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Why and How to Get a PhD?

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Doctoral Symposium @ ISSRE'2017

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About me

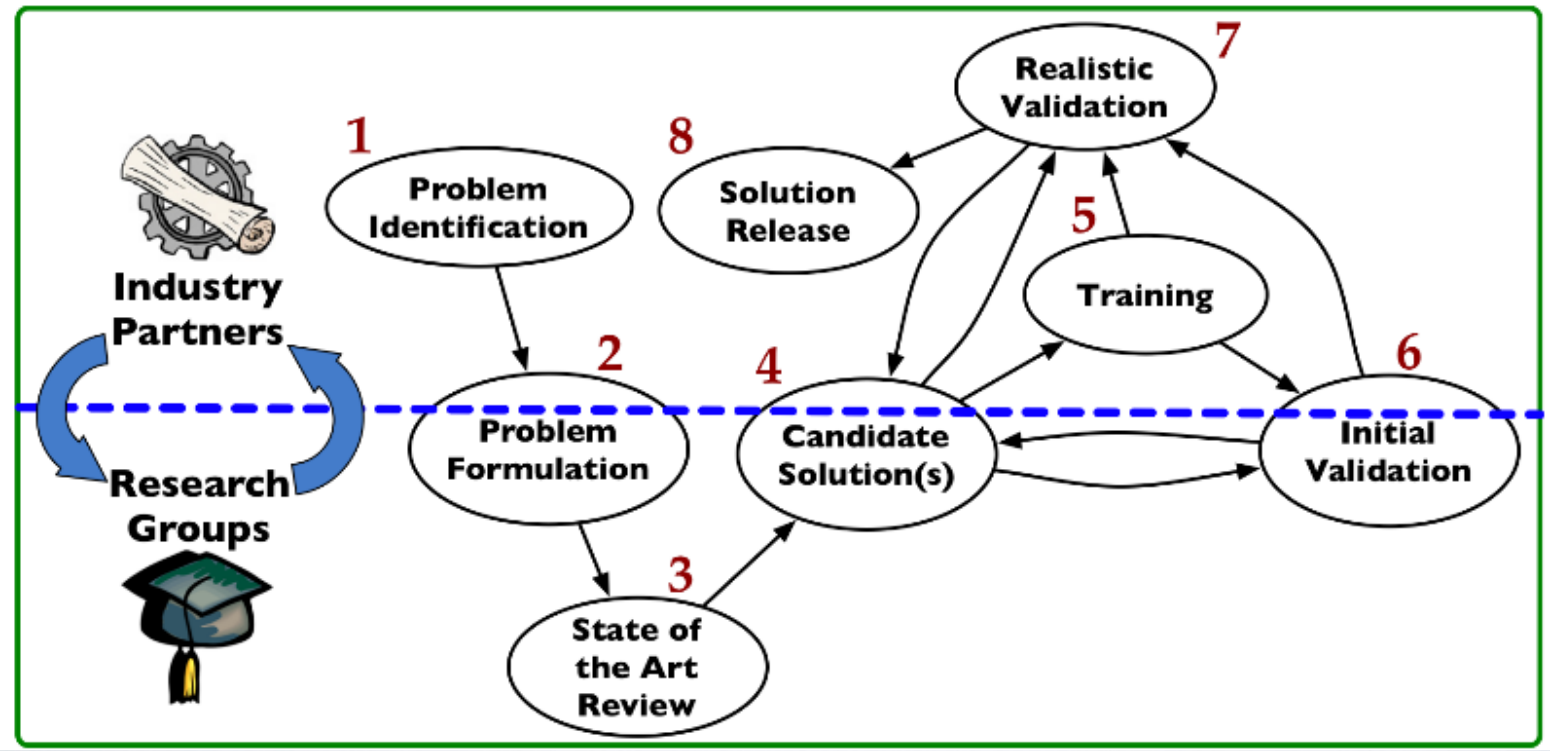
- 23 years of post-PhD research experience
- Worked in six countries
- Graduated 26 PhD students
- IEEE Fellow, Harlan Mills IEEE CS award
- Canada Research Chair, ERC Advanced grant
- ICSE PC co-chair in 2014
- EiC of Empirical Software Engineering (Springer) for 13 years
- Worked with >30 industry partners (aerospace, automotive, health care, finance …)
- H-index = 70, around 23,000 citations

SVV Dept. Overview

- Established in 2012, part of the SnT centre
- Requirements Engineering, Security Analysis, Design Verification, Automated Testing, Runtime Monitoring
- ~ 25 lab members
- Eight partnerships
- ERC Advanced grant
- Budget 2016: ~2 Meuros

Mode of Collaboration

- Strong emphasis on applied research, driven by needs
- Tight, long-term industrial collaborations



Outline

- My slides are just an outline
- Meant structure the discussion
- Please interrupt, contribute your experiences

- Why do a PhD? How can you benefit from it?
- How to be successful at completing a (good) PhD?
- My personal experiences
- Verbose slides

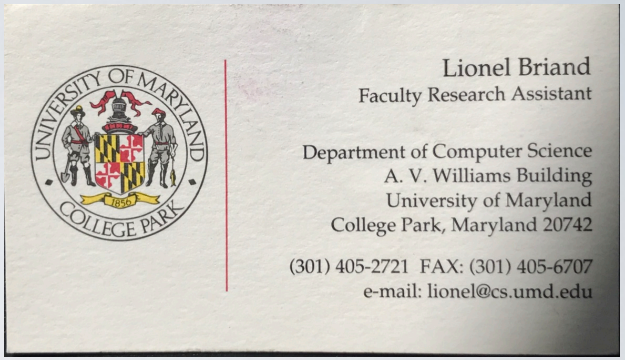
Why you do a PhD?

- A PhD will consume a sizable chunk of your life
- Only a small percentage of PhD graduates will get a faculty position in academia
- Not all positions in academia are worth taking anyway …
- There are, fortunately, many other reasons to do a PhD
- It is important to know why you do it, though you are perfectly allowed to change your mind. ;-)

Potential benefits of a PhD

- Gain deep technical expertise
- Learn how to solve complex problems, e.g., divide and conquer
- Learn how to communicate complex ideas, orally and in written form
- Learn how to construct and conduct an argument
- Completing a (good) PhD is a transforming experience

My PhD



- Software Engineering lab @ University of Maryland, NASA GSFC
- Initially I had no plan to do a PhD
- I did not even know what it meant

- I realized, intuitively, that it was going to change me for the better and that I would benefit from it during my lifetime

What to do with a PhD?

- Academic position, in a research or teaching institution
- Corporate R&D, e.g., Google, Amazon, ABB …
- Public R&D, e.g., Fraunhofer, INRIA, NIST
- Make the right choice for yourself, there is no right or wrong
- Regardless of your choice, your PhD experience will be useful

How to decide

- Do you favor teaching over engineering and technology transfer, or vice-versa?
- Applied research versus more theoretical research
- Problem solving versus developing new concepts
- Advising students
- There is nothing wrong with trying a career path and eventually changing – this is not a failure
- Leaving academia does not mean you failed as a scientist

My Fraunhofer experience

- Fraunhofer institutes run applied research projects with industry in Germany and internationally
- Focus on industrial problems and innovation
- I was not sure about what to do with my PhD. I wanted to keep all options open until I would figure it out
- Combine industry experience and publishable research

My choice

- I loved advising PhD students
- I was also keen on addressing real, industrial engineering problems
- I have looked for a way and a place where to combine both since then

A PhD is a personal challenge

- The challenges are an essential part of the journey and what will make you grow as an individual
- Persistence, patience, resilience
- Intellectual rigor, creativity
- Develop a capacity to lead research
- Those are qualities you will develop or strengthen overtime, if you are to be successful

Choose your topic carefully

- Choose a topic you can be passionate about
- Take the time needed, read all the literature that is relevant
- Define your problem(s) precisely, including working assumptions
- Assess what is the expected impact
- **Aim at a topic with high impact**, scientific and practical

Software Engineering

- **Though mathematical rigor plays an important role, Software Engineering is not a fully mathematical field**, far from that …
- Engineering field with significant human factors and where context is important
- There is a great deal of subjectivity in defining problems, assessing the impact of solutions …
- You will need to develop precise arguments -- mostly in English -- to justify your research and approach, draw conclusions from your results, and assess their impact in context
- Those arguments will have to convince (most of) your peers

Never underestimate clarity

- Clarity and precision are key in presentations and papers
- This is not easy and something you will have to learn during your PhD
- You will have to convince (highly critical) peers with different backgrounds and assumptions, explicit or not
- I find this to be a challenge, even after all these years

Facing challenges

- When facing challenges (e.g., papers rejected)
  - Remember why you do what you do, learn, improve and persist
  - Keep your sense of humor (you'll need it!)
  - Accept once and for all the part of subjectivity and arbitrariness that is part of the job

Context in SE Research

- In SE research, context cannot be abstracted away … as it is too often the case.
- “The Case for Context-Driven Software Engineering Research: Generalizability is Overrated”, IEEE Software, Sept/Oct 2017
- “Embracing the Engineering Side of Software Engineering”, IEEE Software 29(4): 96, 2012

Example

- Satellite industry
- Large project with many stakeholders
- Requirements are a contract
- Hundreds of (changing) natural language requirements
- Ambiguous, incomplete requirements

Problem definition and plan

- Precise problem definition and decomposition into sub-problems
- Plan including intermediary steps with tangible, self-contained and publishable research results
- Problem definition and plan tend to change as you gain experience
- **Write your thesis one paper at a time**

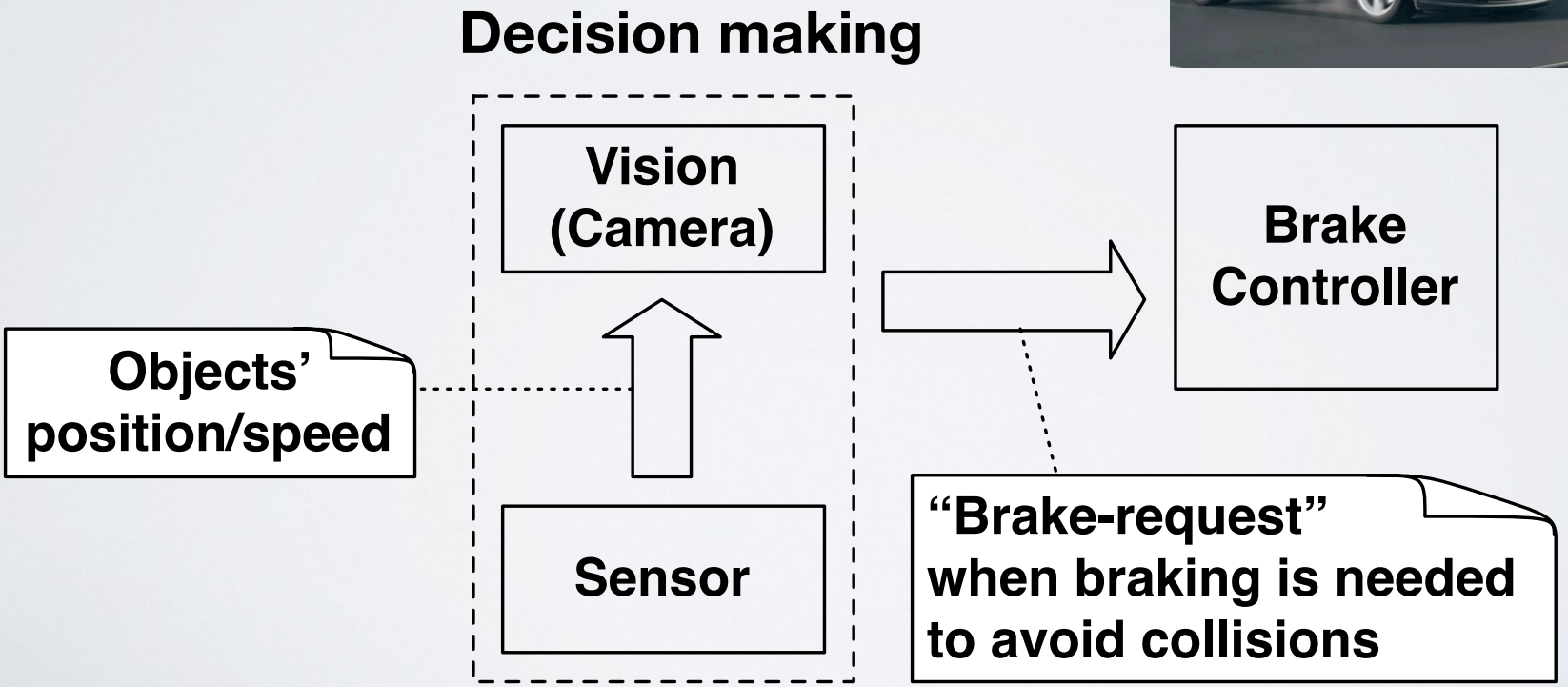
Advisor

- Interacting and getting feedback from your advisor as often as possible is important
- Be prepared for meetings, with clear, structured presentations – your advisor is your first public
- Do not hesitate to brainstorm on detailed points as often as needed
- Provide your advisor with partial drafts of papers early
- Character compatibility

Multidisciplinary research

- Most of the research with potentially large impact is at the interface of different research fields
- In my research: metaheuristic search, machine learning, constraint solving, natural language processing, statistics …
- Seek collaborations
- Software engineering takes place in application domains, e.g., automotive

Automated Emergency Braking



Development process

Model-in-the-Loop Stage

- Functional modeling:
  - Controllers
  - Plant
  - Decision

- Continuous and discrete Simulink models

- Model simulation and testing

MATLAB SIMULINK

Software-in-the-Loop Stage

Architecture modelling
- Structure
- Behavior
- Traceability

System engineering modeling (SysML)

Analysis:
- Model execution and testing
- Model-based testing
- Traceability and change impact analysis
- ...

(partial) Code generation

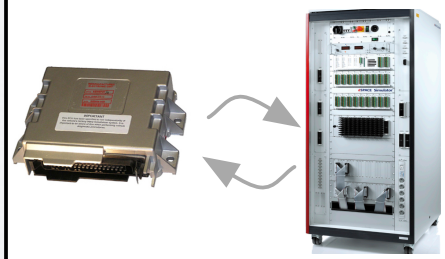
C SysML

Hardware-in-the-Loop Stage

Deployed executables on target platform

Hardware (Sensors ...)
Analog simulators

Testing (expensive)



Publications

- Start with low hanging fruits, to learn how to write and present early, then be increasingly more ambitious
- But avoid “least publishable unit”
- Identify the conferences and journals with communities potentially interested in your work
- Start with conferences to get quick feedback
- Extend into journal papers
- Pick high quality venues, take higher risks as you go

The Role of Publications

- Get your PhD of course, writing your thesis one piece at a time…
- Get your work known
- **GET FEEDBACK**: Especially useful in the early stages of your research. Use the good, ignore the bad, reviews will be a mixed bag but you will always learn something

Papers

- The introduction must convince the reader the paper is worth reading!
- The take-away messages must be clear
- The writing must be precise, concise, and structured
- Get your paper reviewed by a fresh reader (or several!) before submission

Rejections

- It is annoying, sometimes depressing, especially for junior researchers
- Accept it, it is part of the job
- Bad reviews exist, but there is usually at least a good one – Use the feedback! Learn from rejections!
- Remember: Writing clear and convincing papers, even when reporting good work, is not easy

PhD Pitfalls

- ~4 years may seem a long time to complete a PhD, but it is not
- Procrastination: Have a plan, including deadlines
- Exhaustion: Maintain a healthy life style
- Wanderlust: Stay focused on your plan!
- Stuck on a problem for too long: Replan!

Adapted from O. Nierstrasz, “Taming your PhD”

Presentations

- Prepare them very well! Don't underestimate the difficulty of presenting well, within limited time
- They will give an impression of your work (and yourself) to your peers – reputation is everything in our profession
- **Tell a good story**, no need to report on every detail in the paper – presentations are teasers for people to get interested in your paper
- **Don't overdo it** – a presentation must have technical content, it is not just entertainment
- **Learn the tricks: rehearse, look at the audience, speak clearly and slowly, …**

Story outline

- Problem definition
- Why is it important? In which contexts and scenarios?
- Why is the state of the art not satisfactory? What are the current limitations?
- What are you proposing? Why does it make sense given the abovementioned limitations?
- Main, most exciting results

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