Checkpoint:

Project 15: Mouse segmentation and optical properties for bioluminescence tomography (BLT)

TEAM: ALAN CHAM

MENTORS: KEN WANG, BIN ZHANG, JUNGHOON LEE

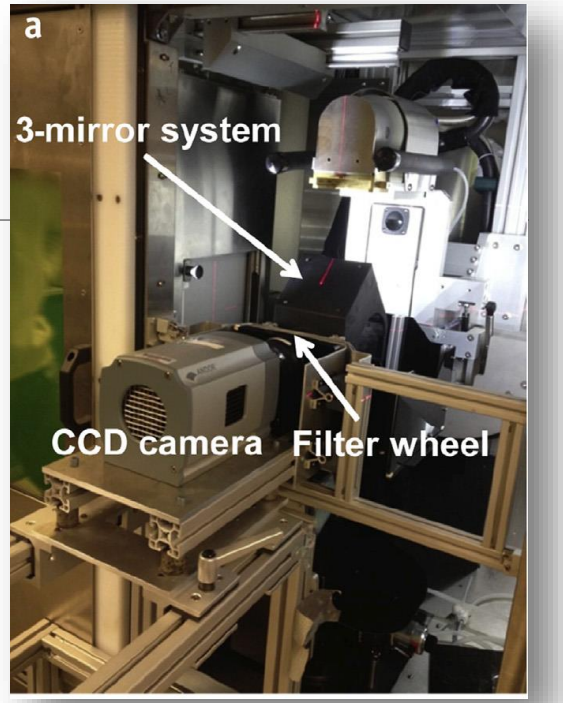
Background

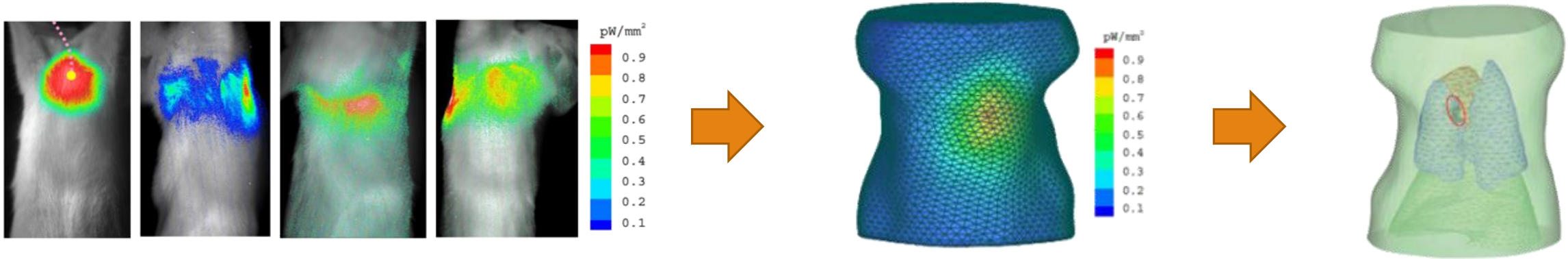
Small Animal Radiation Research Platform (SARRP)

- Preclinical research: mouse imaging and radiation delivery
- BLT to localize targets with low CT contrast

Bioluminescence tomography

- Reconstruct internal light source position from surface intensity measurements
- Previous experiments with implants in relatively homogeneous region (abdomen) of mouse body





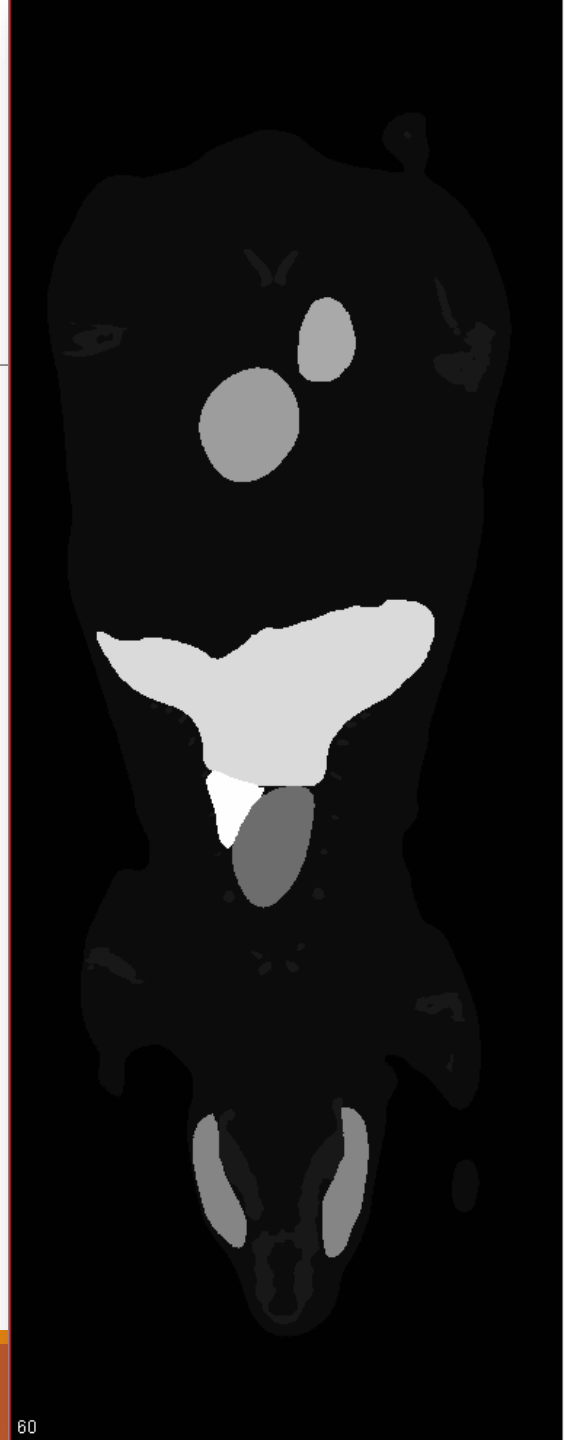
Topic and Goals (RED = Cancelled, BLUE = Clarified)

Original

- Gather literature values of mouse organ optical properties and evaluate their distribution
- Automate the segmentation of cone beam computed tomography (CBCT) images of mice.
- Modify existing BLT reconstruction to address optical property heterogeneity.
  - Implanted light source experiments.
  - Simulated light source experiments.

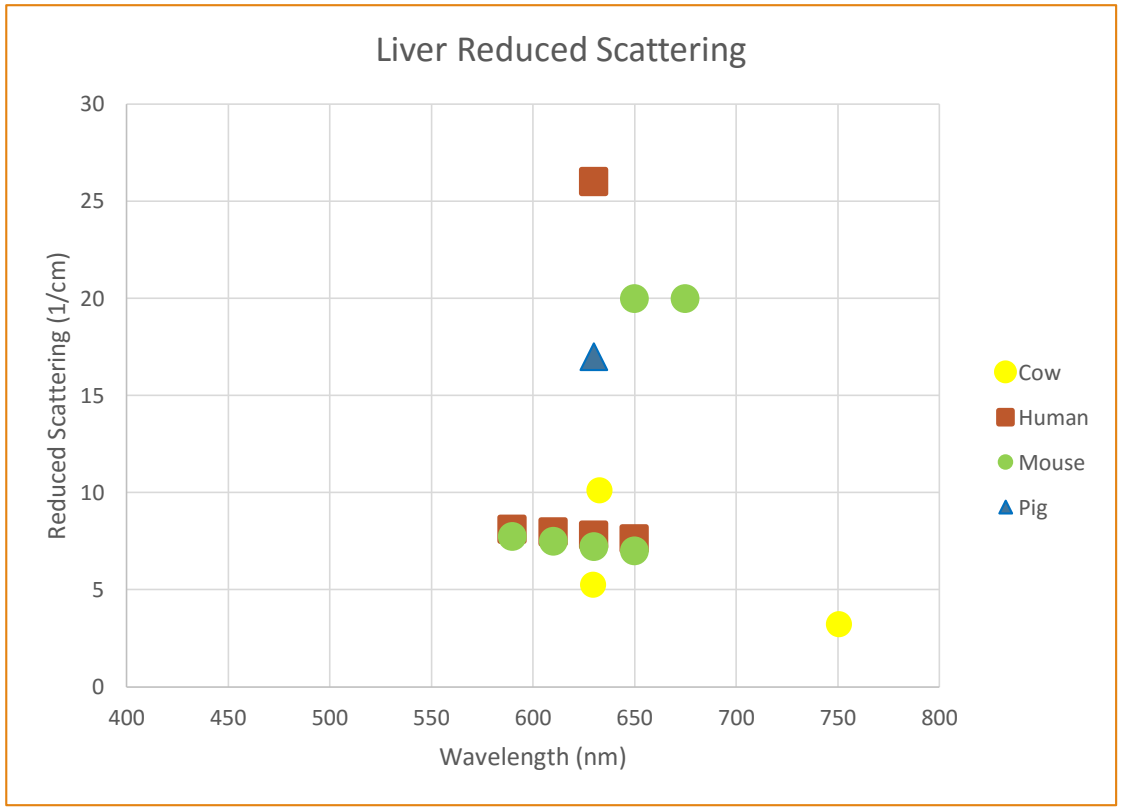
Revised

- Gather literature values of mouse organ optical properties and evaluate their distribution
- Modify existing BLT reconstruction workflow to reconstruct simulation experiment results.
  - Investigate the effects of heterogeneity in simulated light source experiments.



Technical Approach and Progress: Optical Property Values

Example

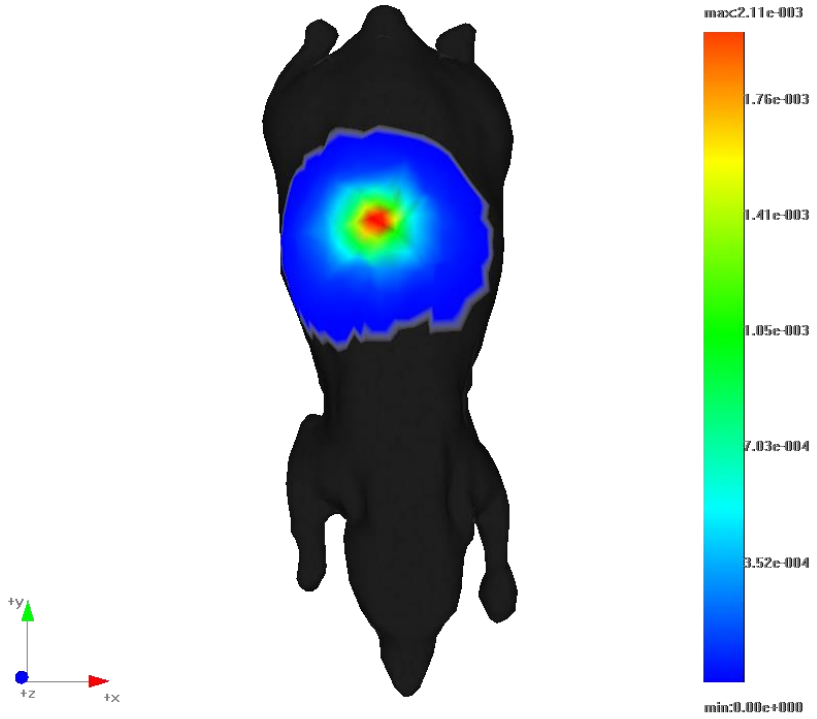


Milestones

Problem: discrepancies between reported literature values

- Gathered and tabulated μ_a and 'μ_s for adipose, bone, bowel, brain, heart, kidney, liver, lung, stomach:
  - Completed: 3.10
- Format data into presentation-appropriate plots
  - Expected: 4.11
- Case-by-case explanation of discrepancy and suggestion for usage/exclusion
  - Expected: 4.15

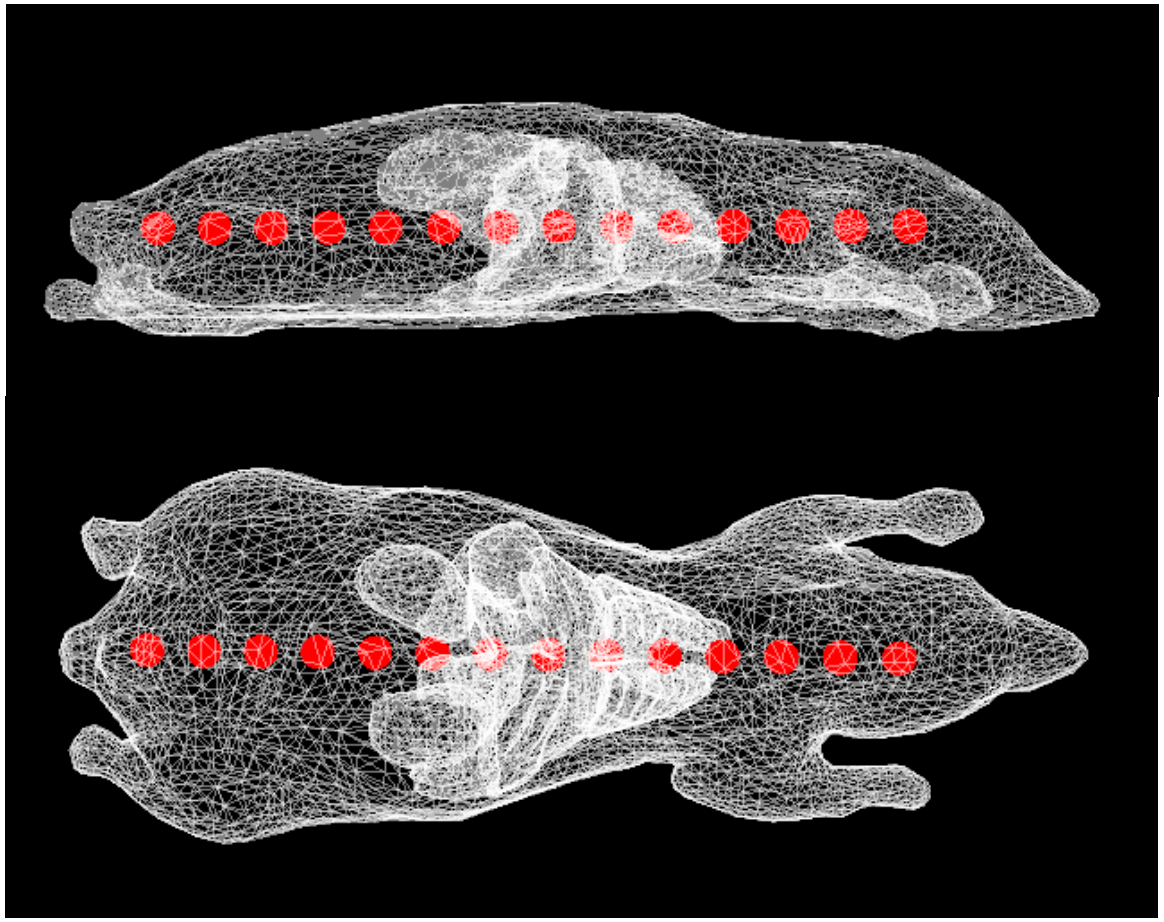
Technical Approach and Progress: Optimal Photon Count



Milestones

- Read MOSE manual and learn to configure/run simulation on MOSE
  - Completed: 3.15
- Document and write code to homogenize regions of MOSE digimouse
  - Completed: 3.30
- Document and write code to plot and record normalized surface intensity measurements for all nodes with measurements greater than relative threshold 10%
  - Expected: 4.11
- Run series of simulations using {1e3, 1e4, 1e5, 1e6 …} photons until ratio between consecutive normalized detector values are near 1.
  - Expected: 4.15

Technical Approach and Progress: Reconstruction Experiments



Milestones

- Document and write code to inter-convert NIRfast and MOSE mesh formats.
  - Completed: 3.15
- Document and write code to map MOSE simulation output '.t.cw' to NIRfast detector and measuremnt '.paa' and '.meas' files.
  - Completed: 3.28
- Document and write code project mouse organs to axis.
  - Completed: 4.11
- Document and adapt BLT code to reconstruct from MOSE simulation results.
  - Expected: 4.15
- Run series of experiments along heterogeneous mouse midline and record error vs. position, then error vs. fluctuated properties.
  - Expected: 4.29

Deliverables (RED = Cancelled, BLUE = Clarified)

Original

Minimum
- Tabulate literature values for optical properties
- Manually segment mouse images for atlas and simulated source
- Modify Matlab code to incorporate organ specific optical properties
- Test code under simulation conditions

Expected
- Workflow for registering new images to atlas set using elastix
- Matlab code for multi-classifier decision fusion strategy

Maximum
- Perform BLT experiment on implanted light source in specific organ
- Determine optimal optical property value sets for reconstruction

Revised

Minimum
- Tabulated literature values for optical properties
  - Presentation of formatted/plotted properties
  - Documentation of point-by-point explanation/justification for suspect data points
- Documented code and workflow for generating forward-problem simulation results
  - Document results for determining optimal photon count for Monte Carlo simulation
- Documented, adapted code for reconstruction of simulation results
  - Quantify reconstruction error as function of source position in mouse and fluctuations in optical properties

Expected

Maximum
- Documentation of optimal optical property value sets for reconstruction and simulation

Project Timeline: Significant Clarifications/Changes Made to Original

Original

Key Milestones Highlighted	Week of: February 21	28	March 06	13	20	27	April 03	10	17	24	May 01
Read Elastix Manual (2-3)											
Read Core Literature (5-13)			1								
Project Plan + Presentation											
Read BLT documentation											
Run BLT on Sample Images				2							
Seminar Presentation											
Manual Segment Atlas Set											
Checkpoint Presentation											
Second Literature Round						3					
Modify BLT code											
Test BLT in Simulation								4			
Try Elastix Parameters											
Multi-class decision fusion											
Experiments with new sets										5	
Final Exam + Poster Session											

1. 3/5: Finished tabulating core literature results and main reading phase.
   - Ready for seminar presentation for week of 3/06
2. 3/12: Able to execute existing BLT workflow and begin modification
3. 3/27: Modified BLT code to incorporate optical properties information
   - Manual segmentations for atlas completed
   - Finished optical property data gathering
   - Ready for checkpoint presentation for week of 3/27
4. 4/16: Tested modified BLT with light source simulation
   - Decided on Elastix registration parameters
5. 4/30: Finished experimenting with reconstruction on new data from implanted sources
   - Ready to produce final report and presentation

	2/22	2/29	3/7	3/14	3/21	3/28	4/4	4/11	4/18	4/25	5/01
Read elastix manual											
Tabulate optical property literature											
Read BLT documentation											
Run BLT on example images											
Read MOSE manual and learn to run/configure simulation											
Document and write code to homogenize MOSE digimouse											
Document and write code to export and record normalized surface intensities											
Photon count experiment											
Format data into presentation-appropriate plots											
Document and write code to convert NIRfast, MOSE meshes											
Document and write code to export simulation results											
Document and write code to project mouse organs to axis											
Document and adapt BLT code to reconstruct simulation result											
Case-by-case explanation of suspicious data											
Midline and fluctuated property experiments											
Proposal presentation											
Seminar presentation											
Checkpoint presentation											
Final Session											

Dependencies: No Unresolved Dependencies

Resource	Status	Comment
Mouse image set for initial BLT example.	Obtained	
Mouse image sets for atlas + experiments	Obtained	No longer needed
BLT reconstruction Matlab source code	Obtained	
SAARP/BLT workflow documentation	Obtained	
Elastix registration software	Obtained	No longer needed
Nirfast light transport modeling software	Obtained	
MOSE simulation environment	Obtained	

Reading List

Bin Zhang, Ken Kang-Hsin Wang, Jingjing Yu, Sohrab Eslami, Iulian Iordachita, Juvenal Reyes, Reem Malek, Phuoc T. Tran, Michael S. Patterson, and John W. Wong. “Bioluminescence Tomography-Guided Radiation Therapy for Preclinical Research”. International Journal of Radiation Oncology*Biology*Physics.User's Manual for Molecular Optical Simulation Environment, version 2.3. Blacksburg, VA. Virginia Polytechnic Institute and State University (2012).

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Honda N, Ishii K, Terada T, Nanjo T, Awazu K; Determination of the tumor tissue optical properties during and after photodynamic therapy using inverse monte carlo method and double integrating sphere between 350 and 1000 nm. J. Biomed. Opt. 0001;16(5):058003-058003-7. doi:10.1117/1.3581111.

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Torricelli, A., Pifferi, A., Taroni, P., Giambattistelli, E., Cubeddu, R. (2001). In vivo optical characterization of human tissues from 610 to 1010 nm by time-resolved reflectance spectroscopy. Physics in Medicine and Biology, 46(8), 2227.

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Welch, A.J, Gemert, M.J.C. Optical-thermal response of laser-irradiated tissue. Dordrecht: Springer; 2011