OVERVIEW OF RESEARCH

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What is scientific research?

- Scientific research means a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge.

What is undergraduate research

- Undergraduate research is an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline.

Wenzel, T. J., “What is Undergraduate Research?,” *Council on Undergraduate Research Quarterly*, **1997**, *17*, 163.

Steps to conducting research

1. Identify a concrete investigative question
2. Identify an appropriate methodology
3. Carry out the actual research project
4. Disseminating results through oral and written communication

Example #1:

1. Question: Do CS majors at Eastern prefer Google or Bing?
2. Methodology: Appropriate sampling of students and an experimental study

Example #2:

1. Question: Is GD-sort better than quicksort? (Note: better would have to be defined)
2. Methodology:
   - Theoretical running time and memory, big O notation
   - Comparison of GD-sort and quicksort using real data

Characteristics of undergraduate research

- Read the scientific literature!
- Design and conduct the research
  - Using reproducible methods
- Students work independently of faculty (but will be *mentored*)
- Students can work on a team
- Written and oral dissemination of work

Why do research?

- In-depth exploration and understanding of an area of interest, that is meaningful to you
- Learn research methodology and how to analyze data
- Gain and demonstrate independence
- Improve oral/written communication skills
- Connect research to course material
- Great for your resume!

- And many more…

Choosing a Research Topic

1. What aspects of computer science interest you?
2. Explore what others have done by reading literature
3. Media can be a good place to start, but you will need to find *research* articles
4. Trending topics
   - Wearable computers (e.g., Google Glass)
   - Self-driving cars
   - 3D printers
   - Quantum computing
   - Targeted advertising
   - Social media

Computer Science is a broad discipline

- Association for Computing Machinery (ACM) knowledge areas
  - Algorithms and Complexity
  - Architecture and Organization
  - Discrete Structures
  - Graphics and Visualization
  - Human-Computer Interaction
  - Information Management
  - Intelligent Systems
  - Network and Communication
  - Operating Systems
  - Programming Languages
  - Software Development
  - Software Engineering
  - Social Issues

For full list see:
http://www.acm.org/education/CS2013-final-report.pdf, page 14

Computer Science

- Computer Science is the systematic study of the feasibility, structure, expression, and mechanization of the methodical processes (or algorithms) that underlie the acquisition, representation, processing, storage, communication of, and access to information…

- Computer Science is not *just* about building computers or writing computer programs!...Computer science is not about the tools we use to carry out computation. It is about how we use such tools, and what we find out when we do.

- More: http://www.cs.bu.edu/AboutCS/WhatIsCS.pdf

Computer science has applications in:

Computer Engineering
Information Technology and Information Systems
Bioinformatics and Computational Biology
Computational Statistics
Mathematical Modeling

What is a computer (part 1)?

- A computer is a *platform* that implements varying algorithms and methodologies for storing, retrieving, and analyzing information
  - Ex: Quicksort is a sorting method that exists and can be analyzed independently of any computer.
  - Ex: The properties of a relational database do not depend on the computer used to store the data
- There is a theoretical component to computer science, but these theories can be tested in practice
- Project ideas:
  - Develop a new method and compare with existing methods
  - Evaluate how altering a method changes the behavior / performance of the method

What is a computer (part 2)?

- A computer is a *tool* that can be used to
  - Analyze (large amounts of) data
    - Example: analyzing Trump's tweets, http://varianceexplained.org/r/trump-tweets/
    - Example: Can Twitter be used to predict crimes? (Answer – yes, to some extent: http://www.citylab.com/tech/2014/03/how-twitter-could-help-police-departments-predict-crime/8651/)
  - Simulate physical or biological system and analyze it
    - Cellular automata models
      - http://mathworld.wolfram.com/CellularAutomaton.html
      - A cellular automata model of traffic flow – investigating the effect of turning (this will be our discussion article next week)
    - Agent-based models
      - Agents move and interact according to rules executed at discrete time steps
      - In some cases this approach has identified emergent behavior that may be counter-intuitive. Ex: should we put a pillar by the front door of the classroom?

        Ex: "The Game": http://www.icosystem.com/labsdemos/the-game/
  - Write a program to download and analyze a large datasets, such as tweets, to answer a specific question
  - Develop a simulation (or modify an existing one) to answer a specific question

Where to find published research

- Library Databases: http://easternct.libguides.com/cis
  - ABI Inform Complete: The database features thousands of full-text journals, dissertations, working papers, etc. Includes IEEE journals.
  - ACM digital library: http://dl.acm.org
  - ACM surveys (CSUR) http://dl.acm.org/citation.cfm?id=J204
    - Provides comprehensive tutorials and survey papers
  - Academic Search Premier: Multidisciplinary database with full text articles (http://www.easternct.edu/smithlibrary/databases/index.htm)

- Undergraduate research:
  - American Journal of Undergrad Research:
    - http://www.ajuronline.org
  - Student Pulse
    - http://www.studentpulse.com/topics/15/computer-science

- Google Scholar (http://scholar.google.com)