

# Research methodology

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# Research

- the *systematic investigation* into and study of materials and sources (any subject) in order to *establish facts* and reach *new conclusions*.

# Steps involved

- Identification of area to match your skillset/ interests/ease
- Course work to build needed general background
- Literature Survey after choosing area (guide or you may decide jointly)
- Identification of problems to be investigated (dynamically changes) which should be present for 3 to four years from now till you submit thesis
- Define Goals –metrics (better performance-efficiency, speed, area, power, novelty, cost, trade-offs)
- On paper explore new solutions (creativity needed)
- Simulate only after you are satisfied on paper
- Evaluation- Benchmarking (where our solution stands)
- Decide to publish- which journal depends on our confidence and experience

# How to Find Research Problems by Jason Eisner

- Cites Loren Eiseley, Biological Anthropologist
- Researchers are of two types
- Small bone Hunters
- Medium bone hunters
- Big bone hunters

# Small bone hunters

- Small bone: Reproduce somebody's work/ state of the art in an understandable way
- Helps you to get educated and help the field of research also
- Small beginning: Tweaks for well known techniques
- Lookout for such bones while reading papers – find harmful simplifications/ assumptions /arbitrary choices/ missing proofs/ counter examples

# Medium and Big Bone hunters

- Write a comprehensive Review which will enrich your knowledge and may give publicity. May become Chapter I of your thesis.
- Build a large program or tool (Does it beat performance records? Does it help user to integrate existing techniques to build his own customized tool?)
- If you are a co-author among many, make sure your distinct contribution elsewhere.

- Flip through latest great conferences try to know current crazy areas
- Example: Today talk of Cloud, Cloud security, Big data, Data Mining, Privacy preserving data mining, IoT, Cognitive Science, super computing, Low power design, machine learning etc
- Everybody now a days tries to use his expertise to spread into these fields
- For example - I look at opportunities in applications to cryptography, Analog ICs, Residue Number systems, Computer arithmetic, VLSOI architectures for above areas

# How to arrive at new problems?

- Read conclusions of papers
- Read suggestions for future work (the author may not do but may suggest).
- Analyze (think also) how to advance the state of the art (by studying limitations of previous solutions)
- Work on paper first (pen and pencil) –no tools – no simulation
- Weed out not so attractive ideas
- Useless ideas also are good- do not think as waste of time; you do not know unless you work out to find whether it is good or bad.
- Arrive at somewhat good or great idea. Then more detailed work – simulation, fabrication



- Experiment or simulation may show your idea may not meet the theoretical claims.
- Why? Non-idealities of components, inadequate modelling, include non-idealities to find deleterious effects
- You can sometimes state honestly– the deviation is due to blah blah
- Honesty is best policy; even if you hide, reviewer may guess due to intuition, wisdom

- Do not wait for very great solution
- Keep some goal- 80% of expectation reached- then send for publication
- Reviewers are gurus. Do not cry if paper is rejected. Read their comments, see where your work is deficient , improve and send to another journal
- Honest self assessment to know in which journal you can publish. (speed of review and acceptance, low risk policy)
- Shall I try for a brief or full paper? Size, depth of treatment, degree of novelty, assessment like comparison with previous work to be examined
- Do you want to submit to Conference? Then, if you submit paper, 60% difference may be needed- self plagiarism. Keep something for Thesis extra also.

# One Exercise for all who know basic mathematics

- Problem: Find square root of 435678
- How many steps are required?
- In each step, how many operations need to be done?
- What have you learnt in childhood –is it useful?
- Get one solution first (if you cannot recall, ask your younger brother/sister)
- Then try to see what can be improved to lead to best solution.
- What brain can do may not be possible to be done by a machine. Make it possible. Now people are working on decimal machines (radix 10).
- For Electronics people (Try solving using digital logic also. Do not use Macros of Companies)

# Solutions at different levels

- B.Tech student: read some book or browse internet. Get some solution. Implement and verify proper functionality, Submit to Indian College Conference
- M. Tech student: More literature survey, Evaluate some implemented design, Benchmark with other state of the art designs, little innovation, Indian Conference of higher level like VLSI design etc
- Ph. D student: More literature Survey, explore and introduce new designs/ ideas, thorough simulation/fabrication/ evaluation to prove the greatness of the design, Submit Journal paper or IEEE reputed International conference

# What to avoid

- Do not go for Quantity
- One good paper per year for one research student in a good journal is great.
- Do not send to open access and paid journals.
- Do not cite these references also in your papers unless they are exceptionally good.
- Cite papers published very recently last 3 years
- Choose indexing terms properly so that it will not go to wrong Associate Editors, Wrong reviewers.
- Avoid writing spoken English , thinking in Hindi or Telugu , Punjabi and translating. Think in English.

# Advice

- Continue research even after getting Ph.D, after becoming Assistant Professor, after becoming Associate Professor, after becoming Professor
- How many single author papers have you authored?

# Various steps

- Choice of an area for research

- Choice of a topic in that area



# Matching of the researcher's skills to those needed to pursue that area

- C++, Java Programming
- MATLAB
- VHDL and VLSI, FPGA specific
- RTL
- CAD/CAM
- Spectre RF
- Unless the area is 100% theoretical

- Literature survey in chosen area
- Look at IEEE explore (includes IET) , Springer, Elsevier, World Scientific
- Find good review papers.
- Read conclusions of papers to see whether any suggestions for future work are given.
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- Gap analysis (what is to be solved or discovered?)
- Sometimes extensions may be sheer scale up of dimension. May not have great novelty but there is a need.
- Example: 32x32 bit multiplier, 256x256 bit multiplier but be sure about the application

- Readjust (acquiring new skills?)

- Relook at the problem (alternative problem)
- But maximum within three months take a decision.
- In general any area, improvement can be made.
- Consider: Can you publish three or four papers in that area in 3 to 4 years?
- Thesis has to be in only one area and not using disconnected topics.

- Picking up one gap (problem) and solve it within a short time

- Benchmark your solution with state of the art solutions

- Excerpts from



- Be honest to say what is the advantage (at least in one respect) and what is the disadvantage.
- Do not wait for the best solution.
- Incremental improvements

- Learn good English

- Choose (weigh the standard of your paper vis a vis a journal) a good journal

- Avoid open access journals (your standard will never improve)

- Submit your work to IEEE Transactions/  
Electronics Letters/IET journals

- Wait for reviews to know what four or other five expert reviewers perceive your work

- Do not get disheartened

- Revise and resubmit to next level journal (Springer, Elsevier etc)



- Meanwhile work on another gap you have found.

# Thesis writing

- Start after you have material for four or three Chapters other than Introduction and literature survey.
- When you start writing you will really do further research to fill up the gaps.
- Write Introduction in the end to suit your work being described in all the chapters.

- ॐ सह नाववत ।  
सह नौ भुनक्तु ।  
सह वीर्यं करवावहै ।  
तेजस्वि नावधीतमस्तु मा विद्विषावहै ।  
ॐ शान्तिः शान्तिः शान्तिः ॥  
Om Saha Naav[au]-Avatu |  
Saha Nau Bhunaktu |  
Saha Viiryam Karavaavahai |  
Tejasvi Naav[au]-Adhiitam-Astu Maa Vidvissaavahai |  
Om Shaantih Shaantih Shaantih | |

### **Meaning:**

- 1: Om, May God Protect us Both (the Teacher and the Student) (during the journey of awakening our Knowledge),
- 2: May God Nourish us Both (with that spring of Knowledge which nourishes life when awakened),
- 3: May we Work Together with Energy and Vigour (cleansing ourselves with that flow of energy for the Knowledge to manifest),
- 4: May our Study be Enlightening (taking us towards the true Essence underlying everything), and not giving rise to Hostility (by constricting the understanding of the Essence in a particular manifestation only),
- 5: Om, Peace, Peace, Peace (be there in the three levels - Adhidaivika, Adhibhautika and Adhyatmika).

How to publish technical papers?

# Types

- Review paper
- Tutorial
- Research paper
- Journal or conference

# Structure

- (a) Title (two lines maximum)
- (b) Authors' name (names); no degrees to be written,
- No designations like Head, Telecom Division etc, only address in footnote, e-mail ID
- (c) Abstract: ten lines stating what is done in this paper. No big Introduction shall be included.
- Indexing terms after abstract give five or six

# Structure

- (d) sections (i)
- Introduction (ii)
- preliminaries or notation etc (iii)
- review of previous work (iv) –(vii)
- Proposed techniques/Algorithms etc
- (viii) Simulation / experimental results (ix)
- Conclusion (x)
- References
- Appendices

# Introduction

- Brief statement regarding relevance of the work (write in your own lines), previous approaches, limitations, motivation, rough outline of approach, organization of the paper  
Section II does this, Section III does this etc
- This is the most important part of the paper. Establish why one should read further?



# preliminaries or notation etc

- This depends on the subject if too many symbols are used in the paper.
- Can be skipped otherwise

# review of previous work

- Give historical account of the state of the art how it evolved.
- Benchmarks till today
- Give references to all statements made
- Limitations of earlier work
- What limitation you want to remove or what you want to improve
- Be honest
- Be up to date. Latest references 50% must be 2013 or 2012 unless you have discovered something after 20 years.
- Give good standard journal references: IEEE Transactions, ACM, not website urls or only not so good conference papers
- Refer to books also.

# Proposed techniques/Algorithms etc

- This depends on your work. Check whether all symbols are explained in the text, all abbreviations expanded first time, References ordered properly, Equation numbers in order, any loose threads

# Simulation / experimental results

- How have you tested your ideas.
- What tools used
- Details of experiments conducted
- How your results agree with your theory developed, % deviations
- Why deviations? due to what assumptions?
- Honest Comparison with earlier work: what improvement? what trade-off?

# Conclusion

- State what have you researched, what have you concluded or improved? Any suggestions for future work by you or somebody else?

# References

- [1] C. Toumazou, F. D. Lidgey, and D. G. Haigh, *Analog IC Design: The Current Mode Approach*. London, U.K.: Peregrinus, 1990.
- [2] P.V. Ananda Mohan, *Current-Mode VLSI Analog Filters: Design and Applications*, Birkhäuser Boston, 2003.
- [3] C. Tomazou, A. Payne and J. Lidgey, “Current feedback versus voltage feedback Amplifiers: History, insight and relationships”, *Proc. ISCAS*, Chicago, U.S.A, vol 2, pp 1046-1049, 1993.
- [4] C. Toumazou and J. Lidge, “Current feedback op-amps: A blessing in disguise?,” *IEEE Circuits Devices Mag.*, vol. 10, no. 1, pp. 34–37, 1994.
- [5] G. Palumbo and S. Pennisi, “Current-Feedback Amplifiers versus Voltage Operational Amplifiers”, *IEEE Transactions on Circuits and Systems-I: Fundamental theory and Applications*, vol. 48, no.5, pp. 617-623, 2001.

# References

- Some journals may want in a different style.
- References shall be Alphabetically arranged.
- Initials after name Lakshmi,P.
- Year after Name Lakshmi, P (2011), etc

# General guidelines Journal Papers

- A4 size, single column
- 1.5 line spacing
- Font size 11
- Center the equations
- Put Page Numbers at right hand edge of page
- Sentences shall be small
- Use simple English
- Do not cut and paste from other papers or your own paper (self-plagiarism).



- Do not say “you may note that” . Say “ the reader may note that..”
- Do not say “I have investigated? Say “We have investigated and our results blah blah”
- Do not say “ He /She has observed that ..” Say “Wilson [ ] has observed that “ first time.
- “They have observed that..” is correct if more than one author is involved in that paper.
- Use et al. in place of giving list of Authors “ Ram, Lakshman, Bharat and Shatrughn have described..” Instead say Ram et al. [ ] have described. In reference full list shall be given. (et al = and others)

# Conference papers

- Stick to template and size (number of pages).
- Figures shall be in place as near the place as they are referred.
- Font size comes automatically when you type in that area.
- Use Headings font size etc as in the template.

# Conclusion

- Have passion to excel
- Benchmark with research published in standard journals
- Then you will reach the destination