A Primer On Getting Involved In Research

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Outline

• Why get involved in Research?
• How to get involved in Research?
• Possible (Exciting) Research Topics
My Background

• Born and raised in NY, NY (just north of Harlem)

• Mother died of cancer: I was 13 years old, 2 brothers (ages 5, 6)

• 1990: PhD from MIT, Joined ASU Electrical Engineering

• Married with 2 kids

• Work/Consulting Experience: IBM, Bell Labs, Eglin AFB, NASA, Intel, Honeywell, etc.

• Research: control systems, hypersonic vehicle design, sustainability, low power electronics, portfolio management

CAREER HAS BEEN WONDERFUL !!!
Why get involved in Research?
Join Ongoing Technological Revolution

We’re experiencing a technological revolution
- Amazing things are taking place
- More amazing things will take place over the next decade

...we want and need you to participate

...the Nation NEEDS YOU!
Many HOT Areas

Amazing discoveries/innovations will take place over the next decade....

• Green energy, electric vehicles
• Mass storage, super computing, immersive asynchronous learning
• Genetic engineering, personalized medicine, prosthetics
• Neuroscience
• Advanced robotics
• Hypersonic vehicles, etc.

We want you to be part of it!

Nation needs you to be significant participants!!

MANY opportunities to take advantage of!!!

(…just need to prepare....)
Why Does the Nation Need You?

- After WWII, US had little competition; with 2 oceans for protection
- NO longer the case…due to increasingly global economy
- To remain competitive, US
  - can no longer afford to rely on imported talent
  - must find & nurture talent from within
  - cheap labor is an issue, need to rely on new technical innovation and creativity
- THAT’s YOU!
  - Financial opportunities;
    Especially for MS and PhD!
    $$$
Nation needs you to be significant participants!!
MANY opportunities to take advantage of!!
(…just need to prepare…)
Why Get Involved In Research?

- Figure out what you really want to do and do not want to do in future
- Type of Work
  - What technical area within STEM do you wish to work in? (Many hot areas)
    - Design, analysis, manufacturing, sales, reliability, testing, customer support
    - Devices, software, hardware, systems, enterprise solutions
- Work Environment: within lab, at desk, behind computer, etc.
  - Instruments, experimental, trial-and-error, computer code, systematic application of STEM principles, development of new theory
  - Left brain (analytical, sequential), right brain (intuitive, more big picture), both
  - Improve old stuff, develop new stuff, develop really new stuff
  - Large or small group/company/lab, freedom of academia
- Learn about your strengths and weaknesses
Why Get Involved In Research?

- Learn about a particular field (The Big Picture)
- Learn what critical areas, sub-areas, and details are being addressed
- Learn how to formulate relevant problems and sub-problems
- Learn how to evaluate and compare alternate technical approaches
- Learn to work in teams and work independently
- Learn to present your work – written and verbally
- Prepare for advanced work; e.g. graduate school, STEM workplace
- Do something significant beyond standard coursework
- Looks good on resume for graduate school, scholarships, fellowships, internships, job

NOTE: No class or book will do this for you!

Sooner you “figure things out,” the better you can plan ahead!!
How to get involved in Research?
When Should You Start?

- Time is precious
- Competition is fierce
  - you are competing within an increasingly global economy
- Cannot afford to procrastinate
- Must prepare for inevitable recovery

YOU MUST START IMMEDIATELY!
How Do You Get Started?

- Read, Read, Read! You cannot read enough!!
  - www (e.g. professor, company, and national laboratory web sites)
  - our career planning web site: [http://aar.faculty.asu.edu/lapdp.html](http://aar.faculty.asu.edu/lapdp.html)
  - professional society magazines, conference papers, some journals, presentations, theses (MS, PhD)
  - do NOT be intimidated - everyone got started by doing lots of “fishing/hunting”

- Attend technical seminars and professional development workshops

- Speak to
  - students (juniors, seniors, graduate students), lab teaching assistants (TAs)
  - professors and practicing STEM professionals (industry people)
  - members of professional organizations (e.g. IEEE, AIAA, ASME, NSBE, SHPE, etc.), student branches

**Come Prepared with GOOD Questions!**
Finding an Exciting Research Topic: HOT Areas to Consider
What do Engineers do? What have they done?

Engineers … Have significantly impacted our world
Are creative problem-solvers
Are essential to our health, happiness, and safety

- Electrification
- Automobile
- Airplane (Jets)
- Water Supply & Distribution
- Highways
- Telephones (Smart Cell)
- Petroleum & Petrochemicals
- Electronics
- Radio & Television
- Agricultural Mechanization
- Computers (Super, desk/lap tops)
- Air Conditioning & Refrigeration
- Spacecraft
- Internet
- Imaging
- Household Appliances

- Health Technologies
- Laser & Fiber Optics
- Nuclear Technologies
- High-Performance Materials

…Quite an IMPRESSIVE LIST!

…But there’s much to be done!!
Exciting 21\textsuperscript{st} Century Challenges

**ENERGY & SUSTAINABILITY**

- **BATTERIES**: Low-cost long-life supercharged batteries (e.g. Li-ion phosphate for electric vehicles)

- **BIOFUELS**: Green biofuels to displace oil consumption and greenhouse gases (e.g. corn or sugar cane based)

- **FUEL**: Turning sunlight into carbon-neutral fuel (replicate photosynthesis)

- **SOLAR**: Cheap highly efficient solar cells

- **BUILDINGS**: Self-sufficient (green) buildings – produce all energy they consumes

- **WASTE**: Safe inexpensive disposal of toxic and radioactive wastes
Exciting 21st Century Challenges

COMMUNICATIONS, COMPUTING, & LEARNING

• **RADIO**: Cognitive radio (frequency switching)

• **COMPUTING**: Exascale supercomputer (\(10^{18}\) calc/sec within 10 years; yotta, zetta, exa, peta, tera, giga, mega flops)

• **MEMORY**: Massive memory (Library of Congress on a Chip)

• **LIBRARIES**: Interactive digital mobile libraries

• **TEACHING**: Immersive High Definition Game-Quality Teaching Software

• **LEARNING**: On-Line Interactive Asynchronous Learning for All

• **LANGUAGE**: Real-time language translation (currently 5000 words/day, 0.15/word)
Exciting 21st Century Challenges

PERSONALIZED MEDICINE

- **DIAGNOSIS**: Earlier disease diagnosis (via saliva sample)

- **DNA SEQUENCING**: Rapid Low-Cost DNA sequencing (e.g. map all forms of cancer)

- **PERSONALIZED DRUGS**: Drugs tailored to individuals

- **CANCER**: Smart anti-cancer therapies (e.g. cell directed nanotechnology)

- **MALARIA**: Cheap anti-malarial drugs

- **VACCINES**: Vaccines for every flu strain

- **ORGANS/LIMBS**: Regenerative organs/limbs

- **PROSTHETICS**: Brain-powered prosthetics
Exciting 21st Century Challenges

MATERIALS

- **ARMOR**: Lightweight vest to stop armor-piercing bullets
- **ENERGY**: Energy efficient materials
- **MEDICAL**: Medical materials that can be used within humans

TRANSPORTATION

- **AEROSPACE**: Two-stage to-orbit (TSTO) via hypersonic vehicles
- **AIR TRAFFIC**: Revamp air traffic control
- **RAIL**: High speed rail
- **CARS**: Electric and hybrid vehicles

See Obama’s 25 Ways to Rebuild America for additional information
GRAND CHALLENGES
Exciting 21st Century Challenges

ENERGY & SUSTAINABILITY

- **BATTERIES**: Low-cost long-life supercharged batteries (e.g. Li-ion phosphate batteries ssto power electric vehicles, 100’s of miles on a single charge)
  
  - GE, IBM, Warren Buffett's Berkshire Hathaway
  - Chinese automaker BYD
  - Watertown (Mass.) based A123 Systems
Exciting 21st Century Challenges

ENERGY & SUSTAINABILITY

• *BIOFUELS*: Green biofuels to displace oil consumption and reduce greenhouse gases (e.g. corn or sugar cane based, exploit wastes)
  - 21 B gallons by 2022 – non food crops
  - Archer Daniels Midland, Deere, Monsanto (e.g. corn field waste)
  - GM, Warreenville (Ill.)-based renewable energy firm Coskata are working on a system to break down cellulosic biomass - as well as certain kinds of trash - and convert it to biofuel
Exciting 21st Century Challenges

ENERGY & SUSTAINABILITY

- **FUEL:** Turning sunlight into carbon-neutral fuel (replicate photosynthesis)

\[
2n \text{ CO}_2 + 2n \text{ H}_2\text{O} + \text{photons} \rightarrow 2(\text{CH}_2\text{O})_n + n \text{ O}_2
\]

Carbon dioxide + electron donor + light energy \(\rightarrow\) carbohydrate + oxygen
ENERGY & SUSTAINABILITY

- **SOLAR**: Cheap highly efficient solar cells (as cheap as paint!)
  - Dow Chemical recently announced solar roof shingles that use low-cost, thin-film photovoltaic cells (no special installation skills, 2011).
  - Ascent Solar Technologies set to begin shipping highly efficient solar cells made from copper, indium, gallium, and selenium.
Exciting 21st Century Challenges

ENERGY & SUSTAINABILITY

• BUILDINGS: Self-sufficient (green) buildings – produce all energy they consume
  - United Technologies and Honeywell
  - developing industrial-specification, energy-efficient systems for heating, ventilation, and water
ENERGY & SUSTAINABILITY

- **WASTE**: Quick, safe, inexpensive disposal of toxic and radioactive wastes
  - Pressure on global suppliers from retail giant Walmart
  - Dell and Apple engineering electronics that don't create waste
  - Other advances will come from govt agencies such as the Environmental Protection Agency when further iterations of nuclear power are explored
Exciting 21st Century Challenges

COMMUNICATIONS, COMPUTING, & LEARNING
• **RADIO**: Cognitive radio (frequency switching)
  - Develop phones and wireless devices that seamlessly switch between radio frequencies whether using Internet, TV, or a cellular signal.
  - Dell, Google, Hewlett-Packard have petitioned FCC to make unused TV spectrum (~7MHz-1GHz) available for cognitive devices
  - Cognitive network could continually adapt and allocate resources according to customer needs and demands
COMMUNICATIONS, COMPUTING, & LEARNING

- **COMPUTING**: Exascale supercomputer \((10^{18} - \text{million trillion} - \text{calc/sec within 10 years; yotta, zetta, exa, peta, tera, giga, mega})\)
  - 2010 – Chinese Tianhe-1, meaning Milky Way, achieved 2,570 trillion calc/sec (petascale)
  - IBM's $133 million Roadrunner was fastest - thousand trillion calc/sec (petascale)
  - HP, Microsoft, DARPA contributing

Significantly impacts ability to solve hard problems; e.g. weather prediction, finding new medicines, hypersonic vehicles
COMMUNICATIONS, COMPUTING, & LEARNING

- **MEMORY**: Massive memory (Library of Congress on a Chip)
  - AT&T and other telecommunication companies already use sophisticated data-compression technologies to store vast sums of information
  - Internet companies such as Facebook and Myspace, which hold information on millions of users, say flash storage is crucial
  - EMC, IBM, HP working to squeeze more memory onto flash drives
  - Flash drive – type of EEPROM (electrically erasable programmable read-only memory) that is erased and programmed in large blocks
COMMUNICATIONS, COMPUTING, & LEARNING

• LIBRARIES: Interactive digital mobile libraries

- Build rich, interactive, digital library for every child
- Amazon's Kindle e-reader ignited an explosion in mobile book and magazine reading.
- Google Books' collection of digitized literature is growing
- Apple’s iPad works with iTunes; a mobile library
COMMUNICATIONS, COMPUTING, & LEARNING

• *TEACHING*: Immersive High Definition Game-Quality Teaching Software

- Build educational software that's as compelling as the best video game and as effective as a personal tutor

- Chicago-based PrepMe has developed customizable test prep software that tracks a student's progress and tailors the educational experience. Company plans to expand offerings into software for classrooms

- Rosetta Stone's innovations in language-teaching software including live chats with experts and intro of game-like, logic-based learning exercises – could be expanded to include many subjects
COMMUNICATIONS, COMPUTING, & LEARNING

• LEARNING: On-Line Interactive Asynchronous Learning for All
  - Sun Microsystems applying open-source model to online textbooks, which the company says will ultimately be freely available.
  - MIT already offers free lecture notes, exams, and videos
  - Apple's iTunes U presents material from many other universities and colleges
COMMUNICATIONS, COMPUTING, & LEARNING

• LANGUAGE: Real-time language translation (currently 5000 words/day, $0.15/word)
  - Create highly accurate, real-time translation between major world
  - Waltham (Mass.)-based Lionbridge Technologies; human-assisted machine translation
  - A computer program tackles 1st round of word-and-sentence conversion, about 90% of work. Human then corrects mistakes, clarifies sentences, and refines the language.
  - Progress in computing power and language research could make real-time translation a reality
PERSONALIZED MEDICINE

**DIAGNOSIS:** Earlier disease diagnosis (via saliva sample)

- Attain early detection of dozens of diseases via a saliva sample.
- Bristol-Myers Squibb and Quest Diagnostics already using spit samples to test for mutations that make some patients immune to certain treatments.
- Google-backed startup 23andMe collects saliva samples and looks for genetic variations in DNA that might reveal possible future diseases.
Exciting 21st Century Challenges

PERSONALIZED MEDICINE

- **DNA SEQUENCING**: Rapid Low-Cost DNA sequencing (e.g. map all forms of cancer)
- **PERSONALIZED DRUGS**: Drugs tailored to individuals
- **CANCER**: Smart anti-cancer therapies (e.g. cell directed nanotechnology)
  - Nanotechnology and microtechnology researchers refining medicines that deliver drugs only to disease-infected cells
  - Univ of Chicago Medical Center, Energy Dept.'s Argonne National Laboratory
  - Bet on pharmaceutical industry to test and bring the new treatments to market
PERSONALIZED MEDICINE

- **MALARIA**: Cheap anti-malarial drugs
- **VACCINES**: Vaccines for every flu strain
  - Develop universal vaccine for influenza to protect against all future strains
  - hundreds of strains circulating; ever-morphing virus - universal vaccine not likely soon
  - closer a vaccine can match a strain, the less severe the virus's effects will be
  - Major US players: Baxter, VaxInnate, Pfizer, Novavax, and Merck
Exciting 21\textsuperscript{st} Century Challenges

PERSONALIZED MEDICINE

\textbf{ORGANS/LIMBS:} Regenerative organs/limbs

- Develop regenerative medicine that can create an organ or regrow a limb.
- Amgen says its prowess in cellular and molecular biology places the company in a prime position to uncover treatments to repair or replace tissue and organs.
- The Wake Forest Institute for Regenerative Medicine - Winston-Salem, N.C. – 1\textsuperscript{st} to grow an organ in a lab, implying it might have success with limb regrowth
- Politically issues: stem-cell research

\textbf{PROSTHETICS:} Brain-powered prosthetics

- Iceland's Ossur
Exciting 21st Century Challenges

MATERIALS

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TRANSPORTATION

- **AEROSPACE:** Two-stage to-orbit (TSTO) via hypersonic vehicles
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Areas That I Have Worked In
Research Interests

- Automatic Control Systems
- Semiconductor Manufacturing
- Robotic Systems
- Electromechanical Systems
- Aerospace Systems
- Sustainability
- Portfolio Management
Flexible Autonomous Machines operating in an uncertain Environment

- semiconductor processes and manufacturing
- robotics and automation
- advanced vehicles and transportation systems

Note: All involve systems that need to be controlled. FAME offers something for everyone...all encompassing umbrella for multidisciplinary research

Started in 1994.
To Dr. Armando A. Rodriguez
Congratulations!

Bill Clinton
What did FAME include?
Bell Laboratories  (Murray Hill, Holmdel, NJ)
  ◦ Control of LANs, Robotics, Complex Systems

Sikorsky Aircraft
  ◦ AFCS design for UH-60A Blackhawk
  ◦ AFCS for Twin Lift Helicopter System
Twin Lift Helicopter System

SIMULINK simulation driving the animation in real-time
Tilt-Wing Rotorcraft
Raytheon Missile Systems (Bedford, MA)
- Patriot Missile Autopilot Design

Eglin AFB (Pensacola, FL)
- Extended Medium Range Air-to-Air Technology (EMRAAT) Missile Guidance and Control System Design
Background

- Intel
  - Control of a re-entrant semiconductor manufacturing line (e.g. Pentium fab)
  - allocate resources in the presence of uncertainty
  - maximize $$\$, minimize average tpt (to help make promises), minimize variance of tpt (to help keep promises)
  - Fab costs ~$3B; makes ~$1M/hr profit
Honeywell

- Space Weaponry/Imaging Systems
  - e.g. Space Integrated Control Experiment (SPICE)
    - Laser beam expander/telescope
      - rapid slewing and precision pointing of flexible structure Satellite Attitude Control

- Satellite Attitude Control
Honeywell/Boeing

- Flight Management System (FMS) Design
  - commercial aircraft guidance
- High Speed Civil Transport (HSCT)
  - 300+ passengers, Mach 2.2
  - Flexible structure (long, thin)
  - Automatic Landing System
Boeing Space and Defense (Seattle, WA)

- M&S of two Major Regional Conflicts (MRC’s)
- Joint Strike Fighter (F-35)
- V-22 Osprey (Tilt-rotor)
- Autonomous vehicles
NASA - Jupiter Icy Moon Orbiter (JIMO)
• NASA – Hypersonic Vehicles, Mach 5-15

X-43A 2004: Mach 7, 10

X-51A 2010: Mach 6
Background

- Robotics
Sustainability

- Management of Renewable Resources
- Management of World Fisheries
- Management of Irrigation Systems
- Energy Efficient Buildings
- Energy Policy to Address Global Warming Concerns
Other Important Things to Consider
What Else Should You Do?

You MUST consider applying for

- Tutoring, grading, laboratory assistant, and teaching/research assistant (TA) positions - Look for university advertised positions
- Unpaid research projects
- Paid research projects
  - ASU
    - FURI (Fulton Undergraduate Research Initiative)
    - WAESO (Western Alliance to Expand Student Opportunities)
- Summer internships: industry, national laboratories (e.g. Sandia, Lawrence Livermore, etc), universities
- Apply here, there…Apply everywhere (Dr. Seuss, “Green Eggs and Ham”)
- ASU, other schools, national laboratories, companies
Getting Involved: Things to Keep In Mind

WANT TO CREATE POSSIBILITY FOR GAINING:

- BIG PICTURE understanding of a STEM area or related areas
  - What problems do they work on? What methods?
  - What potential career/education/growth opportunities exist?

- Useful learning experiences (e.g., technical, etc) to help you figure “things” out


- Information to identify a possible topic or topics for: senior design project, undergraduate (honors) thesis, MS thesis, PhD thesis, future area of work

- Knowledge of your strengths and weaknesses

- Knowledge about relevance of your classes as they related to real-world STEM practices
Getting Involved: Things to Keep In Mind

WANT TO CREATE POSSIBILITY FOR GAINING:

- A more significant follow-up position
- Meeting new people, developing lifelong contacts…i.e. critical networking
- An advisor and/or mentor (advisor ++)
- A good letter of recommendation
  - for scholarships, internships/jobs, fellowships, graduate school, awards, promotions
  - you will need them throughout you entire career
- Experience in presenting your work at a professional conference/meeting
- Fun and memorable travel opportunities
- Another useful “experience line” on your resume
- A little MONEY - $$$$$
CRITICAL Skills You MUST Develop

- Summarizing large quantities of technical information
  
  Understanding the BIG PICTURE is always crucial!
  
  (This is true for everything you do in life!!)

- Technical and analytical skills
- Programming - e.g. C++, JAVA, MATLAB, etc.
- Communication - writing, proposals, presentations, interviewing
- Working on multidisciplinary teams, organizational skills and leadership
- Financial management
- Understanding critical tradeoffs and true costs – to properly prioritize
- Decision making in the presence of uncertainty
THANK YOU

VERY MUCH!