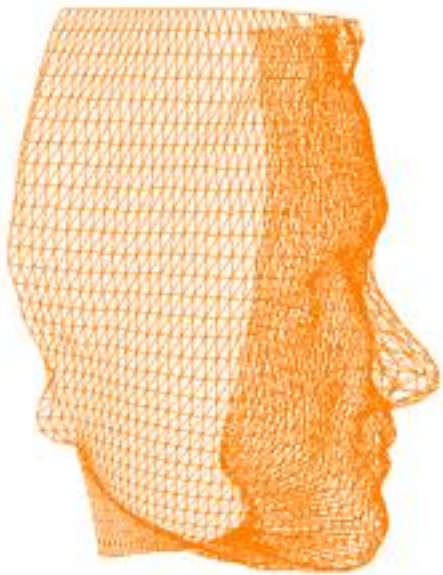


COSC422 Advanced Computer Graphics



0 Course Overview

Semester 2
2021



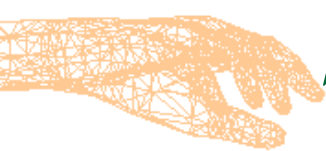
R. Mukundan (mukundan@canterbury.ac.nz)
Department of Computer Science and Software Engineering
University of Canterbury, New Zealand.



Introduction

COSC422 covers a range of topics that find applications in the following areas:

- ❑ Shader based real-time rendering
- ❑ Mesh processing algorithms
- ❑ Scene graphs and character animation



Tentative List of Topics

- Week 1: Introduction to OpenGL-4 shader stages
- Week 2: Tessellation and Geometry shaders
- Week 3: Sprites, Pencil Shading, Transformation Feedback (XFB)
- Week 4: Image Based Rendering (RTT, Impostors, Shadow map)
- Week 5: Mesh Processing: Data Structures, Mesh Simplification
- Week 6: Mesh Subdivision Algorithms
- Week 7: Mesh Parameterization, Morphing
- Week 8: Quaternions, Spherical Linear Interpolation (SLERP)
- Week 9: Scene Graphs, MOCAP, Skeletal Animation
- Week 10: Vertex Skinning, Character Animation
- Week 11: Forward and Inverse Kinematics
- Week 12: Summary



Learning Outcomes

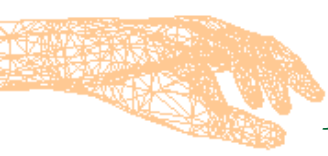
After completing the course, students will be able to

- ❑ Understand, implement and analyze important real-time rendering algorithms used in computer graphics
- ❑ Explain the computational steps in the OpenGL-4 pipeline
- ❑ Develop shader based graphics applications
- ❑ Apply mesh data structures for processing 3D meshes
- ❑ Develop algorithms for mesh simplification and mesh subdivision
- ❑ Design and implement skeletal animation methods for character animation
- ❑ Design character animation sequences using motion capture data and quaternion transformations



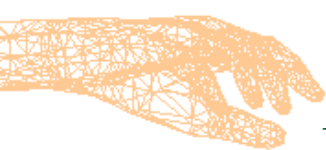
Prerequisites

- ❑ Computer Graphics (**COSC363** or equivalent)
 - ❑ Introductory concepts in computer graphics:
 - 3D Modelling: Polygonal models, Surfaces of revolution etc.
 - Illumination Model (Phong-Blinn equations)
 - 3D-Transformations and Projections
 - Texture Mapping.
 - ❑ The **OpenGL-4 API**, including the shader stages:
 - Buffer Objects
 - Vertex and Fragment Shaders
 - Tessellation and Geometry Shaders
- ❑ C/C++ programming (**ENCE260** or equivalent)



Assessment Items

- ❑ Assignments: 60%
 - ❑ Assignment 1 (20%) Due: 13 Aug 2021
Topic: Terrain Rendering
 - ❑ Assignment 2 (20%) Due: 24 Sep 2021
Topic: Mesh Processing
 - ❑ Assignment 3 (20%) Due: 20 Oct 2021
Topic: Character Animation
- ❑ Final exam (2 hours, Closed book) : 40%



APIs/Libraries

❑ OpenGL Mathematics (GLM)

- ❑ <https://glm.g-truc.net/0.9.9/index.html>
- ❑ GLM 0.9.9.7 (2020)

❑ Open Mesh Library

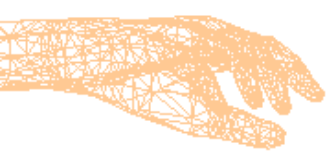
- ❑ <https://www.graphics.rwth-aachen.de/software/openmesh/>
- ❑ OpenMesh 8.1 (2020)

❑ Open Asset Import Library (Assimp)

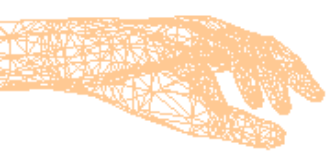
- ❑ <https://www.assimp.org/>
- ❑ Assimp 5.0 (2019)

❑ Open Image Library (OpenIL/DevIL)

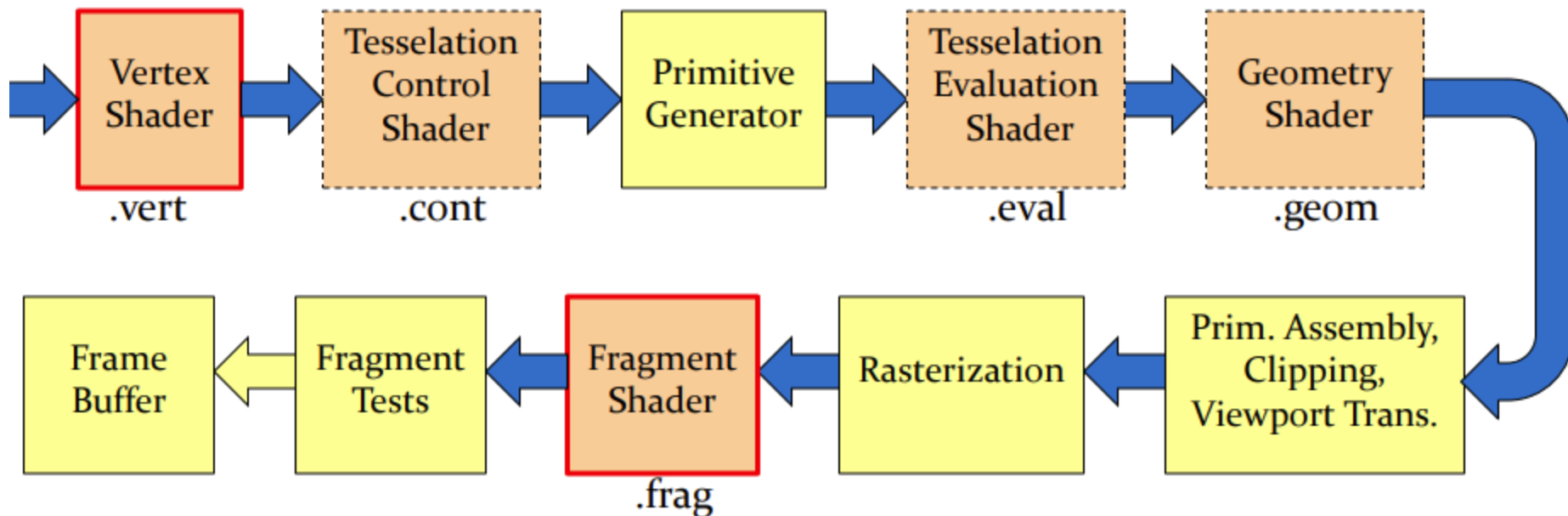
- ❑ <http://openil.sourceforge.net/>

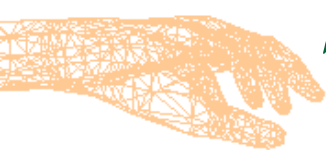


A Quick Tour

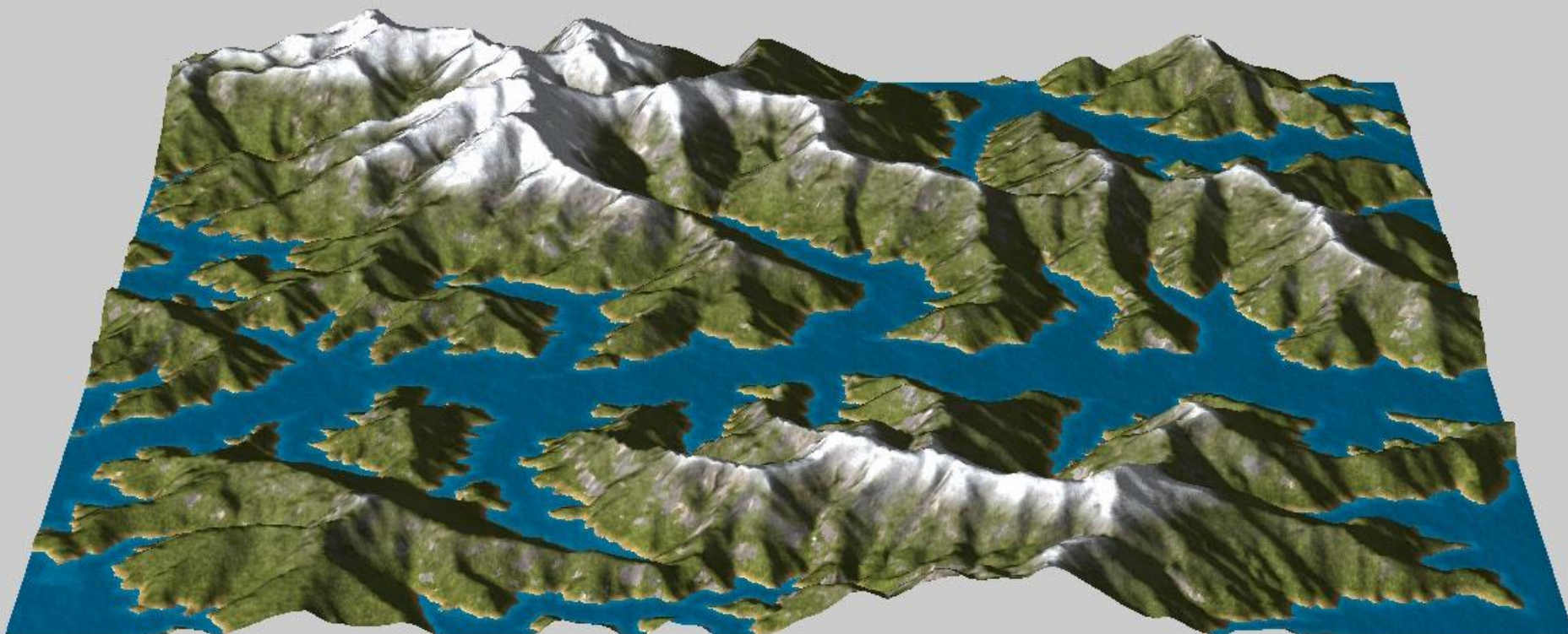


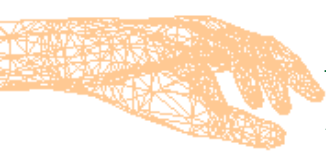
OpenGL-4 - Pipeline





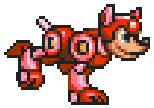
Terrain Programming





Basic Shader Applications

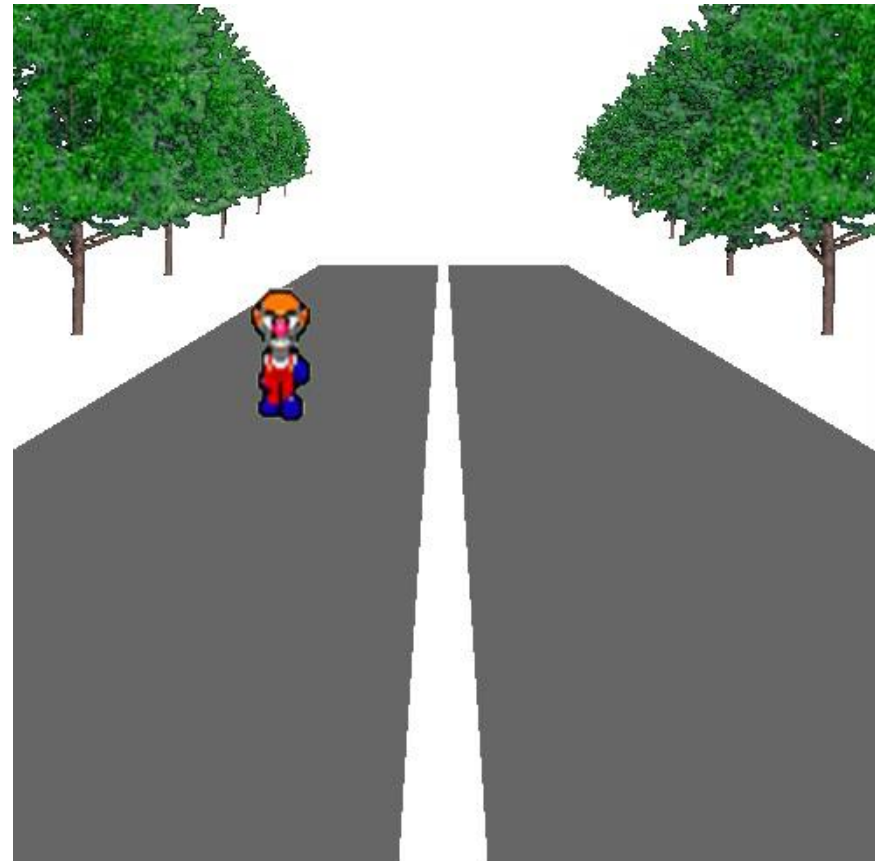
Point Sprites (GL_POINT_SPRITE) - 2D graphics

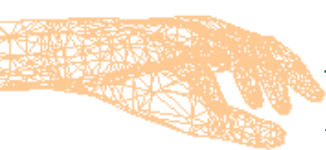


• particle system (2D)



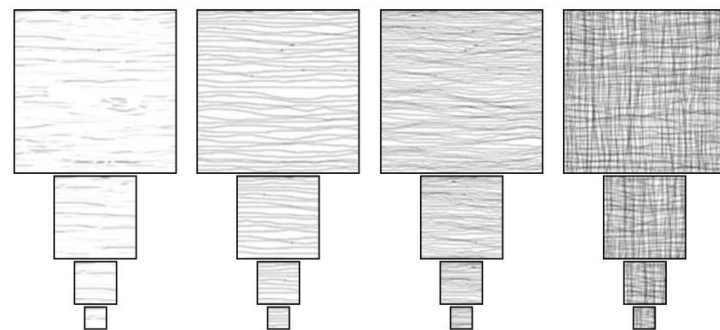
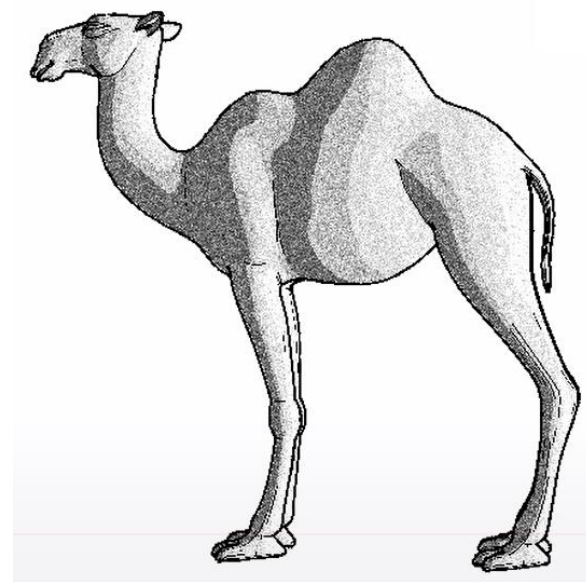
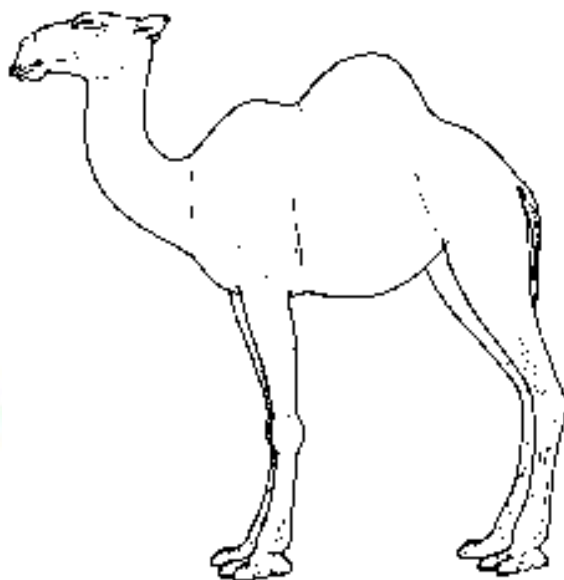
2D animation

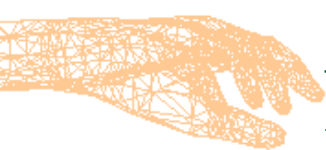




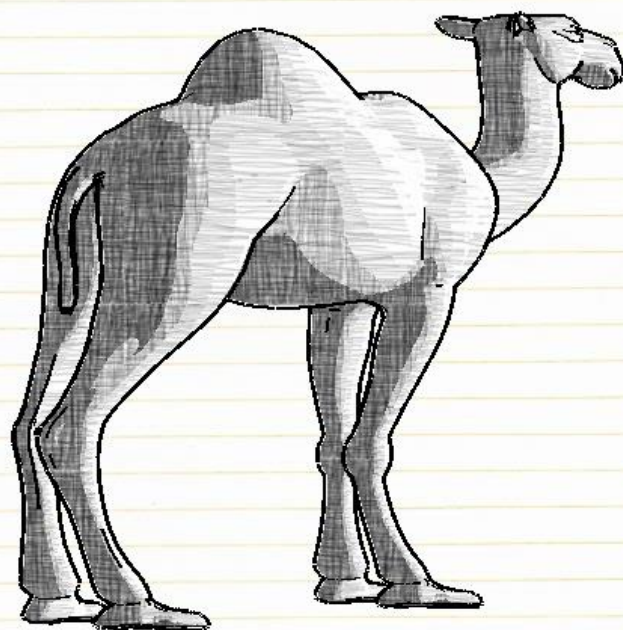
Non-Photorealistic Rendering

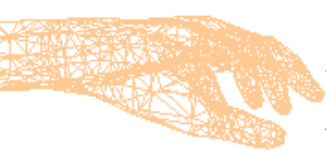
- pencial shading





Non-Photorealistic Rendering





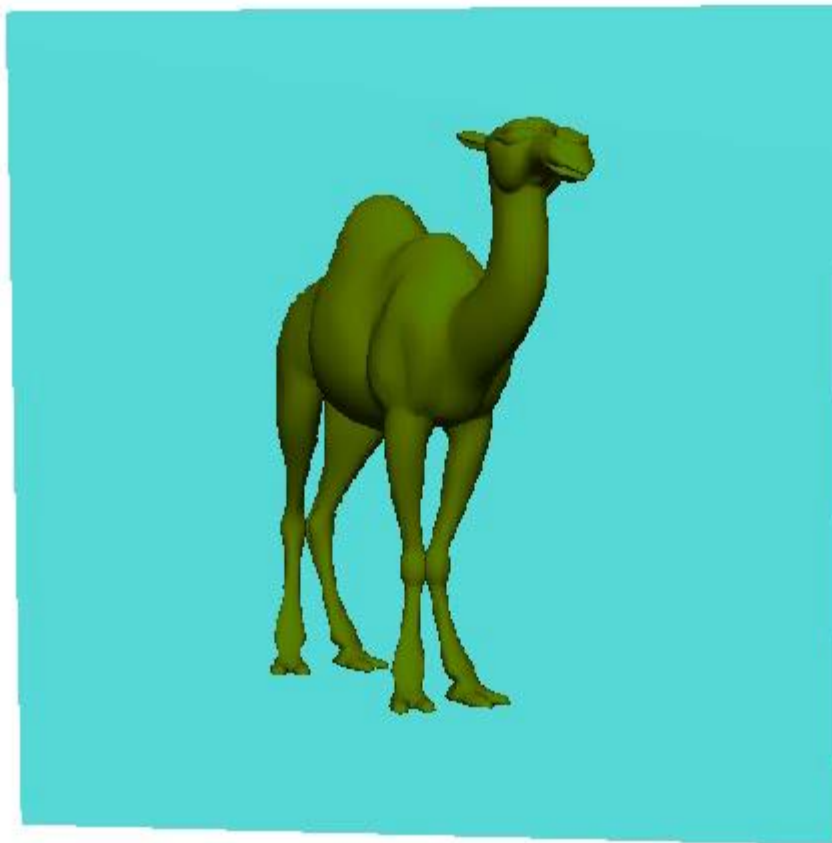
Render to Texture (RTT)

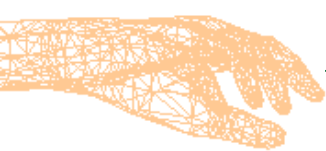
- creating an impostor
(2D polygon)

- rendering a scene to a texture



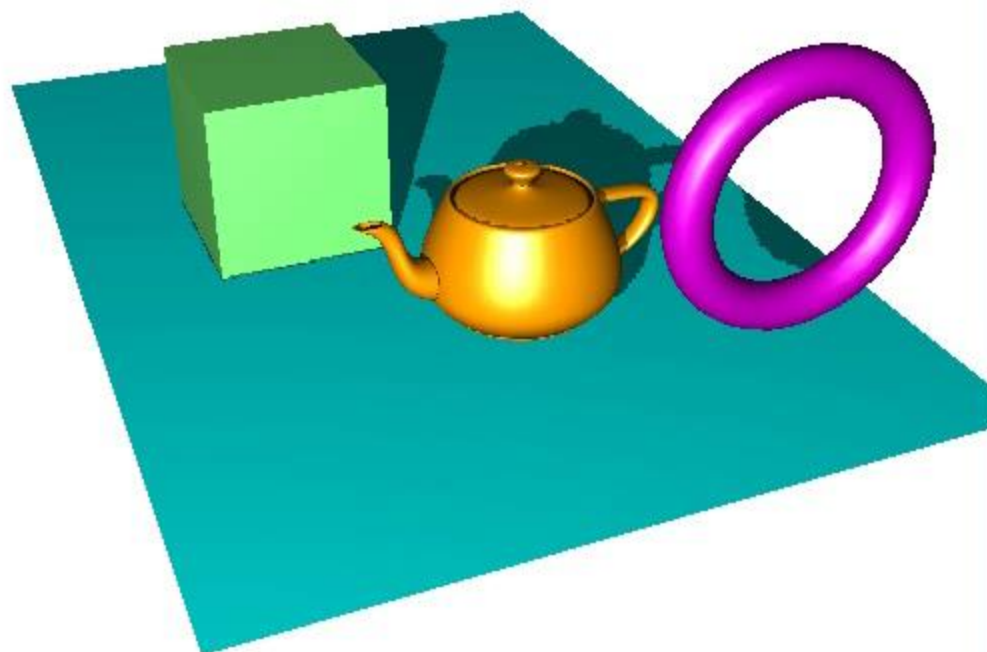
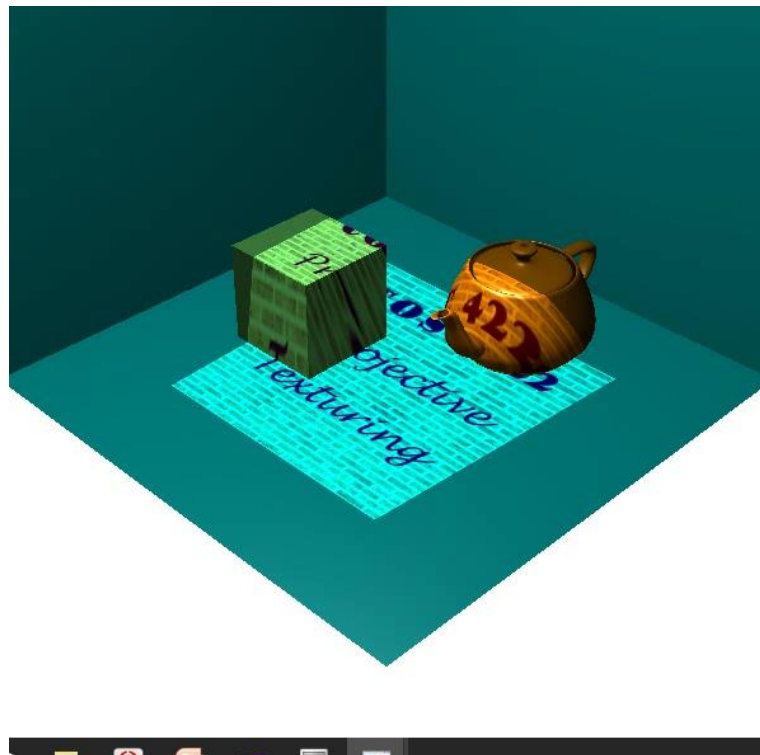
- texture mapped on
polygon.

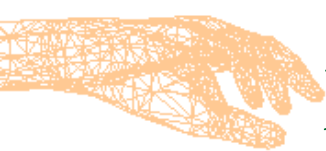




Projective Texturing

- generating complex shadows
 \uparrow shadow map

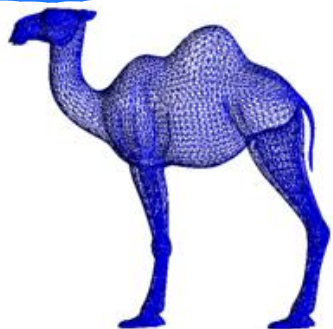




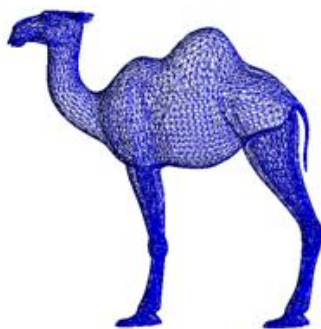
Mesh Processing

- Multiple levels of detail (simplification)

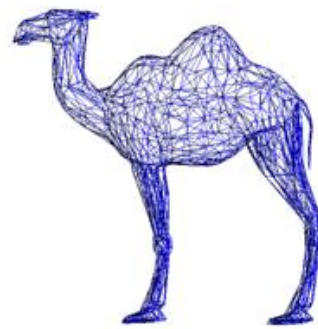
□ Simplification:



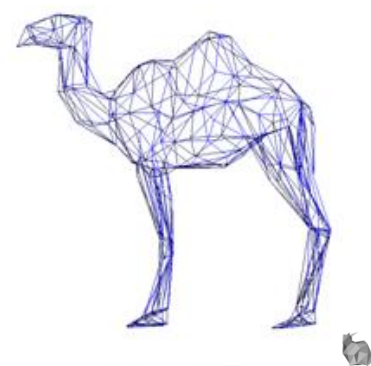
$V = 9000$
 $F = 17996$
 $E = 26994$



$V = 5000$
 $F = 9996$
 $E = 14994$

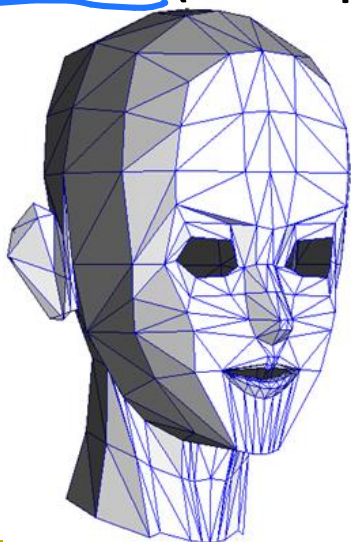


$V = 1000$
 $F = 1996$
 $E = 2994$

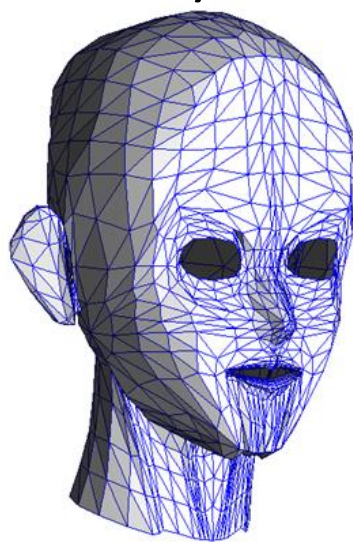


$V = 200$
 $F = 396$
 $E = 594$

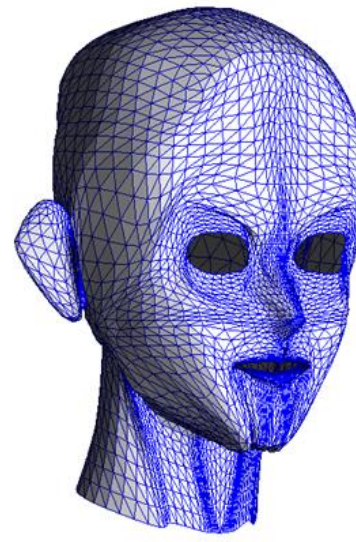
□ Subdivision (Interpolation):



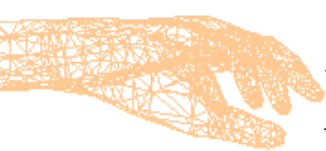
Iteration 0
504 triangles



Iteration 1
2016 triangles

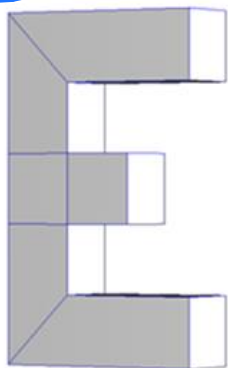


Iteration 2
8064 triangles

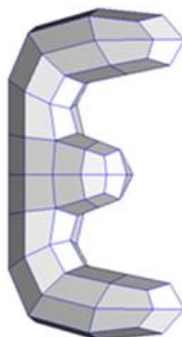


Mesh Processing

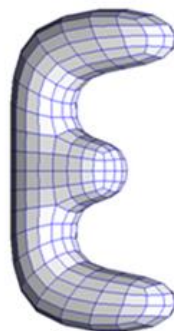
□ Subdivision (Approximation):



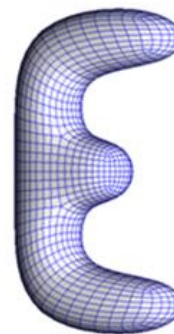
Original mesh
26 quads



Iteration 1
104 quads

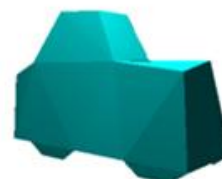
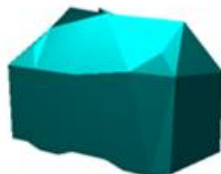
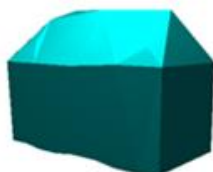
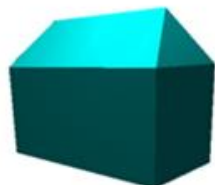


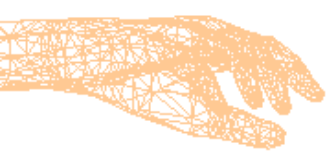
Iteration 2
416 quads



Iteration 3
1664 quads

□ Morphing



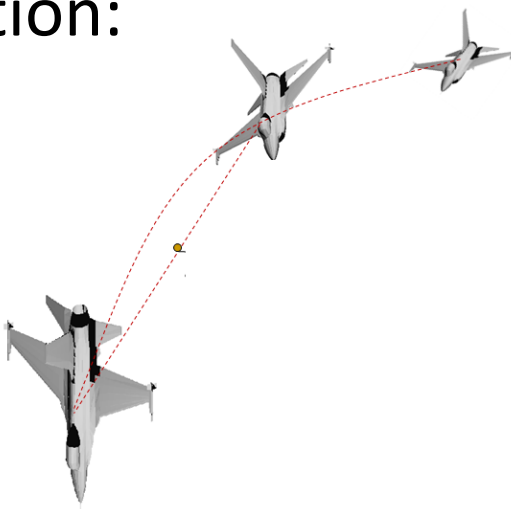


Quaternions –

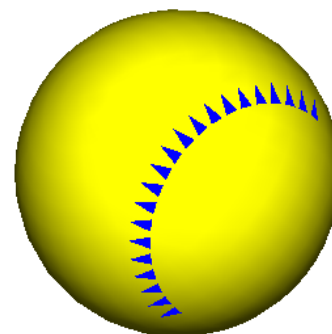
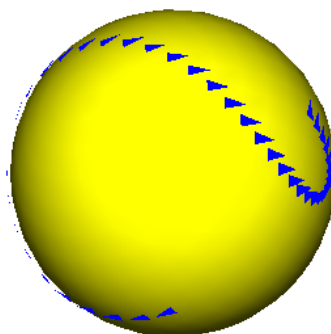
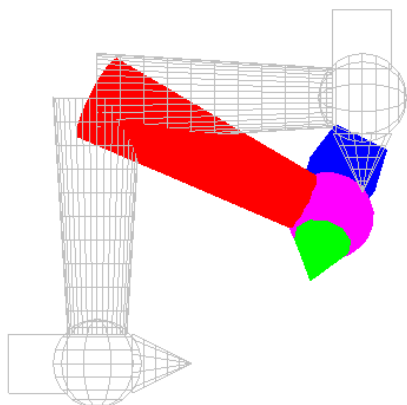
*interpolating
between orientations*

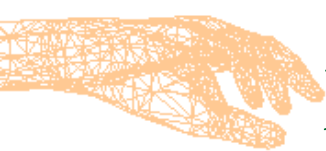
(q_0, q_1, q_2, q_3)

□ Rotation Interpolation:



□ Spherical Linear Interpolation:

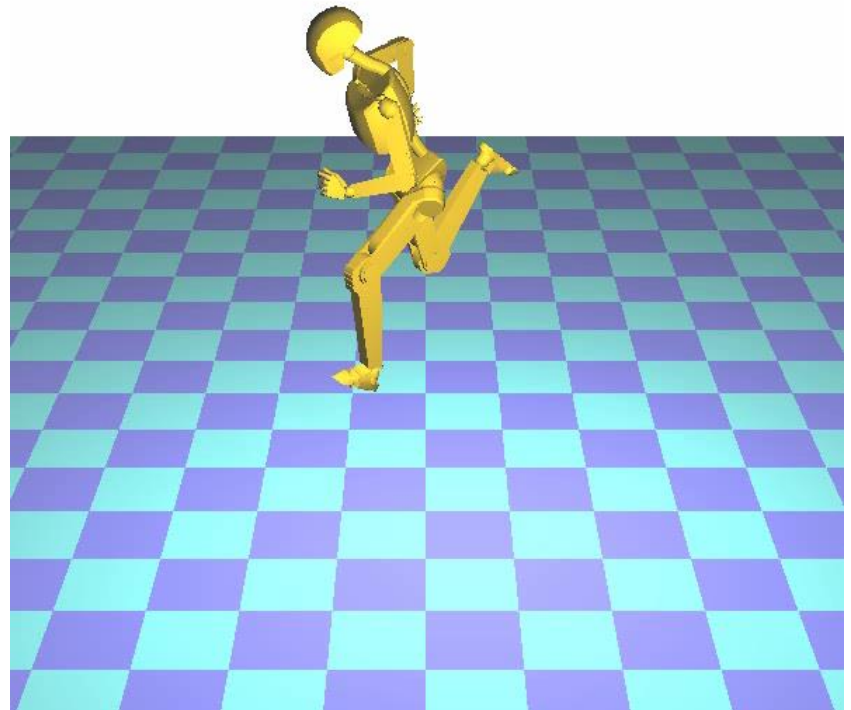
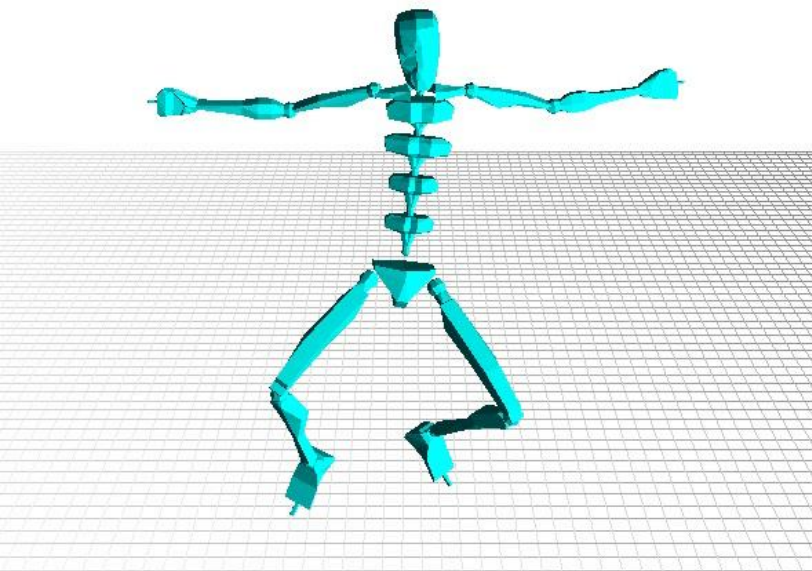




Motion Capture Data

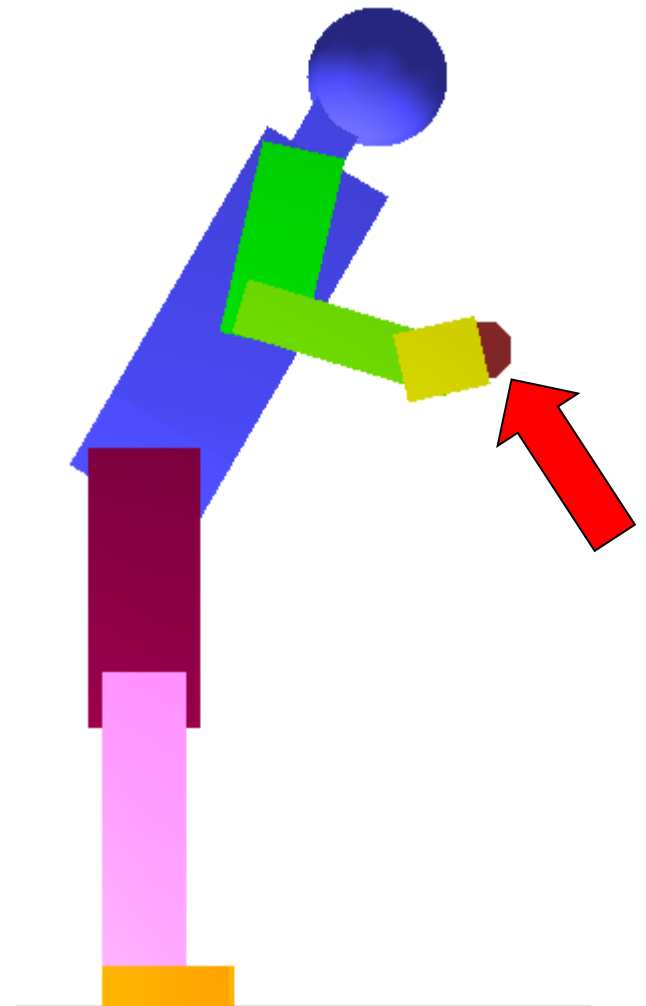
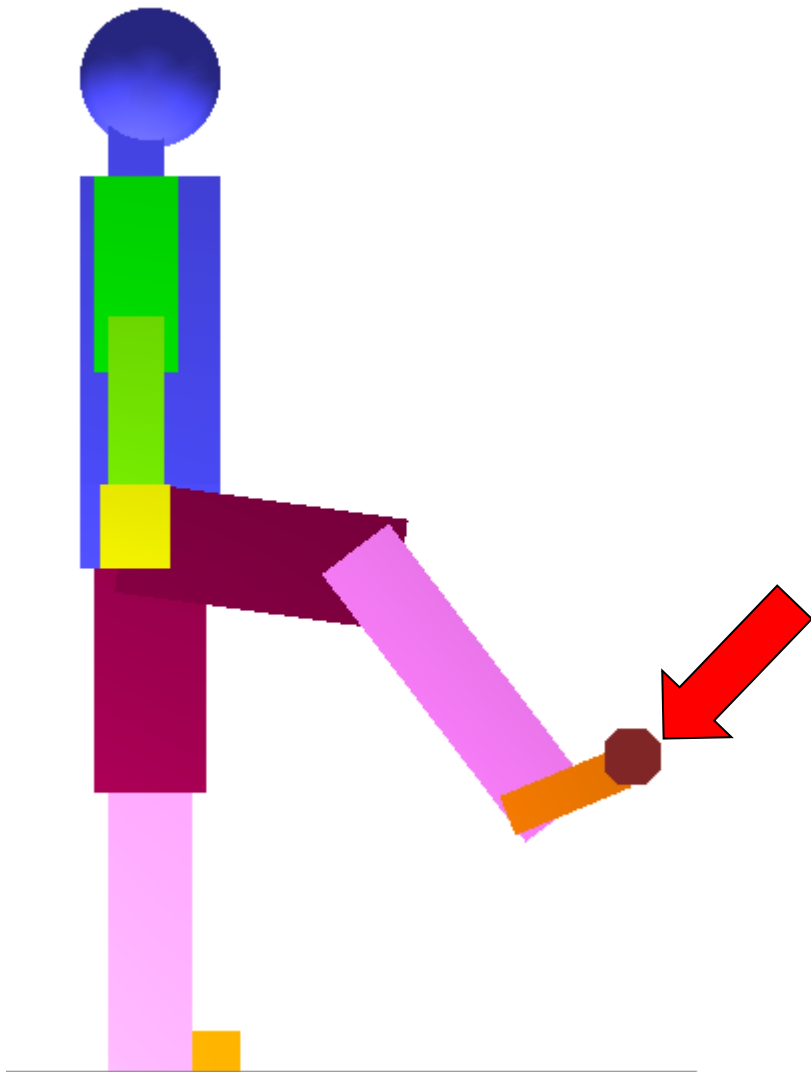


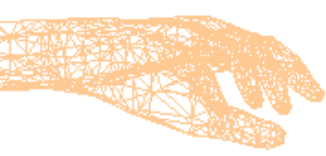
Skeletal Animation



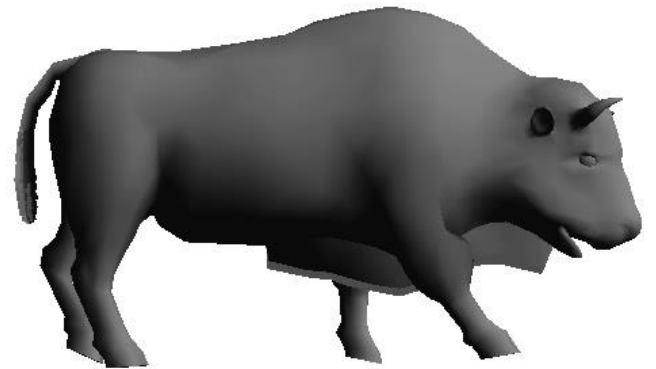


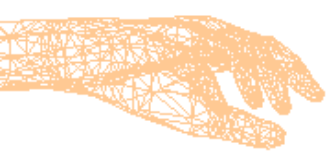
Inverse Kinematics



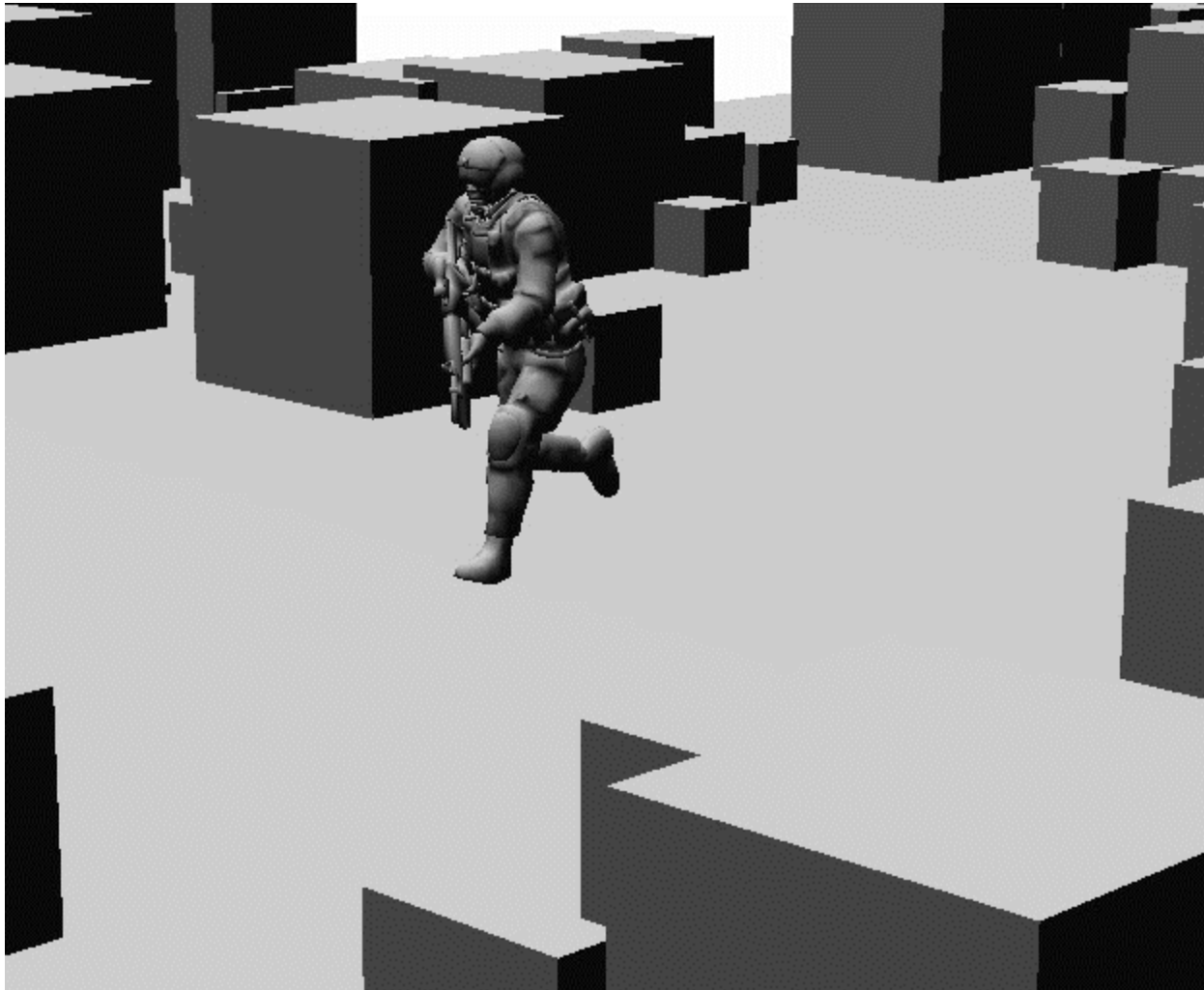


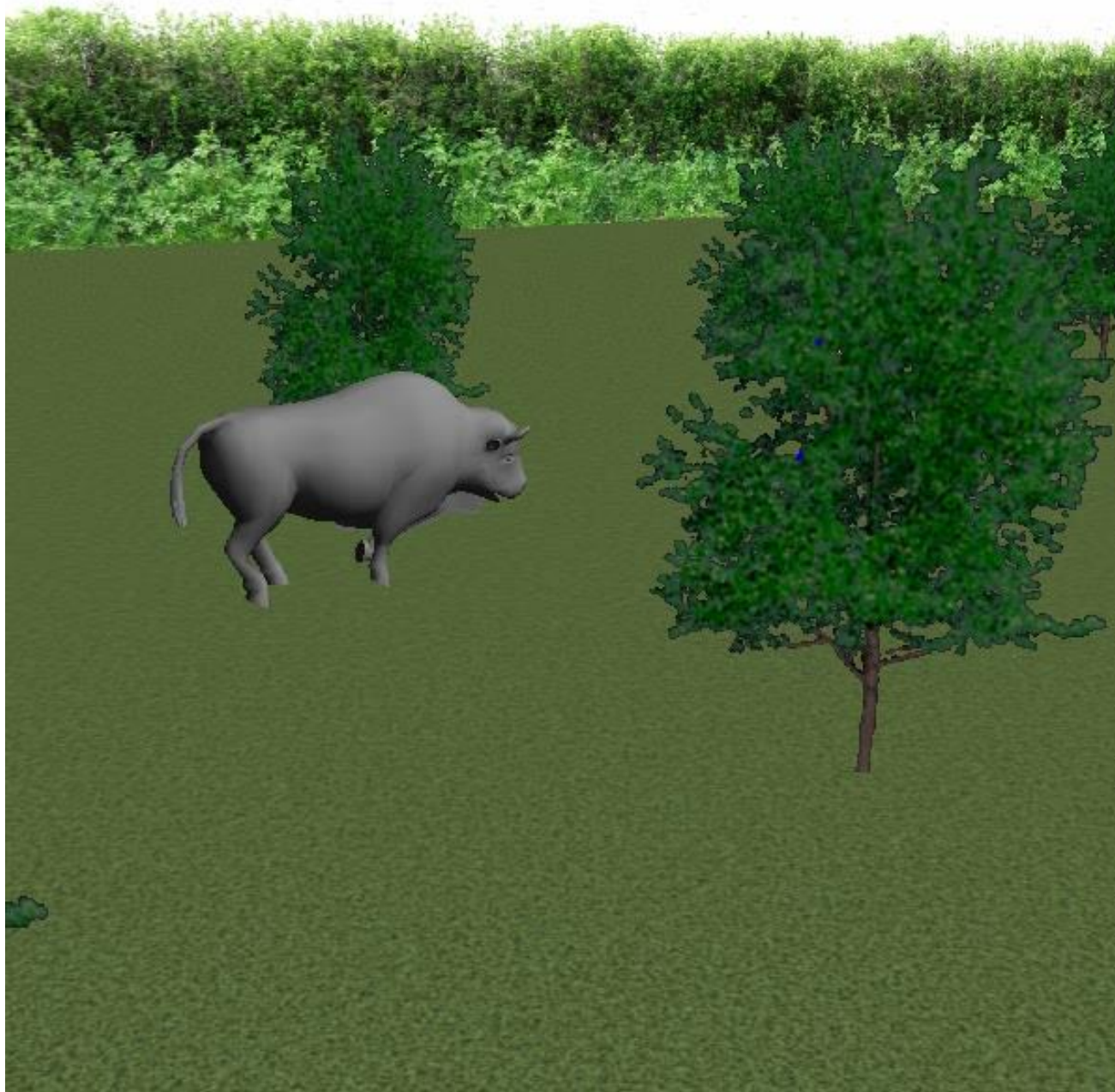
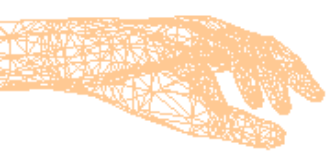
Character Animation

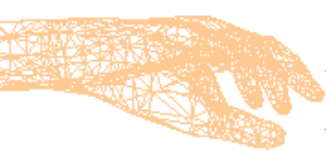




Character Animation

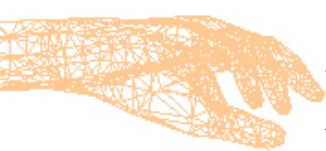






Reference Books

- ❑ A. Boreskov, E. Shikin, **Computer Graphics: From Pixels to Programmable Hardware**, CRC Press, 2014.
- ❑ Tom McReynolds, David Blythe, **Advanced Graphics Programming Using OpenGL**, Morgan Kaufmann Publ. 2005.
- ❑ John Kessenich, **OpenGL Programming Guide Version 4.5 (9th Ed.)**, Addison Wesley, 2016.
- ❑ Tomas Moller and Eric Haines, **Real-Time Rendering**, A K Peters: Massachusetts, 3rd Ed, **2018**.



Reference Book

Mukundan, R. **Advanced Methods in Computer Graphics**, Springer 2012. (Full text access via Library)



UNIVERSITY OF
CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Library Catalogue

[UC Home](#) > [Library](#) > [Library Catalogue](#)

[Search](#) [My Library Account](#)

[Basic](#) | [Advanced](#) | [Previous searches](#)

Search:

 **Advanced methods in computer graphics [electronic resource] : with examples in OpenGL /**
Ramakrishnan Mukundan.

[Add to my list](#)
[Request first available copy](#)

Author: Mukundan, R.

Subject: OpenGL.
Computer graphics.

Published: London ; New York : Springer, c2012.

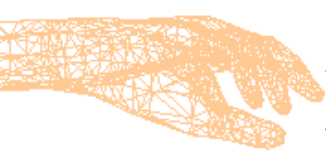
Online access: [Connect to electronic resource](#)

Contents: Mathematical Preliminaries -- Scene Graphs -- Skeletal Animation -- Quaternions -- Kinematics -- Curves and Surfaces -- Mesh Processing -- Collision DetectionMathematical Preliminaries -- Scene Graphs -- Skeletal Animation -- Quaternions -- Kinematics -- Curves and Surfaces -- Mesh Processing -- Collision Detection.

Description: 1 online resource (xiii, 312 p.) : ill.

ISBN: 9781447123408 (electronic bk.)



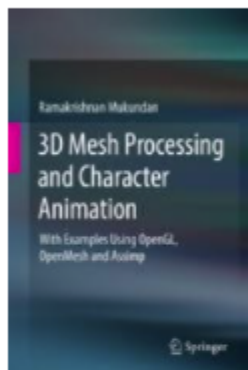


Reference Book

Mukundan, R. **3D Mesh Processing and Character Animation**, Springer 2022.

<https://www.springer.com/gb/book/9783030813536>

» Computer Science » Image Processing



© 2022

3D Mesh Processing and Character Animation

With Examples Using OpenGL, OpenMesh and Assimp

Authors: **Mukundan**, Ramakrishnan

Includes a large collection of important methods used in the fields of three-dimensional mesh processing, tessellation and rendering

» [see more benefits](#)

Buy this book

▼ eBook

- ISBN 978-3-030-81354-3
- Digitally watermarked, DRM
- Included format:
- ebooks can be used on all devices





► Hardcover **C**





» [FAQ](#) » [Policy](#)


Services for this Book


» [Download Product Flyer](#)

 UC LEARN | AKO   My Courses ▾ English (en) ▾ 


 COSC422-21S2


 Participants


 Grades


 Show all sections


Sections ▾


 Course home


 Lecture Material

 Programming Exercises

 Reading Material

 Misc.

 Dashboard

 Site home


COSC422-21S2 - Advanced Computer Graphics




[Dashboard](#) / [My courses](#) / [COSC422-21S2](#)

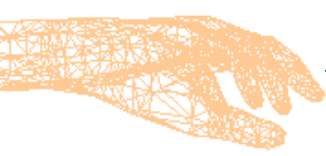
Course home Edit ▾

Welcome to COSC422!

This course focusses on concepts and algorithms in three application domains: OpenGL-4 shader development, three-dimensional mesh processing, and character animation. The topics covered in the course include real-time rendering using tessellation and geometry shaders, image-based rendering using frame buffer objects, non-photorealistic rendering, advanced illumination models, mesh processing algorithms, quaternions, scene graphs, skeletal and keyframe animations, and motion kinematics.

 Course Information, Timetable Edit ▾ ☐

  [COSC422-21S2](#)  Edit ▾ ☐



Programming Exercises

UC LEARN | AKO

My Courses ▾

English (en) ▾

COSC422-21S2

Participants

Grades

Show all sections

Sections ▾

Course home

Lecture Material

Programming Exercises

Reading Material

Misc.

Dashboard

Site home

Content bank

My courses ▸

You can skip this material if you have previously completed COSC363 labs on shader programming.

Exer01.pdf

Exer01 Files

Exer02.pdf

Exer02 Files

2. Tessellation Shader (Exercises 3, 4)

You can skip this material if you have previously completed COSC363 labs on shader programming.

Ex03_SurfaceApprox.pdf

Ex03 Files

Ex04_BezierApprox.pdf

Ex04 Files

3. Geometry Shader (Exercise 5)

Ex05_SurfaceRevl.n.pdf

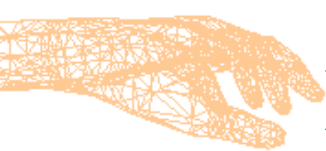
Ex05 Files

4. Terrain Rendering (Exercise 6)




Ex06_TerrainRendering.pdf


Ex06 Files


Useful for
Assignment-1 !





Reading Material

 UC LEARN | AKO   My Courses ▾ English (en) ▾


 COSC422-21S2


 Participants


 Grades


 Show all sections


Sections ▾


 Course home


 Lecture Material

 Programming Exercises

 **Reading Material**

 Misc.


 Dashboard




COSC422-21S2 - Advanced Computer Graphics



[Dashboard](#) / [My courses](#) / [COSC422-21S2](#) / [Sections](#) / [Reading Material](#)


Reading Material






 COSC363 Lecture Notes on Shader Programming






 [COSC363 Lec09_OpenGL4.pdf](#) 




 [COSC363 Lec10_TessellationShader.pdf](#) 






 [COSC363 Lec11_GeometryShader.pdf](#) 



 Tessellation and Geometry Shaders



 [OpenGL Tessellation and Geometry Shaders](#) 



 -