An Expanding and Expansive View of Computer and Information Science and Engineering

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Overview

- CISE: the national imperative
- NSF and CISE
- Future challenges and opportunities (CISE)

CISE Research: Addressing National Priorities

- Big Data R&D
- National Robotics Initiative
- Understanding the Brain
- National Strategic Computing Initiative
- Smart Cities
- CS for All
- Advanced Wireless Initiative
Many STEM jobs are in computing

Job Openings 2014 – 2024 (growth and replacement)
US Bureau of Labor Statistics

Data from the spreadsheet linked at http://www.bls.gov/emp/ind-occ-matrix/occupation.xlsx

Growth in CS Undergrad Majors

Newly declared undergrad CS/CE majors

Source: 2015 CRA Taulbee Survey
From federally-funded research to $B industries

Advances in computing, communications, information technologies, cyberinfrastructure:

- drive U.S. competitiveness, sustainable economic growth (IT: 25% of economic growth since 1995)
- underpin national security
- have profound impacts on our daily lives

From Continuing Innovation in Information Technology, NRC, 2012.
... and this impact will continue

Top twelve economically disruptive technologies (by 2025)

CS and national economic competitiveness: on beyond the Internet and Google

Machine Learning
- Big Data Analytics Market: $125B (Forbes)
- Eric Schmidt: (Google/Alphabet):
  - Google Pittsburgh: generated $30-40B in profit for Google
  - NSF: "where all interesting research gets started..."

Software-Defined Networking (SDN)
- $8B in 2018 (IDC)
NSF/CISE: research leadership in government

- **2016 Federal R&D Strategic Plans:**
  - Privacy
  - CyberSecurity
  - Artificial Intelligence
- Networking and Information Technology R&D (NITRD)
  - Coordination among 18 federal agencies

It is an exciting, impactful and important time to be in computer and information science and engineering!!
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National Science Foundation’s Mission

“To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
CISE by the Numbers: FY 2015

- $933 M FY 2015 research budget
- 8,039 proposals
- 1,887 awards
- 17,868 people supported
- 342 panels
- 7,302 senior researchers
- 1,278 other professionals
- 498 postdoctoral associates
- 6,423 graduate students
- 2,367 undergraduate students

23% success rate
CISE Division Budgets
Modest growth across all CISE divisions

NSF Support of Academic Basic Research
(as a percentage of total federal support)

<table>
<thead>
<tr>
<th>Field</th>
<th>Obligation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Science and Engineering Fields</td>
<td>24%</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>40%</td>
</tr>
<tr>
<td>Engineering</td>
<td>41%</td>
</tr>
<tr>
<td>Environmental Sciences</td>
<td>59%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>61%</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>67%</td>
</tr>
<tr>
<td>Biology</td>
<td>68%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>82%</td>
</tr>
</tbody>
</table>

An expanding, expansive view of computing

**CISE foundations**
- Theoretical foundations
- Algorithms
- Programming languages
- Learning
- Systems: networks, OS, DB
- data to knowledge to action
- Societal impacts

Computational science
- Software
- Security
- Intelligence
- Computational neuroscience
- Information sys
- Communication, control

**Human-centered computing**
- Assistive technologies, affective computing, social informatics, mind/machine interface, brain

**Science, societal applications**
- Science, engineering, humanities
- health, security, environment,
- energy, transport, commerce,
- education

Nano, quantum, molecular, optical

Changing “physicalness” of computing

Smart vehicles & buildings, cyber-physical systems, swarms, mobile/cloud

computing embedded around us
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NSF “Big Ideas”
NSF “Big Ideas”

- Harnessing Data for 21st Century Science and Engineering
- Shaping the new Human – Technology Frontier
- Understanding the Rules of Life: Predicting Phenotype
- The Quantum Leap: Leading the Next Quantum Revolution
- Navigating the New Arctic
- Windows on the Universe: The Era of Multi-messenger Astrophysics

- Growing Convergent Research at NSF
- Mid-scale Research Infrastructure
- NSF 2050
- INCLUDES

*Video of NSB presentation and discussion is at:
http://www.tvworldwide.com/events/nsf/160505/globe_show/default_go_archive.cfm?gsid=2957&type=flv&test=0&live=0
(the presentation/discussion starts about 20 minutes into this video)

An Interconnected NSF – Solving the Big Idea Challenges Together
Harnessing the Data Revolution

Research across all NSF Directorates

Theoretical foundations
- mathematics, statistics, computer & computational science

Systems foundations
- data-centric algorithms, systems

Data-intensive research
- in all areas of science and engineering

Educational pathways
- Innovations grounded in an education-research-based framework

Advanced cyberinfrastructure ecosystem
- Accelerating data-intensive research

Work at the Human-Technology Frontier: Shaping the Future

Emerging technologies and human-technology interactions are transforming the world of work and the lives of workers

Understanding how constantly evolving technologies are actively shaping our lives and how we in turn can shape those technologies, especially in the world of work

• understand benefits, risks of new technologies: efficiency, quality, productivity, human dynamics
• science and engineering: creating technologies that promise to enhance work lives
• Education: changing workplace demands changing workforce
Work at the Human-Technology Frontier: Shaping the Future

Seamless collaboration between human, cyber-enabled systems:
- understanding of reciprocal human-technology interactions;
- Systems: tailored, optimized, continuously adapted for humans; and
- education and lifelong learning to create requisite workforce

Challenge: research investment

- US: now 10th in national R&D (% GDP)
- investment federal support for basic research down 13% from 10 years ago (% of GDP)
- CISE: growing field
Partnerships: Many dimensions

Partnerships build capacity, leverage resources, increase the speed of translation from discovery to innovation

New 2016 activities
- NSF/SRC: E2CDA
- NSF/Intel: Information-Centric Networking in Wireless Edge Networks
- NSF/VMware: Software Defined Infrastructure as a Foundation for Clean-Slate Computing Security
- Innovation Transition DCL
- Infrastructure collaborations

Prescription 3: Establishing a More Robust National Government-University-Industry Research Partnership

Partnerships: Many dimensions

Partnerships build capacity, leverage resources, increase the speed of translation from discovery to innovation

- Cyber Physical Systems (CPS): DHS, DOT, NASA, NIH
- National Robotics Initiative (NRI): DARPA, NASA, NIH, USDA
- Smart and Connected Health (SCH): NIH
- Collaborative Research in Computational Neuroscience (CRCNS): NIH
  all joint with other NSF directorates
Partnerships: Many dimensions

Partnerships build capacity, leverage resources, increase the speed of translation from discovery to innovation

- NSF-BSF (Israel): CCF and CNS core, SATC
- US-Japan: interest in BIGDATA, ML
- NSF-Finland: WIFUS
- NSF-India: S&CC
- NSF-Netherlands: privacy
- NSF-Brazil: cybersecurity

Education: Computer Science for All

- Enable all students to have access to high-quality CS education in K-12:
  - Knowledge base, capacity for rigorous, engaging CS education
  - Teacher PD
- Inter-agency WG under CoSTEM kicking off today!
- Collaboration: industry, non-profits
- NSF: $120 million over five years

“In the new economy, computer science isn’t an optional skill – It’s a basic skill...”
President’s Weekly Address 1/30/2016
Education

Explosion of interest seems different this time around
- broader interests
- minors, other disciplines
Education

- Increasing CISE footprint, program sizes imply increasing TT faculty sizes?
  - additional grant pressures
  - funding expectations based on history 10+ years ago
  - career pathways for PhD students?

- Interesting reading:
  - “Rescuing US Bio-medical Research from its systemic flaws,” Albers, Kirschner, Tilgham, Varmus, PNAS

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Education

- **second sea change (tsunami):** broadening interest in computing among incoming students
- success of K-12 activities
- CS+X
An *amazing* time to be in CISE!

**Ubiquity**
Computing is everywhere – across all of science and engineering, and all of society

**Engagement**
Computing intertwines with many *communities*

**Urgency**
Computing is *rapidly expanding and evolving*. There is tremendous opportunity … *now!*

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Computer Science Department 50th Anniversary Event
THANKS!