**BIOMEDICAL INFORMATICS (BMIN)**

### BMIN 501 Introduction to Biomedical and Health Informatics
This course is designed to provide a survey of the major topic areas in medical informatics, especially as they apply to clinical research. Through a series of lectures and demonstrations, students will learn about topics such as databases, natural language, clinical information systems, networks, artificial intelligence and machine learning applications, decision support, imaging and graphics, and the use of computers in education. It is recommended that students have basic familiarity with biomedical concepts. Non-majors need permission from the department.

Taught by: Fuchiang Tsui
Course usually offered in fall term
Activity: Lecture
1.0 Course Unit

### BMIN 502 Databases in Biomedical Research
This course is intended to provide in-depth, practical exposure to the design, implementation, and use of databases in biomedical research, and to provide students with the skills needed to design and conduct a research project using primary and secondary data. Topics to be covered include: database architectures, data normalization, database implementation, client-server databases, concurrency, validation, Structured-Query Language (SQL) programming, reporting, maintenance, and security. All examples will use problems or data from biomedical domains. MySQL will be used as the database platform for the course, although the principles apply generally to biomedical research and other relational databases. NOTE: Non-majors need permission from the department.

Taught by: Dokyoon Kim
Course usually offered in spring term
Activity: Lecture
1.0 Course Unit

### BMIN 503 Data Science for Biomedical Informatics
In this course, we will use R and other freely available software to learn fundamental data science applied to a range of biomedical informatics topics, including those making use of health and genomic data. After completing this course, students will be able to retrieve and clean data, perform exploratory analyses, build models to answer scientific questions, and present visually appealing results to accompany data analyses; be familiar with various biomedical data types and resources related to them; and know how to create reproducible and easily shareable results with R and github. Prerequisite: Familiarity with basic statistical (e.g., EPID 526, 527 or other first-year graduate level stats course) concepts is expected, as this course will not cover basic concepts in depth. It is recommended that students have completed an introductory-level statistics course and have familiarity with programming or a willingness to devote time to learn it. NOTE: Non-majors need permission from the department.

Taught by: Himes / Masino
Course usually offered in fall term
Also Offered As: EPID 600
Activity: Lecture
1.0 Course Unit

### BMIN 504 Special Topics in Biomedical and Health Informatics
This course is designed to provide an in-depth look at four topics that are of essential importance in biomedical informatics. Each topic will be allotted four consecutive weeks in the class schedule, as four modules, with the intention that each module becomes its own "mini-course". The topics for each module may rotate from semester to semester, based on these criteria: Historical importance to the current field of biomedical informatics research and/or practice; Cutting-edge developments in biomedical informatics; Topics not covered in depth in BMIN 501; Consensus of the program leadership and teaching faculty. It is recommended that students have completed BMIN 502 and BMIN 503 prior to enrolling in this course. NOTE: Non-majors need permission from the department.

Taught by: Jason Moore
Course usually offered in spring term
Prerequisite: BMIN 501
Activity: Lecture
1.0 Course Unit

### BMIN 505 Precision Medicine and Health Policy
Through a series of lectures, readings and response papers, students will learn about topics such as medical ethics, unintended consequences of medicine/research, genetics, genetic interpretation, hospital performance, and informatic methods to assess these factors. The informatics topics covered in this course include: decision support, genetic database, clinical interpretation of genetics, detection of bias in EMRs, detection of bias in guidelines, methods to ameliorate bias, mapping clinical guidelines to computable standards, performance assessment, machine learning, and artificial intelligence applications in this space. NOTE: Non-majors need permission from the department.

Taught by: Boland
Course usually offered in spring term
Activity: Lecture
1.0 Course Unit

### BMIN 506 Standards and Clinical Terminologies
This survey course is designed to provide an overview of health information standards and clinical terminologies. Through a series of lectures, demonstrations, and hands-on exercises, students will learn about topics such as standards, interoperability, data modeling, vocabularies, and health information exchange. It is recommended that students have completed BMIN 501 prior to enrolling in this course. NOTE: Non-majors need permission from the department.

Taught by: Michael Padula
Course usually offered in fall term
Activity: Lecture
0.5 Course Units
Biomedical Informatics (BMIN)

BMIN 507 Human Factors
The course will cover five main topic areas: 1. usability, 2. evaluation and measurement of usability, 3. workflow, 4. user-centered design, 5. implementation, and 6. continuing improvement/optimization. Each topic area will incorporate principles, methods, and applications. In the principles section for each topic, the course will clearly define terminology related to the topic area (e.g., what is workflow?), review how key concepts relate to each other (e.g., relationship between human factors engineering and human-computer interaction), and examine the relevance of the topic area in Applied Clinical Informatics. The methodology section for each topic will address qualitative, quantitative, and computational methods used for the design, implementation, and evaluation of health information technology. The applications section for each topic will use case studies based in the topic area to examine the real-world application of principles and methods. The course will cover a wide range of contexts, from homes/communities to organizations to a broader regional scale. It is recommended that students have completed BMIN 506 prior to enrolling in this course. NOTE: Non-majors need permission from the department.
Taught by: Ross Koppel
Course usually offered in fall term
Prerequisite: BMIN 501
Activity: Lecture
0.5 Course Units

BMIN 509 Telehealth and mHealth Systems and Applications
This course is designed to develop intelligent consumers, managers, and researchers of telehealth and mHealth systems through guided exploration into the components of such systems. The course is designed to introduce many of the challenges facing designers and managers of telehealth/mHealth and remote health care delivery networks. The spectrum of activity ranging from research into implications of system design for applications that bridge geographic distance to the development of practical applications is considered in both historical context and in case studies. The current status and future trends of this emerging domain are reviewed. It is recommended that students have some exposure to health care or health systems prior to enrolling in this course. NOTE: Non-majors need permission from the department.
Taught by: Demiris, George
Course usually offered in fall term
Also Offered As: NURS 529
Activity: Lecture
1.0 Course Unit

BMIN 520 Foundations of Artificial Intelligence in Health
As a subfield of computer science, artificial intelligence is often used interchangeably with the term 'machine learning', which itself is more accurately a subfield of AI dealing with the broader concept of inductive reasoning. However, a wealth of key prerequisite topics that focus on deductive reasoning align with the bulk of biomedical informatics applications being actively utilized today. These founding principles of AI and their intersection with biomedical informatics are the focus of this first course on artificial intelligence. The course is divided into modules that cover (1) introductory/background materials, (2) logic, (3) other knowledge representation, (4) essentials of expert systems, (5) search, (6) uncertainty, and (7) advanced/auxiliary topics. These topics offer a global foundation for branches of AI application and research, including concepts that will later support a deeper understanding of inductive reasoning and machine learning. In a practical sense, this course focuses on how biomedical data can be organized, represented, interpreted, searched, and applied in order to derive knowledge, make decisions, and ultimately make predictions. It is recommended that students have completed any or all of the following prior to enrolling in this course: BMIN 501, BMIN 503, or BMIN 525. NOTE: Non-majors need permission from the instructor.
Taught by: Ryan Urbanowicz, PhD
Course usually offered in spring term
Activity: Lecture
1.0 Course Unit

BMIN 521 AI II: Introduction to Machine Learning and Health Language Processing
The growing volume of unstructured health-related data presents unparalleled challenges and opportunities for informaticians, clinicians, epidemiologists and other public health researchers that seek to mine the rich information "hidden" in plain sight. Clinical records, social media, published literature, are all sources designed for human eyes, but not necessarily for automatic processing. In this class, we will survey the most recent natural language processing methods used for identifying and classifying information present in these sources. The class provides "hands-on" learning of health language processing - that is, the fundamental principles and methods of both natural language processing and machine learning and how they are currently applied in the biomedical domain. Emphasis will be given to classification and sequence labeling through various machine learning methods including deep neural networks. The class will focus on real problems in the context of health research where data are inherently biased, e.g. noisy, missing, or extremely imbalanced (where instances of interest are rare in the data). Methods for addressing these biases, such as distance supervision, active learning, and unsupervised learning, will be deployed and analyzed. NOTE: Non-majors need permission from the instructor.
Taught by: Graciela Gonzalez-Hernandez, PhD
Course usually offered in fall term
Prerequisite: BMIN 520
Activity: Lecture
1.0 Course Unit
BMIN 522 AI III: Advanced Methods and Health Applications in Machine Learning

Machine learning studies how computers learn from data and has enormous potential to impact biomedical research and applications. This course will cover fundamental topics in machine learning with an application focus on biomedical informatics. Specifically, the course will cover supervised learning methods such as linear regression, logistic regression, nearest neighbors, support vector machines, decision trees and random forests; unsupervised learning topics such as clustering, dimensionality reduction and association rules; neural networks and deep learning methods for supervised or unsupervised learning tasks; and the applications of these machine learning techniques to various biomedical informatics problems via analyzing imaging, biomarker, electronic health record, clinical and/or other biomedical data. The precise topics may vary from year to year based on student interest and developments in the field. It is recommended that students have basic knowledge in data analysis and biomedical research. Basic knowledge of machine learning, linear algebra, statistics and probability is preferred.

NOTE: Non-majors need permission from the instructor.

Taught by: Li Shen, PhD
Course usually offered in spring term
Prerequisite: BMIN 525
Activity: Lecture
1.0 Course Unit

BMIN 523 Informatics Prec Med

Course usually offered in spring term
Activity: Lecture
1.0 Course Unit

BMIN 525 Introduction to Python Programming

This introductory course is designed to provide an overview of the python programming language including data types, data structures, variables, packages, modules, programming practices, and more. Using lectures and hands-on demonstrations, students will learn how to write python programs that store, retrieve, represent, transform, analyze, and visualize biomedical and clinical data. Upon completing this introductory course, students will have acquired foundational knowledge using python to solve problems as well as gained the self confidence to expand their knowledge of python well beyond this course. Non-majors need permission from the department.

Taught by: Danielle Mowery
Course usually offered in fall term
Activity: Lecture
1.0 Course Unit

BMIN 533 Statistics for Genomics and Biomedical Informatics

GCB 533 is an introductory course in probability theory and statistical inference for graduate students in Genomics and Computational Biology. The goal of the course is to provide foundation of basic concepts and tools as well as hands-on practice in their application to problems in genomics. At the completion of the course, students should have an intuitive understanding of basic probability and statistical inference and be prepared to select and execute appropriate statistical approaches in their future research.

Taught by: Pablo Camara and Laura Almasy
Also Offered As: GCB 533
Activity: Lecture
1.0 Course Unit

BMIN 549 Exploring Data Science Methods with Health Care Data

The growth and development of electronic health records, genetic information, sensor technologies and computing power propelled health care into the big data era. This course will emphasize data science strategies and techniques for extracting knowledge from structured and unstructured data sources. The course will follow the data science process from obtaining raw data, processing and cleaning, conducting exploratory data analysis, building models and algorithms, communication and visualization, to producing data products. Students will participate in hands-on exercises whenever possible using a clinical dataset.

Taught by: Michael Milo, PhD
Course usually offered in spring term
Also Offered As: NURS 849
Activity: Lecture
1.0 Course Unit

BMIN 990 Capstone

With mentorship from their Capstone Advisor, students will develop and present the results of a clinical informatics project relevant to their interests. During this semester-long course, students will attend a weekly seminar in which they develop, propose, implement, and present their capstone project. Students meet with regularly with their Capstone Advisor, who is also invited to attend the seminars. The seminar affords both students and advisors the opportunity for cross-fertilization of ideas and skills, and ultimately the honing of projects to a high level of value for the students and the clinical environments in which they conduct their projects.

Taught by: Holmes, John H
Activity: Independent Study
1.0 Course Unit