Tool Tracking for Periacetabular Osteotomy using CamC

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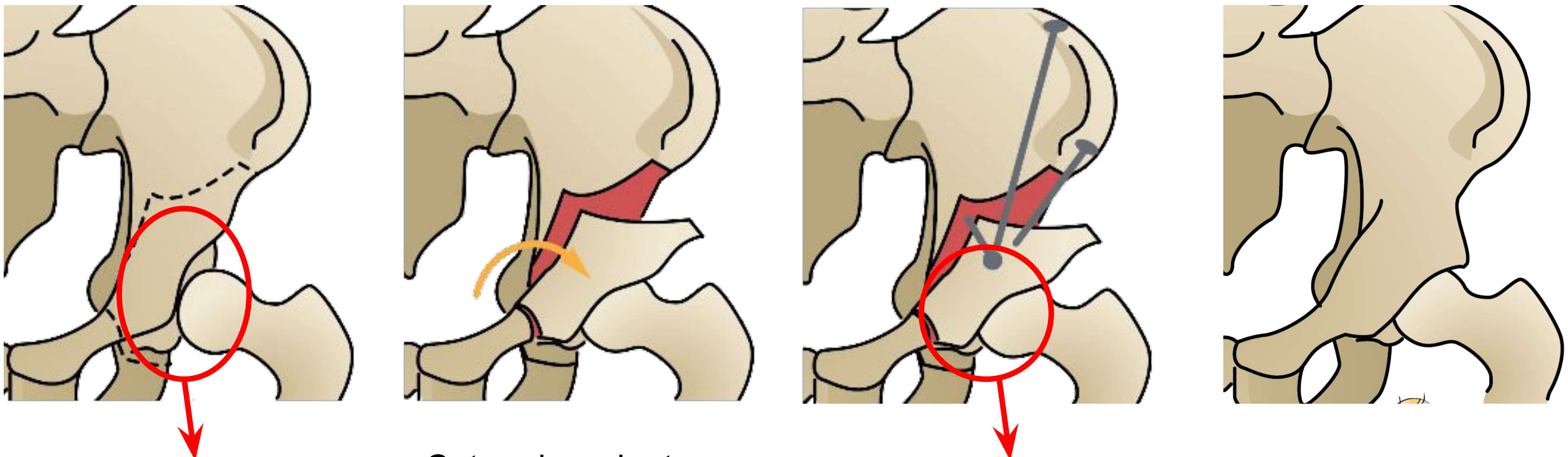
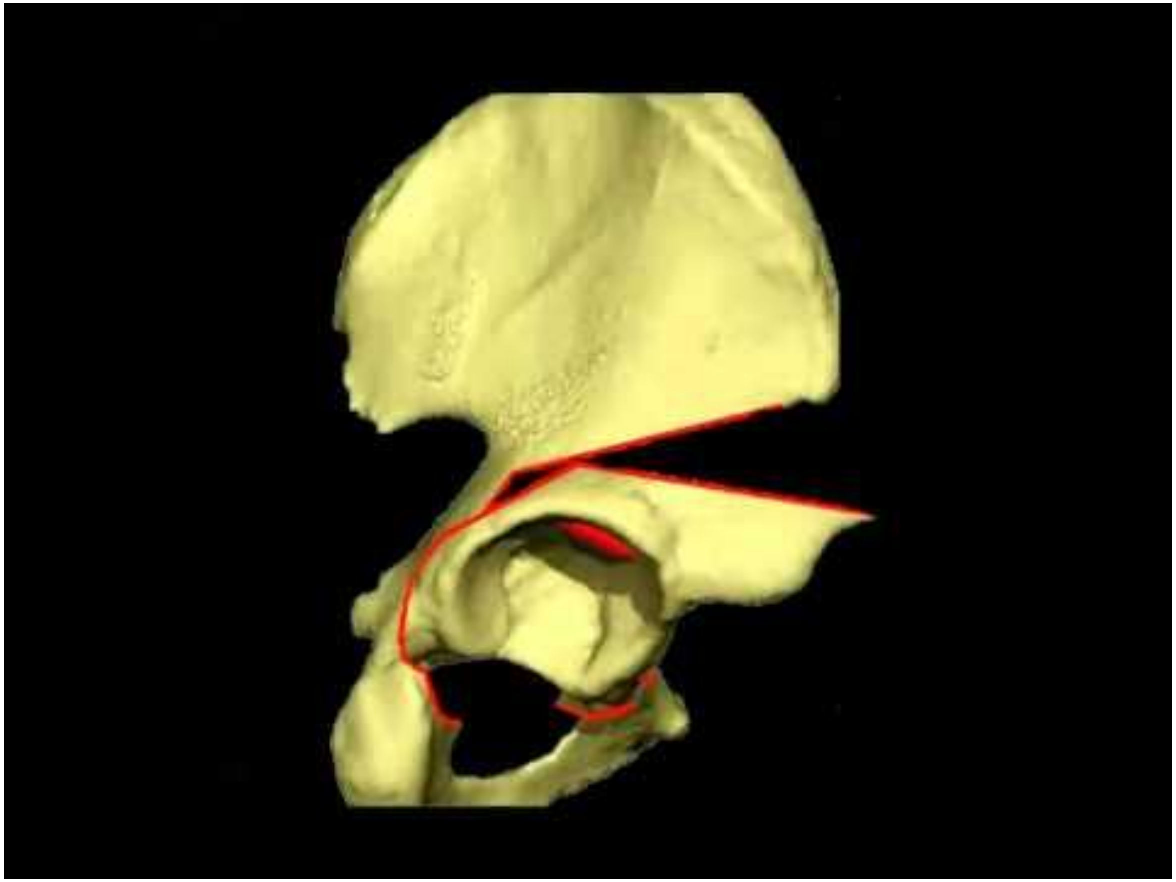
Background

- Periacetabular Osteotomy (PAO) is for patients suffering from developmental dysplasia of the hip (DDH)
- Caused by reduced coverage of the femoral head
- PAO surgery improves poor femoral coverage by reorienting the acetabulum and stabilizing the hip joint



(Image taken from https://hipdysplasia.org/adult-hip-dysplasia/adult-treatments/hip-preservation-surgery-for-adult-hip-dysplasia/)

PAO Movement



(video taken from https://www.youtube.com/watch?v=aWofkU-td08)

Previous works

- 3D/2D registration algorithm of CT to intra-op. [1]
- An intra-operative mixed reality visualisation of 3D medical data and a marker-less tracking algorithm to track surgical tool. [2]
- Pose-aware C-arm for automatic re-initialization of interventional 2D/3D image registration. [3]

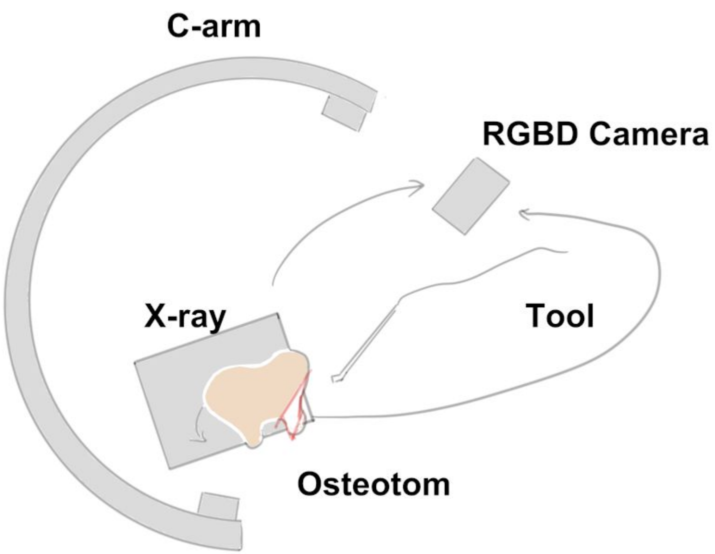
[1] Otake, Y., Armand, M., Armiger, R. S., Kutzer, M. D., Basafa, E., Kazanzides, P., & Taylor, R. H. (2012). Intraoperative Image-based Multiview 2D/3D Registration for Image-Guided Orthopaedic Surgery: Incorporation of Fiducial-Based C-Arm Tracking and GPU-Acceleration. IEEE Transactions on Medical Imaging, 31(4), 948–962. http://doi.org/10.1109/TMI.2011.2176555

[2] Lee, S. C., Fuerst, B., Tateno, K., Johnson, A., Fotouhi, J., Osgood, G., … Navab, N. (2017). Multi-modal imaging, model-based tracking, and mixed reality visualisation for orthopaedic surgery. Healthcare Technology Letters, 4(5), 168–173. http://doi.org/10.1049/htl.2017.0066

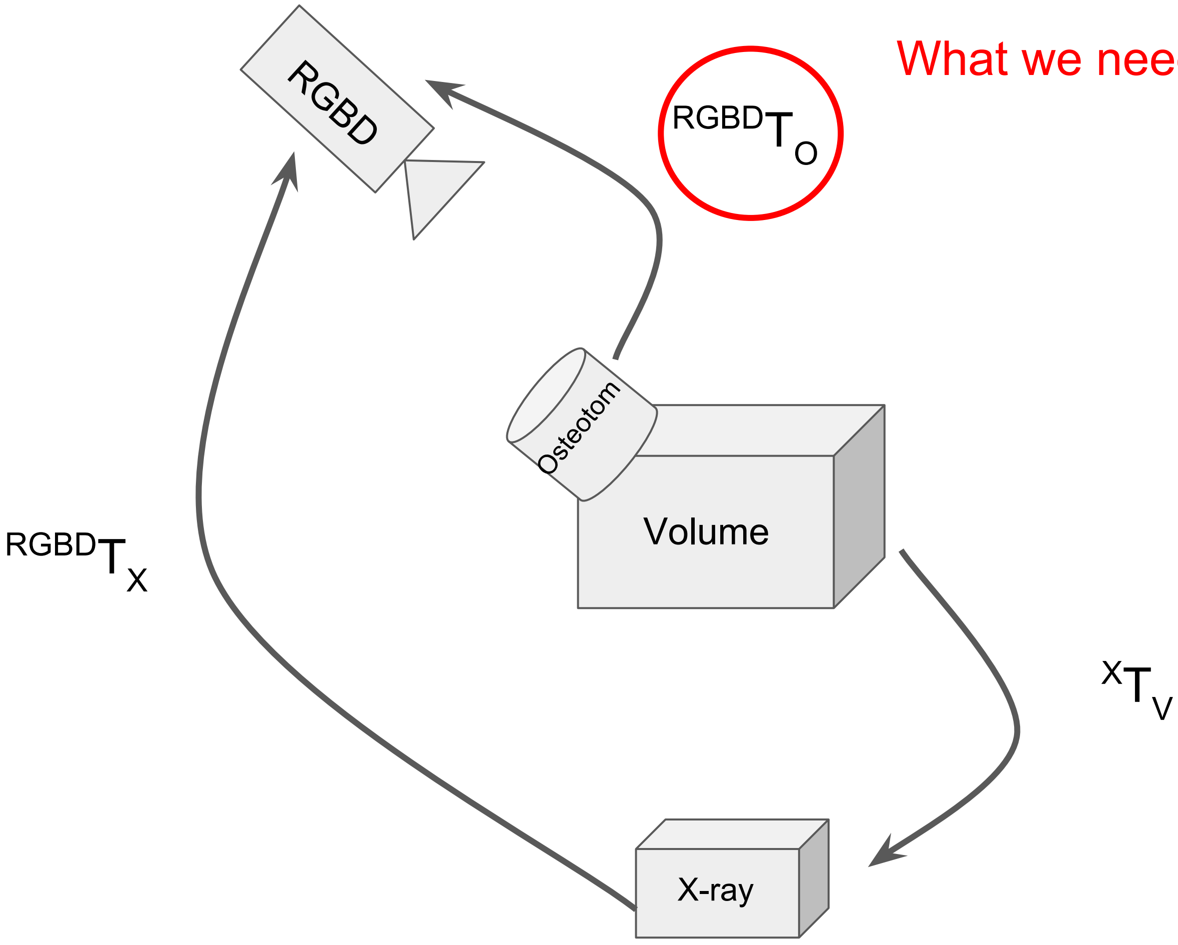
[3] Fotouhi, J, et al. "Pose-aware C-arm for automatic re-initialization of interventional 2D/3D image registration." International Journal of Computer Assisted Radiology & Surgery 12.7(2017):1221-1230. https://doi.org/10.1007/s11548-017-1611-8

Objectives

- Track the osteotom tool with respect to the pelvis in PAO using RGBD and X-ray images
- Update the preplanned osteotomy fracture lines via 3D tracking of the osteotom within the pelvis



Technical approach

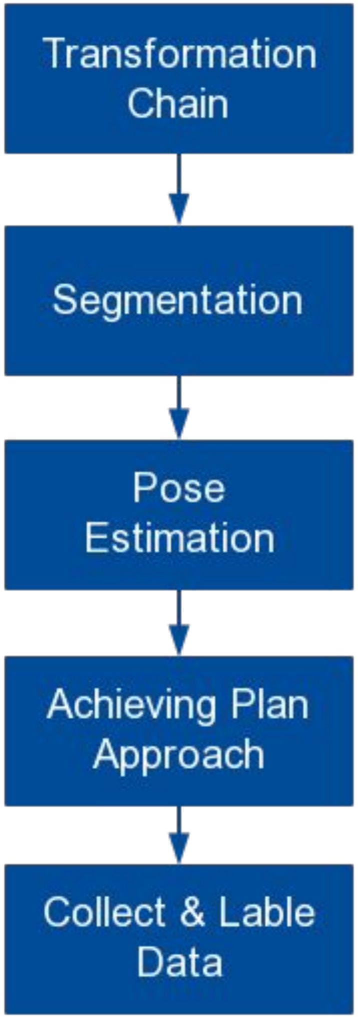


What we need to find out!

What if pelvis moves?
(Fiducials...)

$$^{V}T_O = {}^{X}T_V^{-1} * {}^{RGBD}T_X^{-1} * {}^{RGBD}T_O$$

Workflow



a. Visualize point cloud of osteotom in real time

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a. Background subtraction
b. Improved segmentation

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a. ICP
b. Globally Optimized ICP

If time permits

Using our prototype for future use

Delivarables

format of Input and output of
each module (interfacing)

Documentations:

- C++ source code
- Code documentation
- Report describing the methods and achievements

Minimum deliverables:

Working segmentation (e.g. background subtraction), pose estimation (ICP) and visualization

Expected deliverables:

Improved segmentation (graph cut/ML/etc.), better pose estimation (globally optimal ICP), visualize the cut plane

Maximum deliverables:

Start collect data base upon the prototype; start investigating the planning approach

Dependencies

Dependencies	Solution	Date
Access to previous code (2D/3D registration, etc.)	Email Dr. Unberath	Feb 23
Access to Intel RealSense SDK	Download it from website	Feb 20
Access to PCL (Point Cloud Library)	Download it from website	Feb 20
Access to the C-arm x-ray	Complete radiology certification	Mar 16
Access to RGBD camera, scanner	Email Javad	Feb 23
Access to the CAD model and the True model (Double confirm whether we can get that)	Email Dr. Armand.	Feb 23

Include time for testing and documentation

Schedule

	Feb 19	Feb 26	Mar 5	Mar 12	Mar 19	Mar 26	Apr 2	Apr 9	Apr 16	Apr 23	Apr 30
Familarize ourselves with existing works											
Visualize point cloud in real time											
Finish the background subtraction and basic pose estimation											
Explore and implement better segmentation methods											
Explore and implement better pose estimation methods											
Visualize the cutting plane											
Collect and label data base upon the prototype											
Investigating plan approach											

Key dates and milestones

- Become familiar with preexisting works on the topic: **Febuary 26th**
- Complete Minimum deliverable/ start expedcted/deliverables: **March 11th**
- Expand upon our previous segmentation and pose estimation methods: **April 2nd - April 16th**
- Complete expected deliverables/start maximum deliverables: **April 16th**

Be more concrete
When to settle down the documentations, design, procedure plans of the program so that it’s easier when implementing the code.

Responsibility

Each member will contribute to each part

	Background subtraction	Pose estimation	Visualization	Collect data	Investigate plan approach
Minimum	Nianhang	Wenhao	Billy	X	X
Expected	Nianhang	Wenhao	Billy	X	X
Maximum	Nianhang	Wenhao	Billy	All	All

Management Plan

- Code stored in a private git repository on BitBucket
- Weekly Meetings with Dr. Unberath and Javad to discuss the project
- Additional weekly meetings between the three of us to get together and work on the project (settle that down)

Reading list

Murphy, R. J., Armiger, R. S., Lepistö, J., & Armand, M. (2016). Clinical evaluation of a biomechanical guidance system for periacetabular osteotomy. *Journal of orthopaedic surgery and research*, *11*(1), 36.

Murphy, R. J., Armiger, R. S., Lepistö, J., Mears, S. C., Taylor, R. H., & Armand, M. (2015). Development of a biomechanical guidance system for periacetabular osteotomy. *International journal of computer assisted radiology and surgery*, *10*(4), 497-508.

Murphy, R. J., Otake, Y., Lepistö, J., & Armand, M. (2013). COMPUTER-ASSISTED X-RAY IMAGE-BASED NAVIGATION OF PERIACETABULAR OSTEOTOMY WITH FIDUCIAL BASED 3D ACETABULAR FRAGMENT TRACKING. *Bone Joint J*, *95*(SUPP 28), 84-84.

Otake, Y., Armand, M., Armiger, R. S., Kutzer, M. D., Basafa, E., Kazanzides, P., & Taylor, R. H. (2012). Intraoperative Image-based Multiview 2D/3D Registration for Image-Guided Orthopaedic Surgery: Incorporation of Fiducial-Based C-Arm Tracking and GPU-Acceleration. IEEE Transactions on Medical Imaging, 31(4), 948–962.

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Fotouhi, J, et al. "Pose-aware C-arm for automatic re-initialization of interventional 2D/3D image registration." International Journal of Computer Assisted Radiology & Surgery 12.7(2017):1221-1230.