Proposal for new graduate course – ENAS ---Yale, Spring Semester 2013

Tracer Kinetics and Modeling

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Where do the models that describe **functional image** data come from? Why do we need them? Modern PET and MR scanners can acquire data over time following the introduction of a tracer or contrast agent. These dynamic data sequences are what encodes the “function” in the images. To extract physiological meaning (parameters) from the data, we need mathematical models. Many of these models, naturally, fall into the category of “tracer kinetic models”. This course will cover the fundamental mathematical concepts, innovations and models that undergird present-day quantitative analysis of dynamic imaging data in PET and fMRI (perfusion). Reading material will come from various textbooks, and classic papers (Krogh, Kety, Crone, Patlak, Logan…). Homework will be assigned weekly.

Although the target audience are graduate students engaged in functional imaging research, this course is open to upper-level undergraduates, graduate students, and research fellows who are comfortable with differential equations. Knowledge of biochemistry and physiology will be helpful.

**Grading**: Grades will be assigned based on: performance on homework, tests, and participation in class (including review of modeling papers). Students are encouraged to bring modeling papers that relate to their own data and interests to class and we will incorporate them into the syllabus and discuss them.

A **preliminary meeting** (TBA) will be held with all interested parties to determine the best time and frequency to meet. *Students should email the instructor to signal their interest and availability.*

Key Topics:

Diffusable tracers

The Fick principle

The Kety method

The Krogh cylinder

 Mass balances, control volumes

Renkin-Crone model of extraction

Flow- and Diffusion-limited cases

Crone indicator diffusion method for capillary permeability

linear, time-invariant systems

 compartmental models and methods of solution

 transition matrices

 eigenvectors

 step and impulse responses

 Fourier Transforms

Multiple time graphical methods (Patlak (irreversible trapping), Logan (reversible uptake), etc)

Biases in common graphical methods

Input-output models, convolution, singular value decomposition

The tissue homogeneity (TH) model

The adiabatic approximation to the TH model

Applications in PET and Dynamic Contrast Enhanced (Perfusion) MR