Micro-CT Optimization

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DIMACS REU

5 June 2015

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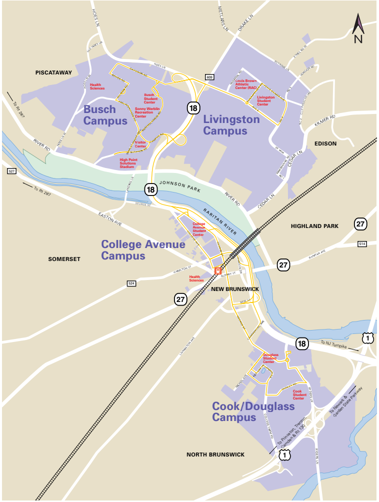
Pre-Clinical Imaging

- step between looking at cells and Phase 1 clinical trials
- put drugs into/try treatments on animals (rodents)
- step in funnel of potential drugs $\rightarrow$ FDA approval

Rutgers University–New Brunswick Overview Map



Introduction to Computed Tomography (CT)

In General...

- CT scans can be used to detect cancerous tissue/bone
- "reconstruct a 3D representation of the specimen that characterizes the spatial distribution of material density" (Bouxsein et al., 2010)
- uses ionizing radiation (used as cancer treatment)
- special x-ray equipment used to create many 2D images
- look at 2D images separately, or together for 3D image
- images created by a standard back projection filter

CT Image Collection/Reconstruction

How is the information taken?

- x-rays pass through an object, detector measures attenuated x-rays
- probability an x-ray is absorbed depends on material
- measurements of the absorption coefficients are stored in a matrix
- produces a shadow image

How are the 2D images generated?

- obtain "virtual slice" by application of a reconstruction algorithm
- collect x-ray attenuation coefficients from their line integrals along the beam path
- back projection: run projections back through image to approximate original

For Rodents...

Micro-CT, in particular

- micro = tiny! (mice!)
- mouse exposed to 60-70 sec of radiation on average

Figure: Micro-CT scan machine

The Problem

What drawbacks does CT have?

- ionizing rad: has the power to alter molecules of body
- supposed to detect cancer . . . but can cause cancer . . . and can potentially cure cancer
- PCI takes mice through stages of cancer

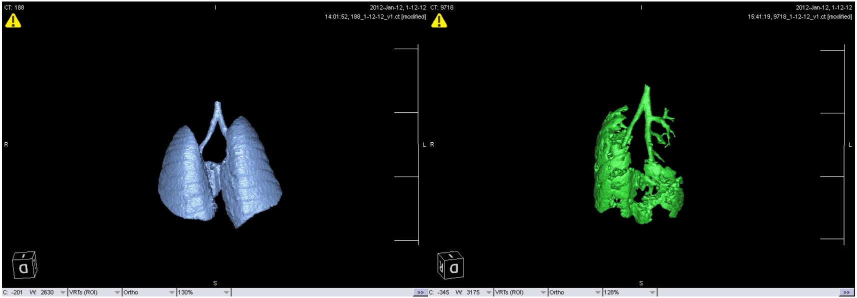
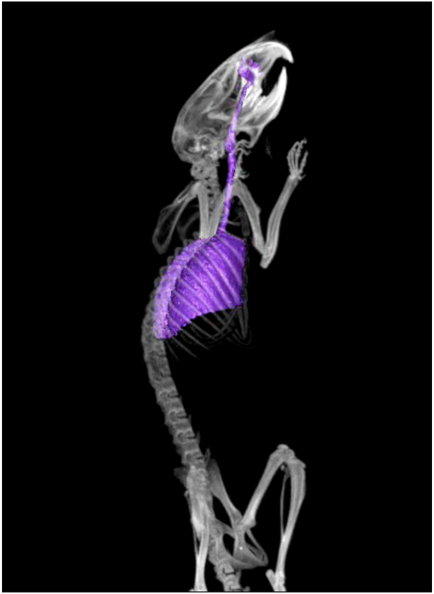


Figure: The difference between healthy and unhealthy mouse lungs.

Micro-CT Scan Analysis

Current techniques

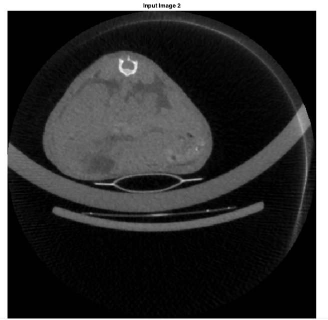
- Inveon software has built-in filters (ex. Gaussian)
- low-pass filters “blur” image to get rid of noise
- high-pass filters used for edge detection (ex. distinguish between lung tissue and bone)
- manually adjust settings to isolate [lung tissue] with the best possible image quality



My Project (Where's the math?)

My Problem

- goal: want to reduce exposure time
- trade off: produces fewer 2D images–harder to analyze 3D output
- have many raw datasets, want to find optimal settings for $\uparrow$ image quality while $\downarrow$ exposure time



(Here's the math)

Strategy

- will predominantly use MATLAB, most likely Image Batch Processor
- get MATLAB to do what Inveon software does, and more
- rewrite functions for filters (some exist already)
- automate the process in MATLAB: feed MATLAB a folder of 2D images, perhaps input some settings, then output a processed folder or 3D image
- rewrite back projection filters (most simple method)
- use (non-standard) metrics in place to decide if image quality is acceptable
- reach goal: be able to use subpar images and still get results (more common as trials progress, animals are sicker & difficult to image)

What have I done so far?

- able to import a folder containing all 2D images from 1 scan, run filter on all images

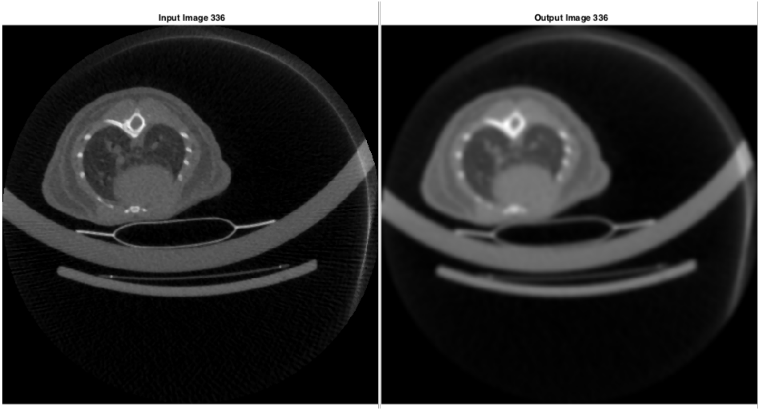


Figure: The result of a Gaussian filter with $\sigma = 3$ on a single 2D image.

References

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- Images:
  - Most images courtesy of Neil Campbell, Lattime Lab, Rutgers Cancer Institute of New Jersey.
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