


Fitting 3D Object Scans

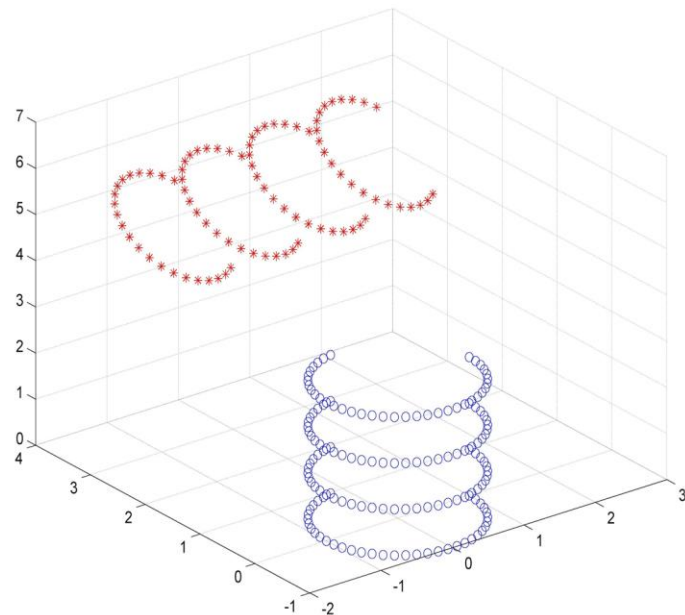
Applied Math - Global Optimization

Songyou Peng
Gourab Ghosh Roy
Raabid Hussain

A decorative light blue triangle is located in the bottom right corner of the slide, pointing towards the top right.

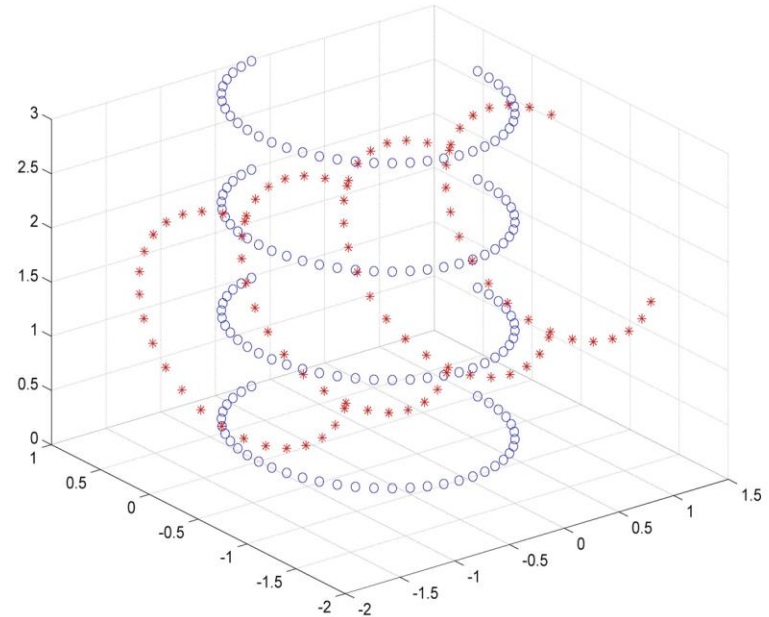
Introduction

- Match Two point clouds in 3D
- One full object, one with missing points
- Both point clouds with missing points



Translation Parameters

- Subtract the mean of two point clouds
- Translation along X,Y,Z axes



Rotation Parameters

$$R_{xy} = \begin{bmatrix} \cos \theta_1 & -\sin \theta_1 & 0 \\ \sin \theta_1 & \cos \theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, R_{xz} = \begin{bmatrix} \cos \theta_2 & 0 & -\sin \theta_2 \\ 0 & 1 & 0 \\ \sin \theta_2 & 0 & \cos \theta_2 \end{bmatrix}, R_{yz} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \theta_3 & -\sin \theta_3 \\ 0 & \sin \theta_3 & \cos \theta_3 \end{bmatrix}$$

$$R = R_{xy} * R_{xz} * R_{yz}$$

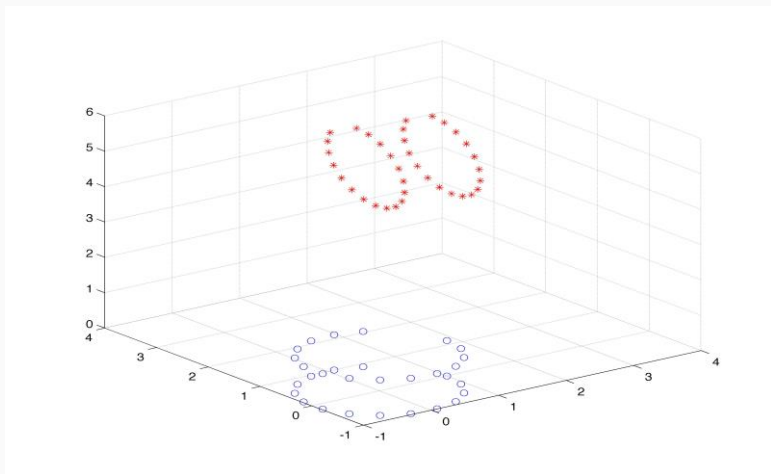
Cost Function

1. Apply rotation matrix to point cloud 2
2. Find nearest point in cloud 1 for each point in cloud 2
3. Sum the Euclidean distance for all such points

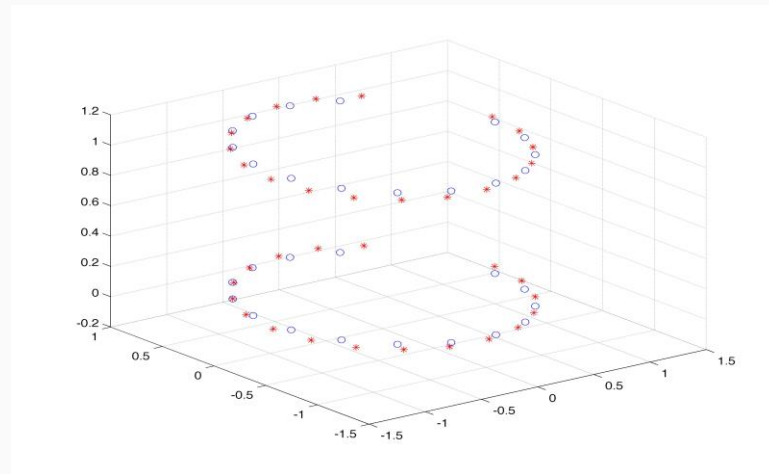
Optimization algorithms

- Brute force
- Simulated annealing
- Particle swarm optimization

Results for cylinder

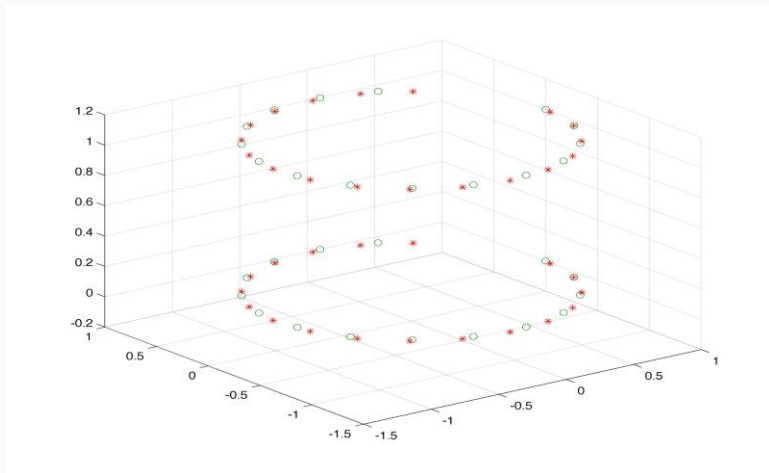


Initial clouds

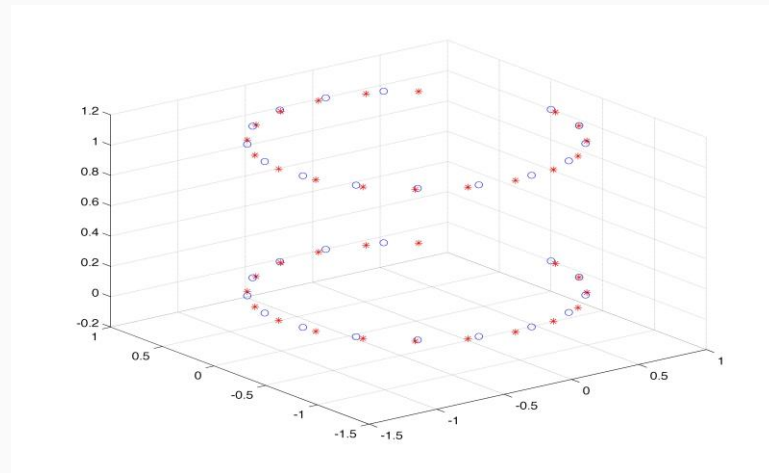


Brute force

Results for cylinder



Simulated annealing



PSO

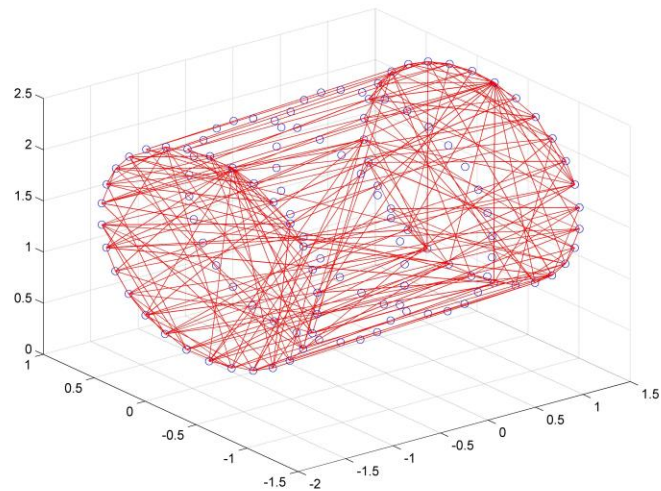
Execution Times

Cylinder 1 (36 points) matched with Cylinder 2 (30 points)

Algorithm	Time (s)
Brute force	96
Simulated Annealing	7.5
PSO	8.5

New Cost Function

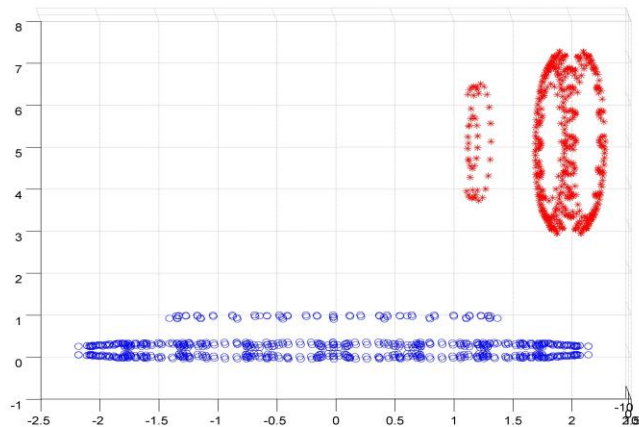
- Based on convex hull **Volume** approximation of point clouds
- Apply transformation matrix on point cloud 1
- Compute volume of point cloud 1
- Combine the two point clouds
- Compute the volume of the combined cloud
- Volume difference



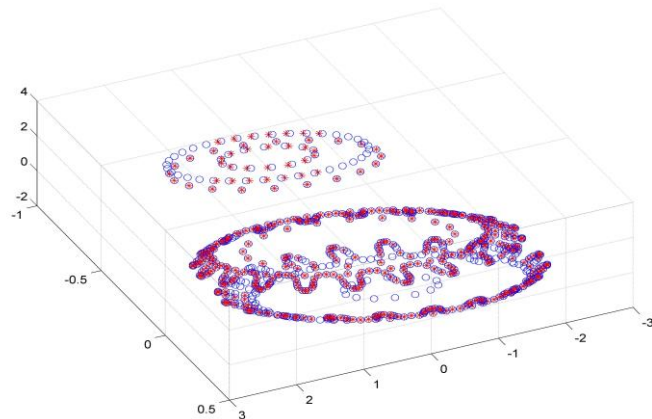
Optimization Strategy

- 6D optimization problem
- Simulated Annealing
- Local minimum search (fminsearch in MATLAB)

Results

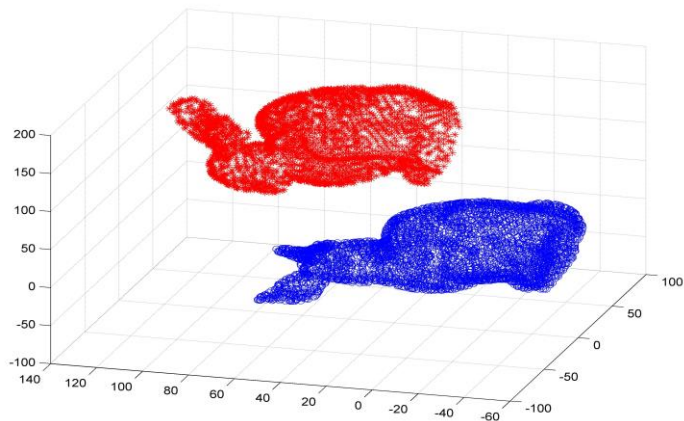


Initial clouds

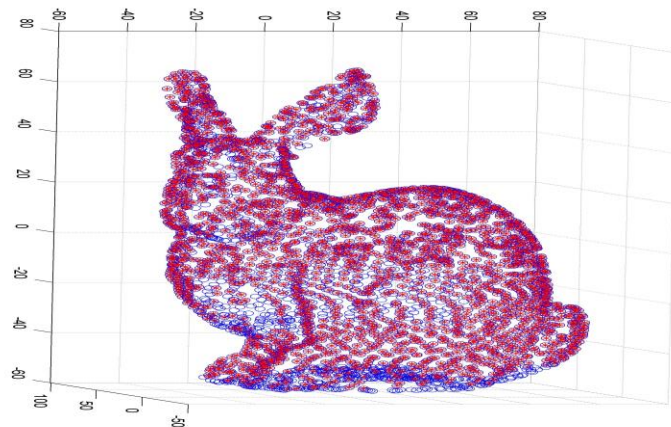


Matched clouds

Results

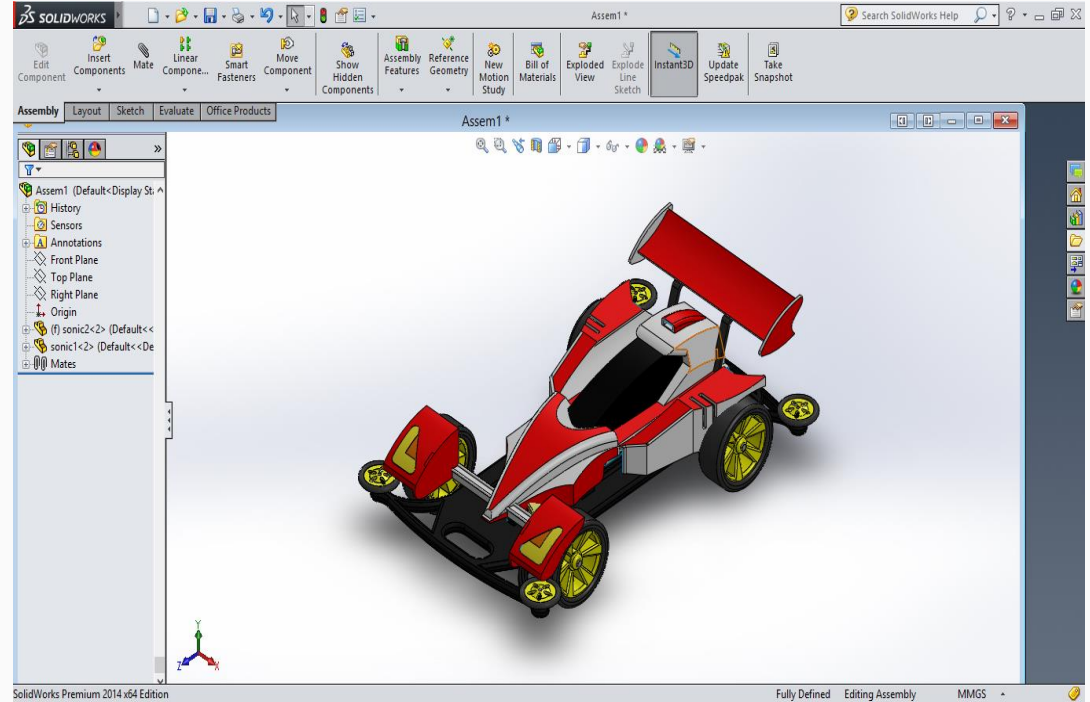
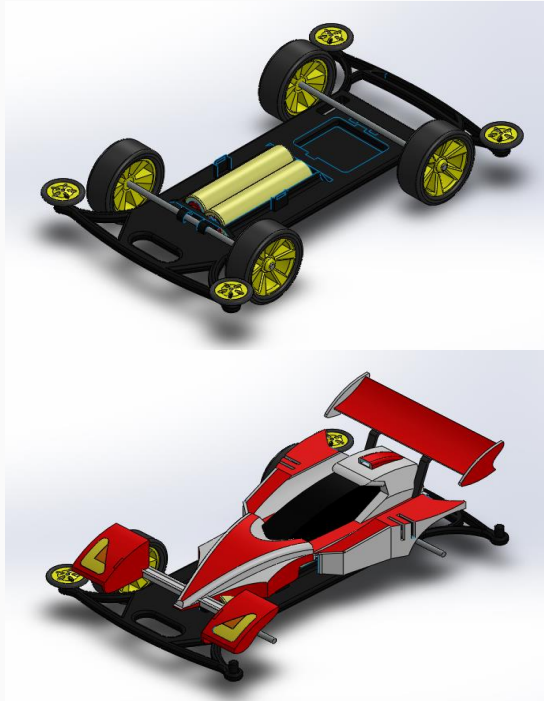


Initial clouds



Matched clouds

Mechanical Modelling Software?



Conclusions

- Two matching algorithms – nearest distance and volume
- Different optimization techniques – SA, PSO
- Test on simulated and real 3D data

References

www.mathworks.com

<http://vision.in.tum.de/data/datasets/clutter>

https://en.wikipedia.org/wiki/Particle_swarm_optimization

https://en.wikipedia.org/wiki/Simulated_annealing

Thanks!

