3D User Interfaces – Tutorial 4

Speaker: Linda Rudolph, M.Sc. (Teaching Assistant)

Responsible Professor: Prof. Gudrun Klinker, Ph.D.

Summer Semester 2023

09:00 – 10:00 time for individual questions

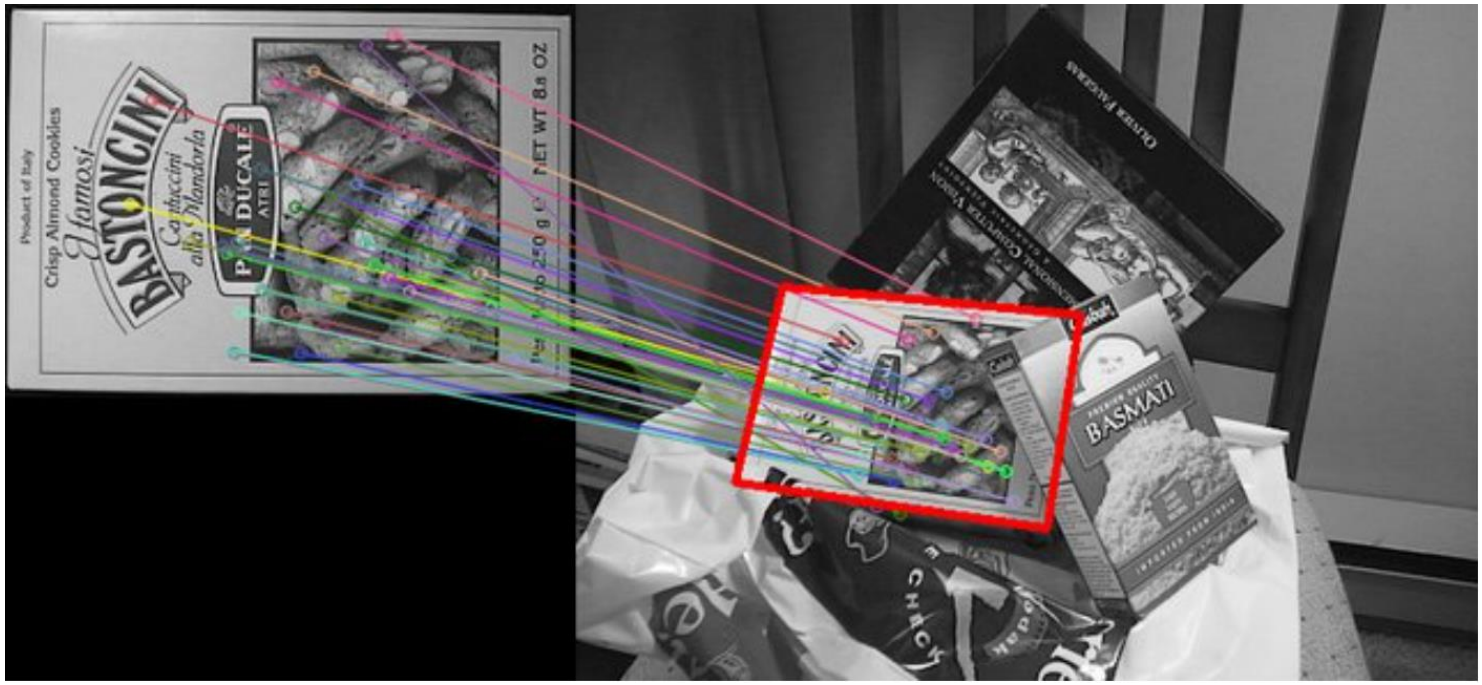
10:00 - ~11:00 lecture part

Topics Today

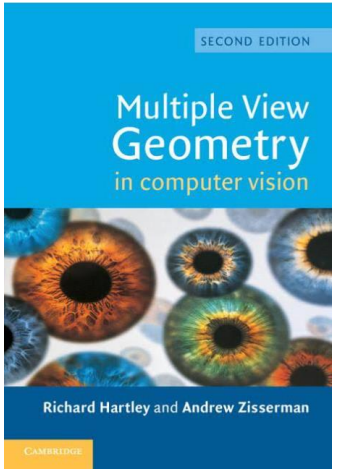
Videos from last week (hopefully)

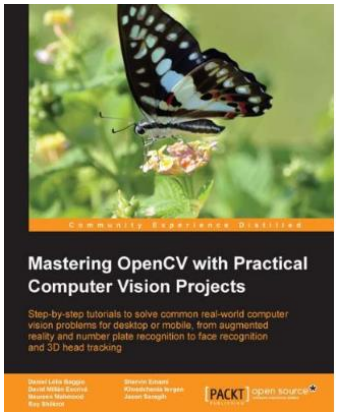
3D data representations in a nutshell

Image Marker Tracking (Natural Feature Tracking)



Img: Jakubović, A., & Velagić, J. (2018, September). Image feature matching and object detection using brute-force matchers. In *2018 International Symposium ELMAR* (pp. 83-86). IEEE.





Further Information

Theoretical (Mathematical) Basis:

Prof. Cremers - Computer Vision II: Multiple View Geometry (also on Youtube)

Hartley, R., & Zisserman, A. (2003). *Multiple view geometry in computer vision*. Cambridge university press.

Practical Guide:

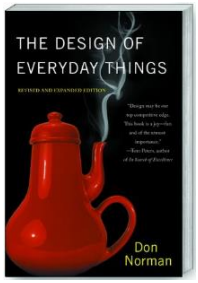
Baggio, D. L. (2012). *Mastering OpenCV with practical computer vision projects*. Packt Publishing Ltd.

Homework 2 – Applications of Image Targets

Source: https://youtu.be/_qHY1qoIPOE Published by Youtube Channel Brick Finder, All rights by Lego, archived for educational purpose

https://www.youtube.com/watch?v=_qHY1qoIPOE

Affordances and Signifiers

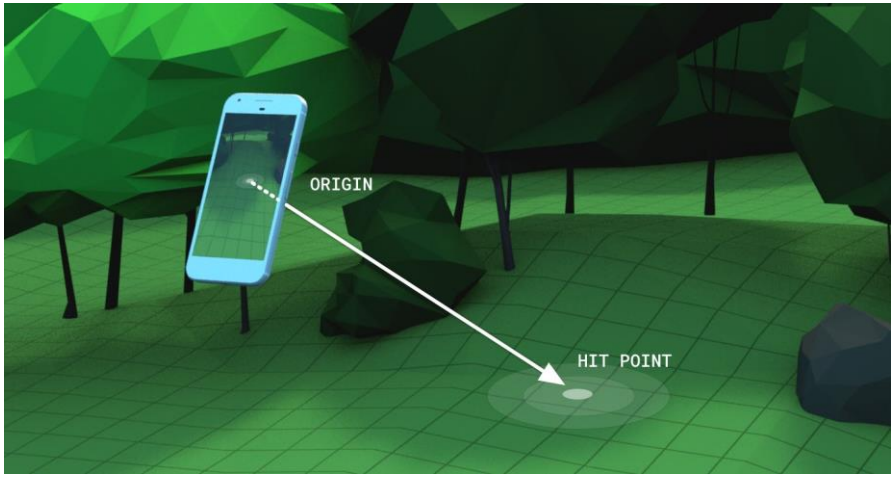


Affordance = What a user can do with a device
Signifiers = Perceivable hints for affordances & constraints

Signifier: That yellow symbol on the table

Affordance: The user can place virtual objects on a physical table

Ray cast methods for handheld AR



Source https://developers.google.com/ar/develop/hit-test?hl=en

Ray from the touch point on the screen to a collider

- Colliders can be…
  - Planes / objects in the “physical” world (Based on your tracking method)
  - Virtual objects

- Two methods: Either use center point of screen or touch position

Ray cast methods for handheld AR

Homework 2: Competition

Winner: Ao Gao & Michl Bayer

Special Price: Simon Dittrich (WebXR)

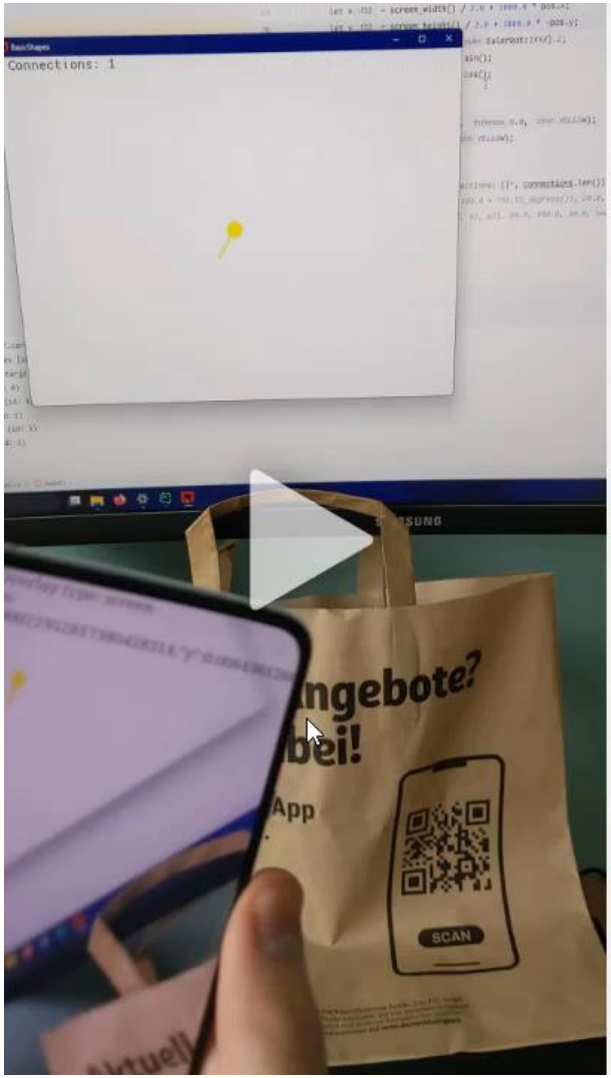
Wall of Honor (random order)

Tatev Tsokolakyan

Martin Hubert Schacherbauer

Paul Pernsteiner

Dhia Nouri



3D Data Structures (In a nutshell)

3D Data Structures

3D geometrical representations

- BREPs, CSG, Cellular Formats (Meshes), Voxels, Pointclouds

3D Data Formats

- ***.**STEP, *.OBJ, *.STL …

Object-oriented Formats

- IFC
- USD
- GLTF

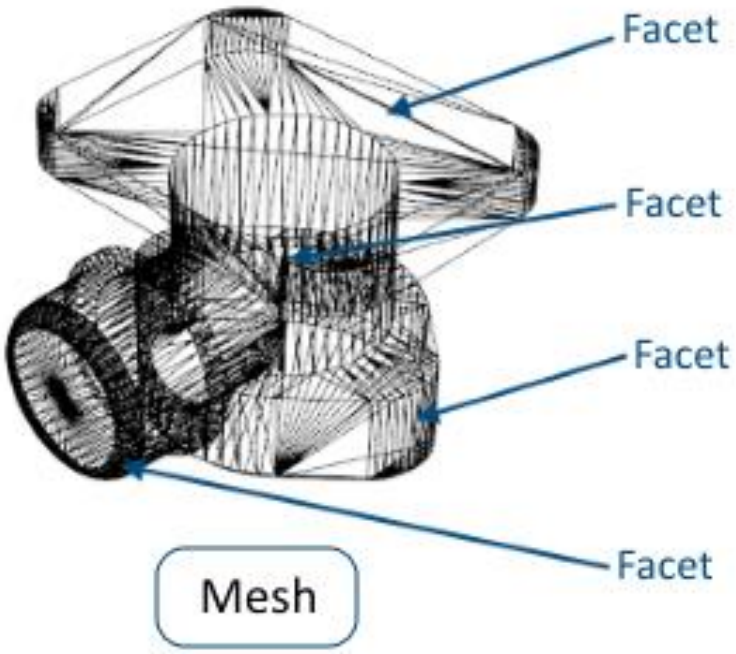
Different Domains need 3D representations

Question to the audience:

Who works with 3D data structures?

Surface-based (Movies, Games, Engineering)

Meshes



- ✓ Simple geometries used (triangles)
- ✓ Supported by most 3D Tools
- ✓ Supported on a hardware level by graphics cards

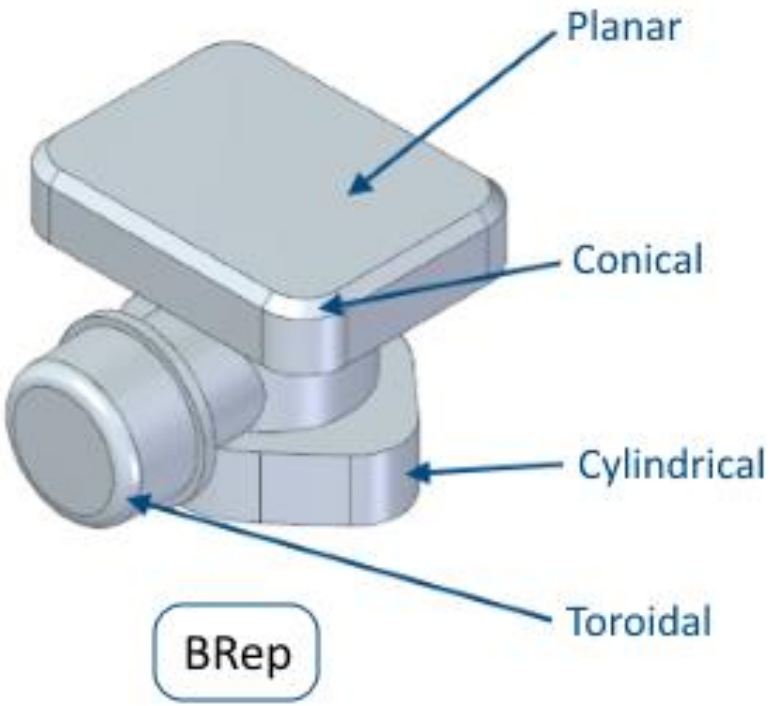
- – Discretized surfaces (not smooth)
- – Many polygones necessary (data size)
- – Not per-se watertight

Exchange Format: various, e.g.
*.obj (widely used, large filesize),
*.stl (3D printing, no textures!),
*.ply (also point clouds),
*.fbx (animations, Unity)

https://blogs.sw.siemens.com/solidedge/cad-is-converging-and-you-are-in-deep/

Surface-based (Movies, Games, Engineering)

B-Reps



- ✓ Precise
- ✓ Minimal amount of data
- ✓ Can “easily” be converted to meshs (other way around is much harder)

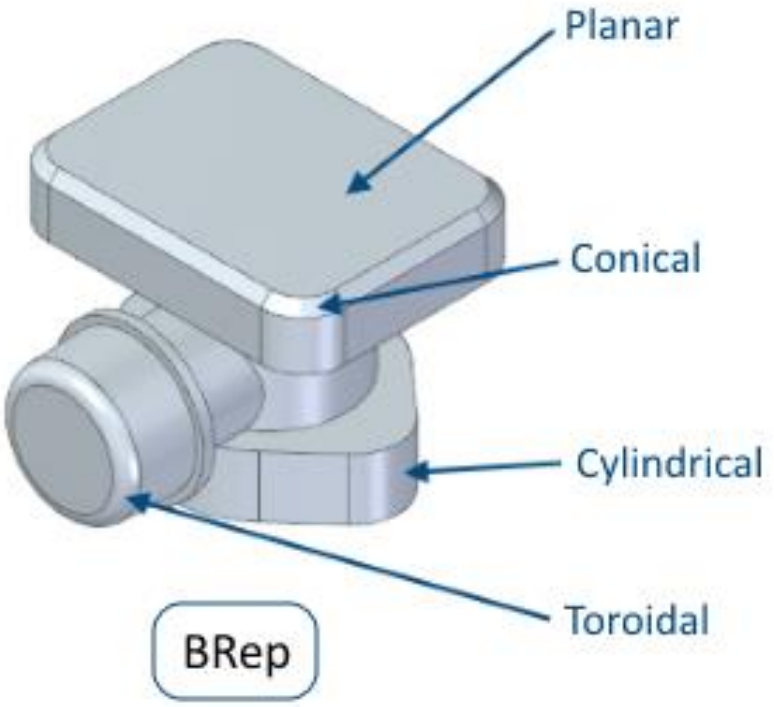
- – Various proprietary definitions
- – Not supported by tools outside the “CAD-World”

Exchange Format: STEP

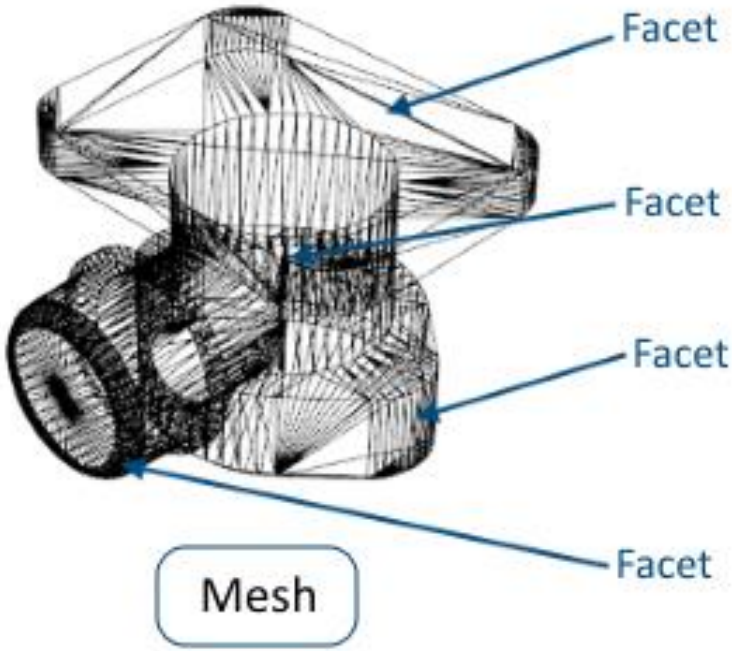
Image: https://blogs.sw.siemens.com/solidedge/cad-is-converging-and-you-are-in-deep/

Surface-based (Movies, Games, Engineering)

Boundary Representations

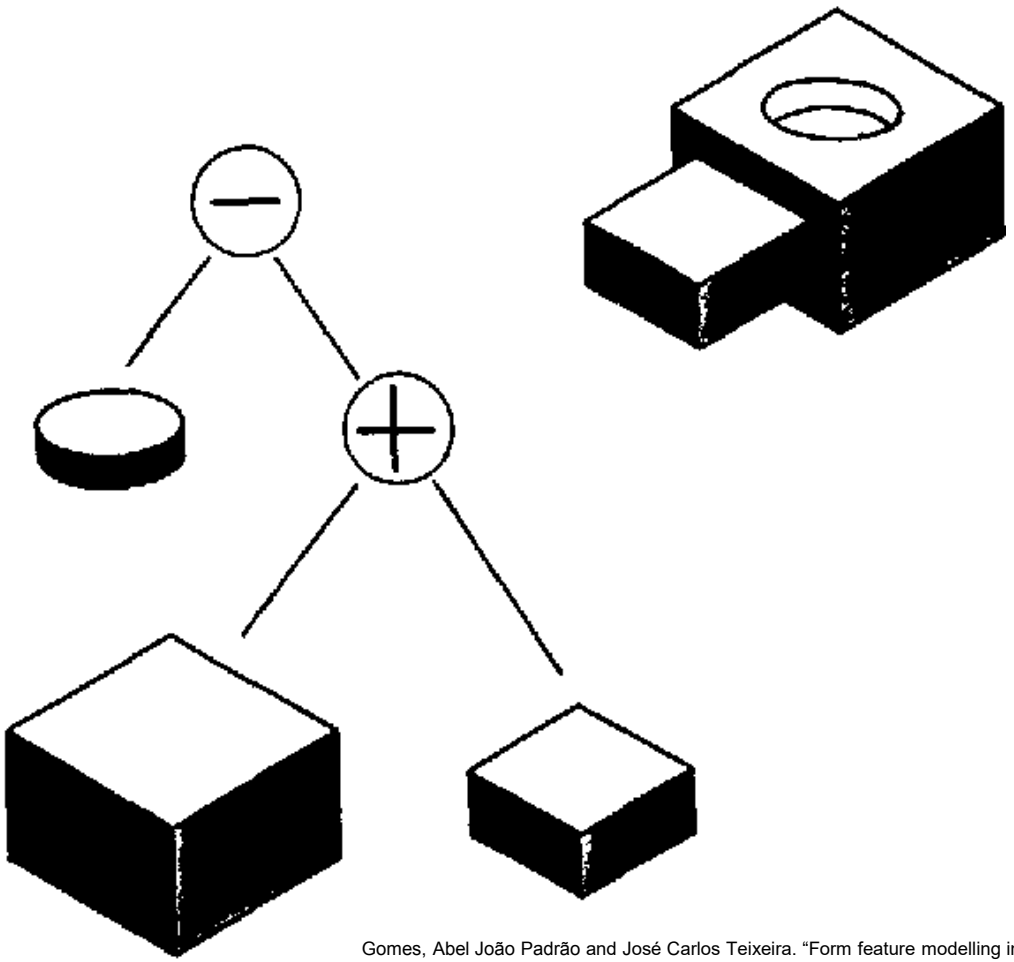


Meshes



https://blogs.sw.siemens.com/solidedge/cad-is-converging-and-you-are-in-deep/

Solids - CSG (Constructive Solid Geometry)

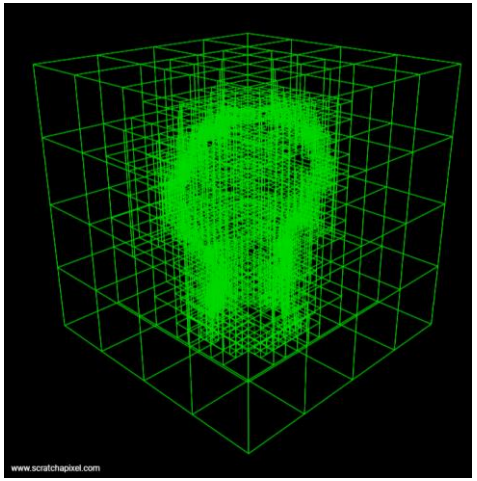


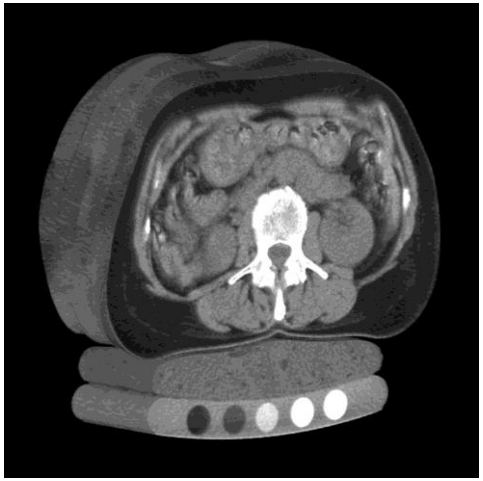
Gomes, Abel João Padrão and José Carlos Teixeira. “Form feature modelling in a hybrid CSG/BRep scheme.” *Comput. Graph.* 15 (1991): 217-229.

- ✓ As precise as B-Reps
- ✓ Always watertight (3D printing)
- ✓ Convenient boolean operators for modelling
- ✓ Minimal datasize

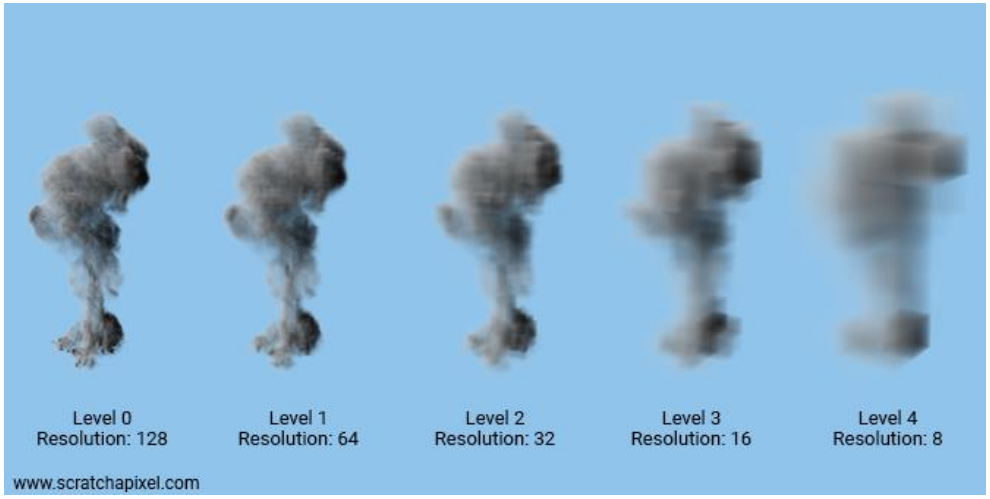
- – Not supported by non-engineering 3D Tools (VR/Gaming etc.)

Volumetric Representations: Voxels & Octrees





By MindwaysCT Software - MindwaysCT QCT Pro brochure, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=23137844



- ✓ Useful for non-surface oriented applications
- ✓ X-rays
- ✓ Non-dense effects (fog, clouds…)
- ✓ Densities & volumetric rendering

- – Discrete
- – Storage-intense

Point Clouds

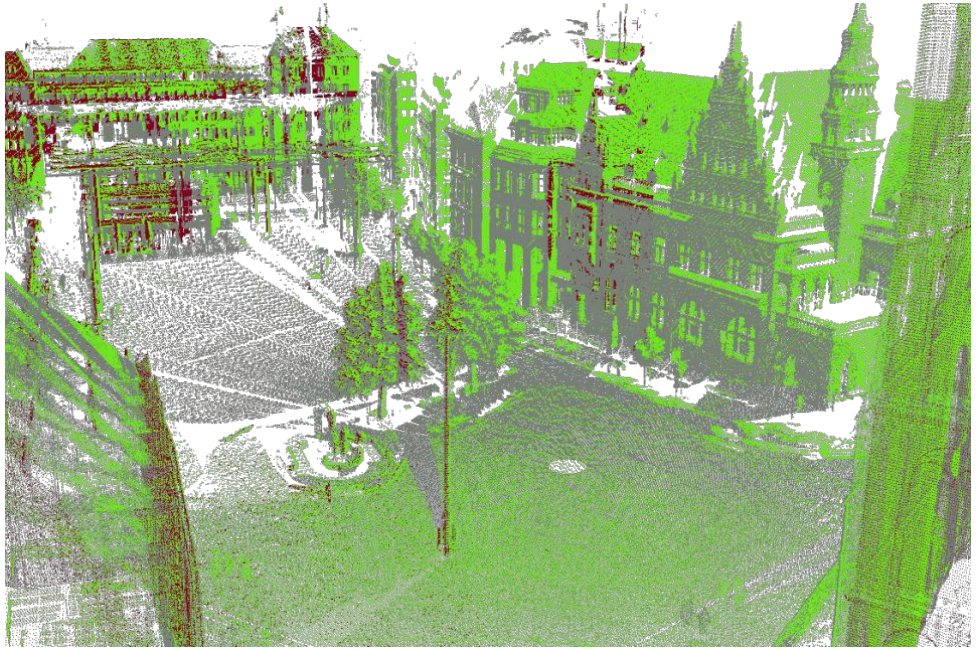


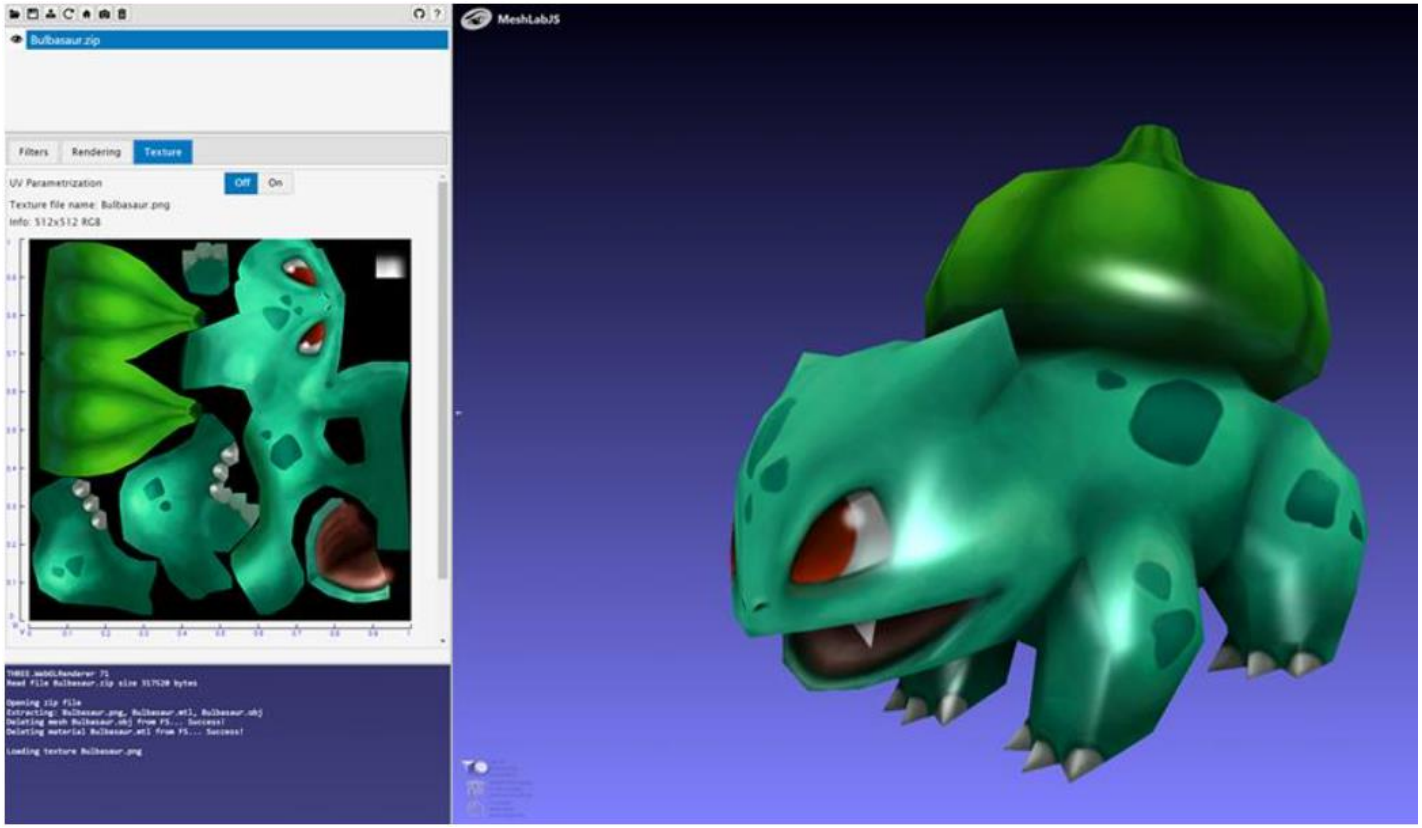
Image: https://ieee-dataport.org/documents/3d-point-cloud-library

"raw-data" of 3D-scanning systems
Often immense file sizes

Include
- x,y,z position of points
- Sometimes! Color
- Sometimes! Normals (can be calculated)

Exchange Formats:
- *.xyz (simple)
- *.ply (also meshes)
- *.laz (laser scans)
- *.e57 (by Matterport ASTM E2807 standard)

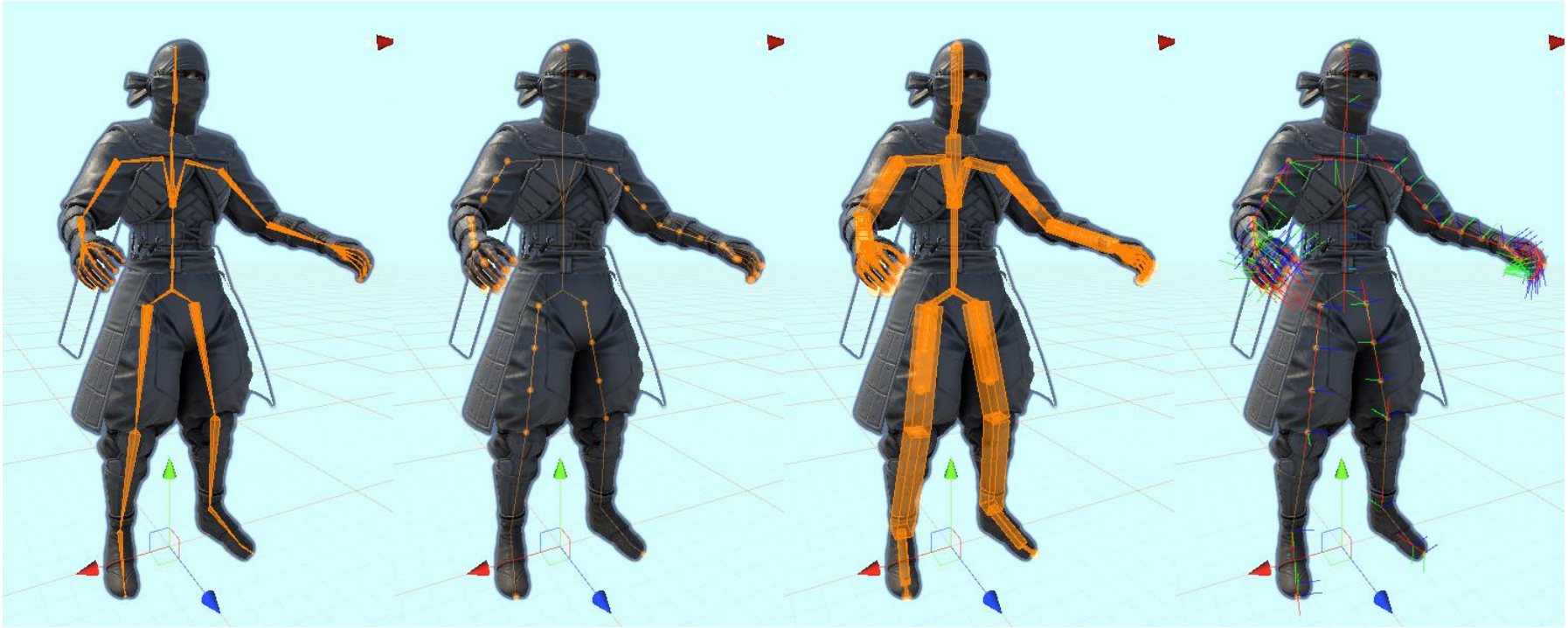
Texture Mapping



https://user-images.githubusercontent.com/6282055/33598043-9f598144-d9a1-11e7-8b84-3022578455b8.jpg

- Texture is added by a pixel – file “uv-map”
- The pixel coordinates (u,v) are mapped to 3D polygones

Rigging



https://docs.unity3d.com/Packages/com.unity.animation.rigging@0.2/manual/index.html

- Adding a skeleton to a mesh
- Important for animation

Domain Specific Formats

Scene Descriptions (animations, rigging…)
USD (Universal Scene Description)

- Open Standard for Scene Graphs in film/VFX domains (made by Pixar)
- Adopted e.g. by Nvidia for the Omniverse

GLTF (GL Transmission Format)

- Open standard by Khronos Group
- Light-weight format, optimized for transmission
- Widely used in Web for XR topics

FBX (Blackbox)

Object-Oriented Formats
Construction industries: BIM IFC

- Stores functional objects (Walls, Doors, stairs) and their (geometrical and non-geometrical) properties
- Based on CAD Models => Brep!
- Many converters to CAD/Mesh formats exist

Homework 4: Import virtual assets

Homework 4.1 (Implementation)

1. Add a hand model to your “monitor” scene as a signifier for the virtual hand–based selection. (e.g. https://sketchfab.com/3d-models/hand-low-poly-2eae7e04983d4db788768e411751b668)
2. Add a 3D model to the image target in the smartphone scene and try out the world-in-miniature metaphor by moving your image target

Homework 4.2 (Use Case definition)

Think about possible use cases for 3DUI as a basis for the project phase

- What is the users‘ goal?
- Who is the target group?
- How could the interface be realized?

Create a one-minute elevator pitch

(Optional) Upload it to moodle and hold the elevator pitch in the class on May, 22nd

Example Use Cases

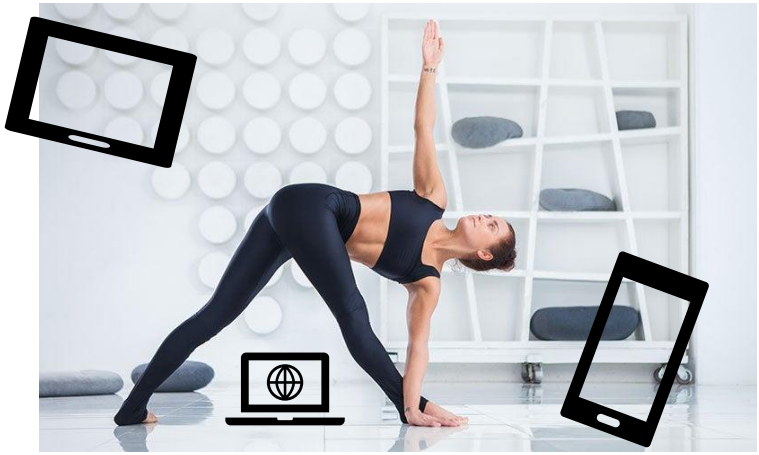
Yoga - Visual Feedback

Problem
If I am doing yoga, I never know, whether I do it correctly. For example, I cannot imagine, whether my shoulder is “directly above my foot”

Target Group
Digital natives with many devices with screens & cameras.
People who are doing yoga at home (e.g. with youtube tutorials)

Vision
I have several (2 - 4) devices with cameras positioned around me. Then, I start a “video conference” to see all views. Via speech control, I take photos to afterwards see myself in postures, in which I should not move my head towards a display.

Advanced: Via body tracking, the system compares my pose to the one of the lecturer and shows me the perspective that is most similar to the one of the lecturer.



https://www.foodspring.de/magazine/vinyasa-yoga

The smart(er) Mensa

https://www.stbam2.bayern.de/mam/header/mga_meckarchitekten_465a095d_heinrich_940x396.jpg

Problem

In the mensa, I have no overview, which meal is served where – therefore, I need move close to each station before I can decide, what I want.

Target Group

Students, Researchers

Vision

With an app that can be authored easily by the staff with a mini map and images of the daily meals, I could plan my route before going to the stations.

In the mensa, I can use AR Navigation to find the right stations or look via spatially anchored video streams whether a meal is still available.

Collaborative 3D Scene planning

Problem
If I want to talk with others about a 3D scenes or plan events – 2D maps limit our possibilities

Target Groups
Fire fighters / Safety instances
Event planner (Concerts)
Museum / Exhibition planners
UAV controllers
Game Masters in Tabletop RPGs

Vision
If we would have one big screen and smartphone based 3D controllers like in the 3DUI exercises…

http://rahll.deviantart.com/art/Hunger-Games-Fire-Interfaces-332896298

And now… be creative!

… walk around your environment with open eyes

… think about situations, where smartphones are used but somehow… limited as interaction & visualization devices

Announcement: Change in the project requirements

- ~~Project needs to be for a target group, you are not belonging to~~

- (new) You have to get qualitative feedback from at least one member of the target group that is not part of the development team