



Intraoperative Registration of Pathology for Postoperative Adjuvant Radiotherapy

Computer Integrated Surgery II Spring 2014

Project #4

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Introduction

- We produced a workflow for evaluating tissue deformation as a tumor is removed
- Includes methodology of actions pre-, intra-, and postoperatively, as well as postoperative image processing
 - Registration of intraoperative tracking data to preoperative image data and registration of preoperative images to postoperative images
- In effect, we have addressed the problem of providing better guidelines to radiation oncologists on where to deliver postoperative radiotherapy, allowing decreased radiation poisoning

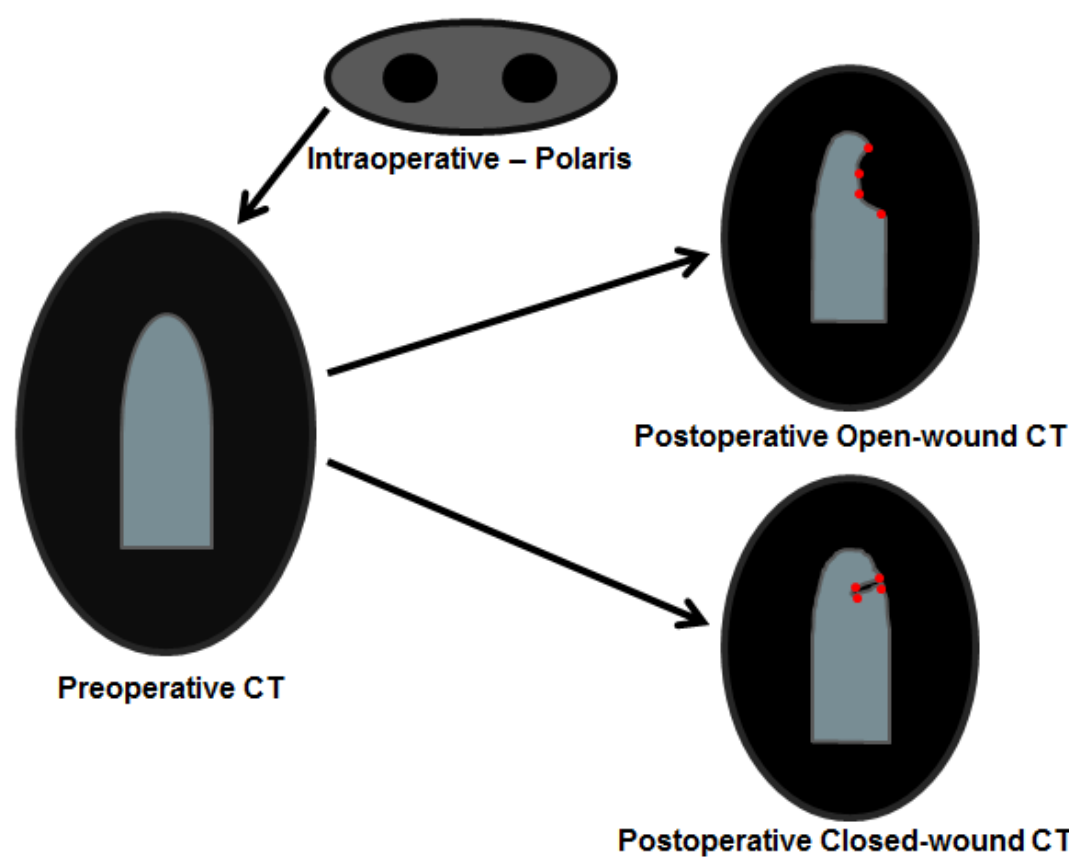
The Problem

- Patient receives surgical resection of tumor and postoperative radiotherapy of surgical bed
- Volume of radiotherapy overestimated → toxicity and negative physiologic reactions
- Need method to evaluate tissue deformation after surgery to decrease volume and increase specificity of radiotherapy

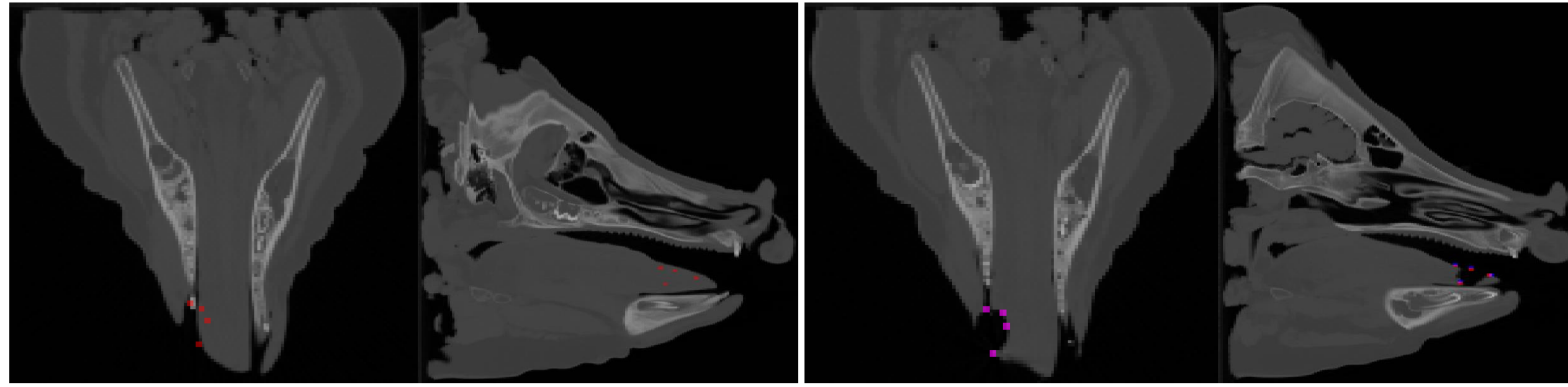


The Solution

- Take three CT scans of patient: preop, postop with open wound, postop after wound closed
- Outline pathology with points using Polaris tracking system; register these points to preop CT
- Using open source medical imaging software, Elastix, to register preop scan to each postop scan
- Use Transfix to monitor points' movement
- Guides postop radiotherapy planning
- Experimental methodology:
 - In 3 pig heads, a portion of the tongue was removed simulating surgical resection of tumor
 - 5 fiducials were placed on the surface of the head to determine intraop to postop registration
 - Placed 4 radio-opaque markers on tongue where Polaris points were collected for gold standard
 - Removed markers from CT images
 - Determined optimal Elastix parameters for best possible image registrations
 - Computed RMS errors between measured fiducials and computed fiducials, and between gold standard markers on tongues and computed tongue points



Outcomes and Results



- Left two images: Registration of intraop Polaris to preop
- Right two images: Registration of intraop Polaris to postop open

Pig	Preop Fiducials(mm)	Open Fiducials (mm)	Open Tongue marks (mm)
1	4.12	3.64	1.95
2	3.99	4.01	6.75
3	6.49	5.07	3.90
Total	8.66	7.42	8.03

- Table above shows accuracy of intraop registration via total RMS error between pre- and postop open fiducials and postop open tongue points
- Fiducials and markers had diameters of approximately 5 mm
- Registration of fiducial points onto both scans is very accurate
- Inherent uncertainty as tongue points on preop scan can be found in unlikely places (off of the tongue) due to movement; creates complications for direct placement of Polaris points on preop scan

Pig	Clip 1	Clip 2	Clip 3	Clip 4	Total
1	32.9	29.6	29.6	28.2	30.1
2	13.1	11.4	7.7	8.8	10.5
3	13.8	12.2	4.3	6.6	10.0
				Avg	19.3

- Table above shows accuracy of registration using the orig. method of preop to postop closed via RMS of tongue clips and total RMS

Parameter Set:	Avg Fiducial RMS (Rigid) (mm)	Avg Tongue RMS (Deform.) (mm)
STD, AMS	20.70	21.07
STD, AMS2	20.14	20.68
STD,AMS, fixed pts	7.47	18.92

- Table above shows RMS error resulting from different parameter sets when postop open is registered to preop and then subsequently registered to postop closed; greater accuracy
- Images below visually show accuracy of this registration method



Pig 1

Pig 2

Pig 3

Lessons Learned

- Inherent error in method: Collecting points around tongue intraoperatively, but intraop tissue doesn't line up with tissue in preop image
- Necessity to think through entire project and pre-define what data we need and what we need to do with it

Future Work

- Explore rigid landmark-based registrations
- Improve marker positions by placing them on surface of tongue, not protruding and creating error

Support by and Acknowledgements

- We thank our mentors for their guidance and funding, as well as Seth Billings for helping us obtain the Polaris

Credits

- KF led data collection process, SL led intraop registration process, MH led image registration process

