# Project 15:

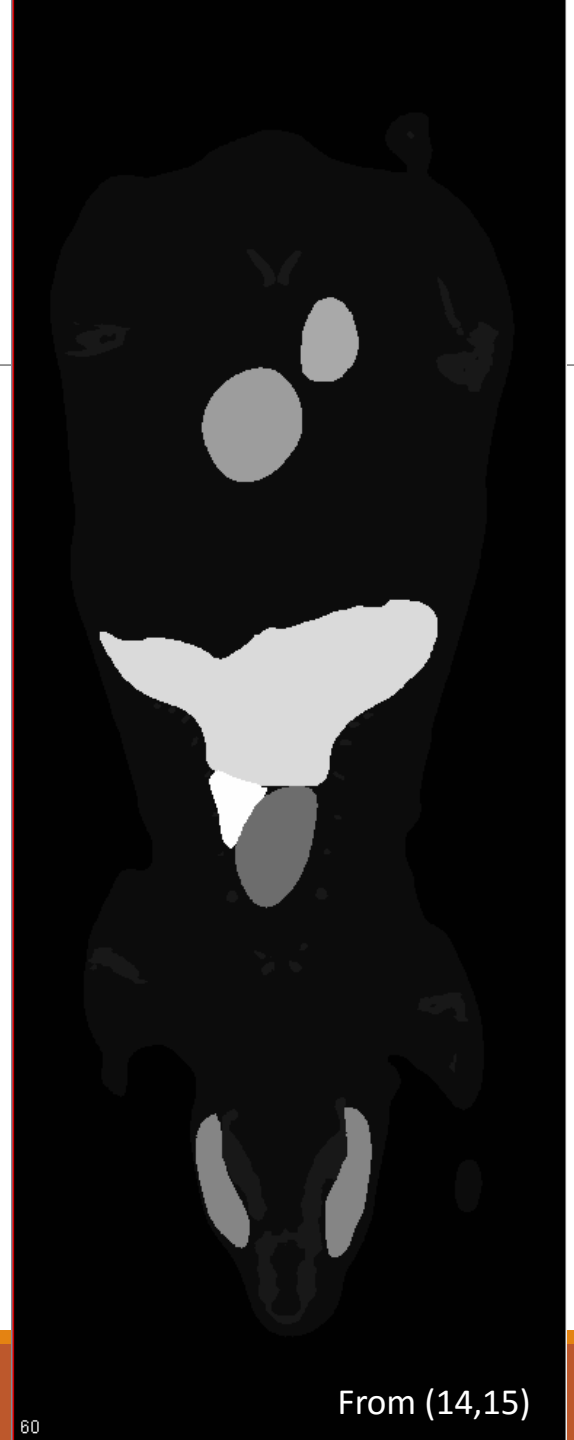
## Mouse segmentation and optical properties for bioluminescence tomography (BLT)

TEAM: ALAN CHAM

MENTORS: BIN ZHANG, JUNGHOON LEE, KEN WANG

# Topic and Goals

- Gather literature values of mouse organ optical properties and evaluate their distribution
- Expedite the segmentation of cone beam computed tomography (CBCT) images of mice.
- Modify existing BLT reconstruction to address optical property heterogeneity.
  - Experiment with optical property sets for best reconstruction.

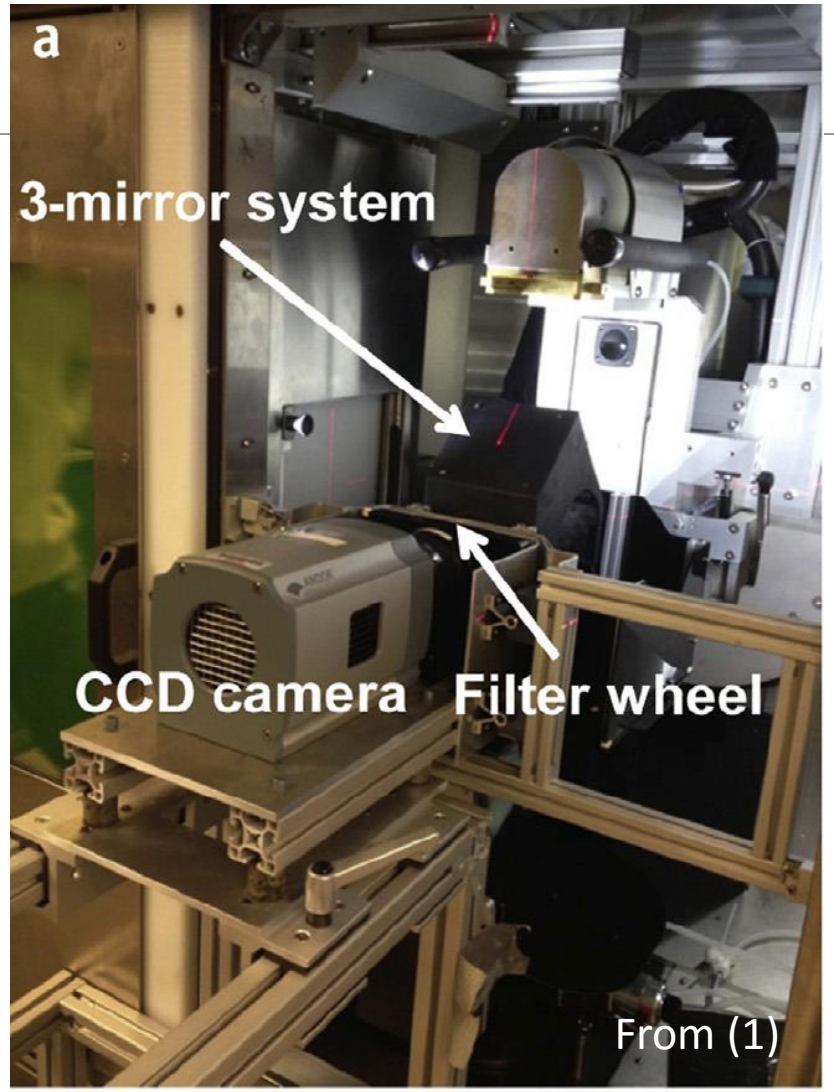


From (14,15)

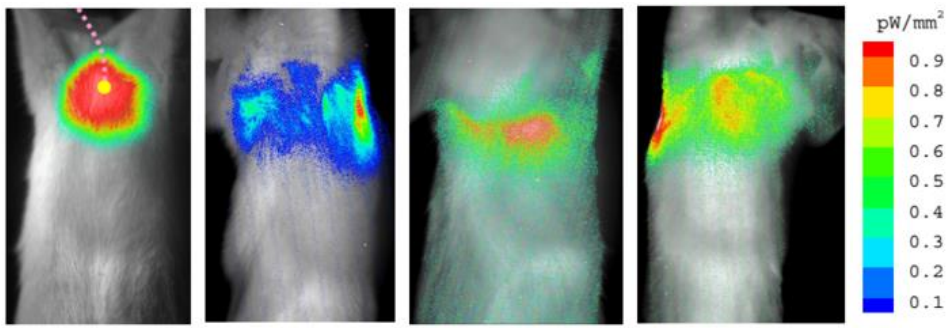
# Statement of Relevance

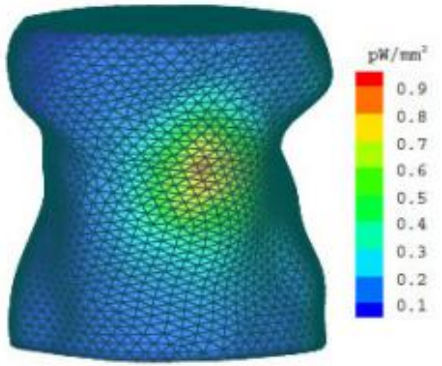
Small Animal Radiation Research Platform (SARRP)

- Tool for preclinical radiation research
- CBCT for radiation delivery guidance
- CBCT has less utility for localizing small/low-contrast targets in soft tissue
- Hence, incorporated bioluminescence tomography (BLT)



# Basic Idea of BLT




(b)

(c)

Images from (16)

# Basic Idea of BLT

Diffusion Approximation

Equations from (1):

$$\begin{cases} -\nabla \cdot D(r)\nabla\Phi(r) + \mu_a(r)\Phi(r) = S(r), \ r \in \Omega \\ \Phi(\xi) + 2A\hat{n} \cdot D(\xi)\nabla\Phi(\xi) = 0, \ \xi \in \partial\Omega \end{cases}$$

Green's Functions

$$\begin{bmatrix} \varphi_1 \\ \vdots \\ \varphi_M \end{bmatrix} = \begin{bmatrix} G_{1,1} & \cdots & G_{1,N} \\ \vdots & \ddots & \vdots \\ G_{M,1} & \cdots & G_{M,N} \end{bmatrix} \begin{bmatrix} s_1 \\ \vdots \\ s_N \end{bmatrix}$$

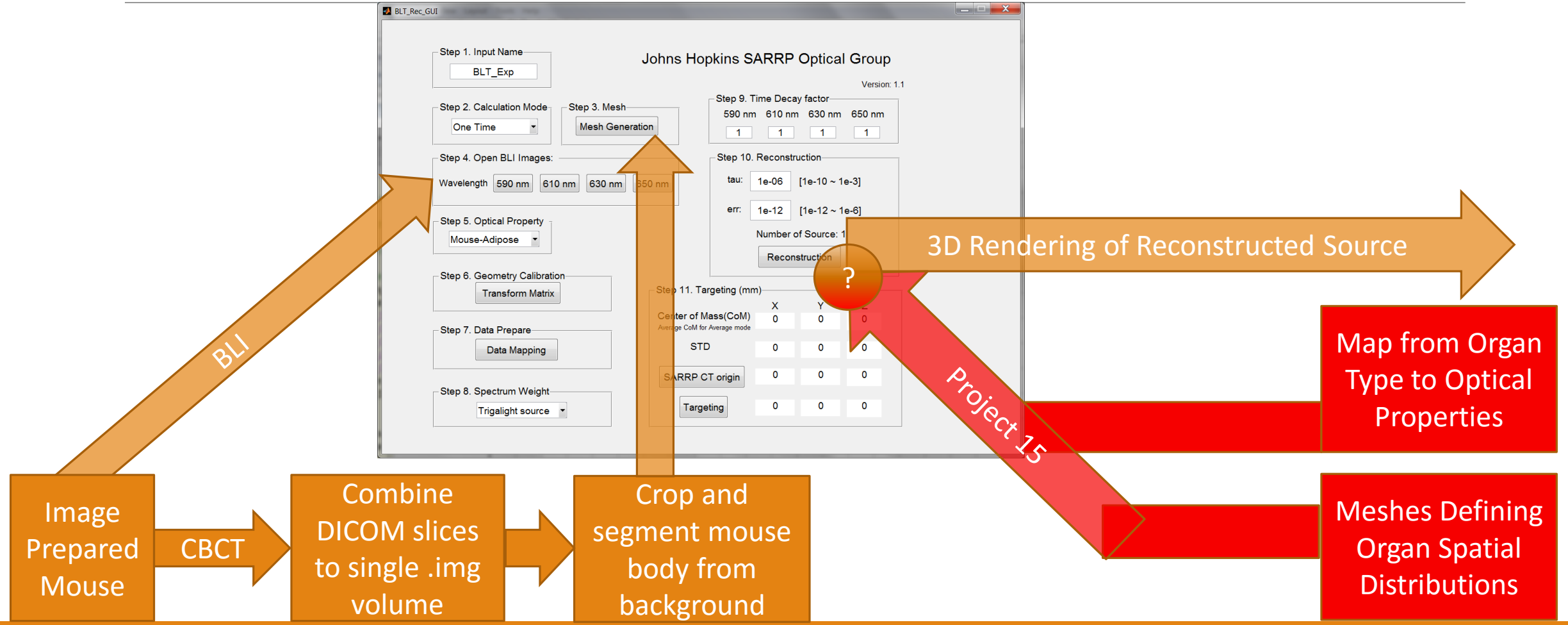
Multispectral Approach (590, 610, 630, 650 nm)

$$\begin{bmatrix} \varphi(\lambda_1) \\ \vdots \\ \varphi(\lambda_k) \end{bmatrix} = \begin{bmatrix} \eta(\lambda_1)G(\lambda_1) \\ \vdots \\ \eta(\lambda_k)G(\lambda_k) \end{bmatrix} [s]$$

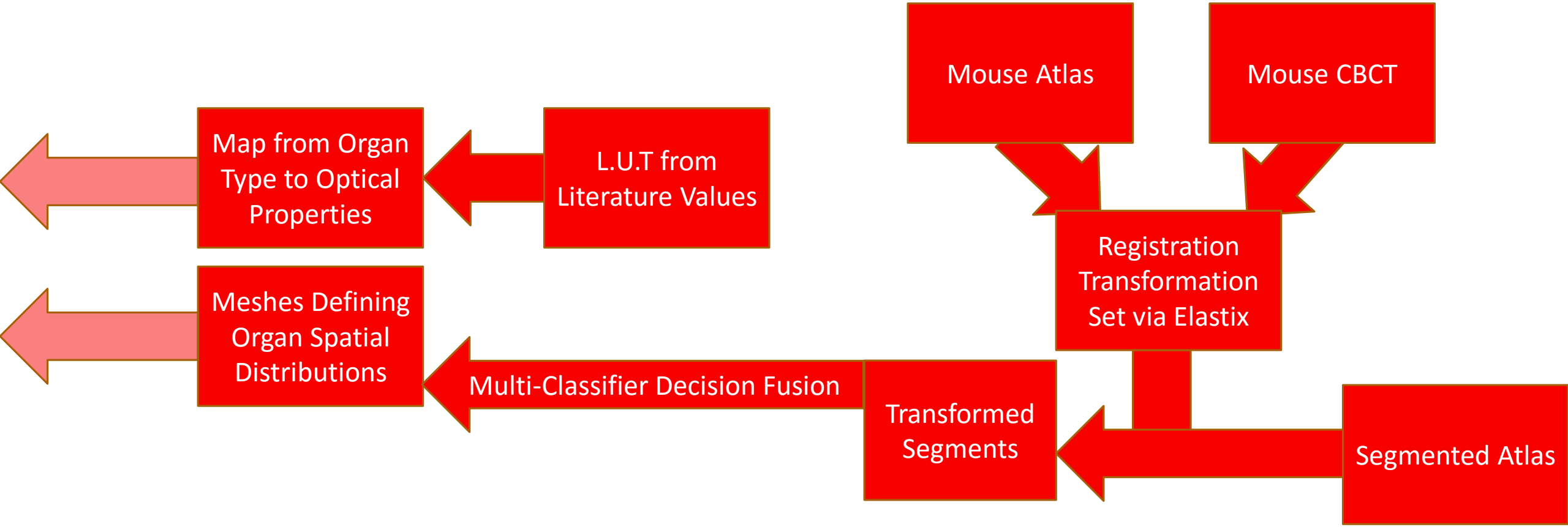
# Project 15:

To address optical property heterogeneity in reconstruction:

# Summary of Technical Approach



# Project 15 Approach



# Deliverables

**Minimum Deliverables**

- 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 Deliverables**

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

**Maximum Deliverables**

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

# Project Timeline

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

# Dependencies

| Resource | Status | Comment |
|---|---|---|
| **Mouse image set for initial BLT practice** | Received | |
| **Mouse image sets for atlas + experiments** | Unknown | To be discussed w/ mentor 2/29<br>Digimouse alternative/complement (14,15) |
| **Matlab source code** | Received | |
| **SAARP/BLT workflow documentation** | Received | |
| **Elastix registration software** | Installed | |
| **Nirfast light transport modeling software** | Received | |

# Management Plan

- Weekly meetings with mentor
- Regular e-mail correspondence
- Progress updates on project wiki

# Skills

- CIS Prerequisites

# Preliminary Reading List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12) Jacques, S.L. (2013). Optical properties of biological tissues: A review. *Physics in Medicine and Biology, 58*(11), R37

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

14) B. Dogdas, D. Stout, A. Chatziioannou, RM Leahy, Digimouse: A 3D Whole Body Mouse Atlas from CT and Cryosection Data, Phys. Med. Bio, 52: 577-587, 2007. http://dx.doi.org/10.1088%2F0031-9155%2F52%2F3%2F003

15) D. Stout, P. Chow, R. Silverman, R. M. Leahy, X. Lewis, S. Gambhir, A. Chatziioannou, Creating a whole body digital mouse atlas with PET, CT and cryosection images, Molecular Imaging and Biology.2002; 4(4): S27

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