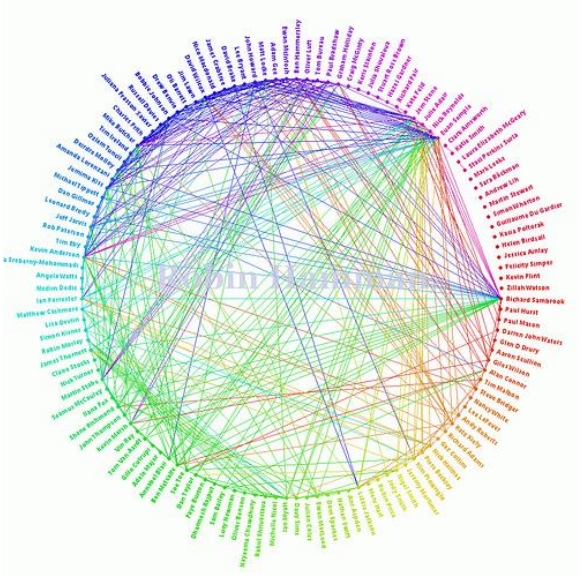
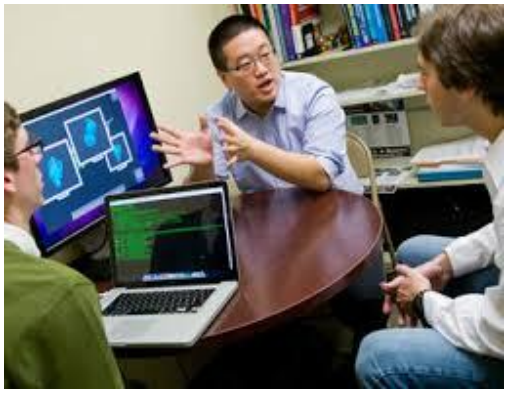
CSC 595
Research Methods for Computer Science



Lecture 4
Your Research

Topics



- What is Research in CS?
  - More Details
- Picking a Topic
  - Advice

What is Research?

- How would you define it ?

➢ **Re ---------- Search**

⌘ **Re means (once more, afresh, anew) OR (back; with return to a previous state)**

⌘ **Search means (look thorough or go over thoroughly to look something) OR (examine to find anything concealed)**

What Is Research?

Merriam-Webster's definition

(*is an American company that publishes reference books and is especially known for its dictionaries).*

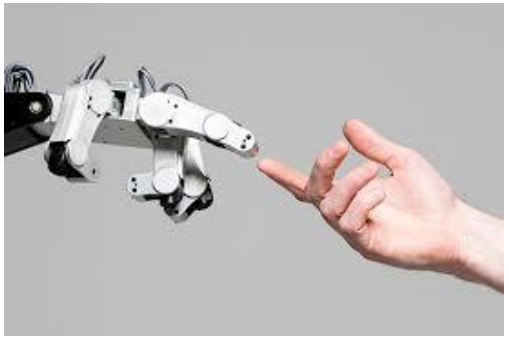
1. Careful or diligent search

2. Studious inquiry or examination; *especially* **:**

   - Investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of new or revised theories or laws

3. Collecting information about a particular subject

What Is Research?



- More General Definitions ….

  “A combination of investigation of past work and effort in the present that will help others in the future”

- Also, other thoughts from Researchers
  - Fun and frustration
  - Small steps and large insights
  - Building on others’ work and contributing your own work

- Finally, finding or developing something new that changes the world….

What Is Research?

Research is an ORGANIZED and SYSTEMATIC way of FINDING ANSWERS to QUESTIONS.

What Is Research?

- **SYSTEMATIC**

  Because there is a definite set of procedures and steps which you will follow. There are certain things in the research process which are always done in order to get the most accurate results.

- **ORGANIZED**

  In that there is a structure or method in going about doing research. It is a planned procedure, not a spontaneous one. It is focused and limited to a specific scope.

What Is Research?

- **FINDING ANSWERS**

  Is the end of all research. Whether it is the answer to a hypothesis or even a simple question, research is successful when we find answers. Sometimes the answer is no, but it is still an answer.

- **QUESTIONS**

  Are central to research. If there is no question, then the answer is of no use. Research is focused on relevant, useful, and important questions. Without a question, research has no focus, drive, or purpose.

Defining Research

1. A collection of methods and methodologies that researchers apply systematically to produce scientifically based knowledge about the social world. *(Neuman)*

- Methodology:

  Methodology & methods, two terms are often treated as synonyms. Methodology is broader and envelops methods. It is understanding the social-organizational context, philosophical assumptions, ethical principals and political issues of the enterprise of researchers who use methods.

- Methods:

  Methods are set of specific techniques for selecting cases, measuring and observing aspects of social life, gathering and refining data, analyzing data and reporting on results.

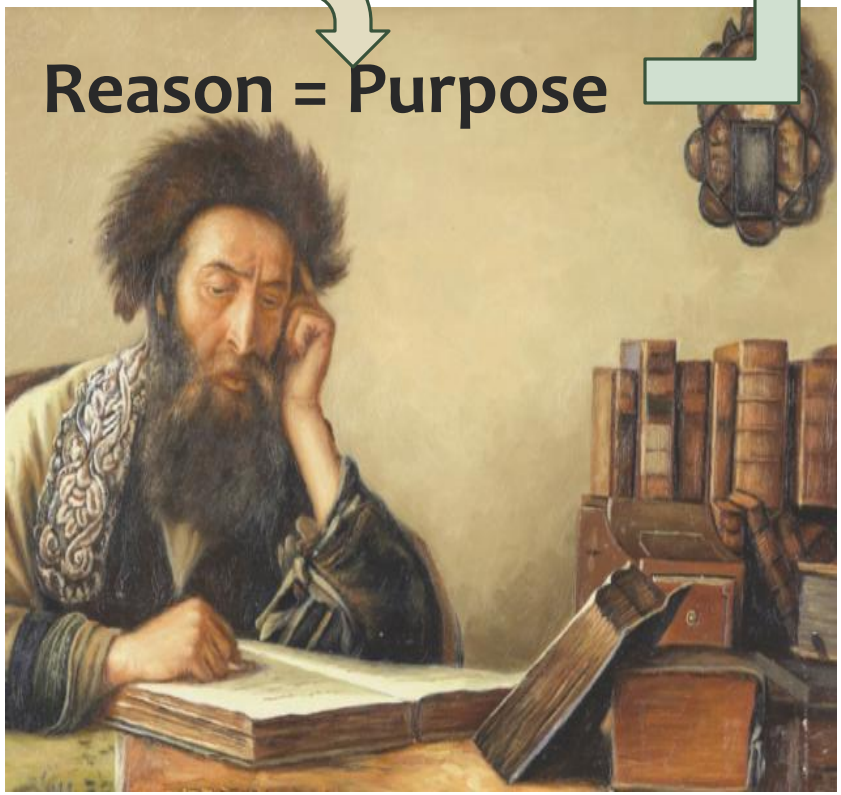
2. Research must be systematic and follow a series of steps and a rigid standard protocol. These rules are broadly similar but may vary slightly between the different fields of science.

Why Conduct Research?

To create new knowledge and/or significantly add to existing literature

You search the Scriptures <u>because</u> you think that in them you have eternal life; It is these that testify about Me.

(John 5:39)



Types of Research

1. Quantitative Research
2. Basic Research
3. Applied Research
4. Longitudinal Research
5. Qualitative Research
6. Descriptive Research
7. Classification Research
8. Comparative Research
9. Explorative Research
10. Explanatory Research
11 Causal Research
12 Theory-testing Research
13 Theory-Building Research
14 Action Research

Quantitative Research

- It is based on methodological principals of positivism and neo-positivism
- It adheres to standards of strict research design.
- Statistical analysis is used in it.

Basic Research

- Purpose of gaining knowledge
- It advanced understanding about social world
- Help in supporting & rejecting existing hypothesis & theories

Applied Research

- Aims at solving specific problems
- Aims at establishing policy programs that will help to improve social life
- Types of applied research are action research, social impact studies, cost-benefit analysis, evaluation research

Longitudinal Research

- It involves study of sample at more than one point in time or occasion
- e.g. Trend studies, Panel studies

Cross sectional Research

- It involves study of many cases at one point in time or occasion

Descriptive Research

- Usually it forms preliminary study of a research project.
- It aims at describe social events, relations and events.
- It provides background information about an event in question.

Classification research

- It aims at categorization of units into groups
- To demonstrate differences
- To explain relationships

Comparative Research

- To identify similarities and differences between units at all levels.

Exploratory Research

- It aims at gaining information about an issue in hand.

Explanatory Research

- It aims at explaining social relations and events.
- To build, test or revise a theory.

Causal Research

- It aims at establishing cause and effect relationship among variables.

Theory testing Research

- It aims at testing validity of a theory

Theory building Research

- To establish and formulate theory

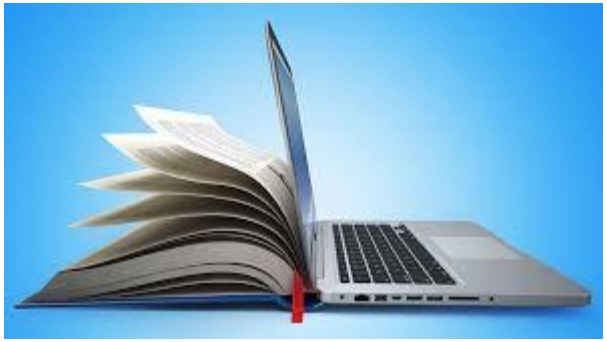
Action Research

- It is application of fact findings to practical problem solving in a social situation with a view to improve quality of action within it, involving collaboration and cooperation of researchers, practitioners and laymen.
- It can be situational (diagnose a problem and attempts to solve it), collaborative, participatory (researcher take part in implementation of findings) and self-evaluation (it involves constant evaluation and adjustment of research and practice)

What is Research?

- Quantitative vs. Qualitative Research
  - **Quantitative** – Use of statistical or numerical analysis to generate results
    - **Main approach:** analysis; causal determination, prediction, generalization of findings
    - **Results:** “This solution is N% better”, Uses measurement
  - **Qualitative** – Not quantitative; Use of non-numeric techniques
    - **Main approach:** Discovery; understanding, extrapolation to similar circumstances, human factor observation, description
    - **Results:** “This is a new way of solving our problem”

What Isn't Research



- Playing with technology
- Book report, or survey paper
- Programming project only
- Doing what others have already done
  - Unless you add to it !!!
- However, each of these can be done as part of research

Who Does Research?

- Graduate Students
    - Masters Degree (lower standard)
    - Ph.D. Degree (higher standard)
- Researchers at universities
    - Post-Doctoral students
    - Faculty members
- Researchers in industry
    - Research scientists
    - Many other technical workers
- Undergraduate students

How to Determine Research

- What would you do to figure out if something is an example of research?
- **Ask Questions:**
  - **What are they trying to do?**
  - Are they ..
    - Conducting an investigation or experiment
      - Is there a hypothesis they are proving?
    - Revising an accepted law
    - Measuring or comparing systems, software or programming languages and analyzing the results
    - Are they trying to create something totally new out of existing components?

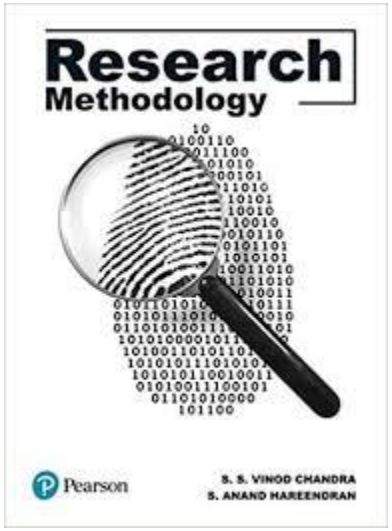
What is Research Methodology?

- Is defined as a highly intellectual human activity used in the investigation of nature and matter and deals specifically with the manner in which data is collected, analyzed and interpreted. (Dr. Derick Pattron)

Research Methodology

- Look at two sets of advice on doing research

- First one is a **general process**
- Second is more detailed in how to select a topic and conduct research



Methodology One

Research Process

- Steps Overview
  - Initial Idea
  - Background Investigation
  - Refinement of Idea
  - Core Work
    - Investigation and Development
    - Documentation
    - Prototype (if appropriate)
  - Evaluation
  - Identification of Future Work
  - Presentation

Research Process

➢ Initial Idea

Stems from critical thinking

- Be on the lookout for and open to seeing problems
  - Gaps in existing research
  - Manual solutions (that can be automated)
  - Inelegant solutions that can be improved upon
- Ask questions
  - “Is something missing here?
  - “Can this be done in a better way?”
  - “Is there a need for a new approach?”
- Should be an area you’re interested in, as:
  - You’ll be spending a lot of time with it
  - It won’t always be easy/fun to continue…

Research Process

➢ Background Investigation

- Given an idea, need to determine Has this work been done previously?
  - What similar work has been done leading up to this point?
  - How is any previous work distinguished from what I'm planning to do?
  - What group of people will benefit by my research?

- Tools
  - Literature Review using library resources (e.g. online databases such as ACM and IEEE, popular magazines)
  - WWW search
  - Talk to your potential advisor

Research Process

➢ Refinement of Idea

- Based on background investigation, need to refine idea
  - Precision – focus on precisely identifying
    - Problem
    - Possible solutions (plural!)

- Scope – need to “build fences”
  - What’s an essential part of this work? (fence in)
  - What’s tangential, additional, or for any other reason best left for later/someone else? (fence out)

Research Process

➢ Core Work, Investigation and Development

- Provide yourself with infrastructure
  - Equipment / software
  - Additional knowledge (“get up to speed”)
- Do the work
  - Experiment
  - Look for better ways of solving problem
    - Can you generalize?
  - Can you Discuss, brainstorm
  - Redevelop a framework?
  - Evaluate as you proceed
    - Look for improvements, changes to your original ideas

Research Process

➢ Core Work, Investigation and Development (2)

Process

- Work regularly
  - Easier to keep going if have a commitment to a regular work time
  - Helps you keep your past work in mind
  - Daily is most helpful if you can

- Allocate large blocks of time for research
  - Takes time to get going
  - Make sure can do something significant each work session

Research Process

➢ Core Work, Documentation

Need to document as you go

1) Maintain a journal for day-to-day thoughts

- Can be paper, electronic, ...
- Keep it with you at all times
  - Never know when good ideas will hit

2) Write up your work

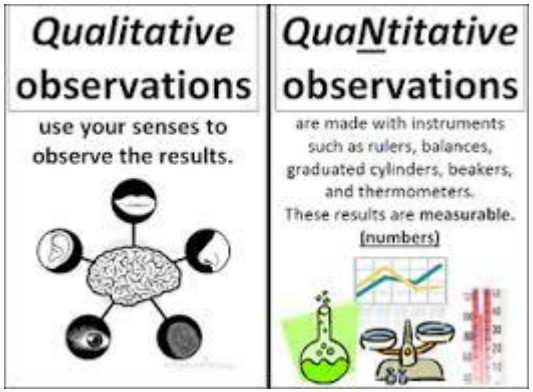
- Periodically, write a few pages on a subset of your work
  - Summarize work, accomplishments, problems
- At end, write up a summary document
  - Can be based on steps discussed here

Research Process

- Core Work, Prototype

  - Need to demonstrate merit of your idea
  - If work is non-theoretical, do this through a developed system
    - No need to build the entire system
    - Just need to demonstrate the value of the core ideas
    - Idea of a prototype system
      - Some of the features or just an interface for future development .. enough to show idea

Research Process



➢ Evaluation

- ❖ Perhaps the most difficult part….
  - Best if can show others are already using your work
- ❖ Quantitative
  - Test your prototype
  - What improvements exist over currently available alternative - measured
  - How much of an improvement do you see-Quantify
- ❖ Qualitative
  - What new capabilities exist because of your idea?
  - What are the benefits of your solution?

Research Process

➢ Identification of Future Work

- Helps you organize any future efforts
  - Work that you might not get time to
- Helps others build on your work

- Sources
  - What you excluded in your idea refinement
  - New problems that have surfaced during your work

Research Process

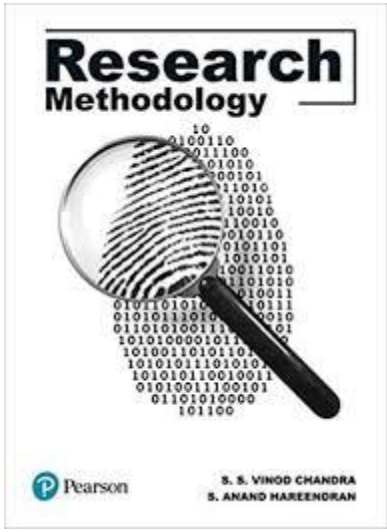
➢ Presentation

- It's not a contribution to the field

  if no one knows about it or can use it

Presentation/Dissemination

- Conferences, Journals, Web
  - e.g. National Undergraduate Research conference
- Papers, Talks, Poster Sessions



Methodology Two

Step 1 – Picking a Topic

http://www.cise.ufl.edu/~helmy/cis6930/research-start.html

Pick a direction or area of interest based on your background

- Courses you have taken, readings, conferences, talks to Professors
- Try to be as specific as possible
- For example, for network topics,
  - Don’t pick 'multicast' (too general),
  - Better 'congestion control for reliable multicast' or 'multicast routing in ad hoc networks‘
  - Don’t pick 'wireless networks' (too general),
  - Better 'systematic testing of wireless MAC layer' or 'efficient handoff for IP mobility‘
- There could be a list of topics that interest you
- **Limit your choices to about three topics**

Step 2 – Select Key Words

- Compile set of 'keywords' to start searching for high quality readings for each of previously selected topics

  Example: Mobile Wireless Networks

  - Keywords: Ad-hoc networks, Sensor wireless networks, Mesh wireless networks
  - Focus your interest with your keywords

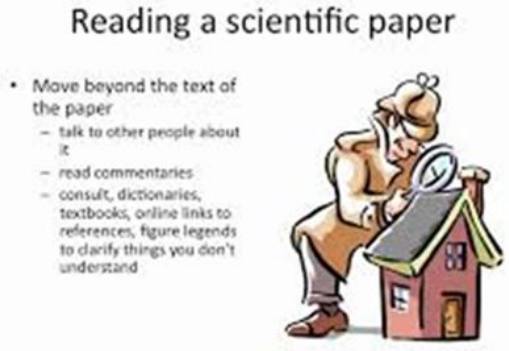
Step 3 – Select Papers

- Out of the search hits, select around 15-20 papers that you think are most related to what you had in mind and are of the highest quality
- Do NOT read all these papers yet!
- Check title, abstract, names of authors, their affiliations, and most importantly conference or journal
- Many IEEE and ACM conferences/Journals are of high quality
  - Some, however, are more selective and competitive than others, (Comment: Will have better papers)
- Some gathered statistics about network conference/workshop acceptance rates can be found through Kevin Almeroth's website

  http://www.cs.ucsb.edu/~almeroth/conf/stats/

- Another hint is to use references and citations
- Usually the most cited work by high quality papers is also of high quality
- If you like a specific paper look at the list of references, this will give you a good direction to follow
  - We already got a start in this with Web of Science

Step 4. Read some papers



- For selected 15-20 papers read only abstract, introduction and conclusion in detail (you may skim the rest of the paper for a general idea)
- Identify the emphasis of each

  paper:
  - (I) Which problem it addresses,
  - (II) What solution it proposes,
  - (III) How the solution differs from previous solutions, and
  - (IV) What are the main contributions and conclusions
- Out of these 15-20 papers, and based on your reading and understanding,
- Pick a list of 4-6 papers that you think are highest quality and that address your research interests and challenges in the field

Step 5. Read Papers in Detail

- Read those 4-6 papers from beginning to end, identifying in detail:
- (I) Main approaches,
- (II) Methods of analysis:
  - (a) metrics,
  - (b) evaluation tools, and
  - (c) analysis and interpretation of resulting simulation or measured data,

- (III) Conclusions.
- My comment: Use the paper reading approach we discussed previously
- At the same time, try to keep a list of what you think the authors may have missed in the paper/study,
- Gaps or limitations that could be improved upon
- Any ideas you have on how to accomplish these improvements

Step 5. Read Papers in Detail

- Some questions to ask include
- Did all/some papers use similar approaches?
- Have they used the same evaluation criteria, or method of analysis?
- If not, then what are the strengths/weaknesses of each method?

- One Way to Organize Your Ideas
- Keep a list of ideas that you want to explore further, or
- Background material you want to investigate
- Keep a Research Journal
  - Like a Lab Notebook if you were a scientist
  - Write down your ideas, and questions
  - Will be all in one place

Step 6 – Write a Proposal

- ✓ Write a two page proposal defining, as clearly as possible, following items:
  - Motivation
  - Research challenges
  - Overview of existing work
  - Limitations of existing work
  - Potential directions and ideas for improvement
  - Expected results and impact on the field.

- ✓ Have some knowledgeable (**trustworthy**) friends review the proposal for you and give feedback
  - Presentation and clarity,
    - Leave technical remarks for the research advisor!
  - Tell you, (In their own words) what they think you are proposing

- ✓ Feedback Continued:
  - If/when you think it is clear, then discuss the proposal with your research advisor
  - If you do not think it is clear, go back and re-write or your advisor might suggest this too!!
  - If you think you have missed some other work,
    - Go back to the 15-20 list
    - Pick another 3-5 good papers to read in detail, and re-write parts of your proposal!!
  - Can be an Iterative process

Step 7 – Final “Starting” Point

- If you have done a good job in creating a 2-page proposal, you are at a good 'starting' point to pursue research!
- Good luck with the rest...
- The next step is to write a 10 page proposal elaborating on the 2 pages above,
  - Outlining your initial thoughts, results and findings,
  - Outlining a clear plan to continue the work