Developing a 20-Year AI Research Roadmap for the US

Roadmap Co-Chairs:
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Workshop Co-chairs:
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Tom Dietterich, Oregon State U
Ken Forbus, Northwestern University
Fei-Fei Li, Stanford U
Kathy McKeown, Columbia University
Dan Weld, University of Washington

January 27, 2018
Important Note

• This presentation gives an overview of ongoing efforts to create a 20-Year AI Research Roadmap for the US. It summarizes current views, and introduces preliminary ideas for potential recommendations.

• The presentation captures interim ideas, and is intended to promote community input and discussion.

• The annual conference of the Association for the Advancement of Artificial Intelligence (AAAI) was considered an ideal opportunity for gathering community input. AAAI is widely considered to be the premier scientific society for AI, and its annual conference is a top venue for publication of AI research, applications, and education. The timing of the conference also fit well the timing of the roadmap efforts.

• A live recording of the session is publicly available at https://aaai.org/Conferences/AAAI-19/townhall-a-20-year-roadmap-for-ai-research/
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. 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.”
National Leadership in AI

Office of Science & Technology Policy (OSTP)

Lynne Parker, NSF Assistant Director for AI
Jim Kurose, NSF Former Assistant Director for AI

National Science and Technology Council (NSTC)

France Cordova, NSF AI Select Committee Co-chair (with DARPA, OSTP)
Erwin Gianchandani, NSF Jim Kurose, NSF MLAI co-chairs
Henry Kautz, NSF NITRD AI WG co-chair
Jeff Alstott, IARPA NITRD AI WG co-chair

A 20-Year AI Research Roadmap for the US
Interim report, AAAI Townhall, 27 January 2019
US National AI Research & Development Strategic Plan

• NITRD Working Group of 40+ Federal Funding Agencies
• Co-Chairs: Henry Kautz (NSF) and Jeff Astott (IARPA)
• April 2019: Update to 2016 Plan and Implementation Report
• Updating 2016 National AI Research and Development Strategic Plan (RFI responses were due Oct 26)
AI Presence and Overall Trends in the US

- AI has gone from an academic research area to permeating our lives
  - Significant impact on society
  - Untapped potential
- Significant influence of AI in innovation and stimulating the economy
  - White house meeting in May 2018
- Concern about safety and transparency of this technology leads to questions for AI research community about how to establish policy
- Concerted initiatives in government and in academia
  - Joint AI Center
- Increases in federal funding investments (DARPA $2B, NSF, etc)
A 20 Year AI Research Roadmap for the US

• Objectives
  • 10 - 20 year research roadmap
  • Guidance for funding agencies and Congress
  • Relate to:
    • AI research in industry
    • International AI initiatives
• Computing Community Consortium with support from US National Science Foundation
  • CCC has developed prior research roadmaps, such as the Robotics Roadmap that led to the US National Robotics Initiative
Reference Documents

• US National AI R&D Strategic Plan, 2016 (currently being updated)

• US National Robotics Roadmap, 2009, revised 2016:

• 100 year study of AI, 2016 report:
  • https://ai100.stanford.edu/sites/default/files/ai100report10032016fnl_singles.pdf

• AI strategies/investments abroad:
  • https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd
Timeline for AI Roadmap

• 3 small by-invitation workshops (Nov-Jan)
  • WS1: Integrated intelligence
  • WS2: Meaningful interaction
  • WS3: Learning and robotics
• Townhall at AAAI (Jan 28, 7:30pm)
• Draft report (Feb)
• Feedback period (Feb-March)
• Final report (April)
### Generating a Technical Roadmap through Community Workshops

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Date</th>
<th>Chairs</th>
<th>Focus Areas</th>
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</thead>
<tbody>
<tr>
<td>W1:</td>
<td>Nov 14-15</td>
<td>Marie desJardins and Ken Forbus</td>
<td>Understanding the mind, Composing intelligent capabilities, Open repositories of knowledge</td>
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<td><strong>W2:</strong> Meaningful Interaction (Jan 8-9)</td>
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<td></td>
<td>Kathy McKeown and Dan Weld</td>
<td>Interactions that matter, Trust and responsibility, People interacting online</td>
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<tr>
<td>W3:</td>
<td>Jan 17-18</td>
<td>Tom Dietterich and Fei-Fei Li</td>
<td>Deeper learning for challenging tasks, Integrating continuous and symbolic representations, Diversified learning modalities</td>
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Identifying Societal Drivers

1. **Boost Health and Quality of Life**: Prevention of illness and elderly ailments, mental/behavioral health, reducing cost (25+% feasible) while improving care, remote patient care.

2. **Lifelong Education and Training**: Personalized, scalable education support. Improve the AI knowledge and skills of people who will lose jobs. Training next generation of AI specialists, data scientists, and software engineers.

3. **Reinvent Business Innovation and Competitiveness**: Evidence-driven companies, which would increase productivity and value and open new sectors/products.

4. **Accelerate Scientific Discovery and Technological Innovation**: Biomedical, environmental, new materials, personalized services, robotics, self-driving cars, etc.

5. **Social Justice and Policy**: Engaging and empowering disadvantaged communities. Improving civic and political discourse.

6. **Transform Cyber Defense and Security**: AI driven systems can compensate for a relatively small cyber defense workforce, adversarial reasoning.
Societal Drivers

- Evidence-Driven Social Policy
- Reduce Cost of Healthcare
- Personalized Education
- Business Opportunities
- Accelerating Science

Technical Areas

- Integrated Intelligence
- Meaningful Interaction
- Self-Aware learning

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Technical Areas

1. Science of integrated intelligence
2. Contextualized AI
3. Open knowledge repositories
4. Understanding human intelligence

Societal Driver Vignettes

• Mental and behavioral health coach
• Accurate models of water reserves
• Speed up vaccine experiments
• Students in remote rural settings
• Retrain factory workers
• Resolve supply chain delays
Integrated Intelligence:
1) Science of Integrated AI

- Components of Intelligence
- Metareasoning and reflection
- Combining deliberation with perception/control
- Memory types and organization
Integrated Intelligence:
2) Contextualized AI

- Customization of general capabilities
- Social cognition
- Cognizance of environment
Integrated Intelligence:
3) Open Knowledge Repositories

- Heterogeneous knowledge
- Knowledge capture and dissemination
- Knowledge integration and refinement
- Diversified use and reasoning at scale
Integrated Intelligence:
4) Understanding Human Intelligence

- AI inspired by human intelligence
- AI to understand human intelligence
- Unifying theories of human and artificial intelligence
Meaningful Interaction

Technical Areas
1. Collaboration
2. Trust and responsibility
3. Diversity of interaction channels
4. Improving online interaction

Societal Driver Vignettes
• At-home robot caregiver/helper
• Collaborative materials discovery
• Training for robot repair jobs
• Custom personal devices business
• Spreading opportunities for homeless youth

Chairs:
Kathy McKeown, Columbia U
Dan Weld, U Washington
Meaningful Interaction:
1) Collaboration

- Modeling human mental states
- Social norms and commonsense
- Supporting complex teamwork
- Reliability and ethical behaviors
Meaningful Interaction:
2) Diversity of Interaction Channels

- Diversity of human ability and context
- Information fusion
- Multimodal explanations
- Privacy preservation across channels
Meaningful Interaction:
3) Trust and Responsibility

- Transparency and explanation
- Debugging behaviors
- Boundaries and responsibility
- Assessment and control of behaviors
Meaningful Interaction:
4) Improving Interactions Between People

- Productive communication and collaboration
- Reputation and factfulness
- Collaborative creation
- Customized presence
Self-Aware Learning

Technical Areas

1. Robust and trustworthy learning
2. Deeper learning for challenging tasks
3. Integrating symbolic and numeric representations
4. Learning in integrated AI/Robotic systems

Societal Driver Vignettes

• Prevent opiate abuse
• Game design startup
• Climate models with physics and data
• Police training
• Food insecurity and distribution
• Resilient cyber-physical systems

Chairs:
Tom Dietterich, Oregon State U
Fei-Fei Li, Stanford U
Self-Aware Learning:
1) Robust and Trustworthy Learning

- Quantifying uncertainty
- Learning in heterogeneous societies
- Durable learning systems
- Learning causal models
Self-Aware Learning:
2) Deeper Learning for Challenging Tasks

- Learning from few examples
- Learning through interactions
- Learning to assist
- Long-term adaptation
Self-Aware Learning:
3) Integrating Symbolic and Numeric Representations

- Abstracting symbols from numeric representations
- Representing complex structures beyond word embeddings
- Explainable and instructable AI
- Integrated symbolic and numeric inference
Self-Aware Learning:
4) Learning in Integrated AI/Robotic Systems

Robust object manipulation

Learning from humans by demonstration and instruction

Sense-Act integration via robot middleware

Real time orchestration of sensing and planning
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A New Era of **Audacious AI Research**

- Audacious AI research tackles broader AI goals
  - More integrative, requiring significant resources and diverse expertise
  - Hard for individual PIs to stand the necessary research environments
- Arguably such environments are mostly available in industry
  - Significant driver for academics to flock to industry labs
- Requires engaging the community in shared resources and goals
  - Eg LIGO and LHC in particle physics
  - Eg Human Genome Project in medicine
  - Eg Hubble telescope in astronomy
Proposed Recommendations:

1) Open National AI Platform

- A shared ecosystem infrastructure for AI research
  - Components and services available for others to use and build on
- Example resources
  - An open knowledge network of knowledge about the world
  - Data repositories
  - Reproducible experimentation environments
  - Computational/cloud resources
- Wide range of contributors and contributions
  - Share research products
  - Experimental harness
- Infrastructure would include hardware, data, software, services, and people
Proposed Recommendations:

2) New Funding Programs and Mechanisms

• Larger scale and broader scale projects are needed to:
  • Support AI research across multiple areas
  • Support multi-disciplinary research
  • Support AI engineering, experimentation, and deployment

• Sustained funding programs

• Rewards for collaboration (rather than competition)
  • National AI Platform as a collaborative
Proposed Recommendations:

3) Broaden AI Education

• Need for development of official degrees and certifications in AI at all levels, and associate curricula – particularly for other disciplines
  • K through grey
• Need for creative incentive mechanisms to retain faculty and students in academia given the resources and salaries available in industry
  • Recommendations #1 and #2
• Fellowships for graduate students
  • Production of AI graduates should keep up with demand at the PhD level
  • Broadening of AI career paths:
    • Students tend to focus on very narrow areas of AI that are more in demand in industry, rather than the broader themes and higher interdisciplinarity of this report
    • Few students undertake new areas such as AI and policy, or AI and law
Recommendations:

4) Promote AI Policy and Ethics

- Promote AI research that focuses on characterizing and quantifying AI systems, that can inform policy and decision makers
  - Report emphasis characterization and quantification of:
    - Responsibility
    - Explainability
    - Competency
    - Robustness

- Need to promote emerging cross-cutting disciplines for AI:
  - AI and economics: impact of automation and the future of jobs
  - AI policy and law: responsibility
  - AI engineering: safety, robustness
Discussion Period

1. Clarification questions

2. Feedback and suggestions
Comments, Suggestions, Feedback?

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