Automated RGBD to C-arm Calibration

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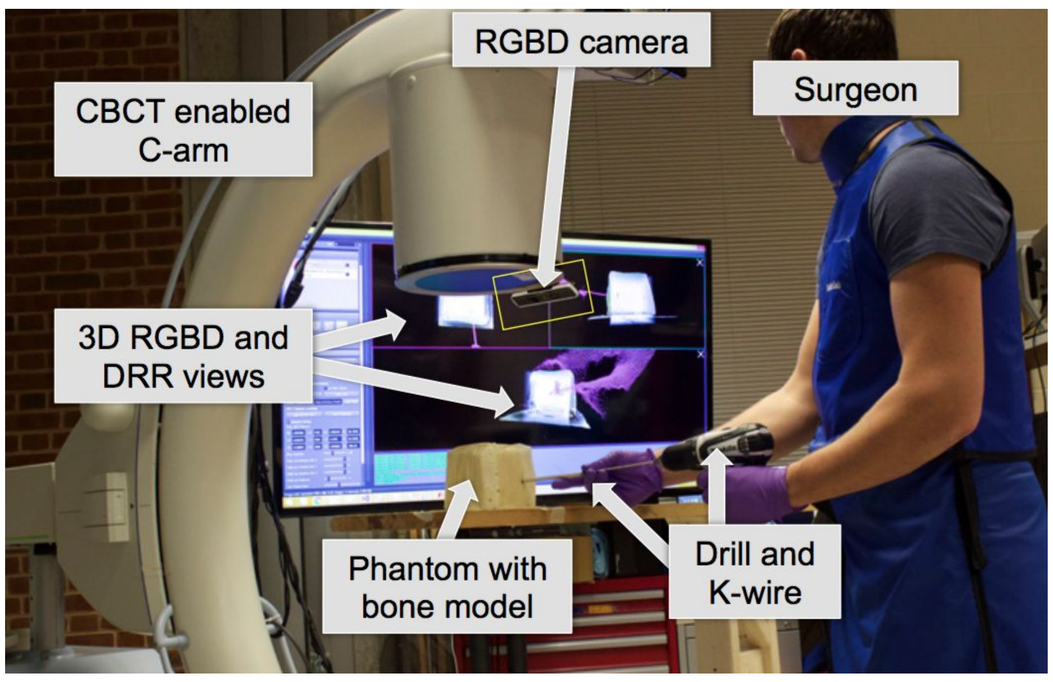
Introduction

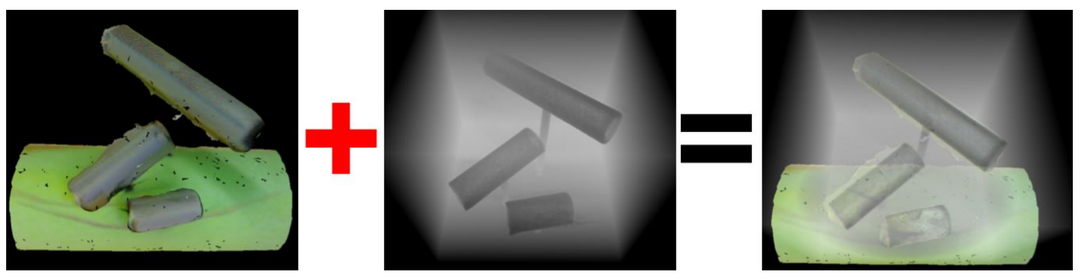
- Orthopedic surgeries require difficult tool placement
- Many X-rays are taken to ensure correct placement
- Creates mixed-reality visualization increases patient safety (fewer X-rays, shorter duration)
- Built an automated calibration algorithm to register a Cone Beam Computer Tomography (CBCT) scanner and Red-Green-Blue Depth Camera (RGBD)



Setup of Camera Augmented Mobile C-Arm (CAMC)

Problem

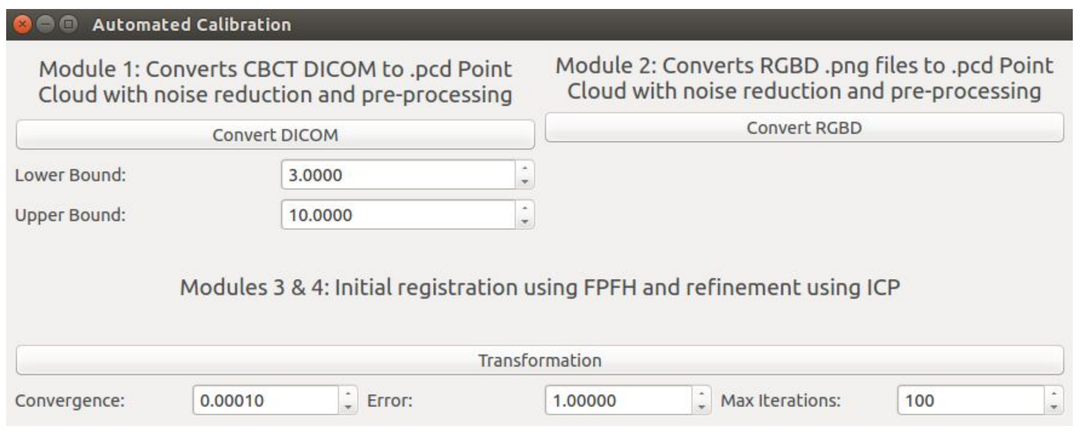
- RGBD and CBCT have different origins and physical properties (attenuation coefficient and depth), requires rigid transformation
- Manual calibration algorithm is time and expertise intensive



Transformation from CBCT to RGBD Space

Solution

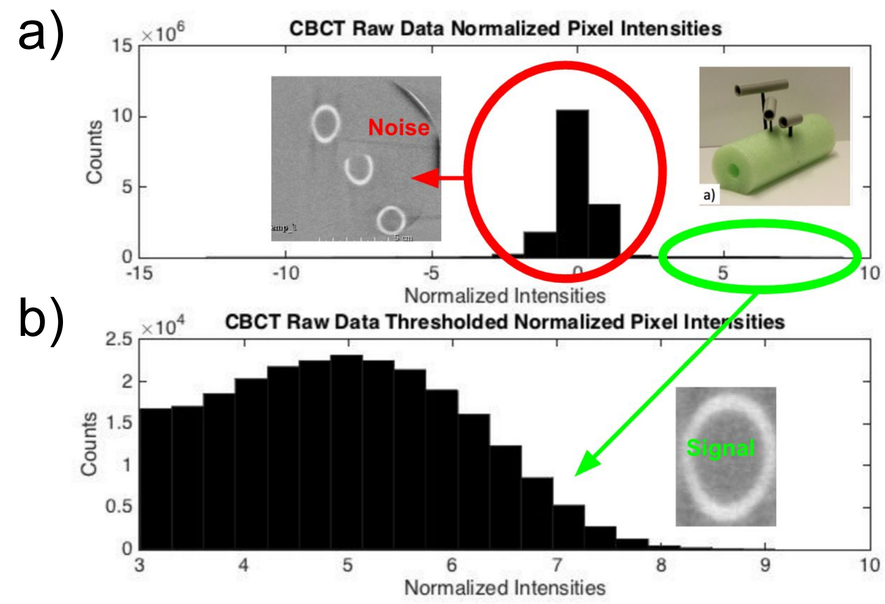
- Developed a faster and automated calibration algorithm to calibrate CBCT to RGBD
- Four modules with graphical user interface (GUI)



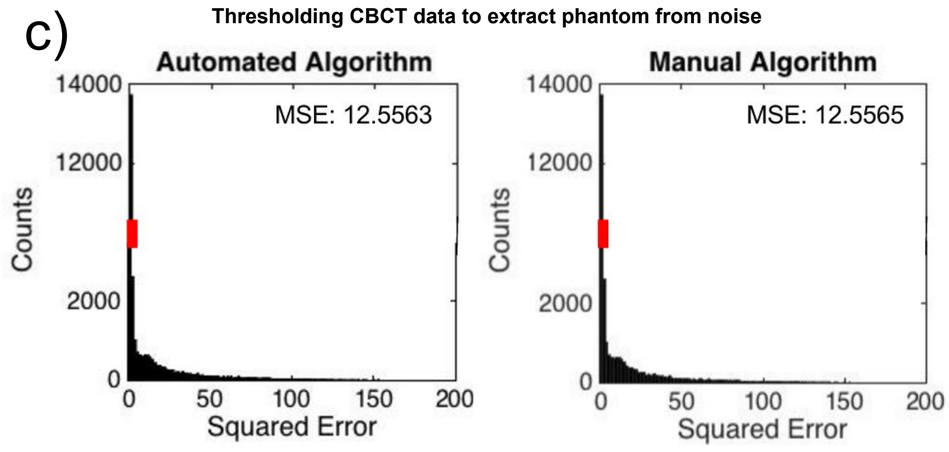
Simple GUI

Results

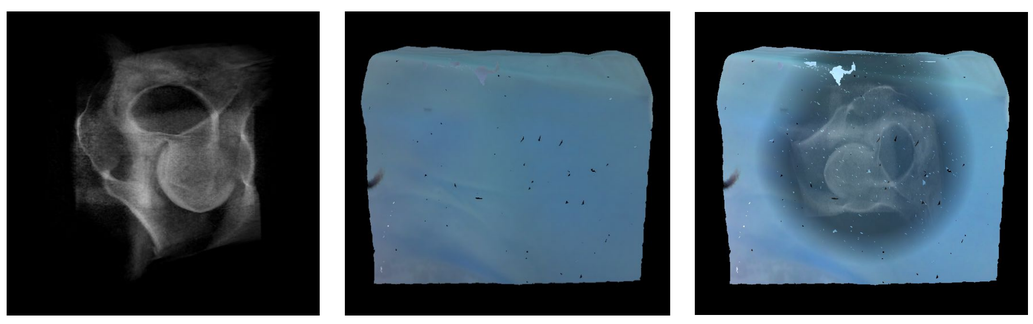
- Successfully automated the manual calibration without the segmentation of point clouds
- Correctly extracted CBCT point cloud from noise
- Results had comparable mean squared error (MSE)



Thresholding CBCT data to extract phantom from noise



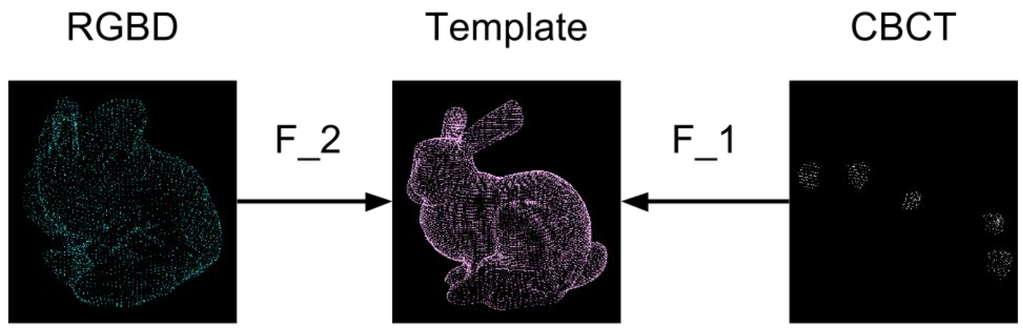
Distribution of Euclidean Distances between RGBD and CBCT Point Clouds



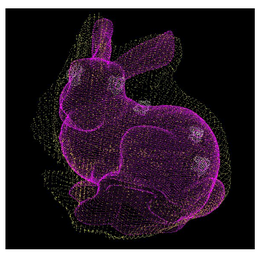
Results of CBCT + RGBD with pelvic phantom under hospital gown

Future Work

- Automated algorithm does not segment point cloud
- New phantom that does not need segmentation



Proposed transformation to CAD Template



Overlaying of CBCT, Template and RGBD

Lessons Learned

- Methodology and culture of research group
- Exploration of third party software and libraries (ImFusion SDK, MeshLab, PCL, ITK)
- Build large C++ application with Qt GUI and numerous dependencies

References

Lee SC, Fuerst B, Fotouhi J, Fischer M, Osgood G, Navab N. Calibration of RGBD Camera and Cone-Beam CT for 3D Intra-operative Mixed Reality Visualization. International Journal of Computer Assisted Radiology and Surgery / International Conference on Information Processing in Computer-Assisted Interventions (IPCAI), Heidelberg, June 2016.

Rusu RB, Blodow N, Beetz M. 2009. Fast point feature histograms (FPFH) for 3D registration. In Proceedings of the 2009 IEEE international conference on Robotics and Automation (ICRA'09). IEEE Press, Piscataway, NJ, USA, 1848-1853.

Nassir Navab, Sandro-Michael Heining, and Joerg Traub. “Camera Augmented Mobile C-Arm (CAMC): Calibration, Accuracy Study, and Clinical Applications”. In: IEEE Transactions on Medical Imaging 29.7 (2010), pp. 1412–1423. doi: 10.1109/tmi.2009.2021947.