3D Reconstruction of Infants' Cranial Shape using Mobile Devices *Checkpoint Presentation*

Group 15 Members: Tara Tang, David Shi

Mentors: Can Kocabalkanli, Dr. Reza Seifabadi & Dr. Özgür Güler

Project Summary

- Clinical Problem: pediatricians need a reliable method for accurately detecting infant cranial deformities such as DPB and craniosynostosis

- Goal: create a software pipeline to reconstruct an accurate 3D model of a baby's head from depth information

- Status: on track
  - Refining the reconstruction and registration software
  - Evaluation code already implemented
  - May need to readjust deliverables for motion robustness

Deliverables

Minimum

- Collected and processed depth data – **complete**
- Working software pipeline and documentation – **nearly complete**
- Accuracy evaluation results (average surface distance threshold #1) – **code complete, results dependent on pipeline**
- Robust pipeline for moving head, slow head motion – **considering moving**

Expected

- Accuracy evaluation results (average surface distance threshold #2)
- Robust pipeline for moving head, linear motion with no acceleration

Maximum

- Robust pipeline for moving head with acceleration

Project Timeline

	February				March				April				May			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Research and Planning																
Literature Review																
Data Processing (Depth Data)																
Reconstruction Algorithm																
3D Model Generation								[M]								
Registration Algorithm																
Documentation																
Evaluation and Improvement																
Ground-Truth Comparisons										+						
Baby Motion Robustness									-							
Final Evaluation												[M]				

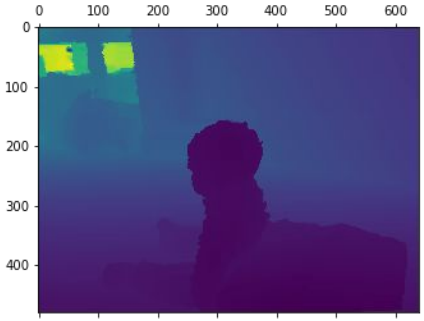
Dependencies

Name	Status	Contingency	Deadline
Depth data	Acquired from online	N/A	3/1
Ground-truth models	Acquired from PediaMetrix	Reference some known object like a deformed ball	3/15
Software for calculating evaluation metrics	Acquired from PediaMetrix	Write our own code for calculating	3/15
Custom depth data collection app	Acquired from Dr. Güler	Evaluate pipeline based on other depth and point cloud datasets	3/15
Compatible iPad for depth data collection	Acquired from Dr. Güler	PediaMetrix can provide us with one of their own	3/15
Hardware for shaker testing	Dr. Seifabadi has a quote for the rocker (shaker)	Manual, slow movement only, calculate speed from video footage	4/5

Early Results – Data Collection

- iPad provided with both Dr. Güler's custom app and Occipital's app
- RGB and depth data uploaded directly to AWS S3 buckets
  - YML file structure
  - Convert this to text so our packages can read it
- Camera intrinsics provided to us

Sample Image

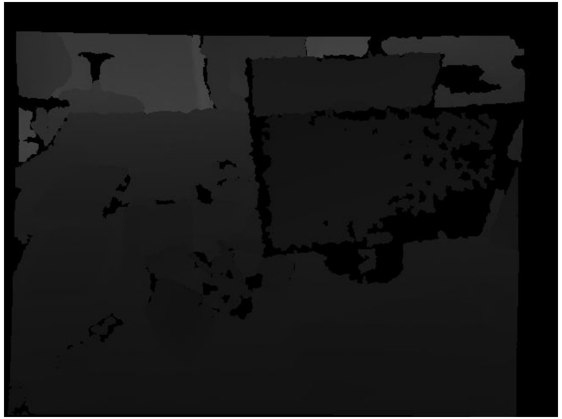


Sample Depth Map

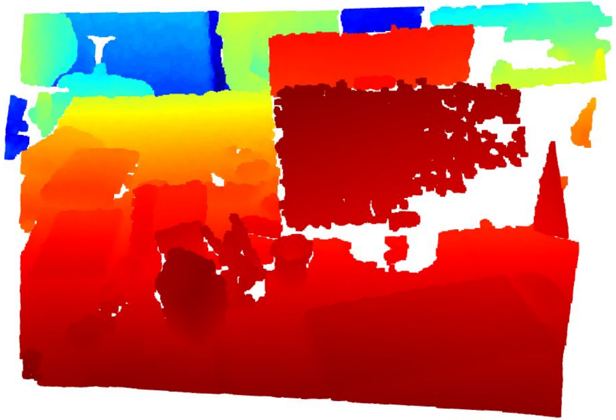
Early Results – Data Processing

- Open3D library in Python [2] – operations on depth maps, point clouds, meshes
- RGB-SLAM datasets – limited angles, but sufficient for testing this component

RGB



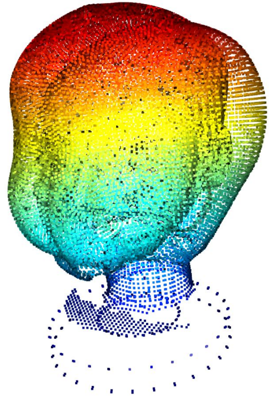
Depth



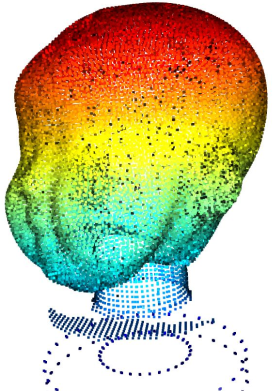
Depth Point Cloud

Early Results – Registration

- All images taken during data collection are registered to the first frame using ICP+pose graph
  - Dependent on significant overlap between images (unclear how much)
  - Registered point clouds are added together
- Registration for evaluation against ground truth
  - Global registration to initialize ICP
    - Difficulty with automatic feature matching from depth only
  - Discussed with mentors, initialization can be found manually

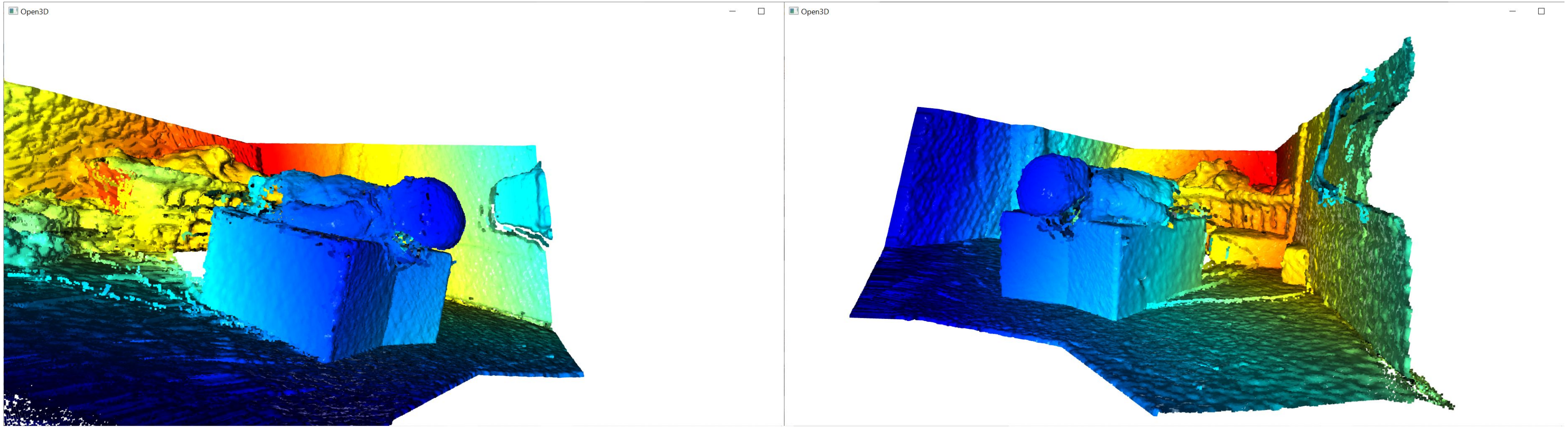


Manually Perturbed Models



Final Registered Point Clouds – surface distance 2.4 mm

Early Results – Reconstruction



- Reconstructed 3D spaces from 5 depth maps covering roughly 180 degrees
- This is a test, will proceed with baby sitting up
    - Working on ways to get rid of the background for speed/clarity

Moving Forward

- Continue weekly meetings with mentors every Tuesday at 3:00pm
    - David and Tara continue meeting two or three times a week for work
- Finishing and refining reconstruction/registration pipeline
    - Remove background during pre-processing
    - Unit testing
    - Mesh generation from point cloud
    - Evaluation and motion robustness testing

References

[1] S. Choi, Q.-Y. Zhou, and V. Koltun, Robust Reconstruction of Indoor Scenes, CVPR, 2015.

[2] Qian-Yi Zhou, Jaesik Park, Vladlen Koltun. (2018). Open3D: A Modern Library for 3D Data Processing. arXiv:1801.09847.

[3] Zhang, Zhengyou (1994). “Iterative point matching for registration of free-form curves and surfaces”. International Journal of Computer Vision. 13 (12): 119–152. CiteSeerX 10.1.1.175.770. doi:10.1007/BF01427149

[4] Zollhöfer, M., Stotko, P., Görlitz, A., Theobalt, C., Nießner, M., Klein, R. and Kolb, A. (2018), State of the Art on 3D Reconstruction with RGB-D Cameras. Computer Graphics Forum, 37: 625-652. https://doi.org/10.1111/cgf.13386