The Future of AI

David Cox
Director, MIT-IBM Watson AI Lab
“Artificial Intelligence”
The evolution of AI

Broad AI
Disruptive and Pervasive

Narrow AI
Emerging

We are here

2050 and beyond
The evolution of AI

**Narrow AI**
- Single task, single domain
- Superhuman accuracy and speed for certain tasks

**Broad AI**
- Multi-task, multi-domain
- Multi-modal
- Distributed AI
- Explainable

**General AI**
- Cross-domain learning and reasoning
- Broad autonomy
The evolution of AI

Narrow AI
Single task, single domain
Superhuman accuracy and speed for certain tasks

Broad AI
Multi-task, multi-domain
Multi-modal
Distributed AI
Explainable

General AI
Cross-domain learning and reasoning
Broad autonomy
The evolution of AI

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General AI
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Tech 2015: Deep Learning And Machine Intelligence Will Eat The World

Anthony Wing Kosner, CONTRIBUTOR

Quantum of Content and innovations in user experience  FULL BIO

Opinions expressed by Forbes Contributors are their own.
man in black shirt is playing guitar.

construction worker in orange safety vest is working on road.
“Teddy Bear”

Meret Oppenheim, *Le Déjeuner en fourrure*
man in black shirt is playing guitar.

construction worker in orange safety vest is working on road.

Karpathy and Li, 2015
a man riding a motorcycle on a beach

Lake, Ullman, Tenenbaum & Gershman, 2016
What’s this?
CCTA usage rate rises sharply, but still eclipsed by MPI
February 23, 2018 -- The use of coronary CT angiography (CCTA) to evaluate chest pain in the emergency department has grown exponentially, but clinicians are still using myocardial perfusion imaging (MPI) far more frequently, according to research published online February 15 in the American Journal of Roentgenology. Discuss

fMRI, machine learning could predict OCD therapy outcomes
February 23, 2018 -- By analyzing resting-state functional MRI (fMRI) brain scans with a machine-learning algorithm, researchers at the University of California, Los Angeles may have devised a way to predict treatment outcomes for people with obsessive-compulsive disorder (OCD), according to results published online in the American Journal of Psychiatry. Discuss
Original Top-3 inferred captions:
1. A red stop sign sitting on the side of a road.
2. A stop sign on the corner of a street.
3. A red stop sign sitting on the side of a street.

Adversarial Top-3 captions:
1. A brown teddy bear laying on top of a bed.
2. A brown teddy bear sitting on top of a bed.
3. A large brown teddy bear laying on top of a bed.
The path to Broad AI

- Explainability
- Security
- Ethics

Learn more from small data

- Learns to transfer
- Reasons

Infrastructure

- Physics of AI
INDUSTRY  ACADEMIA

IBM  ♡  MIT

AI  AI
By the numbers....

$240\text{m}$ investment

Roughly 100 full-time equivalent researchers (60 MIT / 40 IBM), working on 50 projects

10 year time horizon
What’s coming in the next few years in AI?
The path to Broad AI

1. Extend
2. Understand
3. Accelerate
Errors in Artificial Neural Networks

Debugging neural networks enables trust and transparency

Antonio Torralba
MIT

Stefanie Jegelka
MIT

Hendrik Strobelt
IBM

neuron 1679: Bathroom

neuron 867: Kitchen

neuron 1749: House

neuron 795: Bathroom

neuron 1978: Person

AI: Washing dishes
Truth: Brushing teeth

Network confused about the scene and did not detect the brush.
die längsten reisen fangen an, wenn es auf den straßen dunkel wird.
Extend

Explainability + Security + Ethics

Learn more from small data

Learns to transfer + Reasons

Infrastructure + Physics of AI
Methods for Exploiting Unlabeled Data in Supervised Learning

Doing more with less annotation

Kumar et al. NIPS 2018. Alignment for Unsupervised Domain Adaptation
What’s coming in the next 3-5 years?
How many blocks are on the right of the three-level tower?

Will the block tower fall if the top block is removed?

What is the shape of the object closest to the large cylinder?

Are there more trees than animals?
Neuro-symbolic Program Induction

Inferring generative neural programs from data to enable reasoning on complex data and enhance explainability of AI

Top row: hand drawn figures
Bottom row: outputs of inferred generative programs

<table>
<thead>
<tr>
<th>Diego Castillo &amp; Isabel Foster, 2006</th>
<th>Castillo et al. (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauren Dodi and Umair Ahmed, 1998</td>
<td>Dodi et al. (1998)</td>
</tr>
</tbody>
</table>

Inferring text transformation programs from examples, to clean and standardize data, reason about complicated structured text, enhance explainability
<table>
<thead>
<tr>
<th>Methods</th>
<th>Count</th>
<th>Exist</th>
<th>Compare Number</th>
<th>Compare Attribute</th>
<th>Query Attribute</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans [Johnson et al., 2017b]</td>
<td>86.7</td>
<td>96.6</td>
<td>86.4</td>
<td>96.0</td>
<td>95.0</td>
<td>92.6</td>
</tr>
<tr>
<td>CNN+LSTM+SA+MLP [Johnson et al., 2017b]</td>
<td>59.7</td>
<td>77.9</td>
<td>75.1</td>
<td>70.8</td>
<td>80.9</td>
<td>73.2</td>
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<tr>
<td>N2NMN* [Hu et al., 2017]</td>
<td>68.5</td>
<td>85.7</td>
<td>84.9</td>
<td>88.7</td>
<td>90.0</td>
<td>83.7</td>
</tr>
<tr>
<td>Dependency Tree [Cao et al., 2018]</td>
<td>81.4</td>
<td>94.2</td>
<td>81.6</td>
<td>97.1</td>
<td>90.5</td>
<td>89.3</td>
</tr>
<tr>
<td>CNN+LSTM+RN [Santoro et al., 2017]</td>
<td>90.1</td>
<td>97.8</td>
<td>93.6</td>
<td>97.1</td>
<td>97.9</td>
<td>95.5</td>
</tr>
<tr>
<td>IEP* [Johnson et al., 2017b]</td>
<td>92.7</td>
<td>97.1</td>
<td>98.7</td>
<td>98.9</td>
<td>98.1</td>
<td>96.9</td>
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<tr>
<td>CNN+GRU+CBN [Perez et al., 2018]</td>
<td>94.5</td>
<td>99.2</td>
<td>93.8</td>
<td>99.0</td>
<td>99.2</td>
<td>97.6</td>
</tr>
<tr>
<td>DDRprog* [Suarez et al., 2018]</td>
<td>96.5</td>
<td>98.8</td>
<td>98.4</td>
<td>99.0</td>
<td>99.1</td>
<td>98.3</td>
</tr>
<tr>
<td>MAC [Hudson and Manning, 2018]</td>
<td>97.1</td>
<td>99.5</td>
<td>99.1</td>
<td>99.5</td>
<td>99.5</td>
<td>98.9</td>
</tr>
<tr>
<td>TbD+reg+hres* [Mascharka et al., 2018]</td>
<td>97.6</td>
<td>99.2</td>
<td>99.4</td>
<td>99.6</td>
<td>99.5</td>
<td>99.1</td>
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<tr>
<td>Ours (100 programs)</td>
<td>54.0</td>
<td>81.0</td>
<td>50.2</td>
<td>75.4</td>
<td></td>
<td>66.0</td>
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<tr>
<td>Ours (200 programs)</td>
<td>84.6</td>
<td>91.3</td>
<td>72.9</td>
<td>85.9</td>
<td>88.7</td>
<td>86.1</td>
</tr>
<tr>
<td>Ours (500 programs)</td>
<td>99.7</td>
<td>99.9</td>
<td>99.9</td>
<td>99.8</td>
<td>99.8</td>
<td>99.8</td>
</tr>
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Table 1: Our model outperforms current state-of-the-art methods on CLEVR and achieves near-perfect question answering accuracy. (*): training relies on all program annotations (700k).
Causal Inference
Beyond Correlation—inferring and testing for causal relationships in complex systems

![Divorce rate in Maine correlates with per capita consumption of margarine](http://tylervigen.com/spurious-correlations)
Causal Inference
Beyond Correlation—inferring and testing for causal relationships in complex systems
Causal Inference
Beyond Correlation—inferring and testing for causal relationships in complex systems

Divorce rate in Maine correlates with Per capita consumption of margarine
Correlation: 99.26% (r=0.992558)

Data sources: National Vital Statistics Reports and U.S. Department of Agriculture

http://tylervigen.com/spurious-correlations
Using AI to Accelerate Protein Design and Discovery

One third of global food production goes to waste because of spoilage. Can we use AI to design proteins to prevent that?

![Diagram of protein synthesis and analogy to text]

Protein Synthesis

- Amino Acid (building block)

Analogy to Text

- Letter (building block)
- Word (letter sequence with distinct meaning)
- Paragraph (distinct section of a document dealing with a specific topic)
Protein2Drug: Generative AI for Drug Design

How can we use powerful new generative neural network techniques to generate drugs tailored to targeting specific binding pockets

Payel Das
IBM

Rafael Gomez-Bombarelli
MIT
The path to Broad AI

Explainability

Security

Ethics

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Physics of AI