**BME 580.480/680 Precision Care Medicine Syllabus**

**Overview:**

In a perspective article in the *New England Journal of Medicine*, Collins and Varmus state that “what is needed now is a broad research program to encourage creative approaches to precision medicine, test them rigorously, and ultimately use them to build the evidence base needed to guide clinical practice”. *Computational Medicine* (CM) is an emerging discipline that seeks to: develop mechanistic computational models of disease (modeling); methods for personalizing these models using data measured from individual patients (personalization); apply these personalized models to improve the diagnosis and treatment of disease (application). The Core Faculty of the Institute for Computational Medicine (ICM) believe that CM offers one pathway to precision medicine. They are committed to training the next generation of scientists, engineers, and physicians in this approach, and doing this across all educational levels.

Drs. Rai Winslow and Sri Sarma of the Department of Biomedical Engineering and the ICM, and Dr. Adam Sapirstein of the Department of Anesthesiology and Critical Care Medicine have developed this two-semester, first-year graduate design course incorporating the paradigm of modeling, personalization, and application. BME 580.680-681 “Precision Care Medicine” is a combined project and lecture course. Projects will be proposed by faculty of the Anesthesiology and Critical Care Medicine (ACCM) Department and their collaborators. An Advisory Committee composed of members of the ACCM Informatics and Predictive Analytics Research Group has assisted with project solicitation, review, and selection.

The course will be an immersive experience taught in both the ACCM department and at the Homewood campus. In the first semester, students will assemble into teams of 5-6, and will work with their project mentors (ACCM faculty; Drs. Winslow and Sarma) to develop a project work plan and to begin their project work. In the remainder of the course, they will apply methods of CM to solve the important health care problems in their projects. Class time includes: lectures and tutorials covering the physiology, medicine, and engineering principles relevant to each project; project work in a setting where faculty are available to assist students with challenges. Each team will present project updates to the entire class at regular intervals so that teams gain experience with presenting, and so that every student becomes familiar with each project. Teams will also be charged with designing, validating and deploying a web-application that delivers the computational method for solving the underlying healthcare problem to the user. HIPAA regulations, use of human subject data, and requirements for FDA Class II and Medical Device Data Systems approval will be covered.

This transformational class is the first course in which large-scale anonymized patient data sets have been used for educational purposes at The Johns Hopkins University. It is likely that projects will span multiple years, lead to publications in peer-reviewed journals, and provide preliminary data in support of grant applications. BME students completing both semesters will receive design credit for this course.

**Projects**:

**Advanced Risk Stratification and Prediction of Venous Thromboembolism in Critically Ill Patients**

Biomedical PIs: Sapirstein ([asapirs1@jhmi.edu](mailto:asapirs1@jhmi.edu)) & Faraday (nfarada1@jhmi.edu)

Engineering PIs: Winslow & Greenstein

Team Mola Mola: Ryan Brody, AK Meiyappan, Jinrui Liu, Bronte Wen, Elizabeth Wu

**Risk factors for neurologic injury and mortality in critically ill children supported on ECMO**

Biomedical PIs: Bembea (mbembea1@jhmi.edu)

Engineering PIs: Sarma & Greenstein

Team Shiba: Paige Epler, Yuqi Kang, Xuemin Zhu, Chunming Gu

**Predicting Acute Kidney Injury after elevated risk non cardiac surgery**

Biomedical PIs: Lee Goeddel, Thomas Metkus, Jeffrey Dodd-o MD, Derek Fine MD, MPH, Shaun Moeller, Nauder Faraday

Engineering PIs: Winslow & Greenstein

Team Giraffe: Tony Wei, Jarvis Kong, Ran Sui, Yinghe Sun, Evan Yu

**Predicting respiratory decompensation in Pediatric ICU**

Biomedical PIs: Jim Fackler, Mela Bembea, Jules Bergmann

Engineering PIs: Winslow & Greenstein

Team Polar Bear: Zina Kurian, Akanksha Girish, Beini Hu, Michael Young, Yvette Tan

**Delirium Prediction and Subtype Identification Using a Large Multi-Center ICU Database**

Biomedical PIs: Robert Stevens & Jose Suarez

Engineering PIs: Winslow & Greenstein

Team Blue Jays: Kirby Gong, Akaash Sanyal, Teya Bergamaschi, Ryan Lu, Joanna Guo

**A Computational Model to Predict Neurological Recovery Following Moderate and Severe TBI**

Biomedical PIs: Robert Stevens & Jose Suarez

Engineering PIs: Sarma & Greenstein

Team Alpaca: Anil Palepu, Janna Ballard, Adit Murali, Samiksha Ramesh, Robert Li

**Examining the Natural History of ADHD in a Clinical Setting**

Biomedical PIs: Luther Kalb & Calliope Holingue

Engineering PIs: Sarma & Greenstein

Team Unicorn: Indranij Gangan, Sindhu Banerjee, Aamna Lawrence, Bhagyashree Maity, Stephen Li

**Prediction of hypoxemia as an indicator of patient decline**

Biomedical PIs: Jim Fackler, Jules Bergmann

Engineering PIs: Tim Ruchti (Nihon Kohden), Winslow & Greenstein

Team Cool Monkey: Jasmine Wang, Wen Shi, Chaoran Chen, Stephen Kyanakis, Ananya Swaminathan

**Weekly Meetings of Project Teams:**

* Timing to be arranged between teams and project leaders, the engineering contact(above), and Dr. Greenstein
* First goal is to begin work on project plan, due late October

**Times and Locations:**

Monday and Wednesday 1:30 – 2:45

Some (to be determined) Monday Clinical Lectures in Benson Library, Zayed 6206, polycom video-conference available at http://polymea.jhu.edu/309238

Wednesday Engineering Lectures Hodson 313

**Assignments & Readings**

These are posted on the Blackboard site for this course.

**Ethics**

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

The nature of this course is for students to work in teams. Each team will have a team leader. Every student must contribute in a substantial way to project work.

Additional information about university misconduct policies can be found at these sites:

* For undergraduates: <http://e-catalog.jhu.edu/undergrad-students/student-life-policies/>
* For graduate students: <http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/>

**Students with Disabilities**

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516-4720, [studentdisabilityservices@jhu.edu](mailto:studentdisabilityservices@jhu.edu) .

**ABET Outcomes**

* Ability to apply mathematics, science and engineering principles (a).
* Ability to function on multidisciplinary teams (d).
* Ability to identify, formulate, and solve engineering problems (e).
* Understanding of professional and ethical responsibility (f).
* The broad education necessary to understand the impact of engineering solutions in a global and societal context (h).
* Recognition of the need for and an ability to engage in life-long learning (i).
* Knowledge of contemporary issues (j).
* Ability to use the techniques, skills and modern engineering tools necessary for engineering practice (k).

**Lecture Schedule:**

**Thursday August 29 (Introductory Lecture & Meet the Faculty; Winslow)**

* Course overview
* Required HIPAA and Human Subject Training Online Courses
* IP policy
* Grading policy
  + - 10% PI meeting assessments
    - 15% quizzes
    - 25% mid-term project plan
    - 25% mid-term progress presentation
    - 25% final term progress presentation

There will be a mechanism for team member self-assessment

**Wednesday Sept 4 (Probability Theory; Sarma)**

* + Continuous random variables (PDF, E(x), var(x))
  + Gaussian random variable (PDF, E(x), var(x), properties)
  + Discrete random variables (PMF, E(x), var(x))
  + Bernoulli random variable (PMF, E(x), var(x), properties)
  + Poisson random variable (PMF, E(x), var(x), properties)

**Monday Sept 9 Adam Sapirstein: Pathophysiology of Stress and Critical Care**

**Wednesday Sept 11 (Maximum Likelihood Estimation; Sarma)**

**Thursday September 12 (Meet and Greet with ACCM Faculty and Dr Koch)**

Zayed 6206, Tour of Critical Care units

5:00PM

**Monday Sept 16th Jim Fackler: Sepsis and Pathophysiology of Infections**

**Wednesday Sept 18th (Data Pre-Processing & Exploration: Winslow)**

* + Artifact and outlier removal, smoothing and normalization
  + Principle Component Analysis

**Monday Sept 23rd Timothy Ruchti: Hypoxemia**

**Wednesday Sept 25th Quiz 1 (covering Probability Theory and MLE)**

**Monday Sept 30th Lee Goeddel:** **Blood Pressure and Regulation of Organ Blood Flow**

**Wednesday Oct 2 Presentation demo, Understanding/Communicating “The Problem”**

**Monday Oct 7th Melania Bembea: Extracorporeal Life Support in the Intensive Care Unit**

**Wednesday Oct 9 (Generalized Linear Models; Sarma)**

* Bernoulli
* Gaussian
* Poisson

**Monday Oct 14th Alison Pritchard: ADHD: Etiology, Comorbidities, Assessment & Intervention**

**Wednesday Oct 16 (Binary Classification; Winslow)**

* Training and testing models
* Feature selection & evaluation
* Static Threshold Classifiers
* Performance metrics (sensitivity, specificity, etc)

**Monday Oct 21 Robert Stevens: Cardiac Arrest and Arrhythmia**

**Wednesday Oct 23 (Detecting Transition Events; Winslow)**

* + Transitional substate hypothesis
  + Detection rules (threshold on risk score, threshold on smoothed risk score, etc.)
  + Testing performance

**Monday Oct 28 (Team Presentations on Project and Work Plan)**

**Wednesday Oct 30 (Team Presentations on Project and Work Plan, Written Proposals Due)**

**Monday November 4 (TBD)**

**Wednesday November 6 (Class time for revising work plan, preliminary results, presentation)**

**Monday Nov 11 (Class time used for project work)**

**Wednesday November 13 (Hidden Markov Models; Sarma)**

**Monday November 18 (Team Presentations on Progress)**

**Wednesday November 20 (Team Presentations on Progress)**

**Thanksgiving Break November 25 – December 1 2019**

**Monday December 2 (Class time used for project work)**

**Wednesday December 4 (Class time used for project work)**

**Friday December 6 last day of classes**

**Final Presentations to be scheduled during final exam period**