

Research Foundations in Computer Science

Unit I

Introduction to Research

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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.)

- Other definitions:
 - A systematic investigation, including development, testing, and evaluation, which has been designed to develop or contribute to generalizable knowledge.
 - The discovery of knowledge that was not previously known or understood.
 - 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 properties**
 -

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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** (**A**ssociation for **C**omputing **M**achinery) *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

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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 subject
- Experiments
- Validate hypotheses of the above subject
- 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

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3) Research Methods in Computer Science (Cont.)

- **Empirical (Practical , Experimental) 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

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3) Research Methods in Computer Science (Cont.)

- **Analytic Method**

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

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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**

5) Starting Your Research

- Research begins with identifying an area
 - What area(s) 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 (2019)**

- A. General and reference
- B. Hardware
- C. Computer Systems Organization
- D. Networks
- E. Software and its engineering
- F. Theory of Computation
- G. Mathematics of Computing
- H. Information Systems
- I. Security and Privacy
- J. Human-centered Computing
- K. Computing Methodologies
- L. Applied Computing
- M. Social and Professional Topics

See 2019 ACM Computing Classification at

<http://dl.acm.org/ccs/ccs.cfm?CFID=>

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 (2019) [available at <http://dl.acm.org/ccs/ccs.cfm?CFID=>] or other classification scheme
- Select one (or two) area(s) that you are interests in.
- 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 printed hard copy to me, exactly on next session (next week).

Format for Report

نام و نام خانوادگی :

شماره دانشجویی :

شماره تمرین : 1

تاریخ تحویل :

■ 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. }