Research Methodology for Pursuing Research in Engineering-2

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Criteria of Good Research

- The **purpose** of the research should be clearly defined and common concepts be used.
- The research **procedure used should be described** in sufficient detail to permit another researcher to repeat the research for further advancement,
- The procedural design of the research should be **carefully planned** to yield results that are as objective as possible.
- The researcher should **report with complete frankness**, flaws in procedural design and estimate their effects upon the findings.
- The **analysis of data should be sufficiently adequate** to reveal its significance and the methods of analysis
- **Conclusions** should be confined to those justified by the data of the research
- Greater confidence in research is warranted if the researcher is experienced.

How the Research is Judged?

- Impact (What impact it has?)
  - Is it widely used?
  - Does it lead to new directions?
  - Does it effect teaching content?
- Standards of research
  - **Conference**: timely, interesting, simple, share
  - **Journals**: correct, relevant, well-written

Challenges in different fields of Research

- Fundamental problems/research:
  - Lots of prior work
  - Lots of researchers
- Approach used:
  - Do lot of study to choose proper directions,
  - First search is breadth-wise,
  - Next search is depth-wise.

Different Paradigms of Research:

- Theoretical Research
  - "Publish or Perish !" (Publication is very important)
  - E.g., Algorithm that solves some real-life problems (a better search algorithm that searches faster)
  - Evaluation of proof, elegance, clarity
- Experimental/System Research
  - Demonstration of evidence is very essential.
  - Requires the evaluation by experiment, have simplicity and utility.
- Multidisciplinary Research: Involves many fields: Examples: Robotics, solar power production.

Theoretical Research

- Keep an eye on applications to think of theory for that:
  - Great source of problems and interest
  - Invest in a field that is starting to develop
- Look for some thing that has an impact
- Remember the costs (resources required)
  - Speed, space, complexity, etc.
- Strive for simplicity, elegant, clarity

Experimental/System Research

- Find ways to see farther
- Keep an eye on theory - validation or invalidation are both good
- keep other eye on end users
  - main source of problems, feedback
- Look for "some thing to push against"
  - the way to evaluate your system or demo
- Look for insights (lessons, theories, etc.)
- Do separate short projects
- Pickup simple solutions (avoid complex ones)
- Be sure to finish your project
- Do quantitative evaluation

Finding good ideas !

- Look for problems
- In reading, teaching
- By using your own tools / systems
- Have lots of ideas
- Pursue one that:
  - you are uniquely qualified to handle

How to improve?

- Ask lot questions to yourself (why?)
- Read a lot
- Development judgment about:
  - problems
  - solution techniques
  - explanations, evaluations

Writing: Why does it matter?

- Determine if your ideas are:
  - Published
  - Read
  - Understood
  - Cited
  - Taught
- Writing:
  - The *Scientific Style*
  - Writing well, giving talk

The Scientific Style

- Purpose:
  - allow reader judge the research
  - describe present evidence
  - convey ideas and insights
- Different kinds of Writings:
  - teaching (as in textbooks):
    - focus on explanation of science
    - breadth and clarity are more important
    - newness (latest is not important)

Learning how to write?

- Read to observe the style
  - journals in your field
  - major conferences in the field
- Observe, how they:
  - organize
  - explain

The writing Process

- Start by “brainstormig”
- Organize the ideas (as outline)
- Do not “core dump” !
- Once the ideas are on paper, make them clear
- Prefer to edit from paper
- Seek feedback
- Enhance awareness by tracking problems
- Writing is rewriting

Writing my PhD dissertation

- Keep a list
- Hardest lesson: Do not core dump![1]
- Writing is like Programming !

Programming	v/s	Writing
Declarative	is	definitive
Procedure Interface (Specifications)	is	Theorem statement
Implementation	is	Proof
Subroutine	is	Lemma
Comment	is	Remark
Test case	is	Example

[1] The term comes from "dumping" the entire RAM to root directory during Unix system crash, as a core or core.pid

Why Analogy (of writing to program) is helpful?

- Is it well organized?
- Is every thing in proper place?
- Is it maintainable?
- Is there repetition?
- Does it work?

Getting all the related work

- Read other dissertations
- Ask the experts
  - Read the references in good papers
  - Citation index
- Recent conferences/journals
- How to link sentences?
- Linking Idea
  - English sentences have two parts, first links to previous material and the second part provides new information and emphasis

Summary: about pursuing Research

- Look for "some thing to push against"
- Read selectively and critically
- Writing research is like programming
- Strive for clarity
- Strive for honesty
- Do not over-sell

Research Areas CS

- Artificial Intelligence (AI) and Machine Learning (ML)
- Natural Language Processing (NLP)
- Computer Vision
- Robotics
- Data Science and Big Data
- Quantum Computing
- Cybersecurity
- Human-Computer Interaction (HCI)
- Distributed Systems
- Computer Networks
- Software Engineering
- Bioinformatics and Computational Biology
- Quantum Information Science
- Autonomous Systems
- Green Computing

Research Areas EE/ECE

- Power Systems
- Control Systems
- Electronics and Embedded Systems
- Signal Processing
- Communication Systems
- Electromagnetics and RF/Microwave Engineering
- Computer Engineering
- Biomedical Engineering
- Nanotechnology and Microelectronics
- Renewable Energy Systems
- Computational Electromagnetics
- Cyber-Physical Systems
- VLSI design
- HDL, VHDL, Verilog
- Master some languages

Research Areas Civil Engineering

- Materials Science and Engineering
- Thermal Sciences
- Mechanics and Structural Analysis
- Design and Manufacturing
- Robotics and Automation
- Energy Systems
- Aerospace Engineering
- Control Systems
- Environmental Engineering
- Transportation Engineering
- Micro- and Nanoengineering
- Acoustics and Vibrations
- Computational Methods and Simulations

+Interdisciplinary in all

Research Tools

- MATLAB
- Simulink provides a block diagram environment for multidomain simulation and Model-Based Design.
- Scilab is used for its open source nature, cross-platform numerical computational package and a high-level, numerically oriented programming language.
- LabVIEW (Laboratory Virtual Instrument Engineering Workbench)
- OrCAD is used primarily for electronic design automation.
- Xilinx ISE The Embedded Edition includes Xilinx Platform Studio (XPS), Software Development Kit (SDK)
- ChatGPT, R language

Drawing and Plotting Tools

- Dia is free software available under the terms of the GNU GNU General Public License, the GPLv2., Link: `http://dia-installer.de`
- LaTeXDraw is a graphical drawing editor for LaTeX. LaTeXDraw can be used to 1) generate PSTricks code; 2) directly create PDF or PS pictures. LaTeXDraw runs on top of Linux, Windows, and Mac OS X., link: `https://latexdraw.sourceforge.net`
- GIMP: The Free & Open Source Image Editor, Link: `https://www.gimp.org`
- GNU Octave: Powerful mathematics-oriented syntax with built-in 2D/3D plotting and visualization tools, Link: `https://octave.org`

Documentation and typesetting Tools

- Latex: LaTeX is a software system for document preparation. When writing, the writer uses plain text as opposed to the formatted text found in WYSIWYG word processors like Microsoft Word, LibreOffice Writer and Apple Pages. (packages: Texmaker, Kile)
- ▸ overleaf: Latex online editor.
- Lyx: LyX combines the power and flexibility of TeX/LaTeX with the ease of use of a graphical interface. This results in world-class support for creation of mathematical content and structured documents like academic articles, theses, and books.

Bibliography

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One resource for Tex is~\cite{texbook} and other
   is~\cite{lamport94}.
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