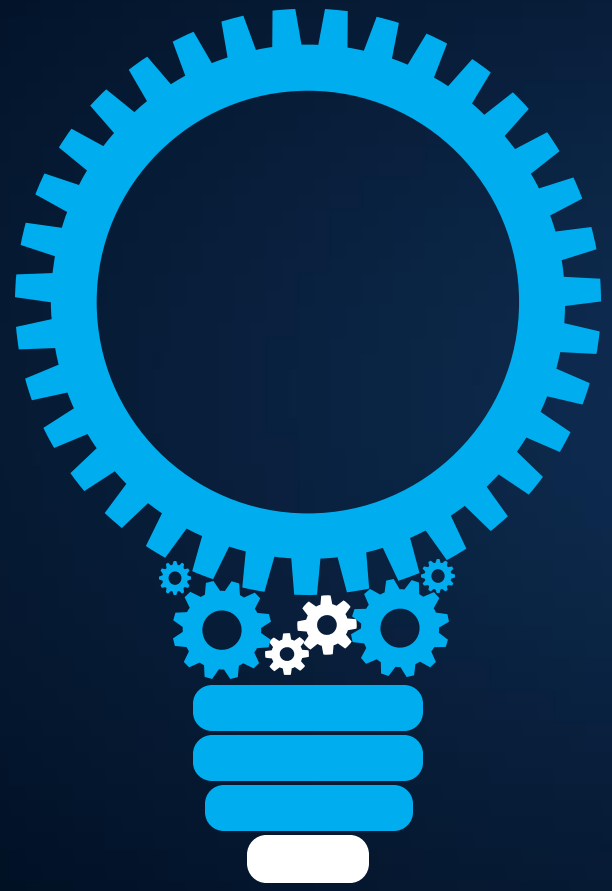


Experimental Environment

Based on QT, VS, OpenMesh, and PCL

Self-Created Experimental Platform





Thank you!

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