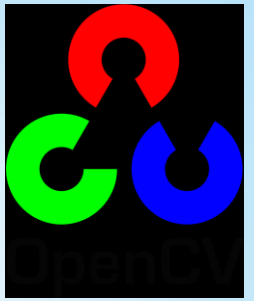


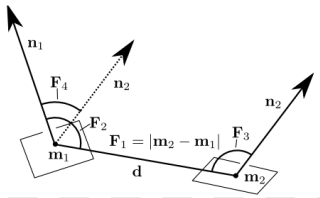
3D POSE ESTIMATION VIA POINT PAIR FEATURES IN OPENCV

Tolga Birdal
GSoC 2014

Google

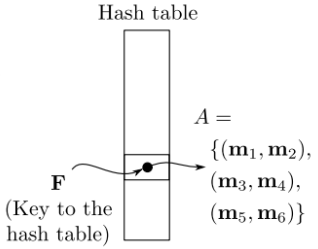
OUTLINE OF THE ALGORITHM

Load / Generate 3D Model



PPF Feature Extraction

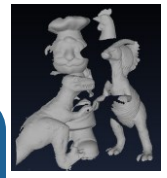
Compute Hashtable & Precompute α_{model}



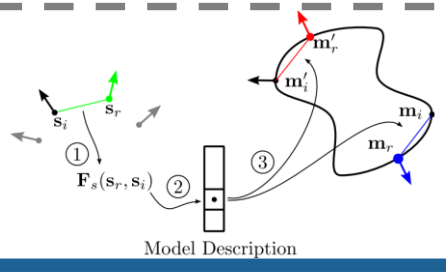
Trained Model

Training

Runtime

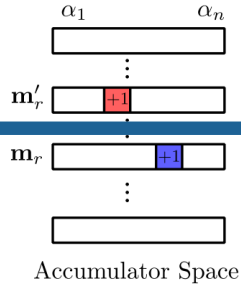


Load / Generate 3D Model



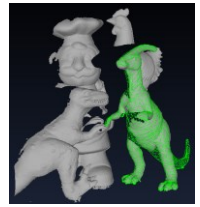
Model Description

Hashtable Lookup & Vote for Pose



Accumulator Space

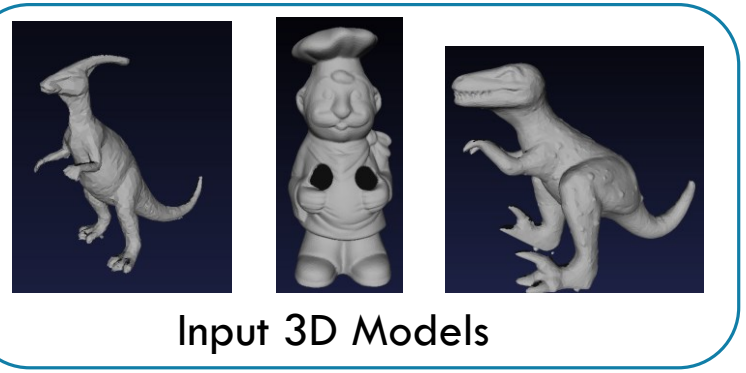
Pose Clustering



ICP Refinement & Final Pose

B. Drost, M. Ulrich, N. Navab, and S. Ilic, "Model globally, match locally: Efficient and robust 3d object recognition." in *CVPR*. IEEE, 2010, pp. 998–1005. [Online]. Available: http://dblp.uni-trier.de/db/conf/cvpr/cvpr2010.html#DrostUNI10

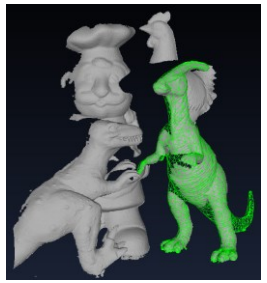
REGISTRATION USING POINT PAIR FEATURES - LASER

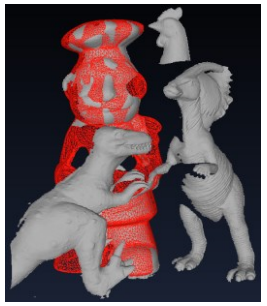


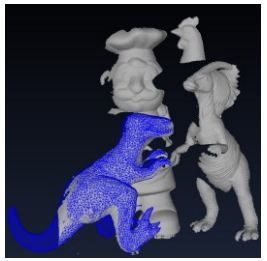
Input 3D Models

Input 3D Scene

PPF + ICP

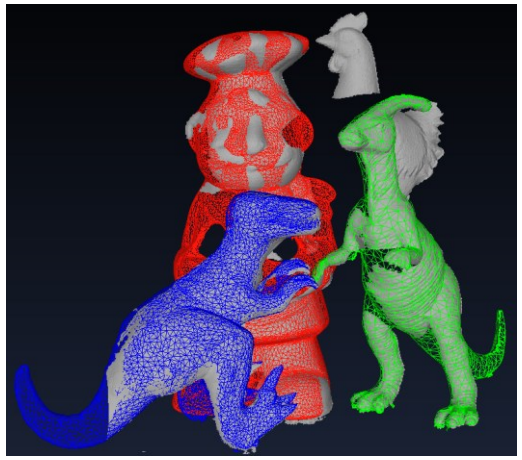






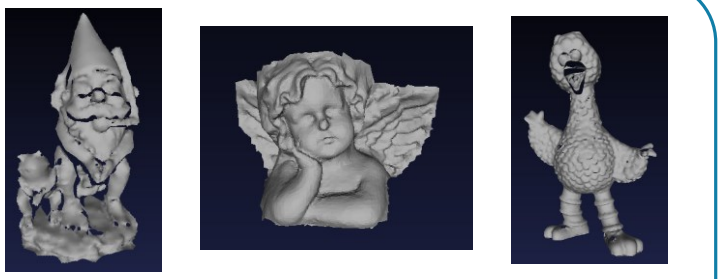
Registrations

All Models

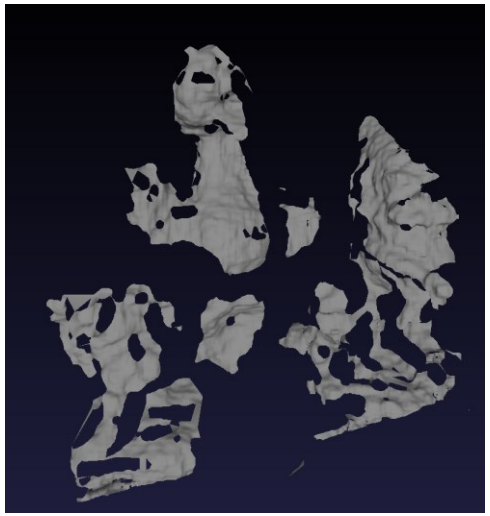


Full Pose Estimation

REGISTRATION USING POINT PAIR FEATURES - STEREO

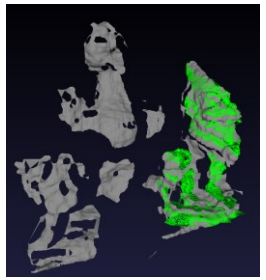


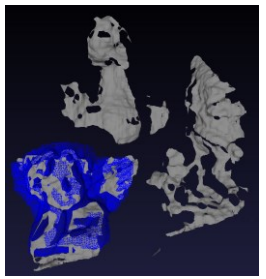
Input 3D Models

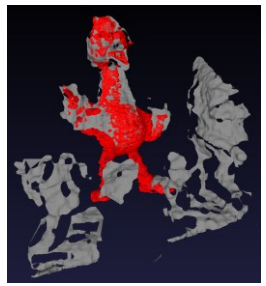


Input 3D Scene

PPF + ICP

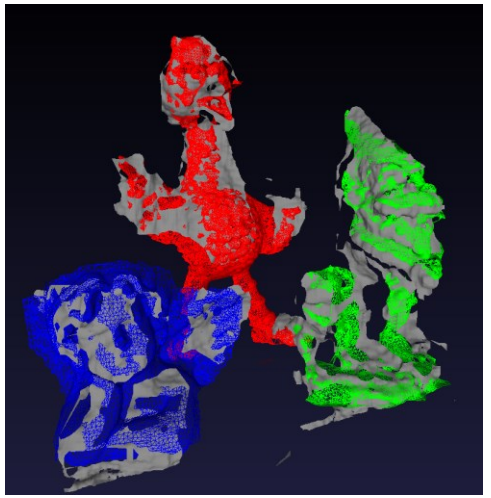






Registrations

All Models

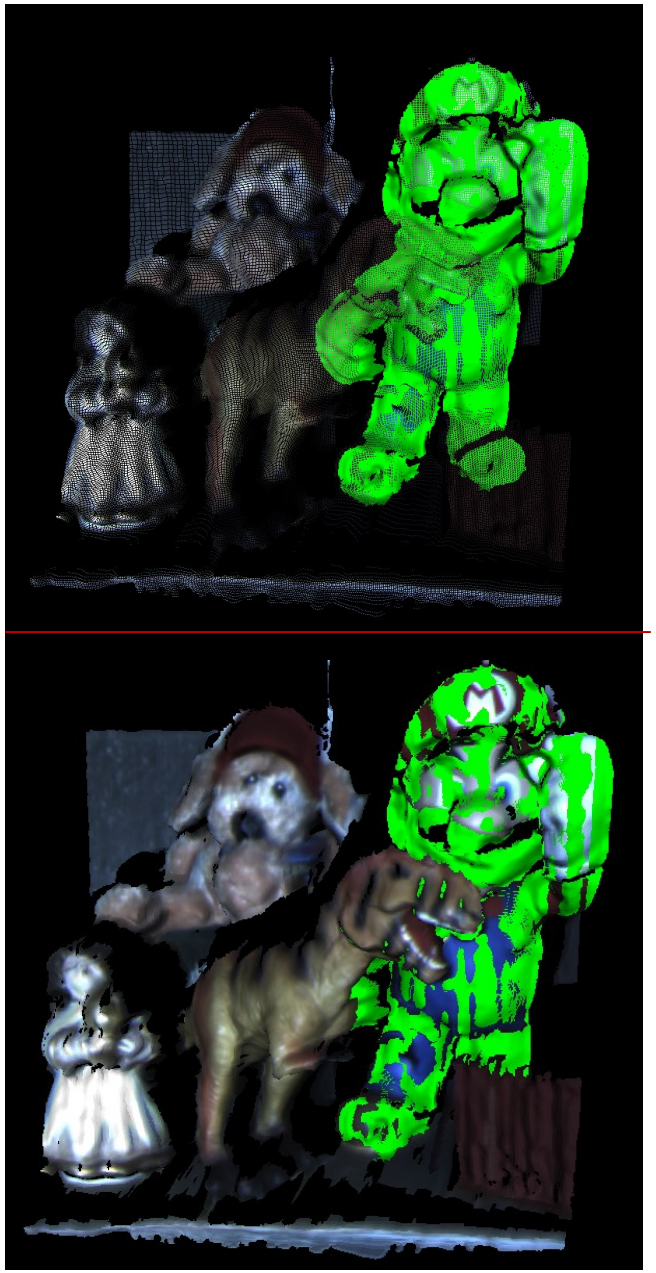


Dataset from http://vision.deis.unibo.it/keypoints3d/?page_id=2

REGISTRATION ON SPACETIME STEREO

Model

Scene



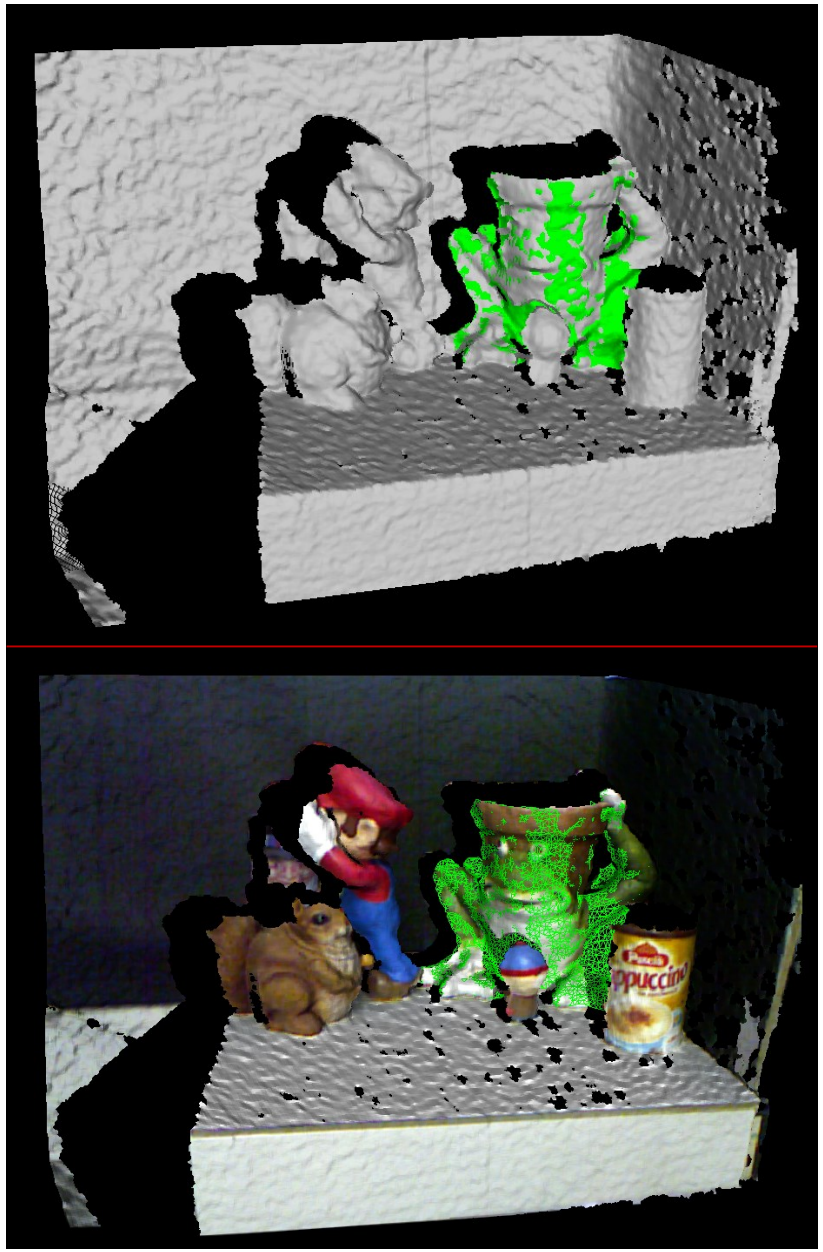
Registered Pose

Dataset from http://vision.deis.unibo.it/keypoints3d/?page_id=2

REGISTRATION ON KINECT

Model

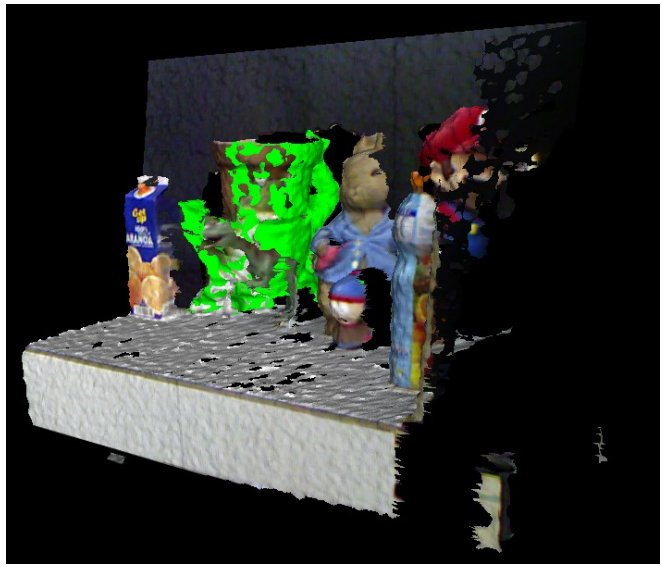
Scene

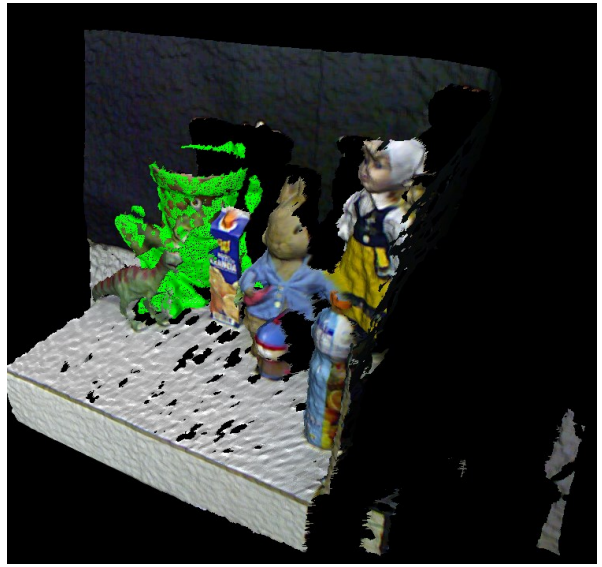


Registered Pose

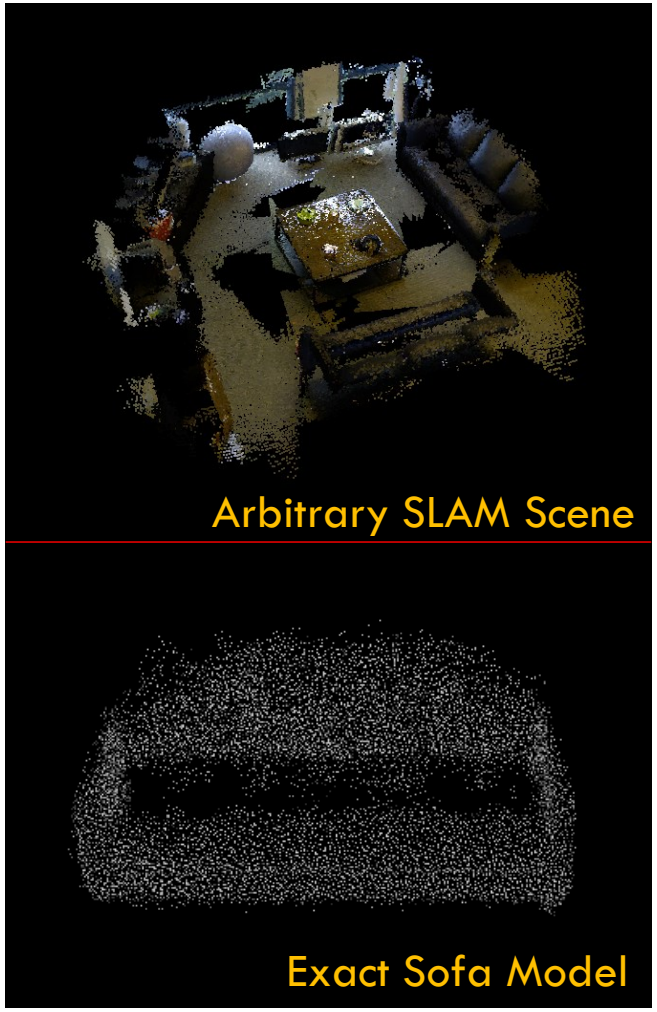
REGISTRATIONS ON KINECT

PPF + ICP

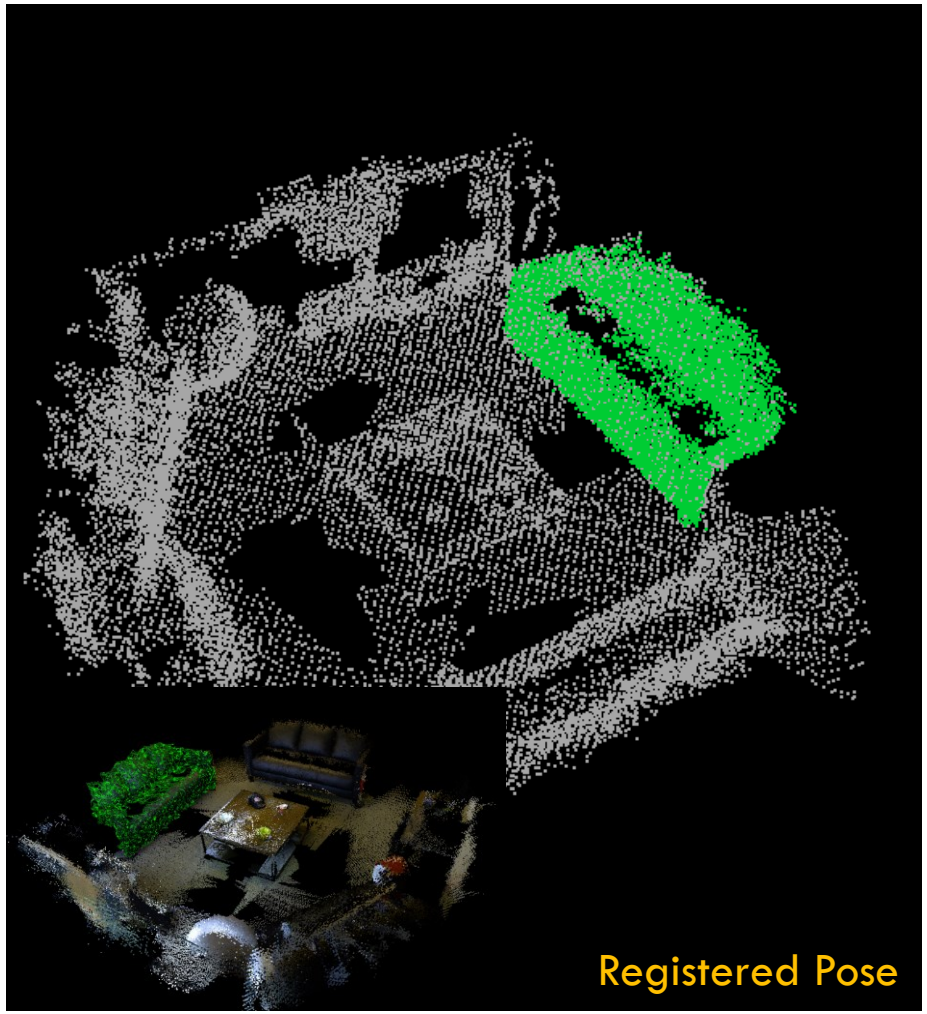




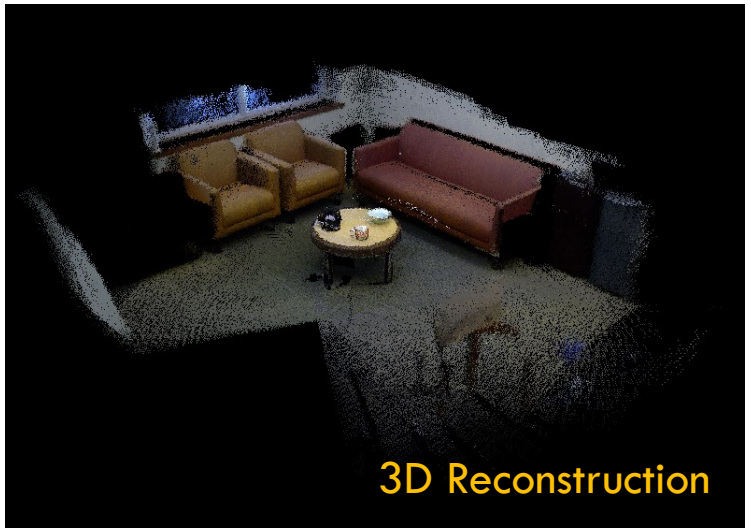
REGISTRATION ON SLAM DATASET - 1

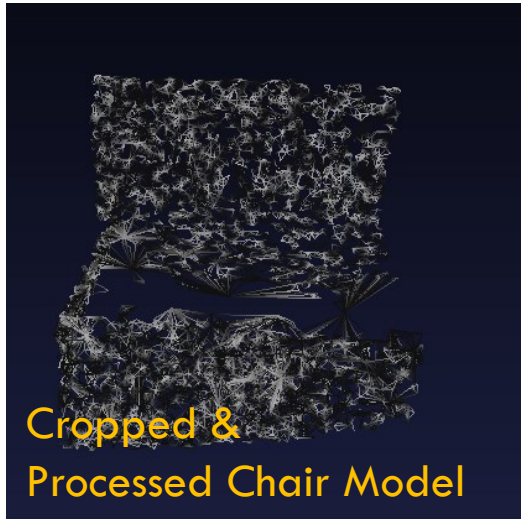


PPF + ICP



REGISTRATION ON SLAM DATASET - 2

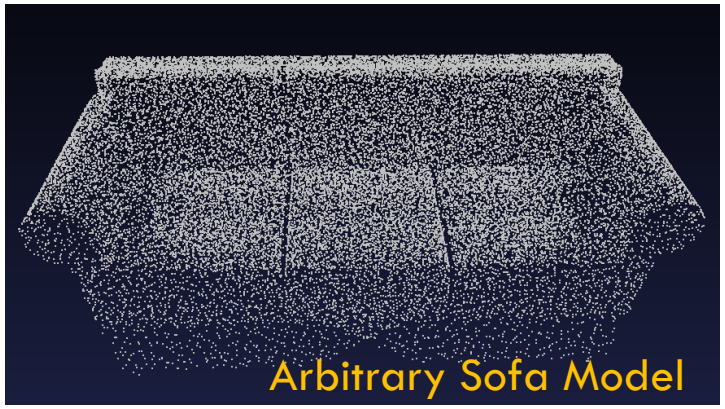




PPF + ICP

FAILING CASES

1



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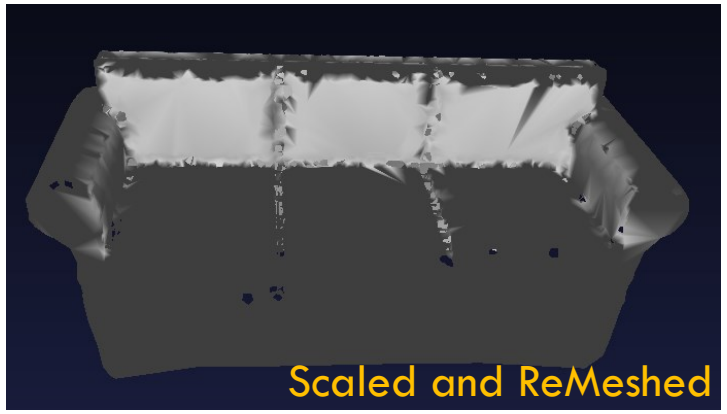
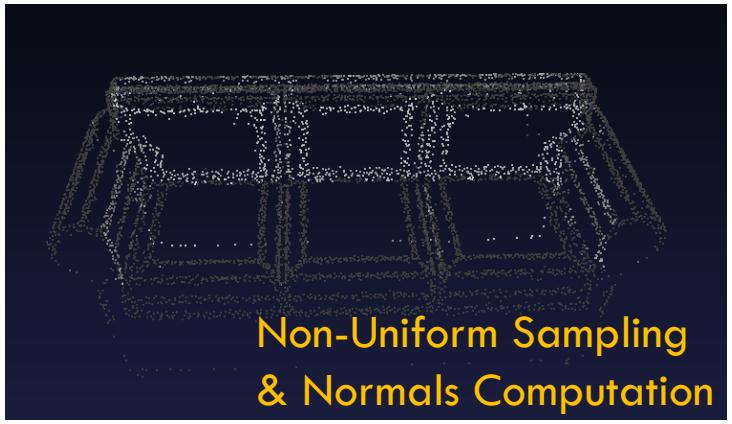
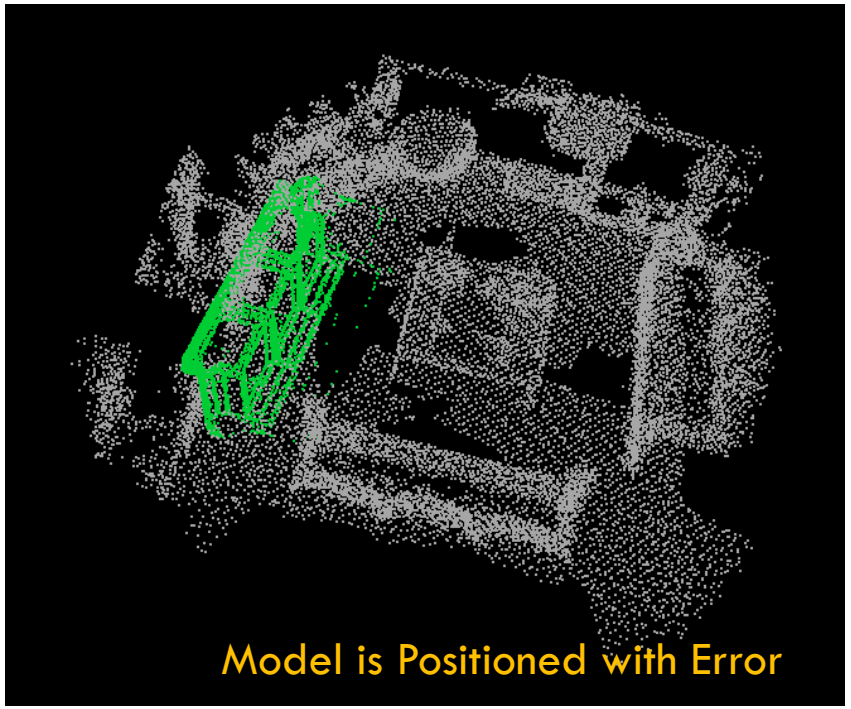


3



Train & Match

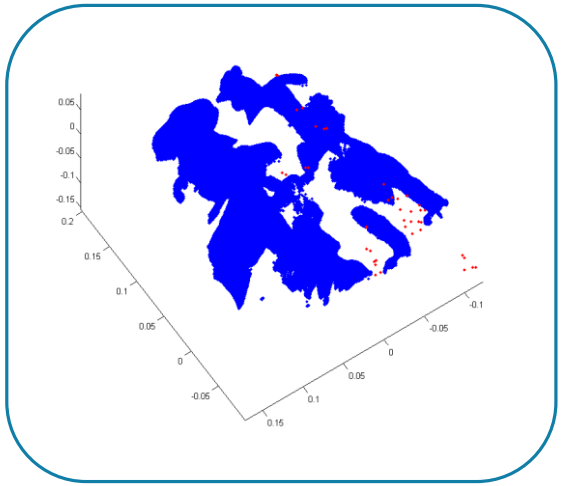
4

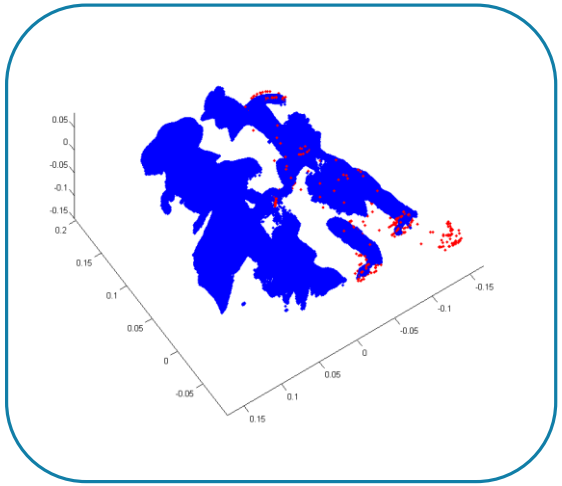


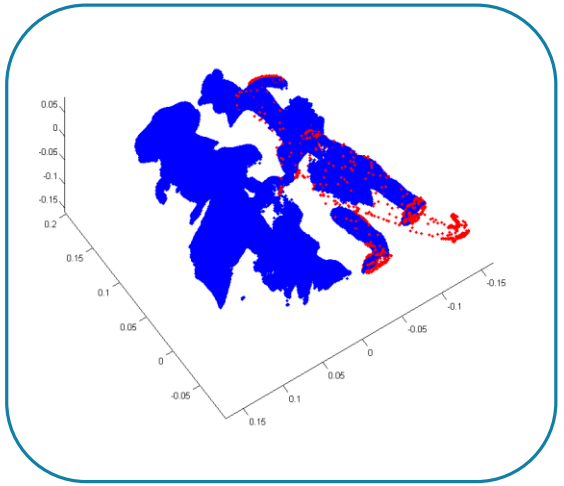
FAST ICP REGISTRATION

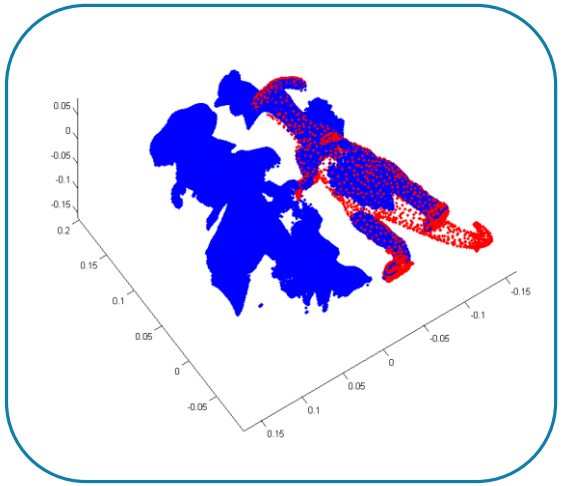
- ✓ Point Cloud Normalization
- ✓ Robust Registration: Median Absolute Deviations
- ✓ Coarse to Fine Registration
- ✓ Linearized Point to Plane Metric
- ✓ Duplicate Assignment Resolution: Picky ICP

Registration in ~300 ms





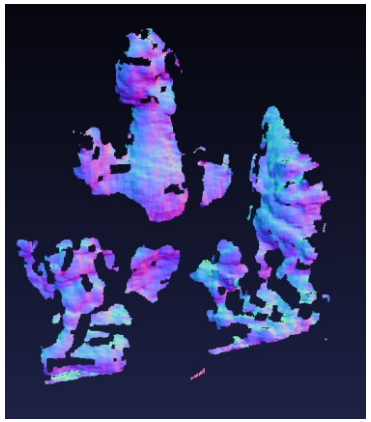




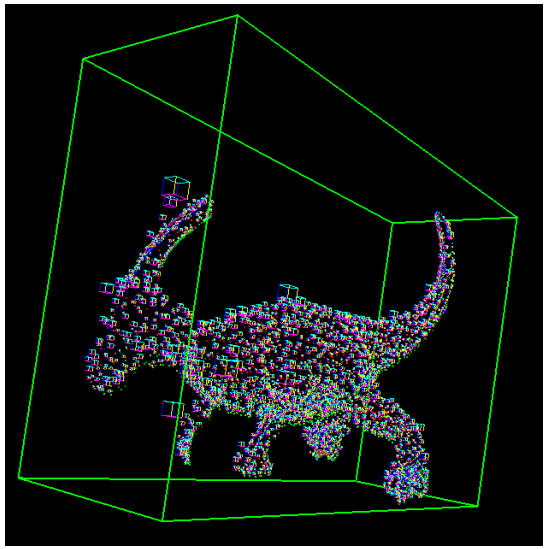
Coarsest Level → Finest Level

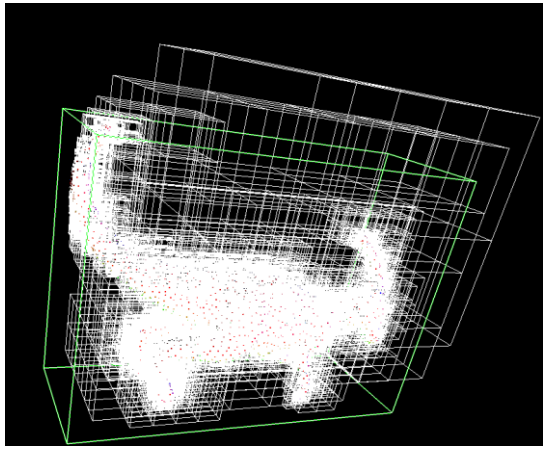
OTHER GAINED FUNCTIONALITIES

- ✓ Bounding Boxes
- ✓ Voxel Based Quantization of Point Clouds
- ✓ Fast Normal Computation of Point Clouds
- ✓ PLY Reading / Writing
- ✓ Naïve Hashtable and Various Hashfunctions



PC Normals





Octrees

REFERENCES

[1] B. Drost, M. Ulrich, N. Navab, and S. Ilic, "Model globally, match locally: Efficient and robust 3d object recognition." in *CVPR*. IEEE, 2010, pp. 998–1005. [Online]. Available: http://dblp.uni-trier.de/db/conf/cvpr/cvpr2010.html#DrostUNI10

[2] P. J. Besl and N. D. McKay, "Method for registration of 3-d shapes," in *Robotics-DL tentative*. International Society for Optics and Photonics, 1992, pp. 586–606.

[3] S. Rusinkiewicz and M. Levoy, "Efficient variants of the icp algorithm," in *3-D Digital Imaging and Modeling, 2001. Proceedings. Third International Conference on.* IEEE, 2001, pp. 145–152.

[4] N. Gelfand, L. Ikemoto, S. Rusinkiewicz, and M. Levoy, "Geometrically stable sampling for the icp algorithm," in *3-D Digital Imaging and Modeling, 2003. 3DIM 2003. Proceedings. Fourth International Conference on.* IEEE, 2003, pp. 260–267.

[5] T. Zinßer, J. Schmidt, and H. Niemann, "A refined icp algorithm for robust 3-d correspondence estimation," in *Image Processing, 2003. ICIP 2003. Proceedings. 2003 International Conference on*, vol. 2. IEEE, 2003, pp. II–695.

[6] L. Zhang, S.-I. Choi, and S.-Y. Park, "Robust icp registration using biunique correspondence," in *3D Imaging, Modeling, Processing, Visualization and Transmission (3DIMPVT), 2011 International Conference on.* IEEE, 2011, pp. 80–85.

[7] K.-L. Low, "Linear least-squares optimization for point-to-plane icp surface registration."

Many thanks to OpenCV Team and Google for making this an ingenious experience.