Research Directions
NSF Directorate of Computer and Information
Science and Engineering
(With an Emphasis on AI)

Jim Kurose
Assistant Director, NSF
Computer & Information Science & Engineering

6th Annual Federal R&D Agency Workshop
State University System of Florida
Oct. 2018
CISE programs address national priorities

- Big Data & AI
- Cybersecurity
- Robotics & Manufacturing
- Quantum Information Sciences
- Advanced Cyberinfrastructure
- Smart Communities
- Computer Science Education
- Advanced Wireless Research
CISE by the Numbers: FY 2017

- $936 M FY 2017 research budget
- 8,723 proposals
- 390 panels
- 1,819 awards
- 21% success rate
- 17,778 people supported
- 7,230 senior researchers
- 1,086 other professionals
- 489 postdoctoral associates
- 6,539 graduate students
- 2,624 undergraduate students
NSF Supports All Areas of Fundamental Research

NSF support as a percentage of total federal support for basic academic research

- All Science and Engineering Fields: 27%
- Physical Sciences: 45%
- Engineering: 46%
- Environmental Sciences: 63%
- Mathematics: 64%
- Social and Psychological Sciences: 68%
- Biology: 69%
- Computer Science: 83%

Economic impact of CISE: From Federally-funded research to billion-dollar industries

Advances in computing, communications, information technologies, and cyberinfrastructure:

- drive U.S. competitiveness
  - IT accounts for 25% of economic growth since 1995;
  - resulted in many billion-dollar industries: networking, software, digital communications, computer graphics, AI and robotics, and more
- have profound impacts on our daily lives.

.... across many industries
This impact continues today

Machine Learning

- Big Data Analytics Market: $125B (Forbes)
- Deep learning rooted in NSF-funded research on neural networks, reinforcement learning

“NSF is where all interesting research gets started…” - Eric Schmidt, Google / Alphabet

Software-Defined Networking (SDN)

- SDN Market: $18B in 2018 (IDC)
- SDN resulted from NSF-funded foundational research

Open Programmable Mobile Internet 2020 project funded by NSF/CISE Expeditions program, 2008, N. McKeown, Stanford U.

Fundamental research powers innovation
CISE Academic Community

“21% one-year, a 64% two-year, and a 107% three-year increase in the number of [tenure track CS faculty] positions being searched for” (Wills, Nov. 2017)

“Enrollments in CS courses and the number of CS majors have risen markedly since 2005 ... no indication that enrollments will fall in the near term. Both CS majors and non-majors have contributed significantly to the recent growth” (NASEM 2017)

Job Openings 2014 – 2024
(growth and replacement)
US Bureau of Labor Statistics
NSF/CISE Division Budgets

Appropriated § (SM) per CISE division


CNS  OAC  IIS  CCF  ITR
NSF/CISE Division Budgets

![Graph showing NSF/CISE Division Budgets from FY 2010 to FY 2019. The graph compares Appropriated $ (M) per CISE division for different divisions: CNS, IIS, CCF, and ITR. The data is presented for each fiscal year from 2010 to 2019, with a color-coded line for each division.]
NSF/CISE Division Budgets

Appropriated $ (\$M) per CISE division

CNS
OAC
IIS
CCF
ITR

FY 2010
FY 2011
FY 2012
FY 2013
FY 2014
FY 2015
FY 2016
FY 2017
FY 2018
FY 2019
CP
NSF/CISE Division Budgets

Appropriated $ (\$M) per CISE division

- CNS
- OAC
- IIS
- CCF
- ITR

FY 2010 - FY 2019
Outline

NSF/CISE Overview
Budget Overview
Selected Programmatics
Looking Forward
AI framework: “Narrow” vs. “General”

Narrow AI

- Solving individual tasks in specialized, well-defined domains: speech recognition, image recognition, and translation
- Source of much recent excitement, e.g. “deep learning”, IBM Watson, DeepMind's AlphaGo

General-purpose AI

- Exhibiting flexibility and versatility of human intelligence in a broad range of cognitive domains, including learning, reasoning, creativity, and planning
- Transferring what is learned or experienced in one task to another
- “intent,” “meaning,” and “understanding” in AI systems
AI framework: “Narrow” vs. “General”

Narrow AI

Classification: a child playing with blocks

(facial) recognition

A stop sign (?)

General-purpose AI

Intelligent, flexible, cooperative behavior

Credit: J. Tenenbaum. MIT Center for Mind, Brain, and Machines
AI framework: “Narrow” vs. “General”
**Artificial Intelligence**

*Transformative science that holds promise for tremendous societal and economic benefit with potential to revolutionize how we discover, work, learn, and communicate*

- **CISE core research programs:**
  - Cyber-human Systems
  - Robust Intelligence
- **Cross-directorate programs:**
  - BIGDATA
  - NRI-2.0: Ubiquitous Collaborative Robots
  - Smart & Connected Communities
  - Smart and Connected Health
  - Collaborative Research in Computational Neuroscience
- **CISE Expeditions in Computing**
- **AI+X: ML as a new horizontal**
- **Overall CISE investment:** $120M

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CISE “core” programs and AI

Information Integration and Informatics → Robust Intelligence → Cyber Human Systems

databases, data mining, reasoning and representation, computational neuroscience, machine learning, computer vision, computational neuroscience, robotics, multi-agent systems, collaborative systems, information extraction, speech and language, visual analytics, human-robot interaction, augmented human, intelligent interfaces, social computing, bioinformatics, databases, information extraction, visual analytics.
Smart and Connected Communities (S&CC)

Improving quality of life, health, well-being, and learning in communities

- Smart and connected community - a community that synergistically integrates intelligent technologies with the natural and built environments, including infrastructure, to improve the social, economic, and environmental well-being of those who live, work, or travel within it.
  - Integrative research that addresses the technological and social dimensions of smart and connected communities
  - Meaningful community engagement that integrates community stakeholders within the project
- Cross-Directorate: CISE, EHR, ENG, SBE
- Growing Collaboration with other agencies
Office of Science & Technology Policy (OSTP)

Lynne Parker
Assistant Director for AI

Jim Kurose (former)
Assistant Director for AI

National Science and Technology Council (NSTC)

France Cordova
AI Select Committee Co-chair (with DARPA, OSTP)

Select Committee on AI

Committee on Technology

Committee on S&T Enterprise

Networking and Info. Tech. R&D (NITRD)

AI R&D Interagency Working Group

Erwin Gianchandani
Jim Kurose
MLAI co-chairs

Machine Learning and AI (MLAI)

Working groups

Subcommittees

Request for Information on Update to the 2016 National Artificial Intelligence Research and Development Strategic Plan

Co-chair (with DARPA, OSTP)
“... bold questions that will drive NSF's long-term research agenda -- questions that will ensure future generations continue to reap the benefits of fundamental S&E research.”
Harnessing the Data Revolution

Research across all NSF Directorates

**Theoretical foundations**
Transdisciplinary Research in Principles of Data Science (TRIPODS)

**Systems foundations**
Data-centric algorithms, systems: BIGDATA

**Data-intensive research**
across all science & engineering
TRIPODS+X

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Educational pathways

Innovations grounded in an education-research-based framework
NASEM study on data science at the undergraduate level;
NSF Research Traineeship (NRT);
NSF Graduate Research Fellowship Program (GRFP)

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Advanced cyberinfrastructure

Accelerating data-intensive research.

Cyberinfrastructure for Sustained Scientific Innovation (CSSI);
Scalable data-driven Cyberinfrastructure Dear Colleague Letter (DCL);
Midscale infrastructure (Midscale Request for Information (RFI))
The Future of Work at the Human-Technology Frontier

Improving the quality of work while also increasing productivity and economic growth with increased technologies

Research Themes

- Building the human-technology partnership
- Augmenting human cognition/performance
- Illuminating the socio-technological landscape
- Fostering lifelong learning
American Innovation and Competitiveness Act (AICA): midscale

“a gap between the established parameters of the Major Research Instrumentation and Major Research Equipment and Facilities Construction programs”

NSF 18-013
Dear Colleague Letter: Request for Information on Mid-scale Research Infrastructure

October 6, 2017

Overview

This Request for Information (RFI) is issued in response to the American Innovation and Competitiveness Act (AICA, Public Law No. 114-329), Section 109. NSF seeks information on existing and future needs for mid-scale research infrastructure projects from the US-based NSF science and engineering community.
Convergence Accelerators

Accelerating Discovery through Convergence Research

**Motivation:** Changing nature of science research - research frontiers at intersection of existing disciplines

- **Research:** more intentionally managed, shorter timelines, milestones, deliverables, teams, partnerships.
- Time-limited entities: accelerating impactful *convergence* research in areas of national importance
- Innovating in organizational structure: separate (from directorates) in leadership, budget, and programmatics
  - aligned with, relying on, foundational disciplinary research
Outline

- NSF/CISE Overview
- Budget Overview
- Selected Programmatics
- Looking Forward
Computer Science for All (CSforAll)

- access to rigorous, engaging CS education for all K-12 students
- Computer Science Principles: new College Board CS AP exam (2017)

CS Undergrad Education (CS+X)

- integrating computing with other fields of knowledge, challenge areas
- builds on previous CISE investments in REvolutionizing engineering and computer science Departments (RED) program
Partnerships: Many dimensions

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

- **Joint NSF/industry research solicitations:** Intel (5), SRC (5), VMware (1)
- **Research infrastructure:** PAWR: Platforms for Advanced Wireless Research, cloud credit for BIGDATA, (AWS, Google, Microsoft)
- **Individual project-based:** I/UCRC, Intrans, GOALI

*Prescription 3: Establishing a More Robust National Government-University-Industry Research Partnership*
Opportunity: Tremendous federal interest in CISE

FY 2019, 2020 R&D Budget Priorities Memo
“Continued leadership in AI, quantum information science (QIS), and strategic computing is critically important to our national security and economic competitiveness. Advances in these areas promise opportunities for major scientific breakthroughs and are quickly transforming American life and industry. Agencies should invest in fundamental and applied AI research, including machine learning, autonomous systems, and applications at the human-technology frontier.”

“prioritize emerging technologies critical to economic growth and security, such as data science, encryption, autonomous technologies,... advanced computing technologies, and artificial intelligence. “
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!*
THANKS!

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@NSF_CISE

Join CISE-ANNOUNCE email
cise-announce-subscribe-request@listserv.nsf.gov

From: "Kurose, James" <JKUROSE@nsf.gov>
Date: Monday, February 12, 2018 at 6:19 PM
To: "cise-announce@listserv.nsf.gov" <cise-announce@listserv.nsf.gov>
Subject: President’s FY 2019 Budget Request for NSF

Dear CISE Community,

Each year, the President transmits to Congress a budget request for the Executive Branch of the Federal Government, including a request for the National Science Foundation (NSF). Today, the President officially submitted that request for fiscal year (FY) 2019, which begins October 1, 2018, and continues through September 30, 2019. The President’s FY 2019 Budget
BACKUP
CISE Broadening Participation in Computing (BPC)

Action plan:
- **Highlight**: Emphasize BP in CISE solicitations
- **Pilot**: Require a “meaningful” BP activity in an expanding set of CISE Programs (expanding to core medium and large proposals, F18)
- **Support**: Provide resources for PIs
- **Review/Report**: Request BPC reporting BP in annual reports

**NSF 17-110**

Dear Colleague Letter: Pursuing Meaningful Actions in Support of Broadening Participation in Computing (BPC)
NSF Takes Steps to Combat Sexual Harassment in Science: Sept. 19, 2018

New measures to combat sexual harassment at grantee institutions:

- new award requirements
- harassment-free research workplaces
- enhanced Web resources

Basic research is done in all environments all over the world. All of those places must be harassment free.

https://www.nsf.gov/od/odi/harassment.jsp
Quantum Leap: Leading the Quantum Revolution

- **Fundamentals** that advance our understanding of uniquely quantum phenomena and their interface with classical systems
- **Elements** that measure, model, control, and exploit quantum particles
- **Software systems and algorithms** that enable quantum information processing
- **Workforce**, including training a new generation of scientists, engineers
Cyberinfrastructure, Cloud

"The emerging conversation is not about whether academic research computing will take place in the cloud as has been the case with many previous reports and meetings, but rather how best to support it."

- Articulate the case for academic institutions to use the cloud
- Articulate the “business case” for cloud providers to support academic users
- Remove artificial costs that make cloud computing less attractive
- Create support structures for academics transitioning to the cloud
- Form a central entity to serve as a nexus between multiple cloud providers on one side and multiple academic institutions on the other
CISE priority setting: science community and other inputs

- **National Academies**
  - CSTB (bi-annual)
  - NAS studies (e.g., ACI)

- **CRA, CCC**
  - 2, 3 meetings/yr
  - Academia, industry
  - Visioning workshops, consensus whitepapers

- **CISE AC**
  - Biannual meetings
  - Academia, industry
  - Subcommittees

- **CoV**
  - Every 4 years
  - Academia, industry

- **Science community**
  - Visits to campuses, industry
  - Visits to NSF

- **Input & advice from science community**

- **Integration & Decision making**

- **Congress**

- **White House**

- **Data-driven portfolio analysis**

- **OD**
  - Other NSF directorates

**Science community input**

**Priorities and Programmatics**