

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

August 2019



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: Roadmap released

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



CCC

Computing Community Consortium
Catalyst

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

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

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:



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



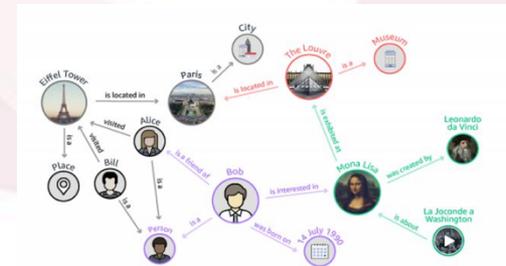
CCC

Computing Community Consortium
Catalyst

OPEN AI PLATFORMS AND RESOURCES

Open, shared R&D resources:

- AI platforms, facilities, testbeds
- Data, knowledge bases
- Toolsets, software, hardware, storage
- ...



CCC

Computing Community Consortium
Catalyst

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.



CCC

Computing Community Consortium
Catalyst

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



CCC

Computing Community Consortium
Catalyst

ROADMAP: RECOMMENDATIONS

- I. National AI Infrastructure
- II. Training an AI Workforce
- **III. Core AI Programs**
 - Maintain and extend funding for these critical programs



CCC

Computing Community Consortium
Catalyst

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



BACKUP SLIDES



CCC

Computing Community Consortium
Catalyst

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



CCC

Computing Community Consortium
Catalyst

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

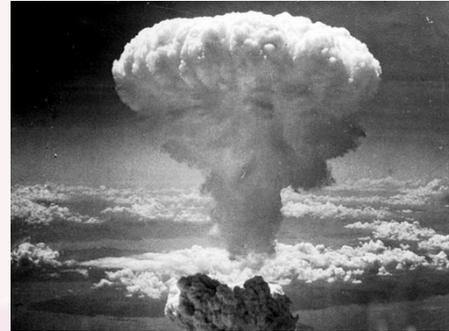


CCC

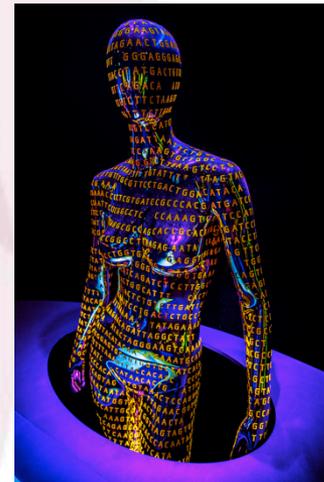
Computing Community Consortium
Catalyst

US R&D LEADERSHIP

- Manhattan Project
- Moonshot
- Human Genome
- Hubble Telescope
- LIGO Gravitational Waves



Manhattan Project
1939: \$2 Billion
2019: \$36 Billion



Human Genome Project
1991: \$2.7 Billion
2019: \$5 Billion



Hubble Telescope
1990: \$1.5 Billion
2019: \$3 Billion



CCC

Computing Community Consortium
Catalyst

CHALLENGES TO THAT LEADERSHIP

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

Quartz

By Dave Gershgorn · December 12, 2018

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

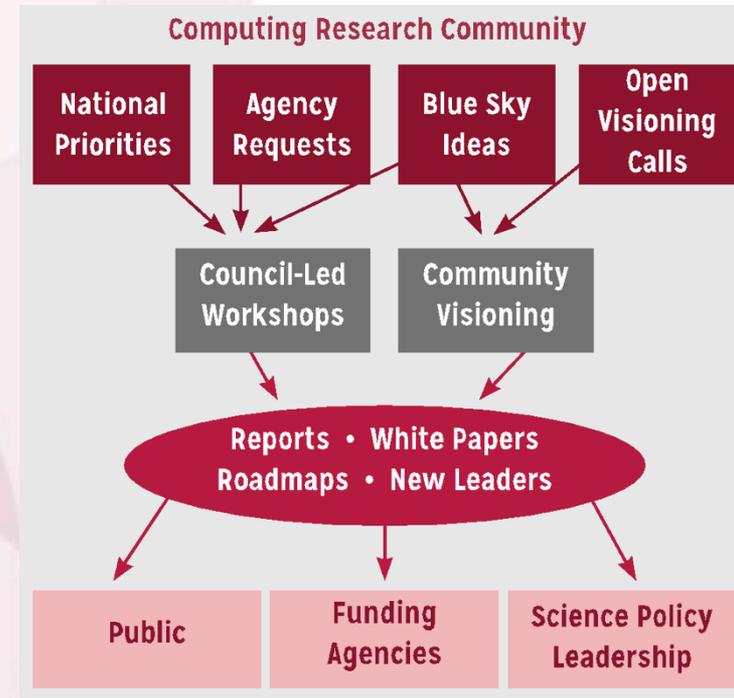


Steve Andriole Contributor
Enterprise & Cloud

Forbes

COMPUTING COMMUNITY CONSORTIUM

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



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.

