Research Foundations in Computer Science

Unit I

Introduction to Research

Outline for Today

1) What is Research?

2) What is Research in Computer Science?

3) Research Methods in Computer Science.

4) Importance of Research.

5) Starting Your Research.

6) Areas of Research in Computer Science.

7) Requirements for Research.

1) What is Research ?

Research is

to see what everybody else has seen,

and

to think what nobody else has thought !!!

1) What is Research? (Cont.)

- Various definitions:
  - **A systematic investigation, including development, testing, and evaluation, designed to develop or contribute to generalizable knowledge.**
  - **The discovery of knowledge that was not previously known or understood, or the development of a new structure that provides a new understanding about the subject matter.**
  - **The systematic process of collecting and analyzing information (data) in order to increase our understanding of the phenomenon with which we are concerned or interested.**

1) What is Research? (Cont.)

- The outcomes of research are :
  - **products**
  - **processes**
  - **intelligent property**
  - **….**

1) What is Research? (Cont.)

- Research involves:
  - Investigation
  - Systematic process
  - Analysis
  - Knowing more about something than before / Having a product or process that was not existing before
  - Discovery / Presentation

2) What is Research in Computer Science?

- Research in Computer Science involves addressing an issue or a problem.
  - What is the problem you are trying to solve?

- Research in Computer Science often (but not always) leads to a “project”, involving programming .

- Programming itself is not research; it is a tool for developing a system.

2) What is Research in Computer Science? (Cont.)

Successful projects in computer science involve :

- Reading widely
  - **Start with *ACM (*Association for Computing Machinery*) Digital Library** http://portal.acm.org/dl.cfm?CFID=6039093&CFTOKEN=86005872
  - **IEEE CS Digital Library** http://www.computer.org/portal/web/csdl
- Establishing goals
- Keeping it simple
- Using appropriate tools
- Building prototypes (where applicable)
- Collaborating (work in partnership)
- Documenting Results

2) What is Research in Computer Science? (Cont.)

Approaches to research in computer science may :

- Research in university → transfer to industry
  - Traditional university research project
  - Attempts to transfer research outputs into practical usage
- Research in Industry → transfer to university ?→? industry
  - Problems taken from industry/customer/user
  - Solutions developed in university environment and then transferred to industry/customer/user

3) Research Methods in Computer Science

- Four basic research methods or approaches to research in computer science :
  - Scientific Method
  - Engineering Method
  - Empirical (practical , experimental) Method
  - Analytic Method

3) Research Methods in Computer Science (Cont.)

- Scientific Method
  - Observe the real world
  - Propose a model or theory of some real world phenomena
  - Analyze and test the above through
  - Experiments
  - Validate hypotheses of the above
  - Making a model or theory
  - If possible, repeat and refine

3) Research Methods in Computer Science (Cont.)

- Engineering Method
  - Observe existing solutions
  - Propose better solutions
  - Build or develop better solutions
  - Analyze, test and evaluate solutions
  - Repeat until no further improvements are possible

3) Research Methods in Computer Science (Cont.)

- Empirical Method
  - Propose a model
  - Develop a working application
  - Apply in Case Studies
  - Analyze, test and measure
  - Validate in wider usage
  - If possible, repeat and refine

3) Research Methods in Computer Science (Cont.)

- Analytic Method
  - Propose a formal theory
  - Develop a theory
  - Derive consequences or results
  - If possible, compare with empirical observations
  - Refine theory if necessary

4) Importance of Research

- Important for development of a field
  - **Development/Revision of knowledge**
  - **Problem solving**
  - **Practical applications**
  - **Growth of business**

- But research in computer science is not just developing systems; it also involves what people want / need, how they use …,

- Every piece of research is important

- Research plays different roles in different businesses

5) Starting Your Research

- Research begins with identifying an area
  - What area of computer science are you **really** interested in ?
    - **Artificial Intelligence**
    - **Computer Systems & Technology**
    - **Information Systems**
    - **Multimedia**
    - **Software Engineering**
    - **Hardware Engineering**
    - …
  - Other areas / interdisciplinary research can be considered
  - Many sub-areas / overlaps in these areas

6) Areas of Research in Computer Science

- **Artificial Intelligence**
- **Communications**
- **Computational Biology**
- **Computer Graphics**
- **Computer Modeling**
- **Computer Programming**
- **Distributed Computing**
- **Encryption**
- **Hacking**
- **Internet**
- **Mobile Computing**
- **Robotics**
- **Software**
- **Video Games**
- **Virtual Reality**
- **WiFi**
- **Network**
- **…**

6) Areas of Research in Computer Science (Cont.)

- The ACM Computing Classification System (2016)
  - **A. General Literature**
  - **B. Hardware**
  - **C. Computer Systems Organization**
  - **D. Software**
  - **E. Data**
  - **F. Theory of Computation**
  - **G. Mathematics of Computing**
  - **H. Information Systems**
  - **I. Computing Methodologies**
  - **J. Computer Applications**
  - **K. Computing Milieus**
  - **See 2016 ACM Computing Classification at**
  - **http://dl.acm.org/ccs/ccs.cfm?CFID=751756863&CFTOKEN=53993242**

6) Areas of Research in Computer Science (Cont.)

- **Computer architecture**
  - **processor architecture, networking, asynchronous VLSI, distributed computing**
- **Artificial intelligence**
  - **machine learning, natural language processing, data mining, knowledge representation, pattern recognition, vision**
- **Databases and Digital Libraries**
  - **database systems, digital libraries, data mining**
- **Languages and Compilation**
  - **programming language design and implementation, optimizing compilers,**
- **Computer Graphics**
  - **interactive rendering, global illumination, modeling, measurement, image-based modeling,**

6) Areas of Research in Computer Science (Cont.)

- **Networks and Distributed Computing**
  - **operating systems, distributed computing, networking, wireless systems, security and protection**
- **Scientific and Parallel Computing**
  - **numerical analysis, parallel computation, computational finance, computational geometry**
- **Computer Security**
  - **secure network services, language-based security, mobile code, privacy, logic, verifiable systems**
- **Theory of Computing**
  - **algorithms, complexity, logic**

7) Requirements for Research

- Research begins with a problem or a question

  (How?, What?, Why?, Who?, When?, Where?)

Problem **: a gap between current state and ideal state.**

- Research divides a problem into smaller manageable sub-problems

7) Requirements for Research (Cont.)

- Research requires a clear goal
- Research builds on others' research
- Research follows a specific plan or procedure
- Research requires the collection, analysis and interpretation of data
- Research requires the findings to be made available for examination

Assignment 1:
Identifying a Research Area

- Examine the ACM Classification Scheme (2016) [available at **http://dl.acm.org/ccs/ccs.cfm?CFID=751756863&CFTOKEN=53993242** or other classification scheme
- Select one (or two) area(s) that interests you.
- Describe in your own words the scope of the classification area.
- Describe in your own words why that area interests you.
- Submit the above subject as a soft copy e-mail attachment by Tuesday 28 Bahman 1394 to : mashaygan2005@yahoo.com
- Submit the above subject as a hard copy to me, exactly on Tuesday 28 Bahman 1394

Format for Report

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- موضوع انتخابی : ...

{ در 2 الی 3 پاراگراف ، موضوع انتخابی خود را توضیح دهید. }

{ در 1 الی 2 پاراگراف انگیزه و دلیل علاقه مندی خود را به موضوع فوق بیان کنید. }