TECHNICAL WRITING FOR PERSONAL AND RESEARCH STATEMENTS

Suren Jayasuriya
Pitt Undergraduate Mathematics Seminar

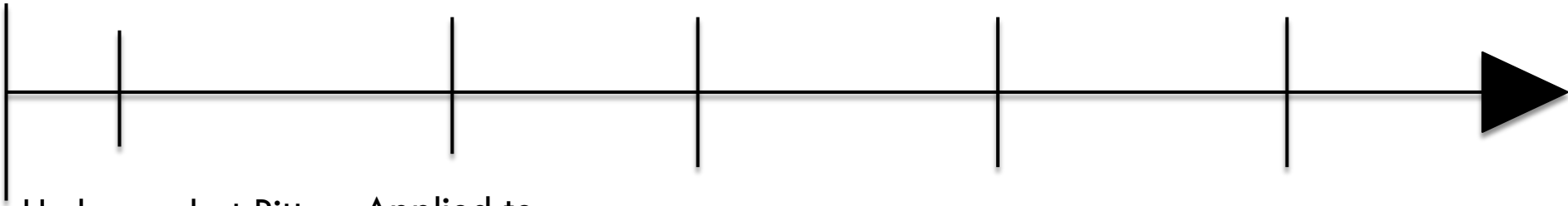
Why have a seminar on technical writing?

- I just want to do math/cs/engineering/physics/etc

Why have a seminar on technical writing?

- I just want to do math/cs/engineering/physics/etc
- For your job, you need to write about **yourself** and write about **your work**
- "Soft" Skills = writing, speaking/presentation, collaboration, leadership

My Experiences with Technical Writing



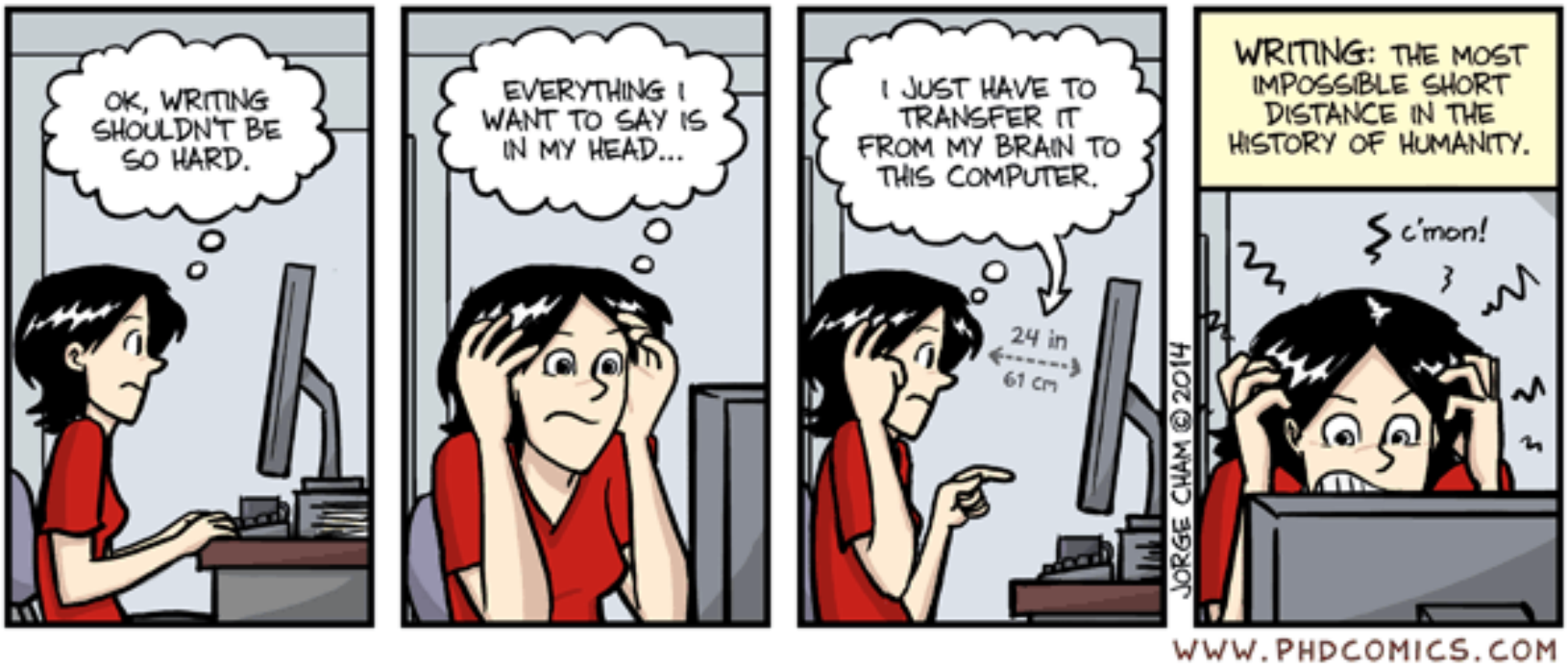
Undergrad at Pitt, double major in math/philosophy in 2012

Applied to grad schools in math and ECE
- Tried for NSF GRFP
- Wrote graduate statements

Went to Cornell for PhD in ECE
- NSF GRFP in 2013
- Qualcomm fellowship in 2015

Postdoc at CMU
- Write grant reports

Assistant Professor at ASU
- Writing several grants


OK, WRITING SHOULDN'T BE SO HARD.
EVERYTHING I WANT TO SAY IS IN MY HEAD...
I JUST HAVE TO TRANSFER IT FROM MY BRAIN TO THIS COMPUTER.
24 in
61 cm
WRITING: THE MOST IMPOSSIBLE SHORT DISTANCE IN THE HISTORY OF HUMANITY.
c'mon!
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Why Fellowships?

- Money (but you won't see too much of this)
- Independence in research/activity
- Prestige (awards = differentiating factor)

Fellowship opportunities

- National Graduate Research Fellowship (NSF GRFP)
- National Defense Science and Engineering Graduate Fellowship (NDSEG)
- Hertz Fellowship
- Paul and Daisy Soros Fellowship for New Americans
- Others (DOE, etc)

Focus of this talk: NSF GRFP

- (but tips will transfer to other fellowships)

= 3 years of funding

Basic Requirements:

US Citizen/National/Permanent Resident

Graduating Senior Undergrad or 1st/2nd year graduate student

Must be going into STEM research

Main Writing Requirements

- Personal Statement, Relevant Background, and Future Goals (3 pages)
- Graduate Research Statement (2 pages)

Personal Statement

- What do they want?
- Relevant background = “research or potential to do research”
- Personal story = “how does your personal narrative fit into their goals”
- Future goals = “Does your future career plans support STEM”

Intellectual Merits and Broader Impacts

Intellectual Merit :

- Fundamental new scientific knowledge/ theories/experiments

Broader Impact Examples:

- Education/outreach
- Diversity
- Dissemination of results: publications, presentations, open source data/code
- Societal impact


HI, CECILIA. HOW'S THE WRITING GOING?
SLOW. I'M FINDING IT HARD TO MAKE PROGRESS.
BUT THAT'S OK. THEY SAY WRITING IS 1% INSPIRATION, 99% PROCRASTINATION.
I THINK IT'S 99% "PERSPIRATION."
YES! YOU SWEAT FROM ALL THE PROCRASTINATION!
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Examples of Intro

For 15 years and counting, I have been fascinated with the concept of manipulating light. During my freshman year at Cornell, I took a course in Lasers and Photonics that introduced me to a career in optics. Over the course of the semester, I built a nitrogen laser and worked with optical tweezers, holography, fiber optics, and various lasers in the laboratory. I became so immersed in the material that the last day of class arrived with a shock. Refusing to let this be the end of my involvement in optics, I decided to major in electrical and computer engineering and minor in physics. Since then, I have had many research experiences—in topics spanning ultrafast

- The classic "This is how I came to love science/math/engineering"
- Not necessarily bad, but the reviewers will read tons of these

Examples of Intro

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Examples of Intro

I intend to pursue a career in either academia or government service with the goal of exploring multi-modal learning as a tool in human-computer and human-robot interaction. Specifically, I will work towards the development of embodied dialogue agents that understand and fluidly respond to natural language while considering both physical context and past user behavior. This task will bring together several high-level fields, including natural language processing, robotics, and computer vision. Dialogue agents could be deployed on robotic platforms for service applications such as search and rescue or assisted living care, as well as educational functions such as research demonstrations and tutoring systems.

Examples of Intro

My interest in electrical engineering stems from my desire to apply mathematical tools and algorithms to concrete signal processing applications. I enjoy interdisciplinary research, and I believe that new computational theories are organically developed from specific engineering applications. The value of computational thinking to understand complex processes is a key component of my teaching philosophy that I have shared with others. A NSF Graduate Research Fellowship would support my efforts to pursue these interdisciplinary research interests and teaching activities to further depths.

Talking about Past Research

Walking by first-years excitedly talking about research, the grad student faintly remembers a time when he was just as naive, misguided, and unbroken. – Lego Grad Student

Talking about Past Research

Our main result was the analytical classification and numerical simulation of complex dynamics during perceptual rivalry. These dynamics had been experimentally observed but not analytically predicted in such models before. I helped develop the main tool of fast/slow timescale analysis and worked independently on both analysis and coding numerical simulations for a year. I realized I could use the analysis to identify parameter regions where such dynamics could be numerically simulated. These simulations generated testable experimental predictions that have broad implications about neural visual processing. **I presented our results at two scientific presentations** at Math Association of America Sectional Meeting in Clarion University and the Society of Industrial and Applied Mathematics Regional Student Conference at Shippensburg University. **I am first author on a publication in the Bulletin of Mathematical Biology**[1]**,** where reviewers commented on its intellectual merit by stating "the numerical results are interesting and the authors discuss them in the context of potential experimental set-ups on perceptual bistability that may uncover new information about the adaptive processes of the visual system."

What you did?
What did you learn from it?
What outcomes/accomplishments happened?

Talking about Past Research

At the end of the summer, I presented the simulation results of my integrated photonic wavelength-division multiplexed communication system to E^3S, UC Berkeley students and researchers, and the general public in the form of a poster, a talk, and a paper. My simulations of integrated photonic devices **helped improve a new, high-return technology** that allows the co-design and co-fabrication of photonic and electronic elements in an existing CMOS platform. It increases access to the **high, scalable data rates and low energy consumption of optically-aided computing** while taking advantage of the **low cost and compact size** of fully-integrated CMOS designs. I gained an appreciation for the complexity of electronic system design, though I did miss the coupling of theory-based simulations with experimental optics. This has shaped my research interests to weigh more heavily toward the optical, as opposed to optical-electronic systems, thrust of integrated photonics.

Broader Impacts

Filling out the “Significance” section of a grant proposal, the grad student gets a chance to exercise his creative writing skills. – Lego Grad Student

Broader Impacts: Education/Outreach

In addition to research, I take great personal interest in **science outreach** because my own academic pursuits were shaped by a visit to an optics lab at NASA Glenn Research Center when I interned there after my freshman year. That same summer, I volunteered at the region's largest science museum for an event showcasing Glenn's ongoing research; I manned an interactive virtual reality exhibit and explained how 3D glasses worked to visitors of all ages. By doing this, I not only spread interest in science, but I also helped bring awareness of the NASA center to Cleveland residents, many of whom were excited yet also surprised to learn it was located in their hometown. During my summer at LLNL, I helped with the lab's **My Brother's Keeper Initiative**, a challenge launched by President Obama to "address the opportunity gaps faced by boys and young men of color." Boys and girls from a local elementary school took a tour of the lab and learned about our cutting-edge technologies, which included visiting my Laser DJ booth where I demonstrated free-space optical signal transmission.

Broader Impacts: Education/Outreach

One of my strongest personal traits is my ability and inclination to be a teacher and mentor for future scientists and engineers. I was a tutor at the Math Assistance Center at the University of Pittsburgh for two years, helping students with calculus and differential equations to even proof-based courses in analysis and abstract algebra. I averaged 12-15 hours a week tutoring during my senior year. I never turned down a question even in courses I had never taken such as topology or quantum physics. This is because I learned that even asking students to clarify basic principles and assumptions underlying a question led to genuine understanding for them. I helped a group of students taking advanced calculus by conducting evening review sessions (off hours) where I created practice exercises to help them learn the content. A frequent issue that arose when tutoring was students' lack of confidence in their mathematical abilities. I helped students overcome this by constant encouragement, support, and enthusiasm. I commonly said, "Lets try this problem together" and was not afraid to show students when I myself would get stuck on a problem. This went a long way in showing students that computational thinking takes time and energy to cultivate, but fulfilling in the end.

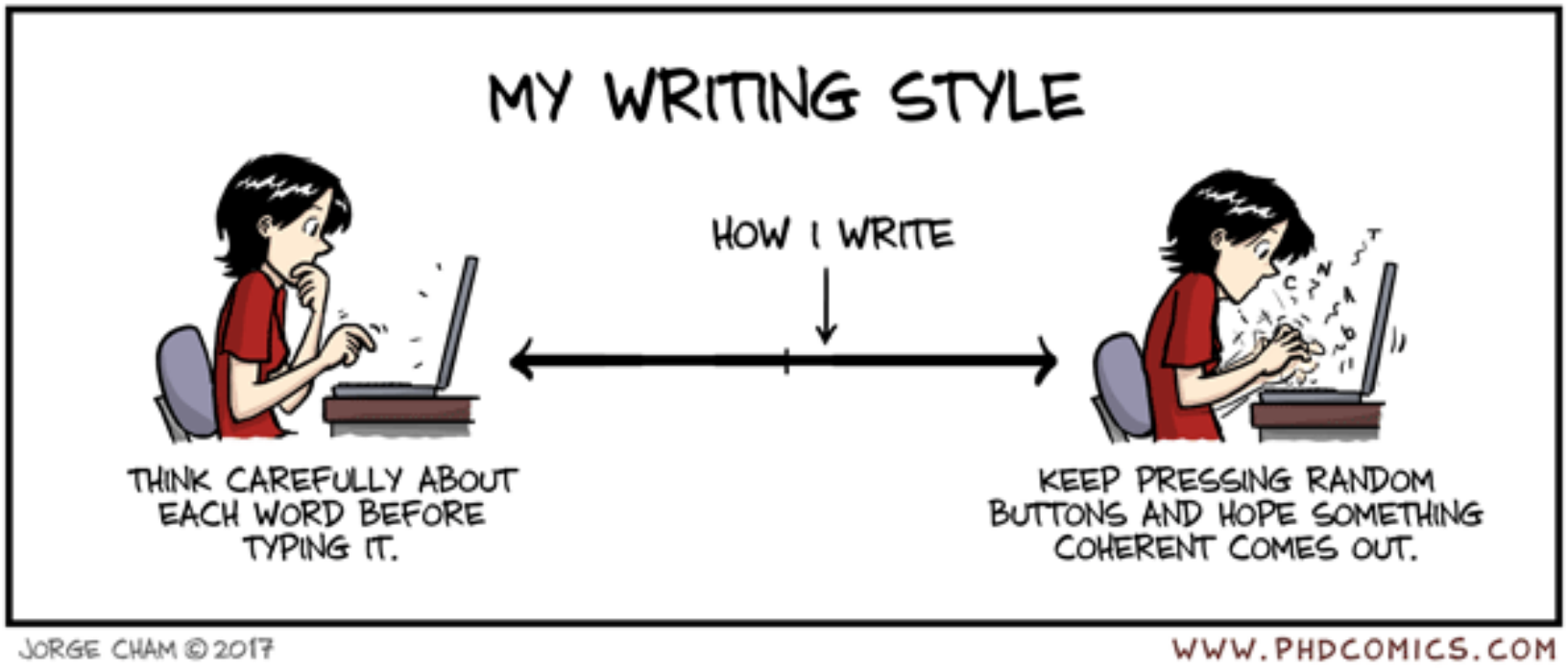
What about extenuating circumstances?

Reading was a challenge due to my dyslexia and I struggled through elementary and middle school seemingly on my own, without proper support, encouragement, or guidance. However, my mother enrolled me in a local technical high school where I graduated with honors and a 4.44/4.0 GPA. Following high school, I received a B.S. in electrical engineering from one of the few universities my mother could afford and within a few weeks of graduation I crossed paths with Dr. Athan, a veteran electrical engineer. Dr. Athan had been mentoring undergraduate engineering students for over twenty years with a proven track record of preparing and transitioning them into highly sought after career opportunities. He hired me as a consultant on an Air Force Research Labs (AFRL) Phase I SBIR contract investigating methods of mitigating radiation effects in microelectronics.

Reviewer comments:

Explanation to Applicant

This student has taken a non-traditional path to graduate school. Typically, we find that graduate students at top schools are either international or come from academic privilege. Instead, this student was raised by a single mother, went first to community college, and studied at the University of South Florida. After college, he worked at NASA Goddard on SBIR grants and other projects. On top of this, he has a disability; the percentage of grad students who have a disability is about 1%; in contrast, about 10% of the US population has some form of disability. So it is really impressive to find this student at Cornell.
Besides this, he has been active in outreach to kids. He mentored URM and low-income students in robotics and supported his mentor on a program called Engineering Minds.


MY WRITING STYLE
HOW I WRITE
THINK CAREFULLY ABOUT EACH WORD BEFORE TYPING IT.
KEEP PRESSING RANDOM BUTTONS AND HOPE SOMETHING COHERENT COMES OUT.
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Research Proposal

- Most undergrads worry about this too much
- Research proposal is not a contract
- Key: get feedback from a professor/advanced graduate student in your research field

A good strategy

- Broad research area
- Then talk about one specific problem – show a bit of equations/math/etc
- Then bring it back out: intellectual merits and broader impacts

The Vision Statement

My graduate research focuses on bridging the gap between advanced signal processing theory and the practical considerations of designing and fabricating ASICs. Currently, I am researching network interference alignment algorithms to minimize signal interference in wireless transmissions. This will influence the design of radio frequency integrated circuit transceivers that employ these algorithms for maximum spectral efficiency over a channel. This is one example of how signal-processing theory can improve integrated circuit design for specific applications. To illustrate in detail the type of proposed graduate research the NSF Graduate Research Fellowship would support, we present the following specific application of image processing using prior information for range finding with novel optoelectronic sensors.

High level overview of proposed research

"Vision" Statement

The Problem Statement

With the advent of self-driving cars, drones, and other autonomous vehicles, there is an increasing reliance on high-resolution radar for navigation and collision avoidance. Correspondingly, there is growing demand for a compact, high-speed analog-to-digital converter (ADC) to digitize these high-frequency signals. Fully-electronic ADCs fabricated in a complementary metal-oxide semiconductor (CMOS) process are experiencing reduced incremental performance gains under their current pace of development, where 5- and 6-bit sampling of 100 and 30 GHz analog signals is presently beyond their abilities [1]. Photonic ADCs have the capacity to push past this bottleneck with high bandwidth, high speed, and significantly lower timing jitter, but until recently, the technology's high cost and fabrication complexity hindered it from entering the market. With the successful demonstration of an integrated photonic microprocessor [2], photonic and electronic elements can now be *co-designed and co-fabricated on a single chip* using *existing* CMOS silicon-on-insulator (SOI) foundry technology. We can apply this innovation to design compact and cost-effective integrated photonic ADCs; however, performance degradations arising from nonlinear optical effects must be mitigated for these ADCs to become a high-functioning, viable technology.

What is the problem?

Going into the details a bit

One main application of ASP sensors is the ability to range find or measure depths of objects present in an image. Let $P \propto \cos(\beta\theta)$ and $Q \propto \sin(\beta\theta)$ represent complementary responses of image intensity recorded by ASPs, where β is angular frequency and θ is the incidence angle of reflected light from the object. We can then recover the depth k at any given location in the image by calculating the following:

$$\beta \cdot \frac{\frac{dQ}{d\Delta x} P - \frac{dP}{d\Delta x} Q}{\left(\frac{dQ}{d\Delta x}\right)^2 + \left(\frac{dP}{d\Delta x}\right)^2} = k,$$

where taking the derivative with respect to Δx is the local difference in adjacent sensor responses. However, these measurements are typically noisy and not robust with respect to optical issues of specular reflection and low illumination. Thus new methods are needed for efficient range finding.

The proposed algorithm development improves these range finding measurements by coupling a denoising method known as total variation regularization with Bayesian prior information of the statistical confidence for each depth measurement. Total variation regularization[2] is an image denoising method that minimizes the following expression:

$$\min_u \iint \frac{1}{2} (u - u_0)^2 + \lambda \sqrt{u_x^2 + u_y^2}\, dx\, dy$$

Going into the details a bit

My proposed research explores the adverse effect of two dominant nonlinear optical processes in silicon—self-phase modulation (SPM) and two-photon absorption (TPA)—on the linearity and sampling bandwidth of an integrated photonic-sampled ADC. SPM is a process that generates spectral broadening in pulsed signals; here it introduces unwanted interference between carrier frequencies that lowers the ADC's sampling bandwidth. It originates from the nonlinear refractive index $n(t) = n_0 + n_2 I(t)$, where the deviation from the linear refractive index is dependent on intensity. SPM-induced spectral broadening is a consequence of the intensity-dependent phase shift $\varphi_{NL}(t)$ that accumulates with propagation distance and the resulting change in the instantaneous frequency of a carrier $\delta\omega(t)$ throughout the duration of a pulse:

$$\varphi_{NL}(t) = -\frac{n_2 I(t)\omega_0 L}{c} \qquad \delta\omega(t) = \frac{d}{dt}\varphi_{NL}(t).$$

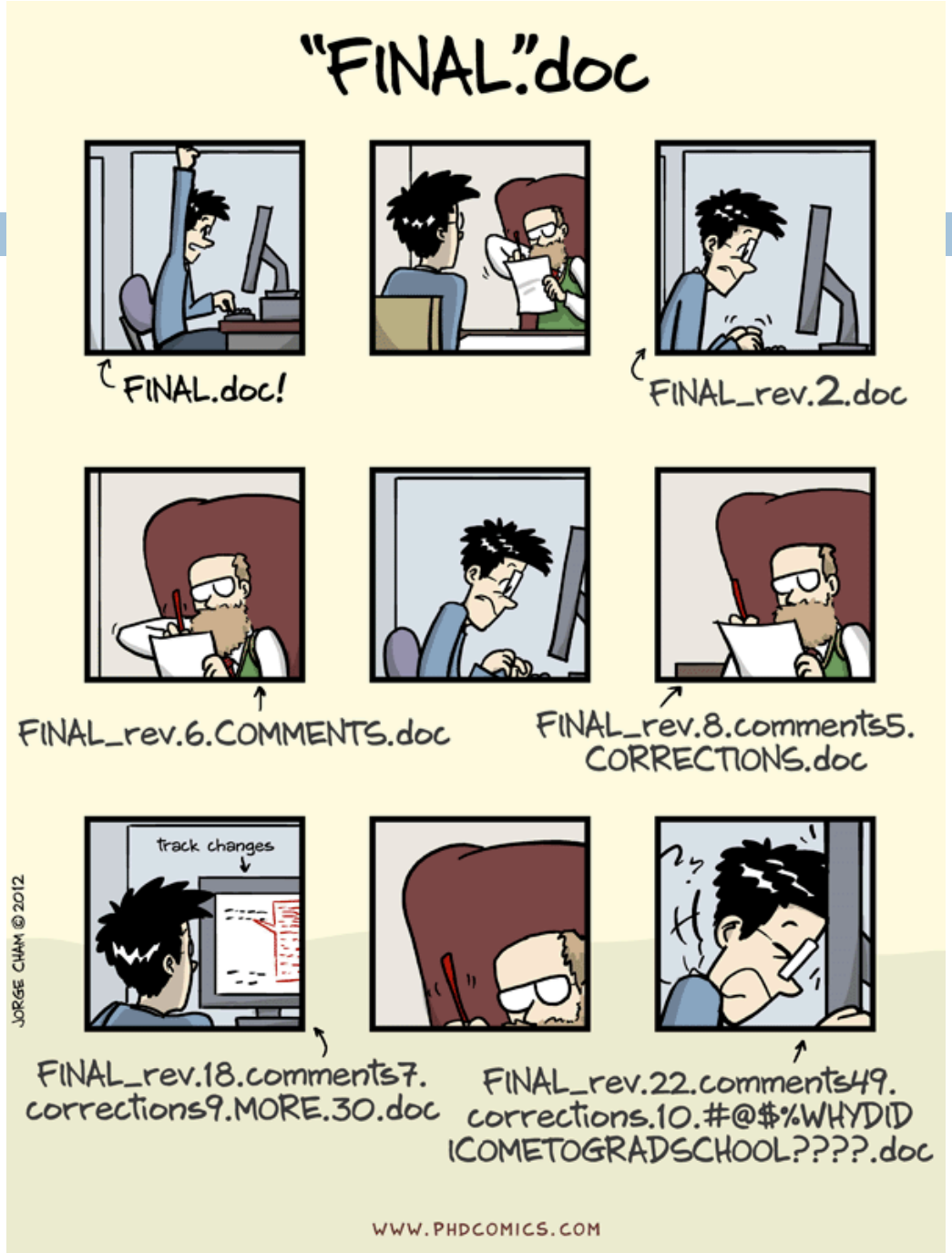
Intellectual Merits and Broader Impacts

Intellectual Merit This research will occur at the intersection of semantic parsing, dialogue systems, and robotics. To my knowledge, this will be the first work to combine these three things, and the integration may serve as a substantial step forward in human robot interaction. I will be well-situated to evaluate live performance in the CS Building, where conversational agents on AI Lab robots will be allowed to interact with students, visitors, and faculty on a daily basis. Because the system will be largely agnostic to context, learning relevant information as it interacts with users, researchers at other universities could deploy it on robots in their own buildings to conduct further studies.

Successful implementation of this system would open many avenues for further research. For example, by combining vision with the natural language understanding components and exploring how dialogue management can help facilitate task learning under human direction, as is done (without dialogue) in [3].

Broader Impact Robots that understand speech, speak back, and react to commands are at the forefront of layman thoughts about computer science. A conversational agent like the one proposed could serve as an inspiration to young children about the possibilities in a computer science career. Demonstrations for underrepresented groups in computer science, including women and minorities, could involve the conversational agent to similarly attract students. Finally, undergraduate and even late high school students to may be excited by the application to explore research in computer science.

The agnostic nature of the conversational agent gives it the flexibility to be implemented in a variety of contexts. Robots with applications from search and rescue to assisted living care could benefit from fluid, natural language communication with users.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What are reviewers looking for?

- They have 1 scoring sheet, consisting of two categories: intellectual merit and broader impacts

- They do this rating for the sum of your two essays, (so make essays cross-reference one another!)

Sample Reviews

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Good

Explanation to Applicant

The academic record of the student demonstrates determination and increasing improvement over the course of the undergraduate program. The need for the research area is well stated however, the approach is not fully developed. The applicant has significant industry experience but these have not resulted in any publications/presentations. The applicant's references offer very good evidence of the applicant's potential success.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

Explanation to Applicant

The applicant describes mentoring high school robotics teams and on-going participation in a colleague's online engineering education program. Additionally, applicant indicates plans to participate in a summer program affiliated with the online program. If successful, the "universal radio" would be a paradigm shift.

Summary Comments

The academic record of the applicant is overshadowed by their broad industry experience. The applicant's references offer very good evidence of the applicant's potential for success. Further development of the research plan would strengthen the application.

Sample Reviews

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Excellent

Explanation to Applicant

Intellectual merit of this work is strong - applicant indicates the value of merging the areas of semantic parsing, dialogue systems and robotics, something that has novelty. Applicant clearly details how this work can be used by other researchers in robotics for other work, leading to new cross-disciplinary studies.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Excellent

Explanation to Applicant

Applicant's proposed research has strong broader impact, not only in the field of robotics but also in increasing participatoin of underrepresented groups. Research also has implications for search and rescue and elder care, and application details this well.

Summary Comments

Applicant has great experience in creation and implementation of dialogue agents, and clearly understands the value and implications of this domain. Applicant has worked with many researchers and at many labs in this area, and has a great foundation upon which to build this work.

Sample Reviews

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Excellent

Explanation to Applicant

The applicant proposes to explore the adverse effects of two dominant nonlinear optical processes in silicon in order to be able to understand how they affect the performance of integrated photonic Analog to Digital Converters (ADC). If these two processes are well understood then the performance of ADC devices can be exponentially improved by employing photonics in their design. The applicant lays out a logical approach to understanding the two effects by first simulating the devices and refining the simulation values by comparing them to measurements. The applicant has a very strong aptitude to research as evidenced by the multiple research internships, grants, awards she acquired and papers she has published. Her recommendation letters attest to her teamwork, professional, research and communication skills. A common thread in her recommendation letters is her ability to draw connections between experiences and offer independent solutions.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

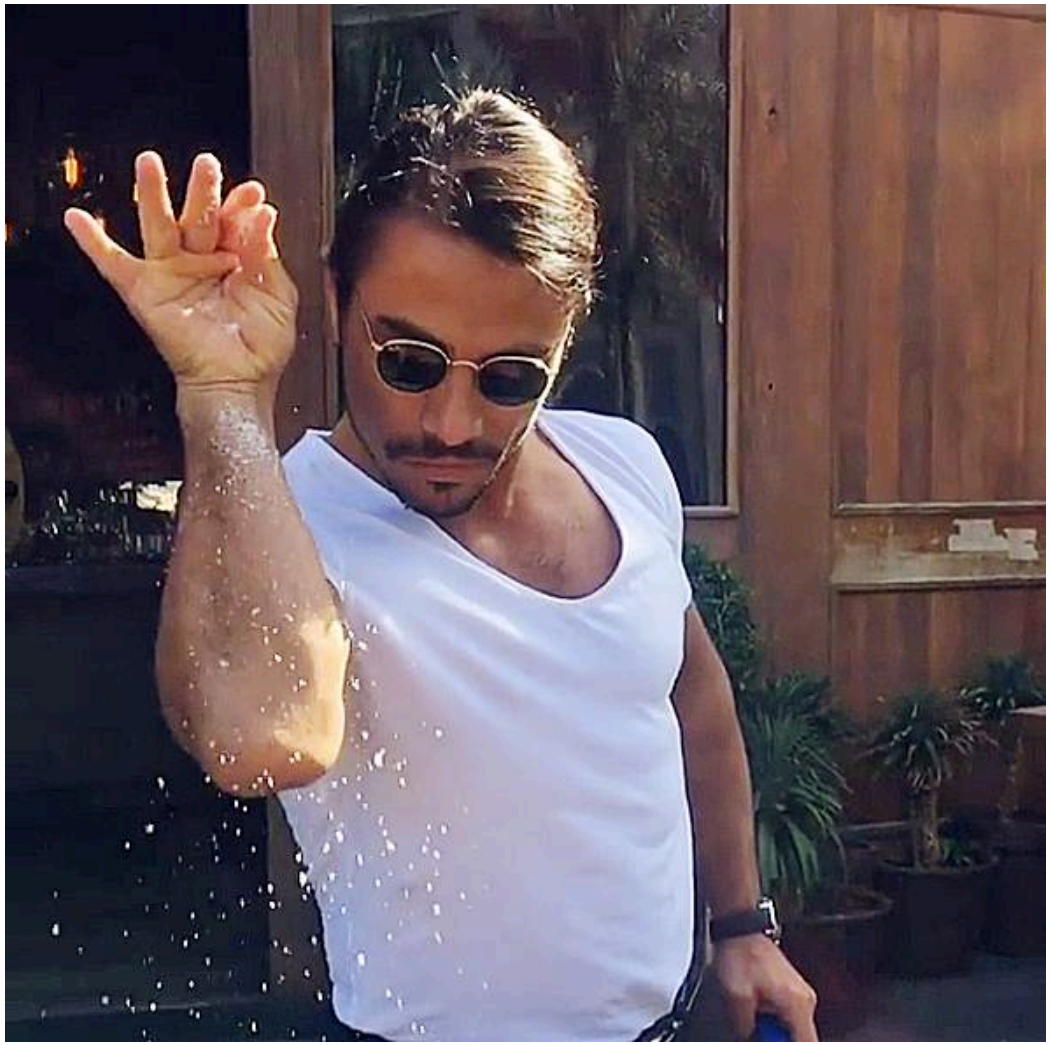
Explanation to Applicant

The applicant has demonstrated her engagement in her scientific community and dissemination of knowledge through the roles she played at her institute and other places where she interned. Her proposed research has also the potential contribute to making autonomous vehicles safe and widespread.

Summary Comments

The applicant has a strong research proposal and a sound plan for attacking the question under investigation. She has demonstrated her strong desire to research through the opportunities she sought so far (REU Intern at University of California Berkeley, DOE Intern at Lawrence Livermore National Laboratory, intern at Glenn Research Center). She also has a number of publications and involvement in her scientific community. Her academic performance is very good. It is to be noted that in her classes related to physics and optics she has As. In her classes related to engineering she average between a B and B+. Her letters of recommendation are very strong praising her ability to make connections, be a strong team player and possessing an eagerness to learn and dig deep to ask questions.

Add some spice



Style and Tone

- Direct voice

  "We may be able to show …"

  "We will show …"

  "In order to show …"

  "To show … "

Tip: Read your essay out loud. If you stumble/ awkward wording, then you should rewrite it.

Show and Tell

During my sophomore year, I assisted with the publication[1] of a student solutions manual for a new statistics book, "Elementary Statistics: Looking at the Big Picture". I solved and wrote annotated solutions for over 500 exercises that deepened the reader's intuition and comprehension of statistical tools needed to solve problems. My solutions were appreciated enough that the company, Brooks/Cole Cengage Learning, hired me to edit online instructional modules[2] for the book. This experience taught me the value of synthesis and dissemination of scientific knowledge in educational materials. The broader impact of this work was the development of educational resources used by universities and colleges to enhance future students' understanding of statistical concepts and methodology.

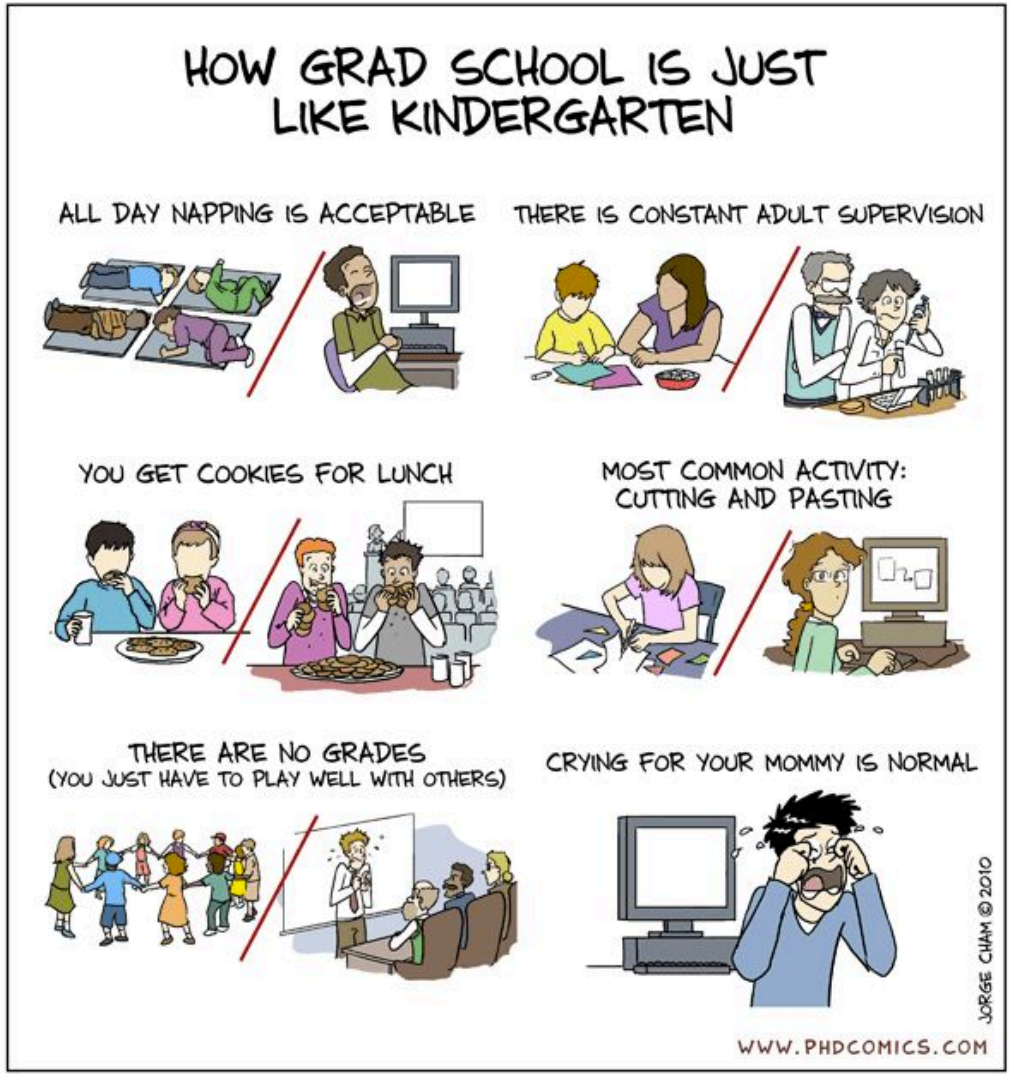
Show = specific example (use numbers, details, paint a picture!)
&
Tell = "the broader impact of this work is …."

Use bold font

I then developed my own alternative interferometry analysis technique that combined the merits of the two conventional methods, each of which failed on its own. I presented my work at the LLNL Student Poster Symposium, **wrote a paper detailing my interferometry technique**,[1] and

Helps identify points for the Reviewers to fill in their scoring sheets!

What about Graduate Schools?



Graduate School Statement of Purpose

- Do not need a research proposal
- Adapt your personal statement (no need to mention broader impacts/intellectual merits)
- Last paragraph = tailor for a specific school. Mention a couple research areas, some professor names

A good strategy

- Intro = basics of who you are, what research areas you like in the field
- Body = previous research or work/project experiences
- Conclusion = why you are a good fit for the school, name some professors you want to work with

Recommendation Letters

Needing a letter of recommendation, the grad student begins to suspect that his advisor is avoiding him. – Lego Grad Student

Recommendation Letters

- Get recommendation letters to confirm and corroborate your past research experiences/ accomplishments

- Sharing your writing samples with them = good feedback and makes your letters better as well

Good Resources

- http://www.alexhunterlang.com/nsf-fellowship
  (several sample essays/advice)

- http://www.pgbovine.net/grad-school-app-tips.htm
  (grad school advice)

- Find a graduate student who has received a NSF fellowship/a friendly professor to look over your materials

Acknowledgements

- Thanks to Cecilia Chen, Jesse Thomason, Joseph Lakeman for sharing their NSF essays/reviews
- PhD Comics and Lego Grad Student ☺
- Thanks to Dr. Jeff Wheeler for inviting me
- Email me at sjayasur@asu.edu if you want a quick read over your materials, advice, etc.