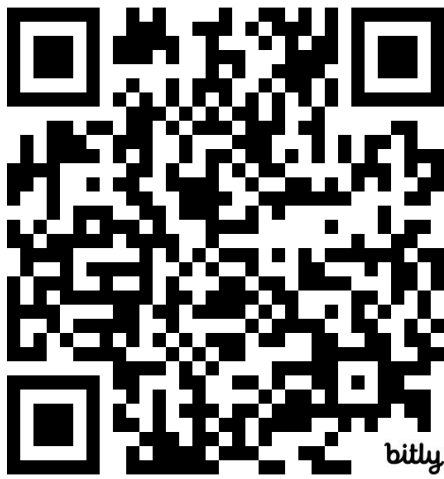


Finding a Research Topic and Interdisciplinary Research

Jaime Moreno, IBM Research (Emeritus)

John Vicente, Chief Technology Officer, CSI, Inc.



[Link to captions](#)



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Activity #1: Where are you now?

- **What is your current level?**
 - MS student, early PhD student, advanced PhD student or Post-Doc?
- **What is your status regarding identifying a research topic/area?**
 1. Still deciding
 2. Some research and ideas
 3. Research identified
 4. Proposal ready, started
 5. Reconsidering alternative research
- **What is your status regarding being able to carry out your research?**
 - a. Advisor ready
 - b. Seeking support and plan
 - c. Support and plan in place



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Quick recap: What is (Computer) Research?

- *The creative and systematic investigation to uncover new knowledge in computing*

- Knowledge applies to a broad range of topics, for example:

- Within traditional branches of computer science
- Within many emerging areas, sometimes at their intersections
- Entirely with other fields

• Theory, systems, software, user interfaces, AI, etc.

• Cross-cutting research within computer science branches
• Vertical research that spans the computing stack

• Research connecting computer science with astronomy, medicine, physics, etc.
• Can enable bi-directional growth and exploration

- There is a broad range of methods of investigation, such as:

- Theoretical: develop abstract models, prove theorems
- Conceptual: conceive and test/simulate new alternatives
- Empirical: build prototypes, evaluate systems
- Observational: uncover insights from experiments and data



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• What does Computer Research look like nowadays?

- Very often, research topic is part of a larger project with multiple co-researchers
 - Enable developing skills in working within teams
- Method of investigation must be appropriate for the topic, expertise, and resources
- There are opportunities to innovate in both topic and method
- You gain new knowledge by asking and answering questions that may:
 - Uncover fundamental knowledge about computing
 - Allow more effectively design, program, and use computers
 - Enable computers to solve new problems in other fields
- PhD research topic usually chosen jointly by student and advisor
 - Topic can be interdisciplinary, although it needs right opportunities



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Interesting Perspective

“The countries, the people that understand how to solve a domain problem in digital biology, or in education of young people, or in manufacturing or in farming, those people who understand domain expertise now can utilize technology that is rarely available to you. You now have a computer that will do what you tell it to do. It is vital that we upskill everyone. And the upskilling process I believe, will be delightful, surprising.”

Jensen Huang (Nvidia CEO)



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Computer Research and Career Opportunities

What you can do:

- New Science
- Novel Products and Applications
- Novel Systems
- New Business
- Novel guidance
 - Education
 - Mentorship
 - Service



How you can do:

- Theoretical
- Conceptual
- Empirical
- Observational
- Single-discipline
- Multidisciplinary
- Individual research
- Group
- Science-oriented
- Product-oriented



Where you can do:

- Academia
- Industry Research Labs
- Government Agencies Labs
- Industry Development
- Business Development
- Startups
- Analysts Organizations
- Consulting
-

Evolution from Research Roles to Journeys, with research focus evolving throughout time



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The winding, branching path...

- Identifying a research topic can be full of twists turns, false starts, new beginnings and crossing paths
 - There are many paths, and everyone's can be different...!
 - Might appear inefficient, but ultimately it will be rewarding
- Some PhD students have a long-standing goal that they methodically pursue
- Other PhD students might face uncertainty, setbacks and confusion as they navigate towards achieving their research goals
- Often, research activities lead to multiple interesting ways forward
 - You *must* choose where to focus
- Follow your curiosity, limiting regard for other factors
 - Learn promptly from any “mistakes”



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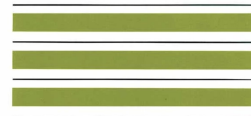
Personal Experience

Jaime

- Pre-PhD interests on microprocessor-based systems, digital networks, among others
- Through PhD coursework, learned about high-performance specialized computing systems
- Entered the world of “systolic array processors”, a popular research topic in the ‘80s
 - Pursued it further while in academia after PhD
- Moved to mainstream industry
 - Switched to high-performance general-purpose processors
- PhD topic rediscovered as part of emergence of specialized engines for AI

Matrix
Computations on
Systolic-Type
Arrays

Jaime H. Moreno
Tomás Lang



Springer Science+Business Media, LLC

John

- Early career heavily influenced by operations research / networking systems; throughout, intrigued by distributed systems design and its complexity.
- Worked in industry, mostly @Intel, before pursuing Ph.D. in Communications & IOT. Full-time job while pursuing my degree (11yrs).
- Academic journey with an amazing and supportive network: mentors/colleagues at Intel/Universities.
- Hallway conversation with Columbia University professor: book “On Intelligence” by Jeff Hawkins, about theory and structure of human brain or neocortex. Book inspired my Thesis on emergence of natural systems and applying computational methods (virtualization & AI/ML) to designing and automating complex, distributed, communication systems.



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Activity #2: What makes a good research topic?

- **Talk to your neighbor and discuss:**
 - **Your opinions about a good research topic**
 - **Your current research topic / plans for topic**



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What makes a good research topic?

- A new problem that has not yet been addressed
- A better approach to solve a known problem
- A goal that has not yet been achieved

Beware:

- **Good problem selection will only take you so far**
- **Execution is crucial**



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Understanding Your Context

- **Your “research story” began long ago!**
- **Contributing factors are both personal and environmental**
 - **Intrinsic**
 - Interests, experiences, expertise, aspirations
 - **Local**
 - Undergraduate and graduate program
 - Faculty, advisors and collaborators
 - Funding, access to resources
 - **Broader**
 - Research community interests
 - Past research, societal interests
 - Economic/political climate, timeliness, etc.
- **Interdisciplinary research compounds all these factors!**

- **Intellectual flexibility**
 - Graduate school is quite different from undergraduate experience.
 - **May start with one idea of what to research but that may change**
 - as you learn more,
 - as you talk to more people,
 - or as the state of the field changes.
 - **Stay curious and be willing to learn**
 - Those traits will serve you well beyond graduate school.



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Finding a PhD Research Topic

• You

- ❖ Your curiosity and passion. Your skills, talents, training.
- ❖ The kind of impact you strive for.
- ❖ Your post PhD goals: academic, teaching, industry, business, ...?
- ❖ What do you want to be expert in?

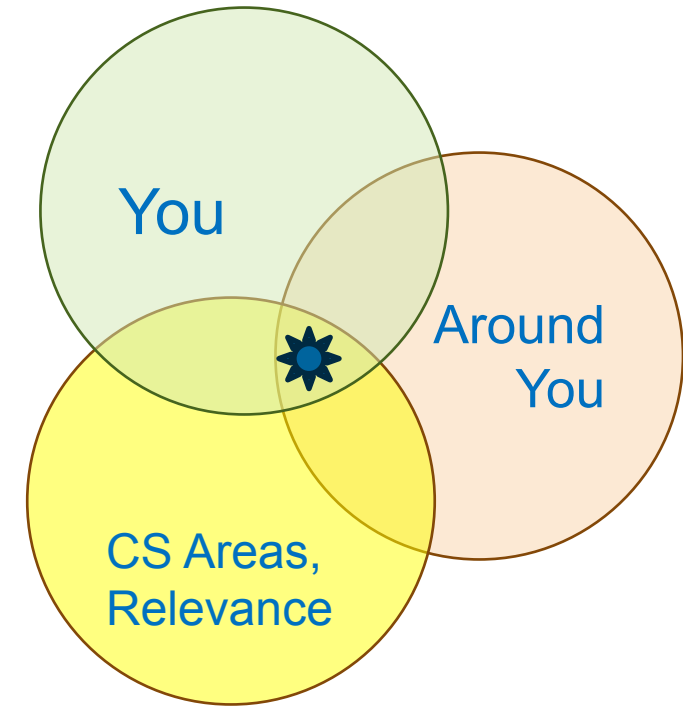
• Around you

- ❖ Resources available to you. What is feasible to do?
- ❖ Support from your advisor. Do you need to find another advisor?
- ❖ Funding available and/or funding that you can apply for.
- ❖ Are there others you can work with?

• Computer Science Areas and Relevance

- ❖ Technical area(s) you would like to pursue.
- ❖ Interests and skills aligned with trends and challenges in those area(s).
- ❖ Interest in doing research on one CS area or across multiple areas (“across stack”).
- ❖ Views about ongoing research areas. What are their limitations?

- Read, talk to people, attend seminars and conferences.
- Narrow the areas of interest as your knowledge increases.

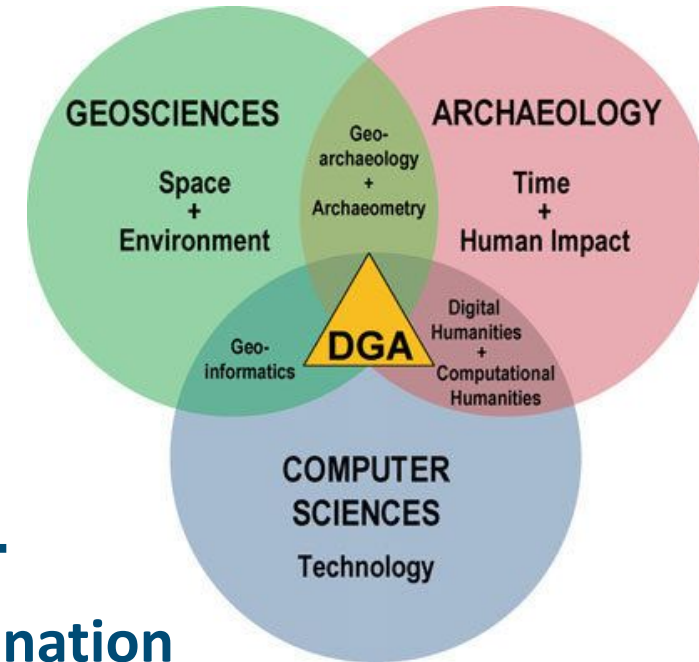


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Finding an Interdisciplinary PhD Research Topic

- Many (perhaps most?) interesting, challenging and high-impact research programs are at the boundaries between disciplines.
- Previous researchers may have been:
 - Untrained in skills to take on these research problems.
 - Unprepared to identify the right problems and ask the right questions.
- Similar principles as for single-discipline research apply, then ...
- .. look for areas of intersection and opportunities for cross-pollination
 - Start by focusing on problems that others are researching.
 - Understand their limitations and shortcomings.
 - Brainstorm on what you would do differently, based on your background.



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• Interdisciplinary Research: Opportunities, Challenges

- **Have you found a problem that matters?**

- Are you passionate about the problem?
- Are there others, or can you convince to be, equally passionate about it?

- **Are you building from established successes, or are you too far out on your own?**

- **Skills, training and access to necessary tools**

- **Community of researchers ready to accept the research**

- **Is there funding available?**

- **Advisors**

- One, two or more advisors and mentors
- Balance breadth vs depth of research
- Core identity that supports or overlaps with yours
- Open-minded and enthusiastic about learning from other fields
- Can they fund interdisciplinary research?

- **Collaborators**

- Community of researchers working in the topic, willing to engage newcomers into the field

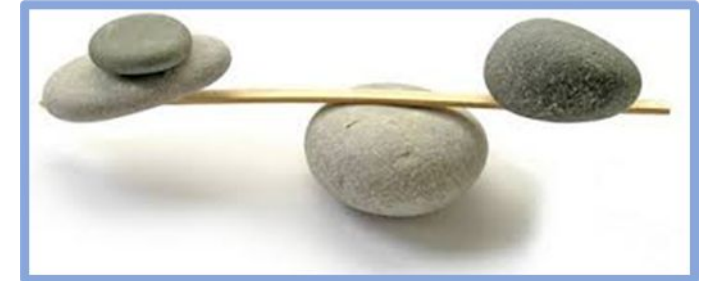


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Ways to do exploration

- Think big, but focus
- Always connect to what you think is important
 - Be intentional about what you choose (or agree) to do
- Take advantage of serendipitous opportunities
 - Speakers you hear or meet
 - Synergy or a spark from a paper you read or a discussion you had
 - Discuss with your lab mates, advisor, course projects
- Make it your own: the more you explore and connect, the more opportunities you have for new insights
- Take time and space -- but not too much..!!
 - “A PhD is a marathon, not a sprint”



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Items to watch out for - Pitfalls

- ✓ **Early fixation**
 - ✓ **Flightiness**
 - ✓ **Too broad, deep, hard...**
 - ✓ **Self deprecation**
 - ✓ **...**
- Forgetting the purpose/end goal
 - Getting scooped
 - Waiting for inspiration
 - Not having the necessary resources
 - Advisor contention
 - Moving goalposts
 - Too personal
 - Going at it alone
 -



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Pitfalls

Early Fixation

- **Often people get fixated on an early idea...**
 - Work on it for long time
 - Expect to present a complete idea to the advisors
 - Expect them to accept/reject it as is...
- **Best Practice:**
 - Most successful proposals go through multiple iterations of a preliminary idea, after its initial conception
 - Such iterations are part of the research process
 - This process is where lots of knowledge is acquired

Flightiness

- **Flightiness is the other extreme**
 - Churn quickly through iterations/ideas without properly evaluating them
- **Best Practice:**
 - Do not move on to the next idea/iteration until you have learned and convinced yourself why the current one doesn't work
 - Keep focused!



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Pitfalls

Too xxx...?

- **Is my topic too ...?**

- Too broad or too niche?
- Too hard or too easy?
- Too risky or too straightforward?
- ...

- **Best practice**

- Be intentional in your research pursuits
- Explicitly evaluate potential ideas
 - Generate lots of ideas
 - Evaluate Impact, Effort, Risk (low, med, hi)
 - Balance higher impact against effort and risk
 - If risk is high, can you fail fast?
- Is it SMART?
 - Specific, Measurable, Attainable, Relevant, Time-bound

Self Deprecation

- **How on earth am I going to do something that has never been done before?**

- **Best practice**

- Remember: Research is acquisition of new knowledge
- Problem + Questions + Methods + Application
- One of these things being new is enough to get started



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Heilmeier Catechism - DARPA

- **Guidelines developed by a former DARPA Director to describe project proposals**
 - 1. What are you trying to do?**
Articulate your objectives using absolutely no jargon.
 - 2. How is it done today, and what are the limits of current practice?**
 - 3. What is new in your approach and why do you think it will be successful?**
 - 4. Who cares? If you are successful, what difference will it make?**
 - 5. What are the risks?**
 - 6. How much will it cost?**
 - 7. How long will it take?**
 - 8. What are the “mid-term” and “final exams” to check for success?**

- **These guidelines are also suitable to describe your research proposal**



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Finding research topics after PhD

- **Academia**

- Initially

- Might be related to ongoing projects of current faculty members
- Sometimes, expected to open research line aligned with PhD thesis

- Soon afterwards

- Establish own research direction and secure sources of funding

- Eventually, become top expert in the field

- **Labs: Industry, Government, ...**

- Initially

- Most likely member of group with existing research agenda

- With time

- Expand role to be able to lead new research agenda
- Topics aligned with Labs' mission
- Usually, alignment with strategic products and directions

- Eventually

- Create opportunities to develop new strategic products and directions

- **In both cases, similar principles apply as those used for the selection of PhD research topic, albeit at different scale.**



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Recap

What are you curious, passionate about?

What do you want to be known as an expert in?

What kind of impact do you strive for?

What is the new approach, knowledge, or problem you will solve?

(Remember Heilmeier Catechism - no jargon!)

What skills, talents, training, funding do you have or need?

What are your post PhD goals: research, teaching, industry, business, ...?

What new things will you need to learn?

What are you willing to sacrifice, postpone or sideline?

What pitfalls do you need to look out for?



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Contact us



John Vicente, Chief Technology Officer, CSI, Inc.

<https://www.linkedin.com/in/john-vicente-phd/>



Jaime Moreno, IBM Research (Emeritus)

<https://www.linkedin.com/in/jhmorenoibm/>



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Copilot: provide advise to a PhD student in computer research on selecting a research topic

Starting a **PhD in Computer Science** is an exciting and challenging journey. Selecting the right research topic is crucial for a successful and rewarding experience. Here are some factors to consider when choosing your research subject:

1. Passion and Interest:

- Choose a topic that genuinely excites you. Your passion will sustain you throughout the long research process.
- Explore areas you find fascinating. Read about existing developments, processes, and research to identify gaps.

2. Relevance and Appositeness:

- Opt for a topic that aligns with current trends and challenges in computer science.
- Consider ongoing research by fellow scholars. Studying topics that others are exploring can help you establish connections and share secondary data.

3. Feasibility and Resources:

- Assess the feasibility of your chosen topic. Do you have access to the necessary resources (data, tools, etc.)?
- Ensure your research can be realistically conducted within the constraints of your PhD program.

4. Practical Impact:

- Aim to provide solutions to practical problems. Research that addresses real-world issues adds value to the field.
- Consider how your work can improve existing processes or contribute to advancements.

Remember, your PhD research is a marathon, not a sprint. Choose a topic that resonates with you, contributes to knowledge, and has the potential to make a meaningful impact. Best of luck on your research journey! 🌟🔍🎓

