3D Scanning & Motion Capture

Exercise - 1

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Team

Professor

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TAs

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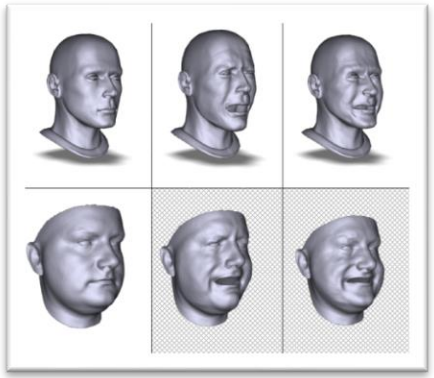
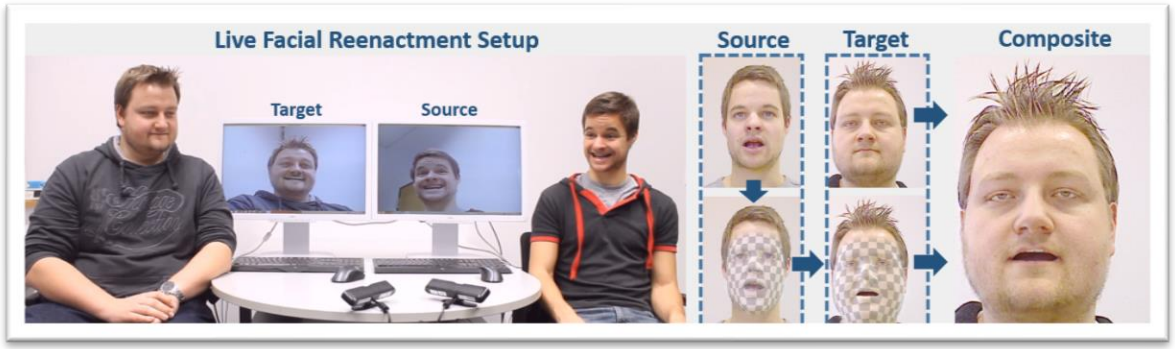
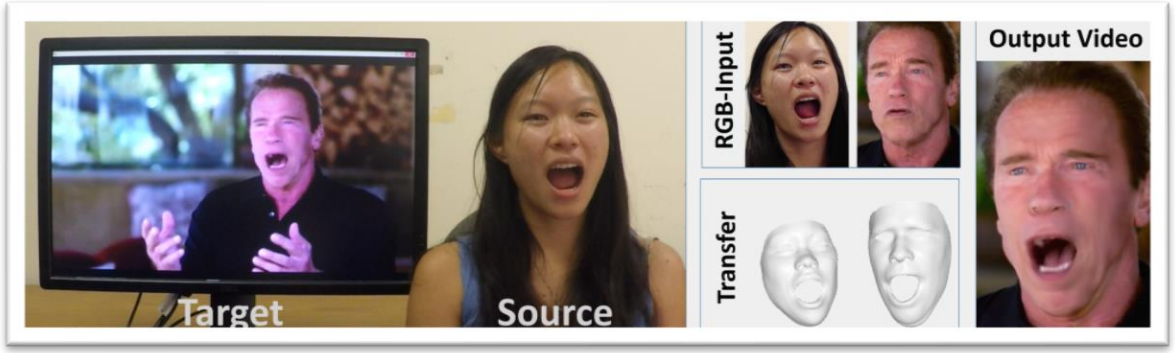
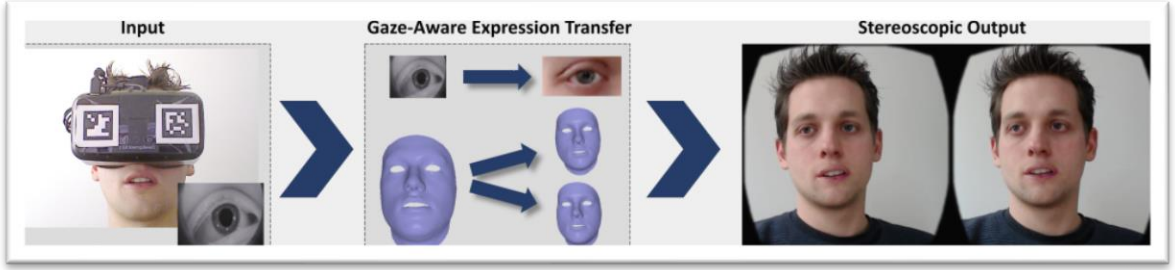
Research Projects









Lecture+Tutorials

- Requirements
  - C++ is a must
  - Profound knowledge of linear algebra
  - Basic concepts of 3D graphics

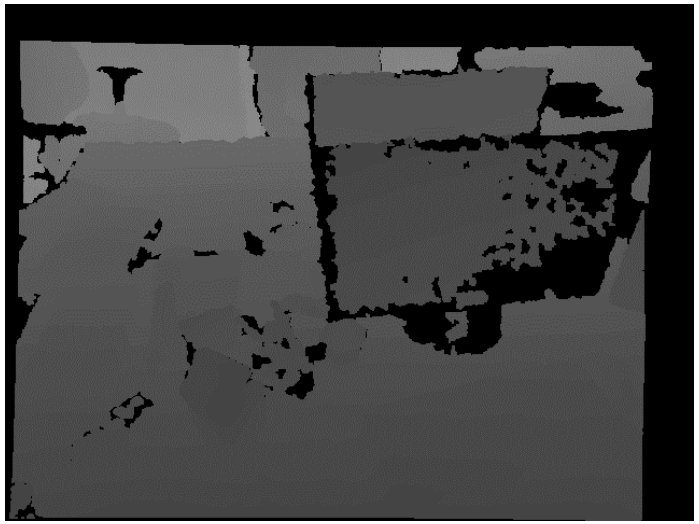
Tutorials

- Basic 3D reconstruction algorithms
  1. Exercise (Camera Intrinsics, Back-projection, Meshes)
  2. Exercise (Surface Representations, Volumetric Fusion, SDF)
  3. Exercise (Object Alignment, ICP)
- 2 weeks of working time
- **Groups of two** are allowed
- Need to pass all three exercise submissions for 0.3 bonus

Project

- 3D reconstruction / tracking project
  - KinectFusion, Face Fitting, Bundling etc. …
- 4/5 weeks
- Groups of 4
- Proposal (abstract 1-2 pages)
- Presentation of the project + abstract (2 pages with results)
- 40% of the exam

Kinect



Kinect – RGB-D Dataset

- https://vision.in.tum.de/data/datasets/rgbd-dataset

https://vision.in.tum.de/data/datasets/rgbd-dataset/download

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Dataset Download

We recommend that you use the **'xyz'** series for your first experiments. The motion is relatively small, and only a small volume on an office desk is covered. Once this works, you might want to try the **'desk'** dataset, which covers four tables and contains several loop closures.

We are happy to share our data with other researchers. Please refer to the respective publication when using this data.

Remarks:

- The file formats are described here.
- The intrinsic camera parameters are here.
- We provide a set of useful tools for working with the dataset.
- The `*_validation` sequences do not contain ground truth. They can only evaluated using the online tool.

Sequence name	Duration	Length	Download	
Category: Testing and Debugging				
fr1/xyz	30.09s	7.112m	tgz (0.47GB)	more info
fr1/rpy	27.67s	1.664m	tgz (0.42GB)	more info
fr2/xyz	122.74s	7.029m	tgz (2.39GB)	more info
fr2/rpy	109.97s	1.506m	tgz (2.13GB)	more info
Category: Handheld SLAM				
fr1/360	28.69s	5.818m	tgz (0.45GB)	more info

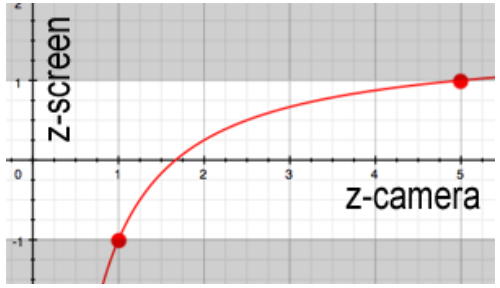
Tasks

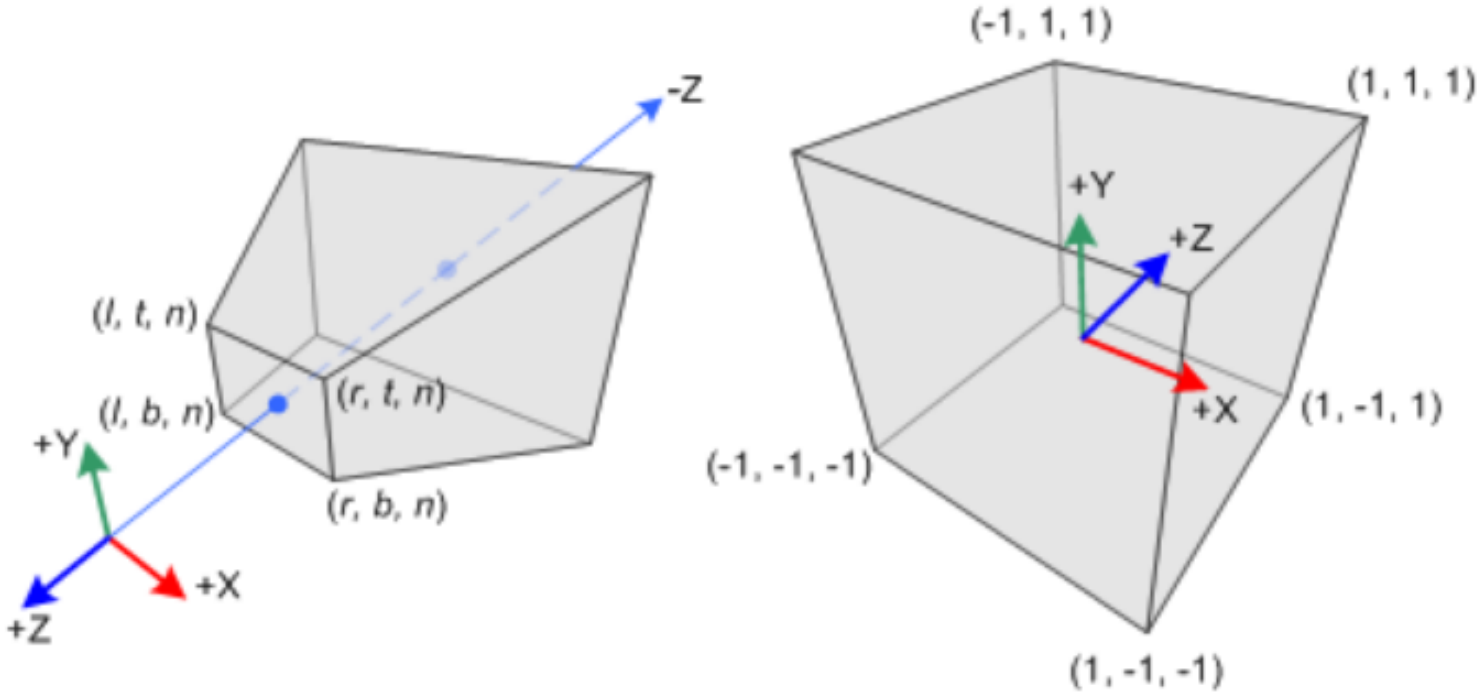
- Back-Projection
  - Use the given intrinsics, extrinsics and the camera trajectory to project the camera observation back to world space
  - Assign the color to the back-projected points
- Write a 3D mesh
  - Write an OFF file containing the back-projected position and color information
  - Make use of the grid structure of the observation to perform the triangulation

Perspective Projection in CG

$$\begin{pmatrix} \frac{2n}{r-l} & 0 & \frac{r+l}{r-l} & 0 \\ 0 & \frac{2n}{t-b} & \frac{t+b}{t-b} & 0 \\ 0 & 0 & \frac{-(f+n)}{f-n} & \frac{-2fn}{f-n} \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

OpenGL Perspective Projection Matrix





Perspective Frustum and Normalized Device Coordinates (NDC)

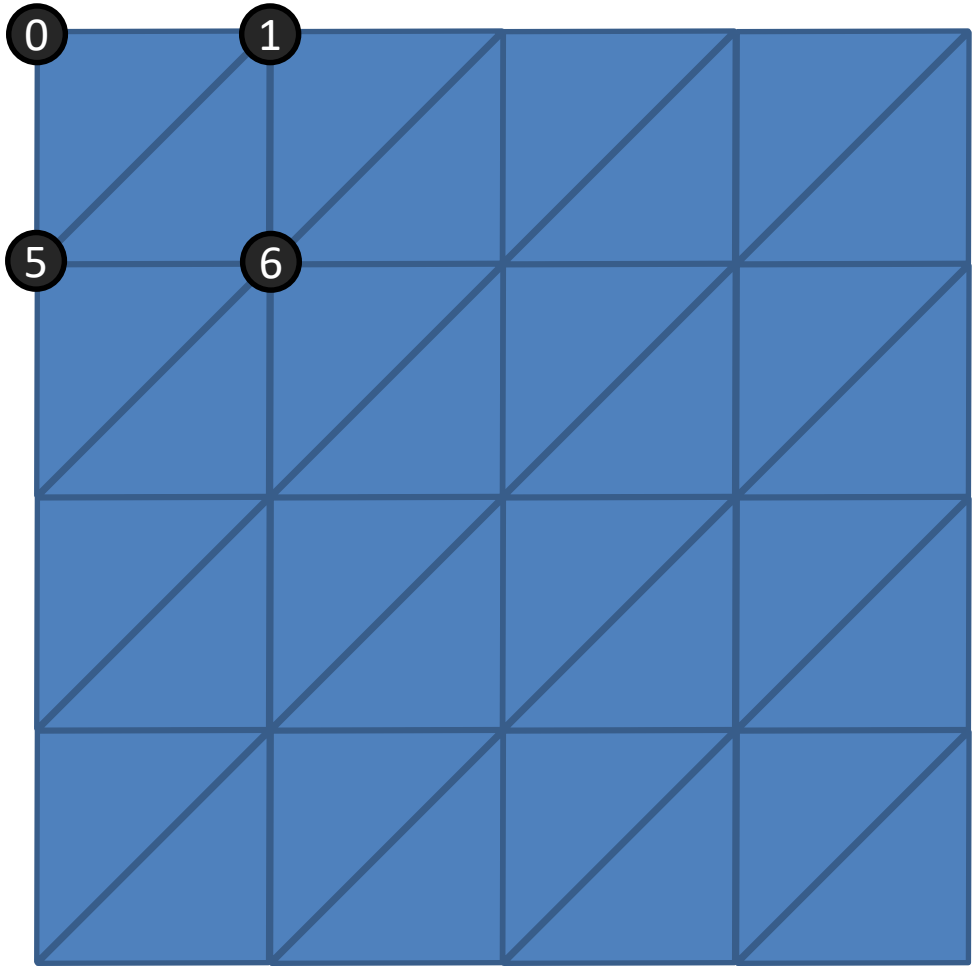
- http://www.songho.ca/opengl/gl_projectionmatrix.html
- https://www.scratchapixel.com/lessons/3d-basic-rendering/perspective-and-orthographic-projection-matrix/opengl-perspective-projection-matrix

Perspective Projection in CV

$$\begin{pmatrix} fov_X & 0 & c_x \\ 0 & fov_Y & c_y \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} x \\ y \\ \boldsymbol{z} \end{pmatrix} = \begin{pmatrix} u' \\ v' \\ w' \end{pmatrix} \xrightarrow{\text{Dehomogenization}} \begin{pmatrix} \boldsymbol{u} \\ \boldsymbol{v} \end{pmatrix} = \begin{pmatrix} u'/w' \\ v'/w' \end{pmatrix}$$

- Keep track of the unmapped z values!

Mesh Structure



Ensure consistent orientation of the triangles!

Example:

First triangle: 0-5-1

Second triangle: 5-6-1

Visual Studio 2017 Community

- https://www.visualstudio.com/de/downloads/

- Known issues:
  - fatal error LNK1104: cannot open file ‘gdi32.lib‘
    - https://stackoverflow.com/questions/33599723/fatal-error-lnk1104-cannot-open-file-gdi32-lib