Biomedical Computing

Introductory Lecture
September 8, 2005

6.872 / HST 950
Introduction

Definition: Development and application of information science and technology for/to/in biomedical sciences.

Background: Biomedical sciences and engineering.

For (support): Improve management, research and care in terms of speed, accuracy, efficiency (electronic clinical records).

To (enablement): Do something that would be otherwise impossible (CAT scan and shotgun sequencing).

In (embedment): Be integral part of biomedical research (bioinformatics).
History of Biomedical Informatics

1950: R. Ledley’s dental data at National Bureau of Standards.
1964: NIH Computer Research Study Section.
1966: MGH starts the development of COSTAR/MUMPS.
1972: NLM fellowship training program started.
1988: Human Genome Initiative and NCBI started.
1995: Shotgun sequencing (computer intensive) developed.
2001: Publication of Human Genome draft.
2003: Medical Informatics becomes Biomedical at Columbia.
2003: Computer scientist moves to Genetics, Stanford.
2006: HMS Dean announces Center for Biomedical Informatics
For (Support) Biomedical Informatics

Scope: Processing of biomedical information.

Goal: Support, streamline, and make more efficient the processing of biomedical information (clinical records, lab tests, etc).

Impact: Empower patients with control and dissemination of information; make healthcare delivery more efficient and cheaper; improve healthcare quality (96,000 death/year in US due to medical error).

Applications: Electronic medical records, information security and confidentiality, telemedicine.
To (Enabling) Biomedical Informatics

Scope: Use computer to ... science and technology.

Goal: Develop applications leveraging on information science and technology.

Impact: Change the way medical care is delivered; develop new tests and therapies; deliver new methods to control and manage disease outbreaks.

Applications: Genomic sequencing; image processing; real-time surveillance and early detection of population-wide events.
In (Embedded) Biomedical Informatics

**Scope:** Analysis of biomedical information.

**Goal:** Develop methods to analyze biomedical data as part of the overall research endeavor.

**Impact:** Change the way biomedical data are analyzed; deliver new views of natural phenomena; develop new methods to discover the bases of diseases.

**Applications:** Genomics, proteomics, bioinformatics.
Bioinformatics: Application of information technology to genomic information.

Clinical Informatics: Application of information technology to medical (clinical) information.

Biosecurity and Public Health: Application of information technology to population data to monitor and infer global behavior and detect unexpected events.

Note: there are for/to/in components of biomedical informatics in all of these areas.
Bioinformatics: Research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioral or health data, including those to acquire, store, organize, analyze, or visualize such data.

Computational Biology: Development and application of data-analytical, theoretical methods, mathematical modeling and computational simulation to the study of biological, behavioral, and social systems.

BISTIC Definition Committee, NIH, 2000.

Flesch Readability Index: 0.1 - Bush Inaugural (75), Sports Illustr. (65); NY Times (39); Auto Insurance Policy (10).
Since work started in the past decade, we now have the complete genetic sequences of over 600 organisms.

Complete human genome draft published, with final quality sequence, on April 25, 2003.

At least 40-60% of genes in genome have unknown function. Many, many fewer have a solved structure.
Bioinformatics

**Genome:** sequencing and genotyping.

**Transcriptome:** expression and regulation.

**Proteome:** protein expression and interactions.

**Metabolome:** biological process on a larger scale.

**Bibliome:** navigation and mining of annotation databases.

**Pharmacogenomics:** genomics to create/test terapies.

**Genomic Privacy:** data security.
Clinical Informatics

Clinical Databases: electronic medical records.
Patient Privacy and Confidentiality: cryptology and distributed systems.
Just in time clinical information: real-time delivery of medical information.
Telemedicine: remote distribution/collection of medical information.
Pharmaco-economics: Optimization and prediction of drug discovery and development.
Biosecurity

Public Health Informatics: Collection and distribution of population-wide medical information.

Geospatial Analysis: Analysis of population-wide medical data.

Population Confidentiality: Collecting population data without endangering the single individual.

Biosecurity: Real-time surveillance of man-made or natural disease outbreaks.
Syllabus

Class: Tuesdays and Thursdays, 2:30-4:00pm.

Goals and Rationale

Objective: Introduction to the basic notions and current trends of biomedical informatics.

Strategy: In-depth description of basic notions through their presentation in basic trends:
  - **Basic Notion Lectures:** Necessary and sufficient information covering a particular topic.
  - **Case Study Lectures:** Guest lecturers describe a particular project/problem/trend in a domain.

Lecturers: Computer scientists, CIOs, computational biologists, geneticists, clinical trials leaders, biosecurity experts.
Grading

Class participation (30%) Attendance and contribution to discussions are a critical component of the class. Much of the material will be taught by guest lecturers who are uniquely knowledgeable in their areas.

Homework assignments (30%) We plan to give a half-dozen homework assignments. Some of these will include programming tasks as well as thinking and writing. **Note:** With the exception of medical excuses, assignments will be penalized 50% if they are turned in up to two days late, and will receive no credit thereafter.

Project (40%) Students will work on projects of their own choice related to the topic of the class. Grading will be based on both a written paper due at the end of the semester and oral class presentations on each project. Ask guest lecturers for help!

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Faculty

Bioinformatics
- Alvin Kho, HMS/CHIP
- Stefano Monti, Broad/MIT
- Gil Alterovitz, HMS/CHIP
- Scott Weiss, HMS/BWH
- Steve Sonis, HSDM/BWH

Clinical Informatics
- Aneel Advani, HMS/CHIP
- Octo Barnett, HMS/MGH

Public Health and Biosecurity
- Daniel Nigrin, HMS/CHIP
- John Halamka, HMS/BI
- John Glaser, Partners
- Hamish Fraser, HMS/CHIP
- Stan Finkelstein, Sloan/MIT
- Kenneth Mandl, HMS/CHIP
- Ben Reis, HMS/CHIP
- Chris Cassa, HMS/CHIP