Research

Expectations

- We will spend time learning about research
- We will learn about best practices
- We will create a foundation for the quest of knowledge and innovations
- Participate actively and learn through practice

Disclaimers

❖ No one-size-fits-all

❖ No recipe for success

❖ No clear success or failures defined

❖ Some advices may not fit individual needs

Topics

❖ What is research?

❖ Selecting a Topic for Research

❖ Type of Research Efforts

❖ How to Read a Paper?

❖ Problem Formulation

❖ Research Approaches

❖ Evaluation and Validation

Scope of this course

❖ Conference and Journal Publications

❖ Writing Technical Papers

❖ Presenting Papers

❖ Writing Research Proposals

❖ Professional Ethics

❖ Collaborative Research

What is research?

❖ Research is an <u>art of investigation</u> of <u>new</u> and <u>innovative</u> aspects of any branch of knowledge.

❖ It comprises of <u>defining and redefining problems</u>, <u>formulating hypothesis</u>, <u>suggest solutions or solution approaches</u>, <u>collecting and analyzing data</u>, <u>deriving</u>, <u>experimenting</u>, and eventually <u>validating the hypothesis</u> or <u>deducing new conclusions</u>.

Hypothesis

In the world of statistics and science, most hypotheses are writes as "if ..then"

For **example** someone performing experiments on plant growth might report this **hypothesis**:

"If I give a plant an unlimited amount of sunlight, then the plant will grow to its largest possible size."

What is research?

❖Research is the <u>process</u> of solving problems and finding <u>facts</u> in <u>an organized way</u>. Sometimes, Research is used for challenging or making contribution to generalizable knowledge. We may have to find some new algorithms, methods or replicate existing method to against others by proving the facts.

  ✓ Research is done by applying <u>what is known</u> (if anything), and building on it. Additional knowledge can be discovered by proving existing <u>theories</u>, and by trying to better explain <u>observations</u>. Research should be systematic, organized and <u>objective</u>.

What is Research?

Ph.D. = Doctor of "**Philosophy**"

Culture: Research is a culture, to be practice through continual quest for innovation.

Attitude: Needs hard work, dedication, perseverance, and an appropriate attitude

Motivation: Research planning cannot and should not follow "scheduled" or "time sensing" approaches

Dignity: Not everyone has to do research and it should not be pursued for glorification.

Motivations for Research

❖Meaningful and long-lasting contributions towards the advancement of mankind and society.

❖Intellectual satisfaction of doing something innovative and creative

❖Enjoy the challenges of solving unsolved problems

❖Attain higher level of understanding of fundamental concepts as well as practical significances

❖Degrees, financial benefits, and respect comes along the way

Essential Components of Research

Identifying Topic

Defining Problem

Solution

Validations

Presenting

Writing

Topic Selection

❖ Realize your expertise and limitations

❖ Focus in your breadth of knowledge first

❖ Be specific about your <u>topic</u>, but flexible <u>about the scope</u>

❖ Do not set rigid barriers regarding the topic

❖ The topic may not be discipline specific

❖ Be prepared to revisit the topic selection if needed

Expanding Knowledge

❖It is desirable to expand your breadth of knowledge on the selected topic

❖Read the fundamentals on the topic to build up the foundation for your research

❖Although not immediately evident, these efforts pay off in the longer run

❖Feel open about broadening the scope of the topic as you build up on it.

Building Foundation

❖ **Should like and enjoy the topic**

❖ You should have or build a very strong background and foundation on the broad area of your topic

❖ You need to have some ideas about the state of the art

❖ New topics - Need to envision the future prospects of your intended topic

Broad Topic Selection

Computer Networks
- Wireless Networks
  - ▸ Cellular Networks
    - Performance, reliability, security

Operating Systems
- Resource management
  - ▸ Power conservations
    - Specific vs. general

Research Classification

❖ Descriptive

- Surveys, comparative and correlational methods

❖ Analytical

- Analyze and make critical evaluation of information

❖ Applied

- Address practical problems and solutions that can be implemented for near-term benefits

❖ Fundamental

- Generalization and formulation of theories

Research Classification

❖Quantitative

- Provides numerical results to validate the claims

❖Qualitative

- Comparative development of enhancing the usage patterns and experiences

❖Conceptual

- Abstract ideas or theories

❖Empirical
- Relies on experience and observations

Other Research Classification

❖ Combinations of two or more types

❖ Diagnosis
  ✓ Medical Research

❖ sensitivity studies
  ✓ global warming

❖ Exploratory

❖ Decision-oriented

❖ Laboratory Research

❖ Historical

❖ Discovery of unique phenomenon
  ✓ Physics and astronomy

Reading Papers

❖ Researchers must read **<u>a lot</u>** of papers

❖ Reasons:

  ▸ Cultivate knowledge in the area

  ▸ Learn about recent advances

  ▸ Literature survey

❖ All papers do not require the same level of attention

❖ Careful selection of papers saves a lot of time

https://scholar.google.com

Three-Pass Approach (Keshav)

❖**Quick Scan**

- Helps you decide whether you need to read this paper any further

❖**Reading with greater care**

- Helps in grasping the content

– Helps summarize the main thrust of the paper

❖**Detailed reading**

-Fully understand the paper

-Helps in identifying ideas for future work

The First Pass

❖Read the title, abstract, and introduction

❖Peruse through the sections and subsection

❖Headings

❖Read the conclusions

❖Glance over the references

❖Try to answer the following
  ▸ Category
  ▸ Context
  ▸ Correctness
  ▸ Contribution
  ▸ Clarity

Subsequent Passes

❖ Read the whole paper but with non-uniform emphasis
  - Identify the areas of your interest and relevance to the scope of your topic
  - Think and ask questions
  - Good to scribble important points, thoughts, and questions

❖ Identify papers from the reference list and make your reading list

❖ Learn good presentation and writing skills

What am I Planning to do? "Problem Formulation "

Defining and scoping out the problem for your research is one of the most important task

Problem:

▸ What is the specific goal to your problem?

▸ Why you want to pursue that goal?

▸ How do you intend to do it?

▸ Where does it fits into your overall research goal?

10-80-10 rule vs. 40-40-20 rule

❖Problem Formulation – Solution Efforts – Dissemination

❖More often that not, efforts on problem formulations guides to solutions

❖More efforts on problem formulations opens avenue for other innovations

❖Dissemination (writing and presenting) your research is very important, otherwise, it won't qualify as your contributions
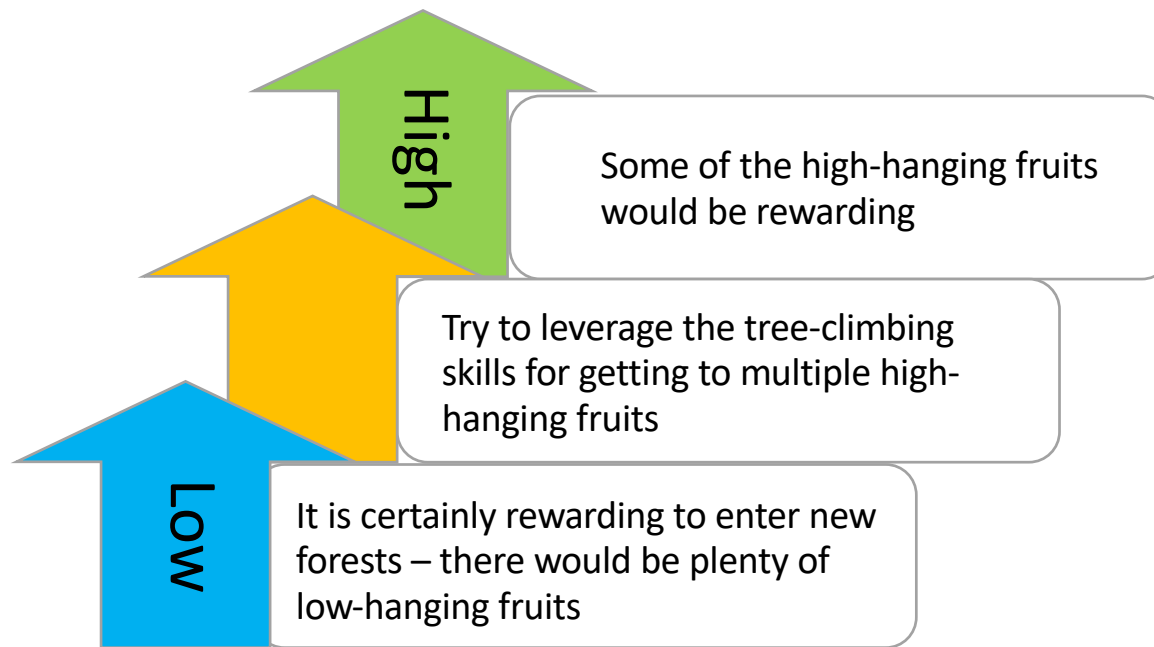
Discomfort Zone

❖The tendency is to always stay in the comfort zone

❖Comfort zones inhabits innovations and creativity

❖Step out of your comfort zone and walk into the discomfort zones

❖Learn to build bridges and avenues between various comfort and discomfort zones

Low-hanging & high-hanging fruits

High

Some of the high-hanging fruits would be rewarding

Try to leverage the tree-climbing skills for getting to multiple high-hanging fruits

Low

It is certainly rewarding to enter new forests – there would be plenty of low-hanging fruits

Critical Suggestions

Methods are tools

- Use them, don't let them use you

Think on a clean slate

To think outside of the box, you need to step outside the box too.

Question yourself

About why you are doing, what you are doing

Motivate your problems and evaluate your solutions

Some Guidance

❖Foundational work versus incremental efforts

❖Focus on Innovation

❖Explore beyond the boundaries

- Concepts from one domain can be applied in another domain
- Learn from real-life experiences
- May need to visualize what others cannot envision

Tuning Problem Definition

❖Start with small and simple ideas

❖Assume whatever can make the problem simpler, slowly relax the assumptions

❖As you learn more, you may need to tune your problem definition

❖Sometimes preliminary results helps in redefining the problems

❖Keep the scope flexible

Some Suggestions

❖ Could start with incremental efforts left undone in prior studies, follow through until completion

❖ Explore the abstractions of simple problems that hinders or impacts usage of technology – applications could be the drivers of your thoughts

❖ Can you make the current state better?

❖ It is always rewarding to scope out new problem definitions – try hard!

Basic Approaches

❖Abstraction of the thoughts provides a guided approach

❖Simplicity should be always the quest

- Start with the simplest approach and tune it as you dive deeper; complexities added as and when needed

❖Keep enriching and exploring new concepts

❖Write in parallel with your work

❖Every now and then, check if you are not getting list in the forest

Deeper Efforts

❖Do not shy away from challenges
- Go deep and focus on fundamentals
- Keep in view of useful applications
- Learn new theories, tools and methodologies

❖If you are stuck, try something completely different and then come back again

❖Do not hesitate to track back and/or abandon efforts pursued in a certain directions – it is never a wasted effort

❖Enjoy the learning experience with a very positive spirit

Major Types

❖ New invention and discoveries

❖ Theoretical Foundation

❖ Analysis, Model Development

❖ Experimentation and Implementation

❖ New Concepts, metric, approach, protocol

❖ Enhance existing practices

❖ Large-scale Data Analytics

Cross-area approaches

❖ Can the concepts and methods used in one area be adopted to solve problem in a completely different area?

❖ Ant colonies

❖ Biological evolutions

❖ Game Theories

❖ Social Network

❖ Putting things together from multiple areas

❖ Do not get fixed or get dragged on one!

Evaluation

❖ What did we propose to evaluate and why?

❖ Evaluation methodology
  - Are there any contributions?
  - Why we picked what we picked?

❖ Thoroughness and completeness

❖ Repeatable and ease of evaluation methodology

Validation

❖Both validation and invalidations are useful contributions

❖Do not pre-guess the results

❖Analyze the results very carefully – a deeper analysis is a contribution by itself

❖The limitations of the validations must be stated – nothing wrong about the limitations

❖It is better for you to state the limitations than having the reader/reviewer discover those.

Conference and Journals

❖Publishers

❖Reputations

❖Professional Societies

❖Quality and Metrics

❖Impact factors

❖Citations

❖Accessibility to researchers

❖Electronic Versions/Web-based

Citations and Impact Factors of Journals and Conferences

❖Citations clearly quantify the impact of a paper. However, the quality of paper citing your work also has a role to play.

❖Impact Factor(If) is used for journals conferences and is defined as the average number of citations that a paper published therein receives.

❖Impact factors could be misleading in some of the shady publication venues.

Cited by 12,651

LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." *nature* **521, no. 7553 (2015): 436.**

Google Scholar Publication Impact Factor

	Publication	h5-index	h5-median
1.	Nature	362	542
2.	The New England Journal of Medicine	358	602
3.	Science	345	497
4.	The Lancet	278	417
5.	Chemical Society reviews	256	366
6.	Cell	244	366
7.	Nature Communications	240	318
8.	Chemical Reviews	239	373
9.	Journal of the American Chemical Society	236	309
10.	Advanced Materials	235	336
11.	Proceedings of the National Academy of Sciences	226	291
12.	Angewandte Chemie International Edition	213	295
13.	JAMA	209	309
14.	Nucleic Acids Research	208	392
15.	ACS Nano	199	279
16.	Physical Review Letters	197	286
17.	Energy and Environmental Science	196	330
18.	Journal of Clinical Oncology	196	279

Author:

- A **h-index** of 20 means that an academic has published at least 20 papers that have received at least 20 citations each.

- **i10 index** refers to the number of paper with 10 or more citations

H-Index

❖ Hirsch's index – history

❖ Is somewhat of a meaningful measure for quantifying individual author's research impacts

❖ An h-index of n means that n of your papers are referred by n or more papers

❖ Variation: g-index, i-10 index …

Peer Review Process

❖Papers are reviewed by peer researchers who are generally knowledgeable about the problem scope

❖In addition to recommendations, the reviewer's feedback help improve the quality of papers

❖Reviewers will not spend much time as you want them to.

❖If the reviewer got it wrong, it implies that you could not convey your message adequately

❖Peer-reviewing systems is not perfect! However, anything else can best be a distant second.

All About Conferences

❖Very useful for quick dissemination of your research

❖In some areas, the impact of conference papers are exceeding that of journals

❖Provides and opportunity to verbally communicate and follow up discussions

❖Helps explore new thoughts and extensions

❖Facilitates interactions and networking with peer researchers

Generally Good Journal and Conferences

❖IEEE and ACM Transactions

❖Society Magazines are good for survey

❖IEEE and ACM Conferences

❖A look at the people in the organizing committee would depict the quality if the conferences

❖Scope and appropriateness of the conferences and journals should be considers

Selecting Appropriate Venue

❖Choosing an appropriate conference for your paper

❖Scope of the conference and match with your work

❖Level of competitiveness

❖Nature of work – does it match with the conference?

❖The community that attends this conference – who will be your audience?

❖Which conferences do your peers meet?

Conference Paper Selection

❖ Role of **program chairs**
- Define scope, From the **technical program committee** (TPC)
- Coordinate the TPC meeting
- Have a final say in the paper selection

❖ Papers sent to 3-4 reviewers (including TPC members)

❖ The TPC gets together (physically or virtually) to discuss reviewers feedback and recommendation

❖ The number of accepted papers are bounded by the space/time availability at the conference venue

IEEE BigDataSecurity 2019
http://www.cloud-conf.net/datasec/2019/committees.html

It's all about "Networking"

❖Networking involves meeting and engaging in technical discussions with peers

❖Network should be done at a broader scope

❖Enhances reputation, visibility, and to some extend – credibility

❖Facilitates collaborations and engagement in large and broader projects

Paper Reviews

❖The level of reviewers engagements vary; largely depends on the interest aroused

❖Writing style and quality has a significant contribution

❖ If you disagree with the reviewer, more often that not, the cause of the disagreement is due to the clarity in explanation

❖Reviewers feedback is a priceless service; do use it in a constructive manner. Of course, some of the suggestions can be discarded

Journals

❖Journals are archival in nature

❖The length of the papers are usually longer (compare to conferences)

❖The research effort is expected to be more mature and rigorous

❖The turn-around time between a submission and its publication is not fixed and is usually long

❖The peer-review process is more rigorous

❖You have an opportunity to respond to the reviewer's comments

Research Impact

❖Translation to an useful application: (Product, method, process)

❖Citation and instigations of new areas of research or lines of thoughts

❖Impact on industry

❖Impact on other researchers or other areas of research

Publishing Papers

❖Focus on quality rather than quantity

❖Focus on your contribution and Impact of your research

❖Do not wait till the completion of your work to start writing

❖Choose appropriate venue

❖Quality of writing is important

Writing Research Papers

❖Writing is a very critical aspect of research

❖Writing creates an everlasting (or vanishing) impact of your research

❖Good writing style puts you at an advantage in publishing your work

❖Need to develop a habit of writing continually – preferably daily

General comments on writing

❖ You are writing for your reader – need to keep their interest

❖ It is important to write what the readers should know, rather than what you endured

❖ Write short sentences, clearly delineated paragraph, using pictures generously, and provide intuitive reasoning

❖ Maintain the interest – avoid over-stating or under stating your contributions

❖ Revise and seek feedback continually

❖ Spelling and grammar – very important

Paper Types

❖**Survey papers**
- Do not cut-paste
- Have a theme and carry on that

❖**Trend-setting**
- Focused on motivations, issues, and challenges

❖**Original Research and Contributions**

Research Papers Components

Statement of problem
▸ Be precise, provide motivation, significance, and applications

Proposed solutions
▸ Algorithm

▸ System design and development

▸ Evaluation (performance, reliability, security, etc.)

▸ Theory

Results and inferences
▸ Sufficient details for validations

▸ Novel aspects

▸ Significance, limitations, and impact

Paper Organization

Title
- It should be short and meaningful.
- It should arouse interest

Abstract
- Abstract should be written at the end.
- What is the paper about?

Introduction

State of Art (related work)

Main Contribution (Proposed Approach)

Results and Discussions

Conclusions

Introduction

❖ What is the topic?

❖ Why it is important

❖ What is your idea and what is its significance?

❖ How is it better or why should anyone be interested in it?

❖ Summary of your contributions

❖ Organization of the paper

Main Idea/Main Contribution/Proposed Approach

Main Idea
- Bring in the main idea soon. Explain it very clearly. Identify novelty. Describe the intuition, if any.

Limitation
- In addition to describing the novelty and benefits of your idea, states its limitations, if any

Conclusion
- Conclusions should be succinct and clearly identify the contribution, inferences, and future pointers

Evolution
- Evolution and/or validation of your idea or claims is essential.
- Be very clear and candid about your evaluations/validations – state what it is!
- Provide enough information about reproducing the results; not always possible though
- State limitations, if any

Paper organization

❖Writing should not follow research; it should be in parallel or better be ahead of your work

❖Seek criticism and improve continually

❖Focus and short and to-the-point stories of your work. Think what the readers would be interested in – not what you are interested in

❖What may seem obvious to you, may not be so to others

❖Keep the "forest and trees" story in the mind while writing