A 20-YEAR COMMUNITY ROADMAP FOR ARTIFICIAL INTELLIGENCE RESEARCH IN THE US

CRA Computing Community Consortium
Association for the Advancement of Artificial Intelligence
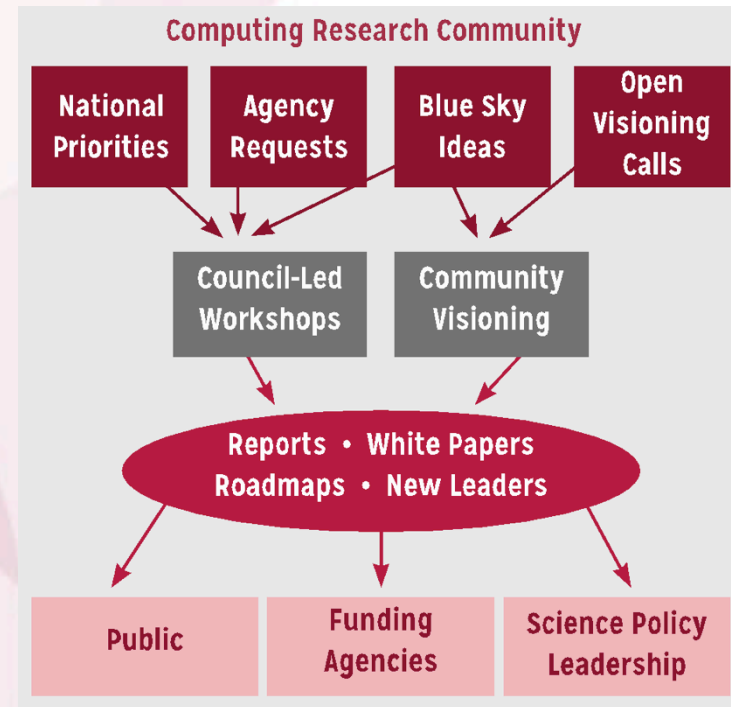and the computing research community

Leads: Yolanda Gil and Bart Selman

ITIF AI Policy Network
22 October 2019
Presenting: Liz Bradley, with help from Ann Drobnis and Peter Harsha

AAAI Association for the Advancement of Artificial Intelligence

CCC Computing Community Consortium Catalyst

COMPUTING COMMUNITY CONSORTIUM

The mission of the Computing Research Association's Computing Community Consortium (CCC) is to **catalyze** the computing research community and **enable** the pursuit of innovative, high-impact research.

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ASSOCIATION FOR THE ADVANCEMENT OF ARTIFICIAL INTELLIGENCE

The Association for the Advancement of Artificial Intelligence (AAAI) is an international scientific society devoted to promote research in, and responsible use of, artificial intelligence.

AAAI also aims to increase public understanding of AI, improve the teaching and training of AI practitioners, and provide guidance for research planners and funders concerning the importance and potential of current AI developments and future directions.

ROADMAP: PROCESS

- Summer 2018: CCC discusses potential Roadmap leaders with academia, government, & industrial stakeholders; selects AAAI president (Gil) & president-elect (Selman)

- Fall 2018: Co-leaders, together with AI community, design three workshops

- Nov 2018-Jan 2019: Workshops take place

- Jan 2019: Town hall at AAAI; meetings with key stakeholders

- Mar-Apr 2019: DC briefings at OSTP, NSF, DARPA, NITRD AI-IWG, DIB, and Hill with CRA

- Apr 2019: CCC and community feedback

- August 2019: final release of Roadmap

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ROADMAP: FINDINGS

- AI will be transformative: rapid, worldwide impact

- At the same time, there are many concerns about the security and vulnerability of systems with these capabilities, as well as about the future of work in an AI-enabled world

- Accelerating industry successes in AI: built on academic foundations and facilitated by massive data sets, compute power, and human resources

ROADMAP: FINDINGS, CONT.

- Few of AI's big challenges can be solved by piecing together academic research projects

- Many of the associated issues and problems are outside of industry scope, priorities, and timelines

ARTIFICIAL INTELLIGENCE (AI) LANDSCAPE

- Data-driven AI methods are highly effective but have important flaws
- Industry focuses largely on practical, near-term solutions using massive proprietary resources
- Academia asks many of the fundamental long-term questions that lay the foundations for AI

- The next generation of AI challenges will require bringing academia, industry, and government together

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ROADMAP: RECOMMENDATIONS

- I. National AI Infrastructure
    - National AI Research Centers
    - Mission-Driven AI Labs
    - Open AI platforms and resources
    - Sustained community-driven AI challenges
- II. Training an AI Workforce
- III. Core AI Programs

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NATIONAL AI RESEARCH CENTERS

- Multi-university centers with affiliated institutions, focused on pivotal areas of long-term AI research (e.g., integrated intelligence, trust and responsibility)

- Decade-scale funding to support on the order of 100 faculty, 200 AI engineers, 500 students, and necessary computing infrastructure

- Visiting fellows from academia, industry, and government will enable cross-cutting research and tech transfer

Some possible models:

National Artificial Intelligence (AI) Research Institutes:
Accelerating Research, Transforming Society, and Growing the American Workforce

PROGRAM SOLICITATION
NSF 20-503

National Science Foundation

Directorate for Computer and Information Science and Engineering

Directorate for Biological Sciences

Directorate for Education and Human Resources

Directorate for Engineering

Directorate for Geosciences

Directorate for Mathematical and Physical Sciences

Directorate for Social, Behavioral and Economic Sciences

Office of Integrative Activities

Anticipated Type of Award: Standard Grant or Cooperative Agreement

Estimated Number of Awards: 9 to 14

NSF plans to make 1-6 Institute Awards and approximately 8 Planning Grants.

Anticipated Funding Amount: $24,000,000 to $124,000,000

National Institute of Food and Agriculture

Department of Homeland Security, Science & Technology Directorate

U.S. Department of Transportation, Federal Highway Administration

U.S. Department of Veterans Affairs

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The 2019 update to the National Artificial Intelligence Research and Development Strategic Plan, informed by visioning activities in the scientific community as well as interaction with the public, identifies as its first strategic objective the need to make long-term investments in AI research in areas with the potential for long-term payoffs in AI. This funding opportunity seeks to enable such research through a set of new AI Research Institutes.

National Institute of Food and Agriculture

Department of Homeland Security, Science & Technology Directorate

U.S. Department of Transportation, Federal Highway Administration

U.S. Department of Veterans Affairs

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MISSION-DRIVEN AI LABORATORIES

- Living laboratories for AI development in targeted problem domains with great societal impact (AI-ready homes, hospitals, schools, …)

- Designed to allow AI researchers access to unique data and collaborations

- Decade-scale funding to support on the order of 50 permanent AI researchers, 50 visitors from AI Research Centers, 100-200 AI engineers and technicians, and 100 domain experts and staff
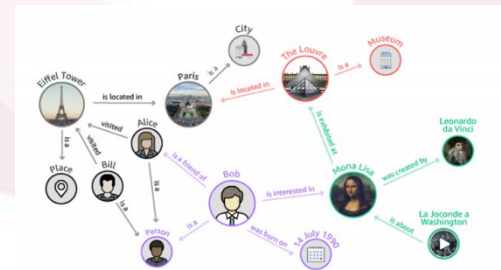

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OPEN AI PLATFORMS AND RESOURCES

Open, shared R&D resources:
- AI platforms, facilities, testbeds
- Data, knowledge bases
- Toolsets, software, hardware, storage
- …

AI CHALLENGES

- Sustained community-driven AI challenges

  – To move AI to the next step, we need to capitalize on the energies and synergies that are fostered by healthy competition, while promoting concerted progress on hard AI problems.

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ROADMAP: RECOMMENDATIONS

- I. National AI Infrastructure

- II. Training a 21st Century AI Workforce
  - Curriculum development, at all levels, incorporating AI ethics and policy

  - Education and training beyond the traditional BA/BS (e.g., community college programs, certificate programs, online post-baccalaurate programs, …)

  - Recruitment and retention programs (students *and* faculty, under-represented groups, …)

  - Incentivizing interdisciplinary AI studies (incl. policy, law, societal impact, …)

- III. Core AI Programs

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ROADMAP: RECOMMENDATIONS

- I. National AI Infrastructure

- II. Training an AI Workforce

- III. Core AI Programs
  - Maintain and extend funding for these critical and fertile programs

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National AI Research Infrastructure

National AI Research Centers

- Focused on cross-cutting research themes
  - Examples: Center on AI Trust and Responsibility, Center on Integrated Intelligence, etc.

- Resources in each Center would include at least:
  - 100 full-time faculty (in AI and other relevant disciplines)
  - 50 visiting faculty fellows and industry fellows
  - 200 AI engineers
  - 500 full-time students (graduate and undergraduate)
  - Computing and infrastructure support

- Multi-university centers with affiliates

- Multi-decade funding

- Train students at all levels

- Small-scale example models: Allen Institute for AI, CMU's SEI, USC's ICT

Mission-Driven AI Laboratories

- Focused on societal drivers
  - Examples: AI-ready hospitals, AI-ready homes, AI-ready schools, VR/robotics labs, etc.

- Living laboratories for hands-on research and collection of unique data

- Operations as well as workforce training

- Directors must have substantial AI credentials

- Resources in each laboratory would include at least:
  - 50 permanent AI researchers
  - 50 visitors from AI Research Centers
  - 100-200 AI engineers
  - 100 domain experts and staff (e.g., health experts collaborating in AI research)

- Multi-decade funding

- Analogous to Google's DeepMind (larger scale, approx. 400 AI scientists + 600 software developers), SLAC, NCAR, etc.

Community Driven AI Challenges

Open AI Platforms and Resources

All-Encompassing Workforce Training

CHALLENGES TO US LEADERSHIP IN AI

SCIENCE \ US & WORLD \ TECH

China is about to overtake America in AI research

China will publish more of the most-cited 50 percent of papers than America for the first time this year

By James Vincent | Mar 14, 2019, 7:03am EDT   **The Verge**

China Is Starting To Edge Out The US In AI Investment

February 12, 2019

Artificial Intelligence   China   United States   **CBINSIGHTS**

Intelligent Machines

China may overtake the US with the best AI research in just two years

The number of influential AI research papers coming from China is increasing rapidly, a data analysis shows.

by Will Knight   March 13, 2019   **MIT TECHNOLOGY REVIEW**

BRAINPOWER

Europe—not the US or China—publishes the most AI research papers

By Dave Gershgorn • December 12, 2018   **Quartz**

3,992 views | Sep 7, 2018, 12:03pm

Is South Korea Poised To Be A Leader In AI?

Kathleen Walch Contributor
COGNITIVE WORLD Contributor Group ⓘ
AI & Big Data   **Forbes**

16,236 views | Nov 9, 2018, 12:10pm

Artificial Intelligence, China And The U.S. – How The U.S. Is Losing The Technology War

Steve Andriole Contributor ⓘ
Enterprise & Cloud   **Forbes**

ROADMAP: RESEARCH PRIORITIES

Research Priorities

Integrated Intelligence

· Science of integrated intelligence

· Contextualized AI

· Open knowledge repositories

· Understanding human intelligence

Meaningful Interaction

· Collaboration

· Trust and responsibility

· Diversity of interaction channels

· Improving online interaction

Self-Aware Learning

· Robust and trustworthy learning

· Deeper learning for challenging tasks

· Integrating symbolic and numeric representations

· Learning in integrated AI/robotic systems

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ROADMAP: SOCIETAL DRIVERS

- ❖ Boost health and quality of life
- ❖ Provide lifelong education and training
- ❖ Reinvent business innovation and competitiveness
- ❖ Accelerate scientific discovery and technical innovation
- ❖ Expand evidence-driven social opportunity and policy
- ❖ Transform national defense and security

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A 20-Year Community Roadmap for Artificial Intelligence Research in the US
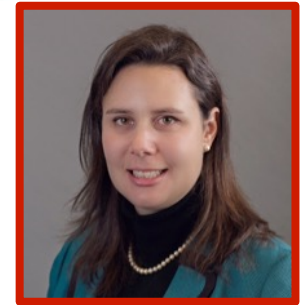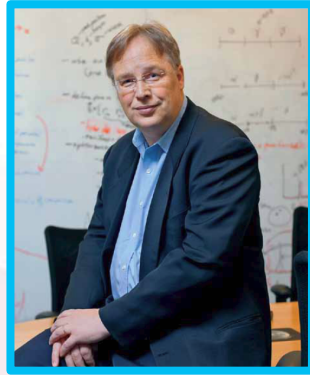
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Thank you

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WORKSHOP LEADS

Integrated Intelligence
- Science of integrated intelligence
- Contextualized AI
- Open knowledge repositories
- Understanding human intelligence

Meaningful Interaction
- Collaboration
- Trust and responsibility
- Diversity of interaction channels
- Improving online interaction

Self-Aware Learning
- Robust and trustworthy learning
- Deeper learning for challenging tasks
- Integrating symbolic and numeric representations
- Learning in integrated AI/robotic systems

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# BACKUP SLIDES

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- Melanie Mitchell, Portland State University
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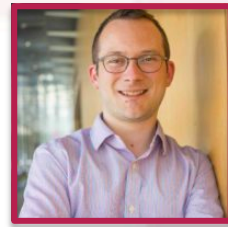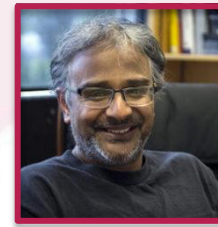
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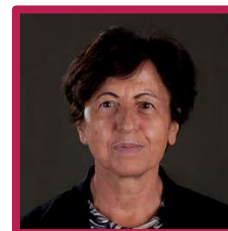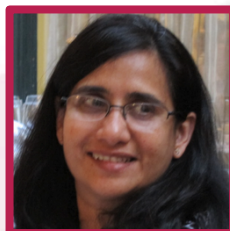
ARTIFICIAL INTELLIGENCE

"Artificial Intelligence is the study of ideas that enable computers to be intelligent. Intelligence includes: ability to reason, ability to acquire and apply knowledge, ability to perceive and manipulate things in the physical world, and others." (PHW 1984)

- *Symbolic AI*
- logic systems
- planners, theorem provers
- rule-based systems
- qualitative reasoning
- …
- *Statistical AI*
- machine learning
- neural nets
- support vector machines
- Bayesian techniques
- …

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- Symbolic AI:
- reasons generally and can report on its reasoning
- but someone has to feed it the operative knowledge
- and "knowledge engineering" is hard.

- Statistical AI:
- works really well, but requires lots of information to learn from (training sets, priors, …)
- output = statistics, not explanations

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