3D Scanning & Motion Capture

Exercise - 2

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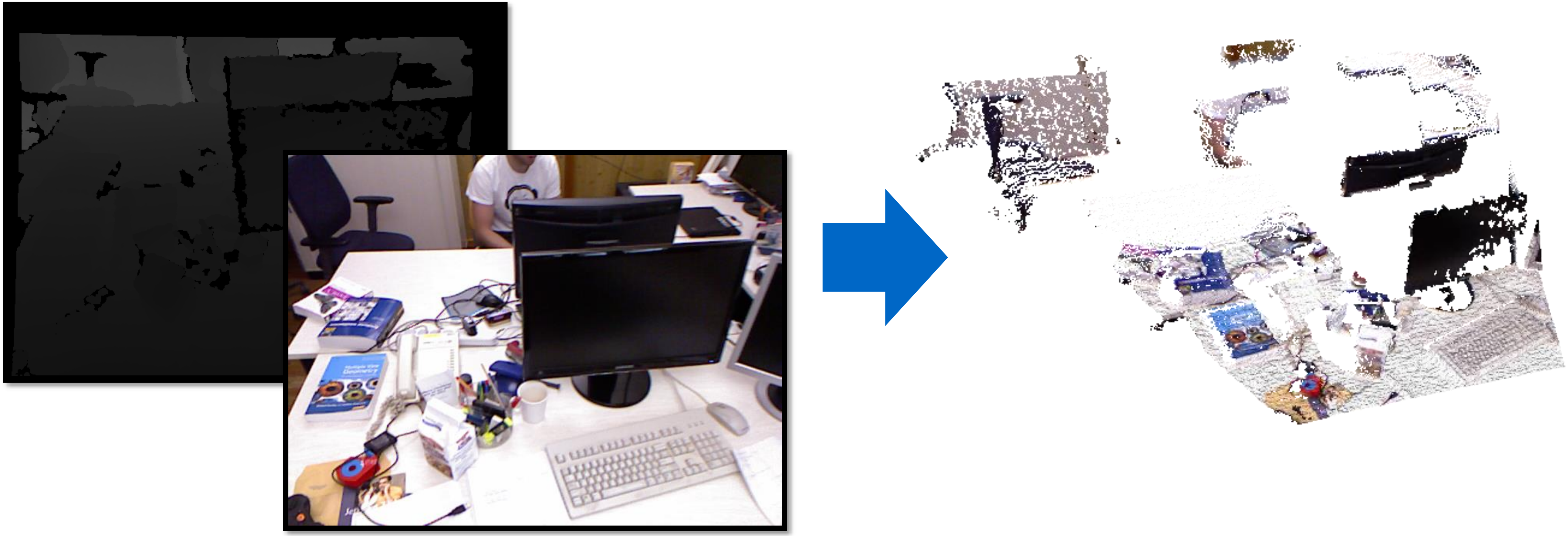
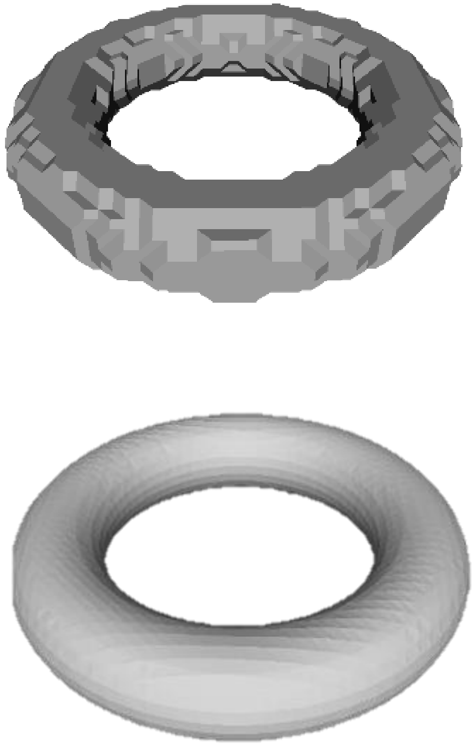
Exercises – Overview (1/5)

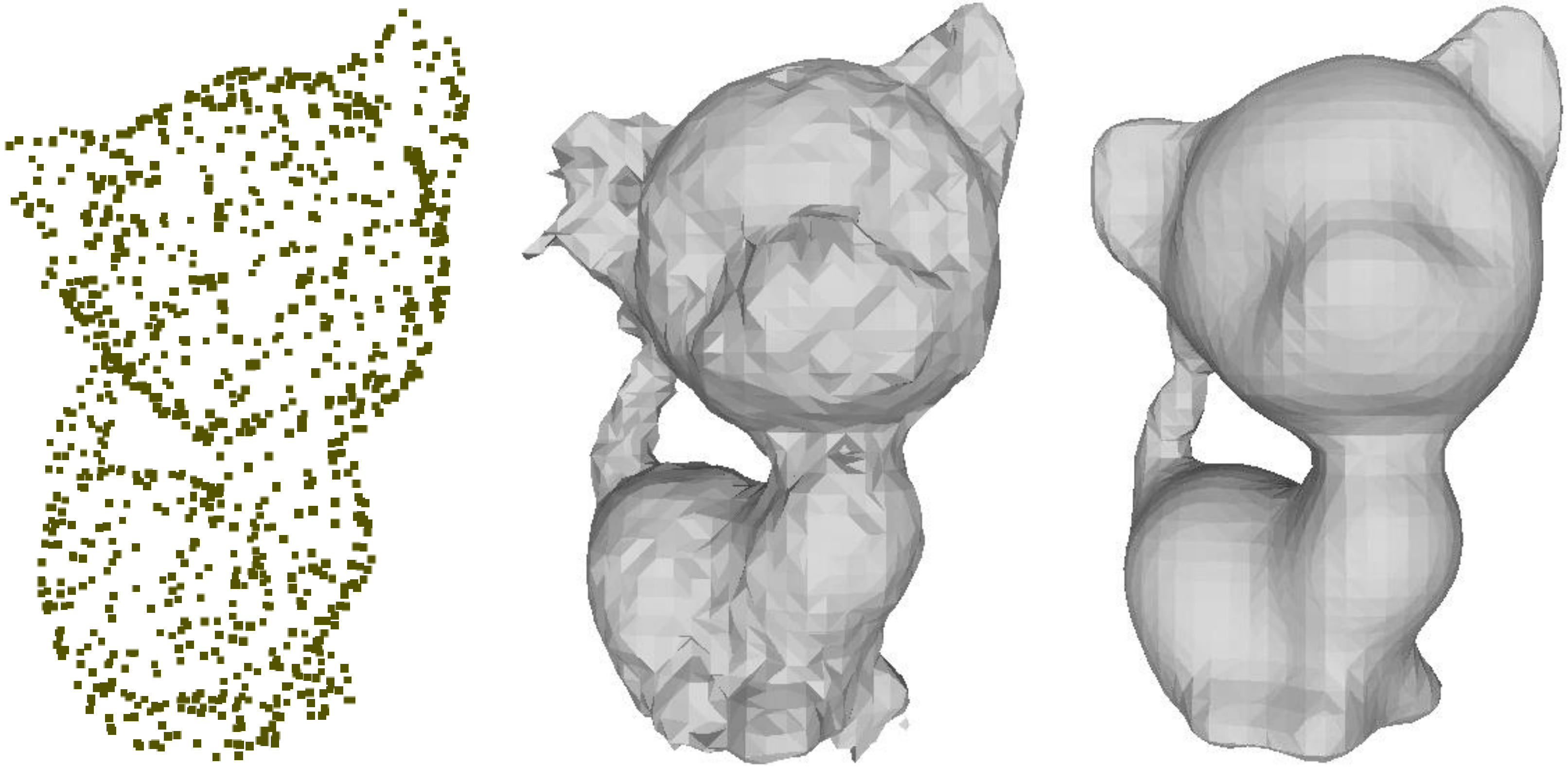
1. Exercise → Camera Intrinsics, Back-projection, Meshes



Exercises – Overview (2/5)

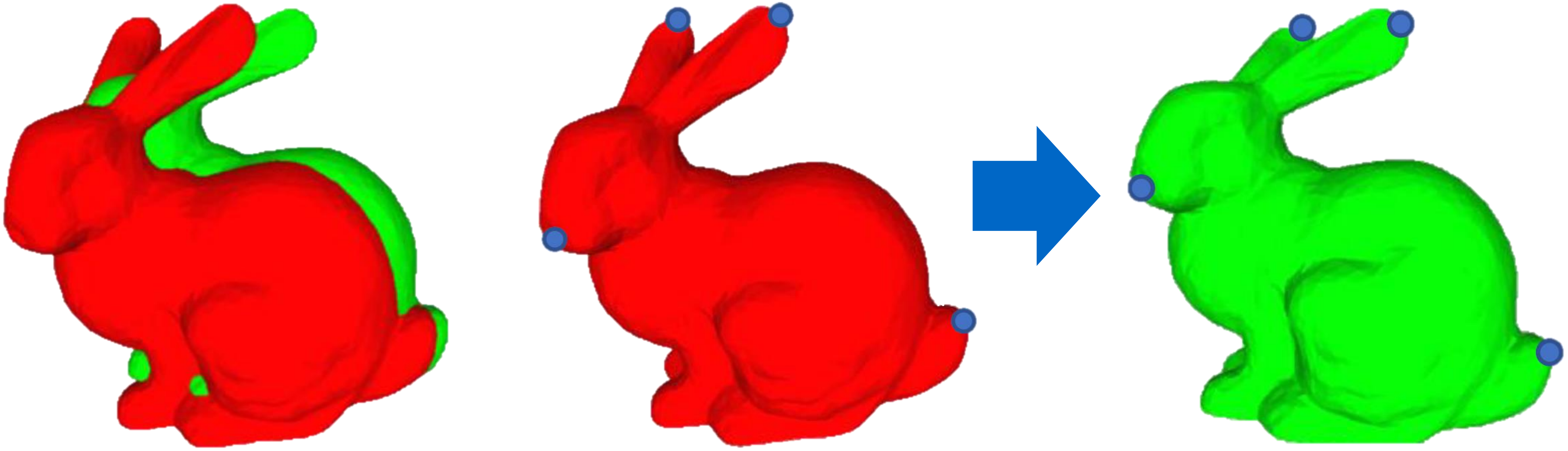
2. Exercise → Surface Representations





Exercises – Overview (3/5)

3. Exercise → Coarse Alignment (Procrustes)

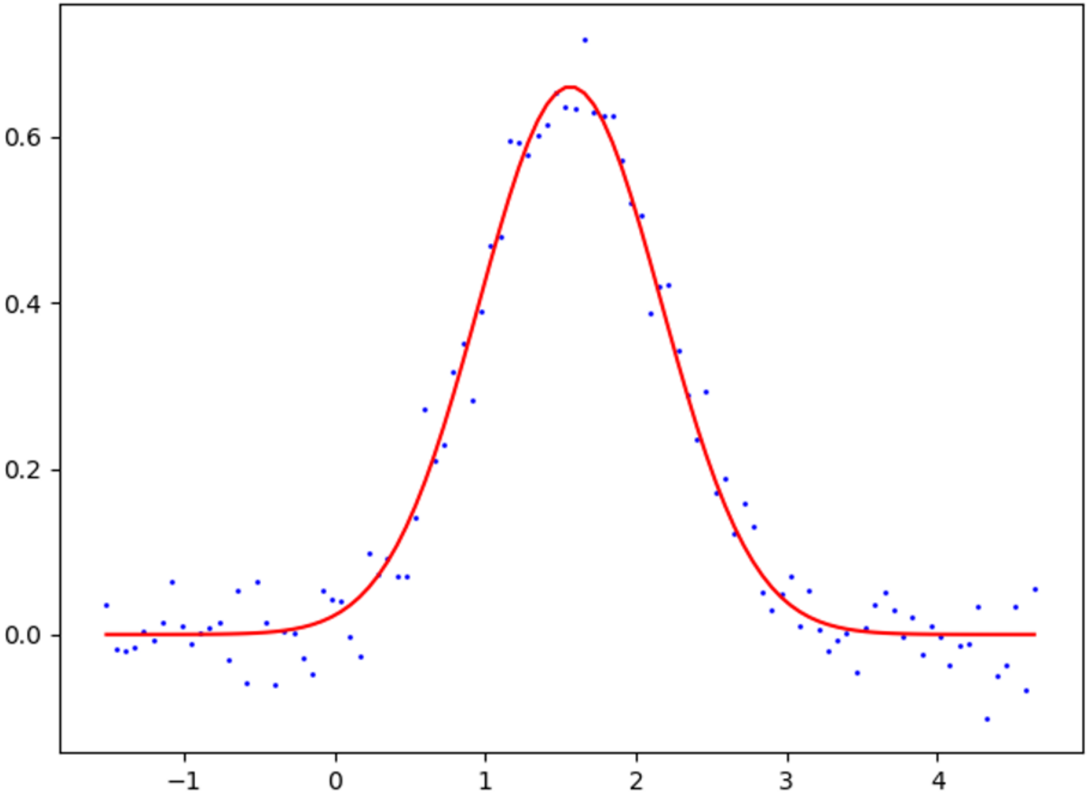


Exercises – Overview (4/5)

4. Exercise → Optimization

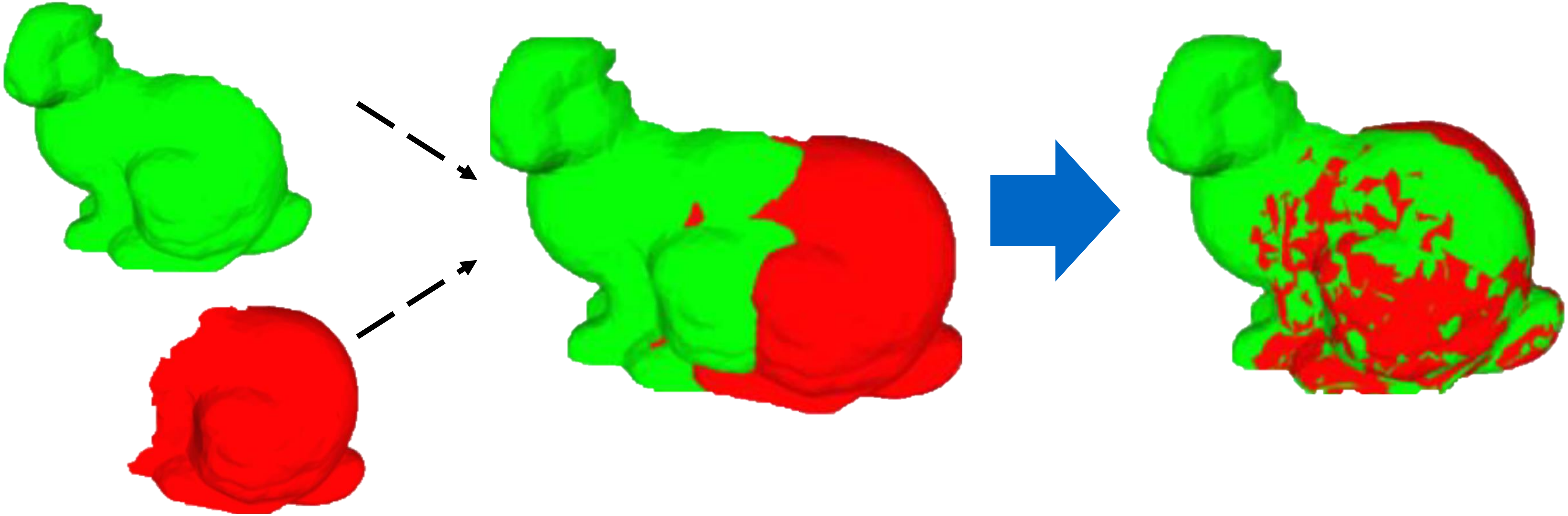
$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Find $\boldsymbol{\mu}$ & $\boldsymbol{\sigma}$ for points



Exercises – Overview (5/5)

5. Exercise → Object Alignment, ICP



Exercises – Overview

1. Exercise → Camera Intrinsics, Back-projection, Meshes
2. **Exercise → Surface Representations**
3. Exercise → Coarse Alignment (Procrustes)
4. Exercise → Optimization
5. Exercise → Object Alignment, ICP

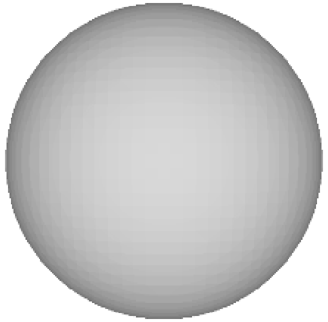
Exercise 2

Surface Represenations

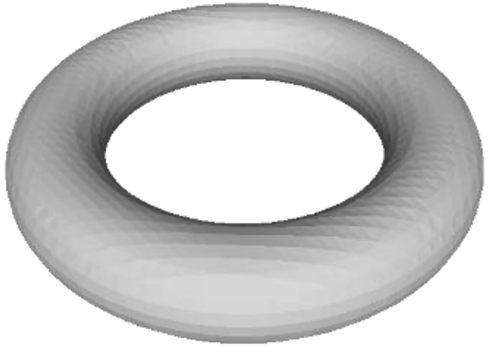
Tasks

1. Project dependencies & CMake configuration
2. Implicit Surfaces
   - Implement the functions defining the surfaces of spheres and tori
3. Linear Interpolation
   - Implement the linear interpolation between two points in 3D
4. Hoppe
   - Convert a point cloud to an implicit surface
5. Radial Basis Functions
   - Setup and solve system of linear equations

Task 2) Implicit Functions – Sphere / Torus



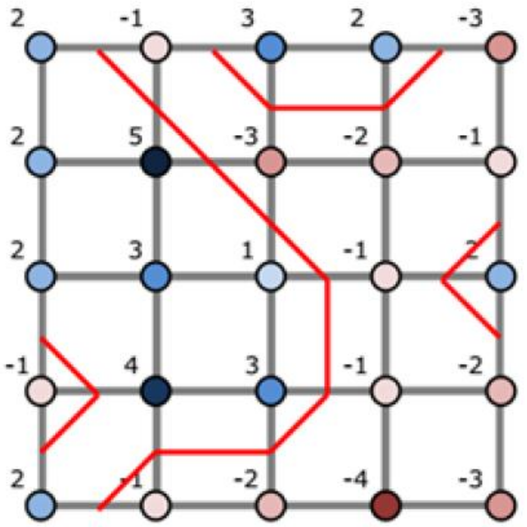
$$f(x,y,z) = x^2 + y^2 + z^2 - R^2$$



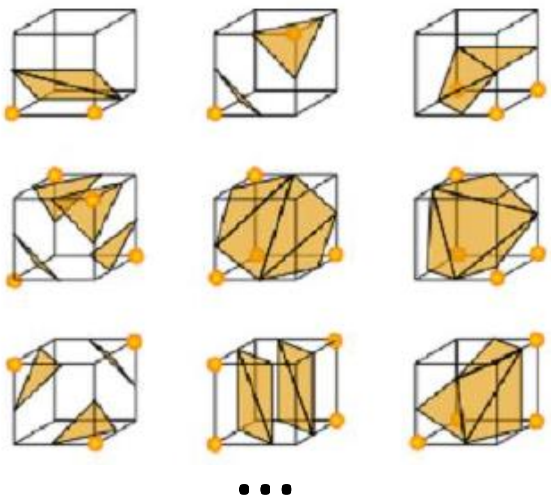
$$f(x,y,z) = (x^2 + y^2 + z^2 + R^2 - a^2)^2 - 4R^2(x^2 + y^2)$$

Task 3) Marching Cubes

- Regular grid/volume → Extract iso-surface
  - Check for zero-crossings within each cell



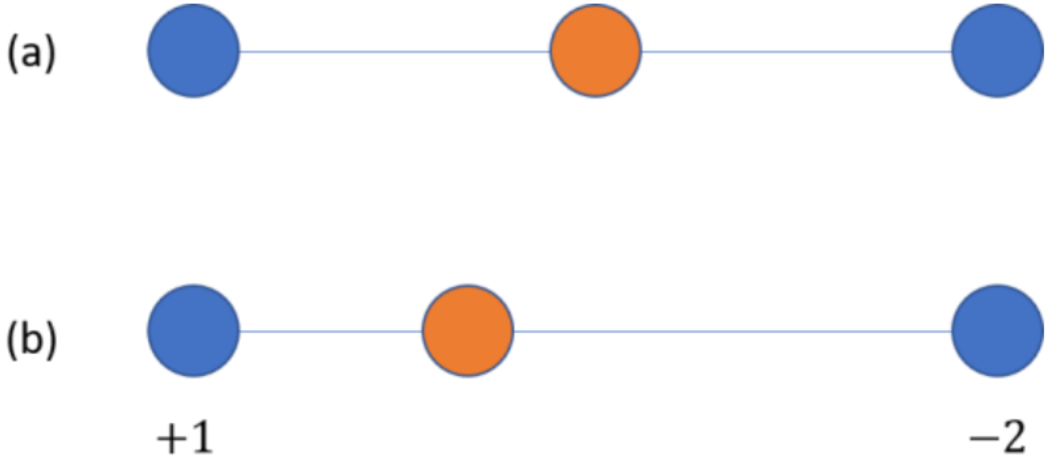
Marching Squares (2D)
16 configurations



Marching Cubes (3D)
256 configurations

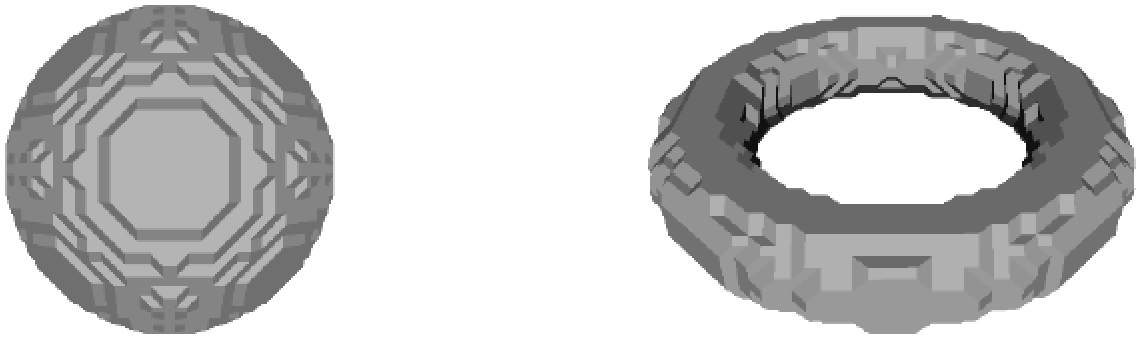
Task 3) Linear Interpolation

- Compute the linear interpolated point using the provided distances
  - (a) shows the basic implementation
  - (b) shows an example with *isolevel* = 0, *valp1* = +1 and *valp2* = −2 .

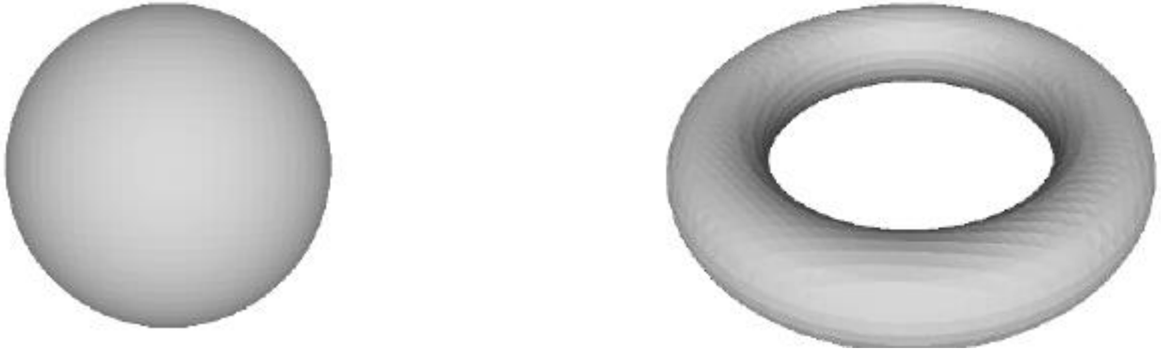


Task 3) Linear Interpolation

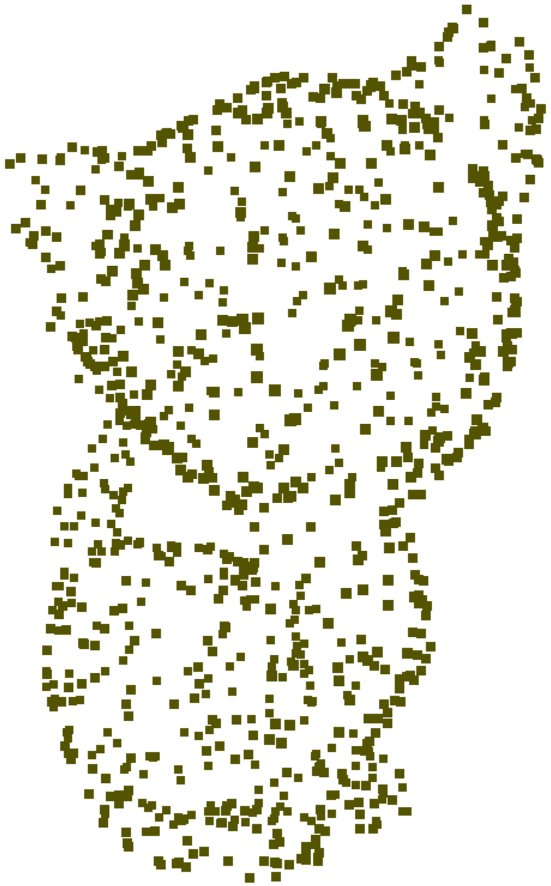
- Without linear interpolation
  - i.e. taking midpoint of each edge



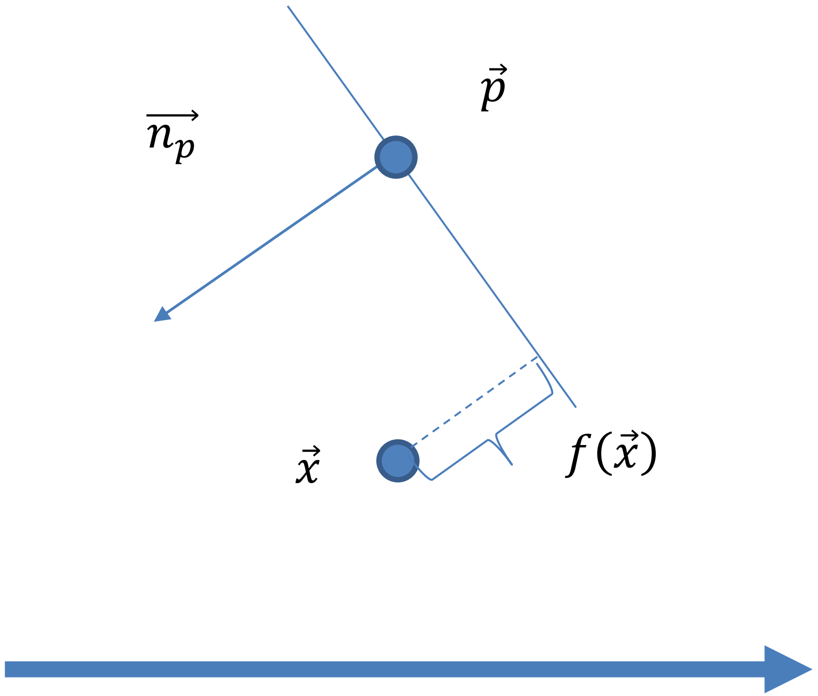
- With linear interpolation



Task 4) Hoppe

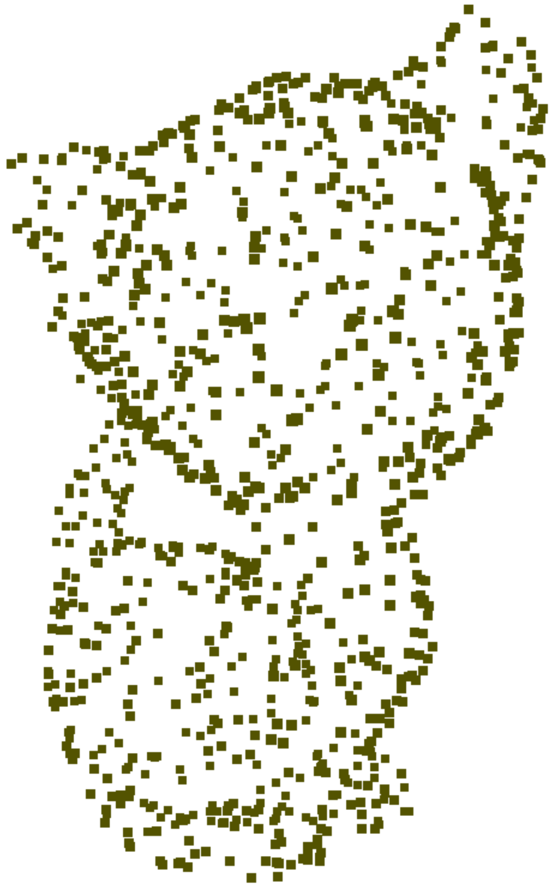


Input Points

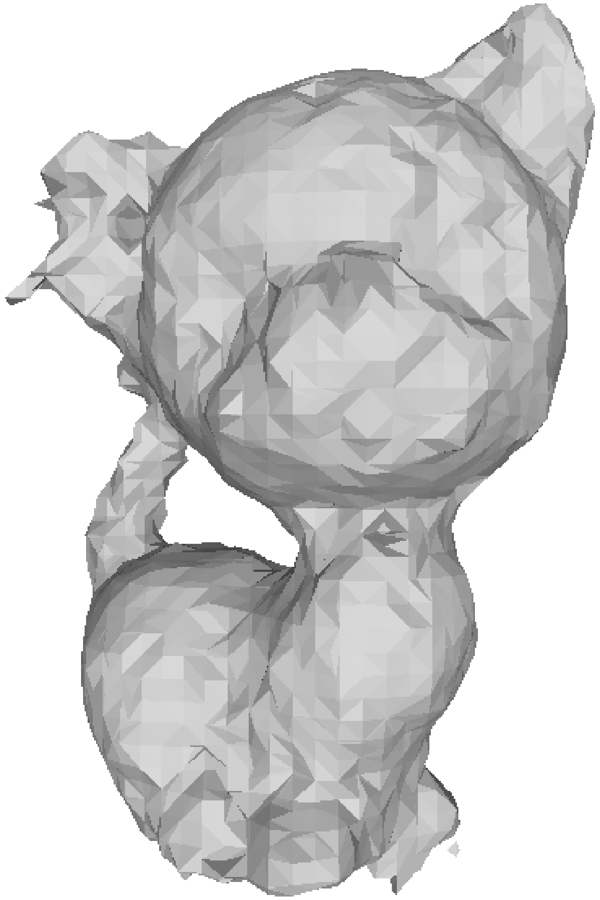


Piecewise linear surface approximation

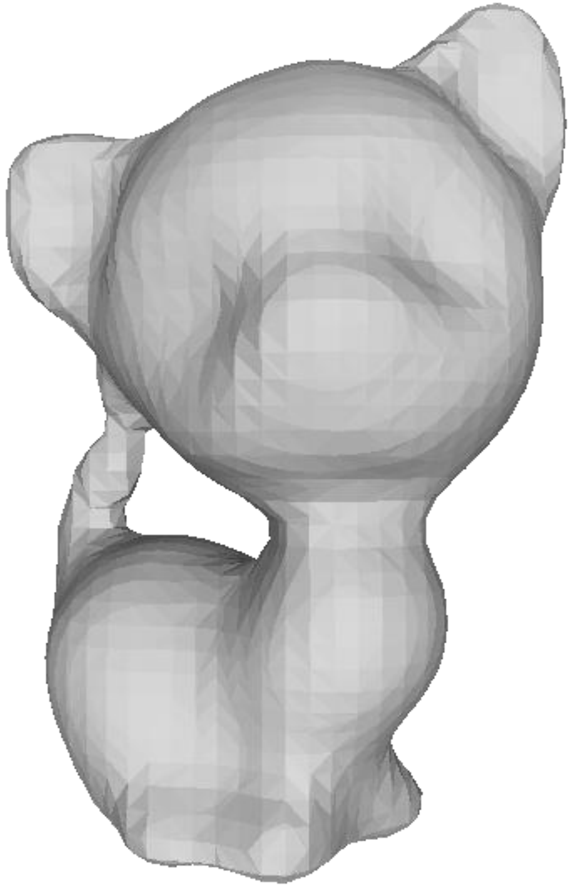
Task 5) Radial Basis Functions (RBF)



Input Points



Hoppe

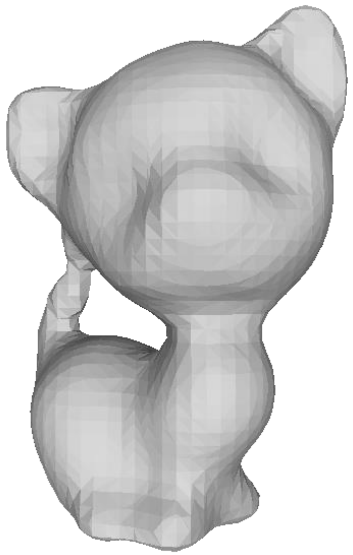


RBF

Task 5) Radial Basis Functions (RBF)

$$f(\vec{x}) = \sum_i \boldsymbol{\alpha_i} \cdot \|\vec{p}_i - \vec{x}\|^3 + \vec{\mathbf{b}} \cdot \vec{x} + \boldsymbol{d}$$

$$\begin{array}{r} \\ \text{on surface points} \\ \\ \\ \text{off surface points} \\ \\ \end{array} \underbrace{\left[\begin{array}{ccccccc} \varphi_{1,1} & \cdots & \varphi_{1,\mathrm{n}} & p_{1,x} & p_{1,y} & p_{1,z} & 1 \\ \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \varphi_{\mathrm{n},1} & \cdots & \varphi_{\mathrm{n},\mathrm{n}} & p_{n,x} & p_{n,y} & p_{n,z} & 1 \\ \varphi_{\mathrm{n}+1,1} & \cdots & \varphi_{\mathrm{n}+1,\mathrm{n}} & p_{n+1,x} & p_{n+1,y} & p_{n+1,z} & 1 \\ \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \varphi_{2\cdot\mathrm{n},1} & \cdots & \varphi_{2\cdot\mathrm{n},\mathrm{n}} & p_{2\cdot n,x} & p_{2\cdot n,y} & p_{2\cdot n,z} & 1 \end{array}\right]}_{A} \cdot \underbrace{\begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_n \\ b_1 \\ b_2 \\ b_3 \\ d \end{bmatrix}}_{\vec{x}} = \underbrace{\begin{bmatrix} h_1 \\ \vdots \\ h_{2\cdot n} \end{bmatrix}}_{\vec{b}}$$



Questions?