Data-Starved Artificial Intelligence

This material is based upon work supported by the Assistant Secretary of Defense for Research and Engineering under Air Force Contract No. FA8721-05-C-0002 and/or FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Assistant Secretary of Defense for Research and Engineering.

Dr. Sanjeev Mohindra

MIT Lincoln Laboratory

5 March 2018

Examples of Artificial Intelligence Applications

amazon alexa

2014

- **Intelligent assistant capable of voice interaction**
- **Speech recognition is performed with deep neural networks trained on large data**

AlphaGo

2016

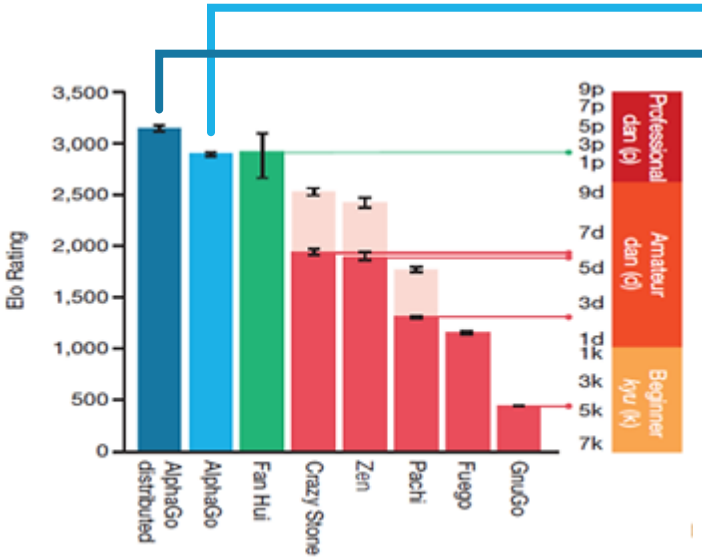
- **Defeated top ranked Go players**
- **AlphaGo's supervised learning drew on 160,000 games containing 29.4 million positions. It then played itself millions of times to get better and better**

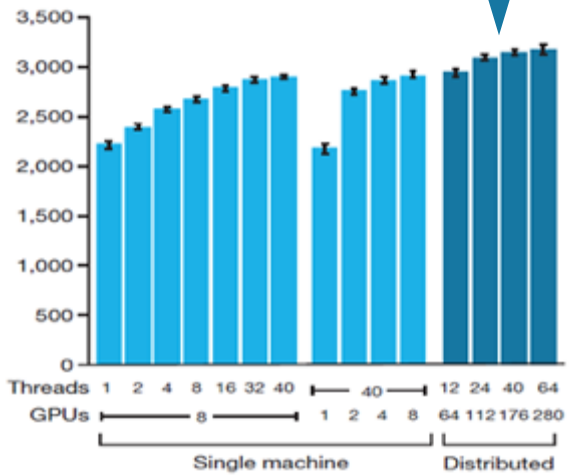
WAYMO

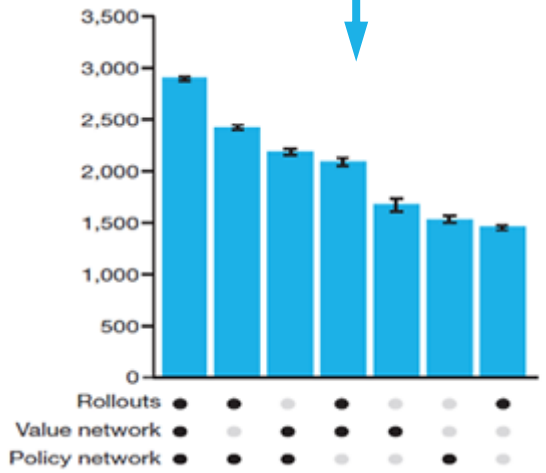
2017

- **Testing autonomous cars without a driver**
- **Scene understanding is powered by deep neural networks learning on 2.5 million real-world miles and 1 billion virtual miles in 2016**

What Makes AlphaGo Go?







Access to Data

- AlphaGo's supervised learning drew on 160,000 games (played by 6–9 dan players) containing 29.4 million positions
- It then played itself millions of times to get better and better

Computing Power

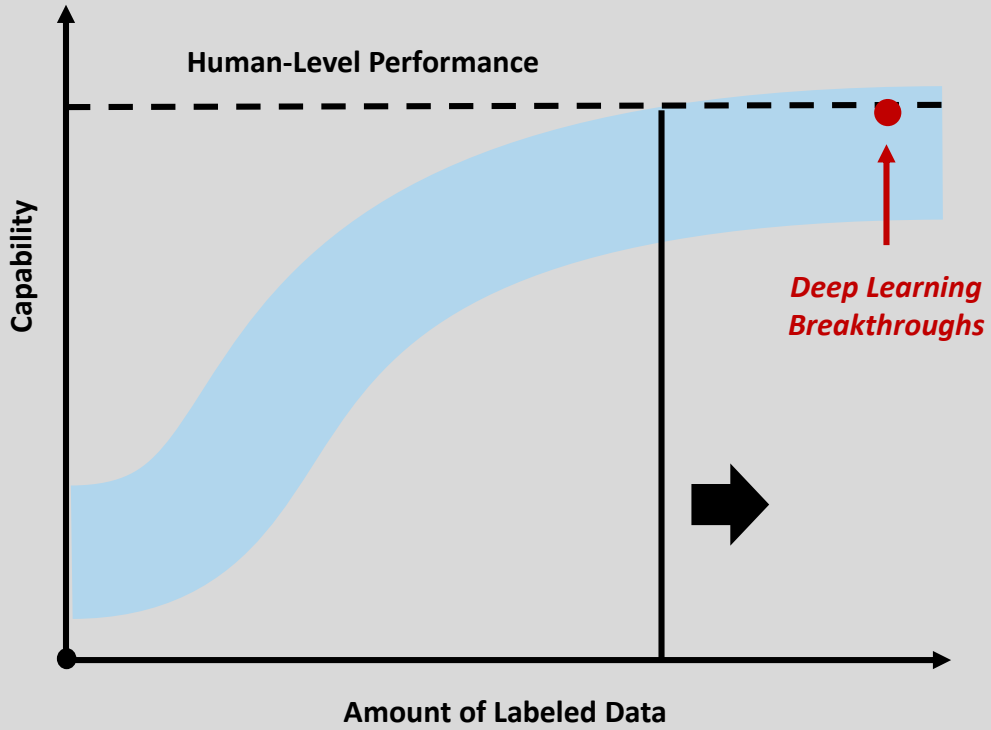
- Distributed version of AlphaGo used 40 search threads running on 1202 CPUs and 176 GPUs
  - Google Tensor Processing Unit (TPU) used when playing Lee Sedol

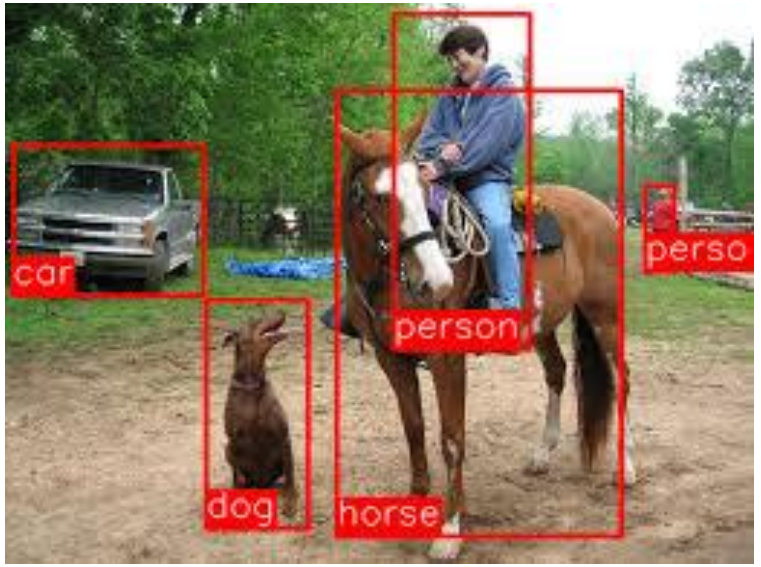
Algorithm Advances

- Two deep neural networks
  Value: 13 layers , Policy: 15 layers
- Monte-Carlo tree search provided the means to heuristically prune the huge move space

Availability of data and advances in computing hardware and algorithms have led to machines approaching or exceeding human performance in some domains

Applying AI to National Security

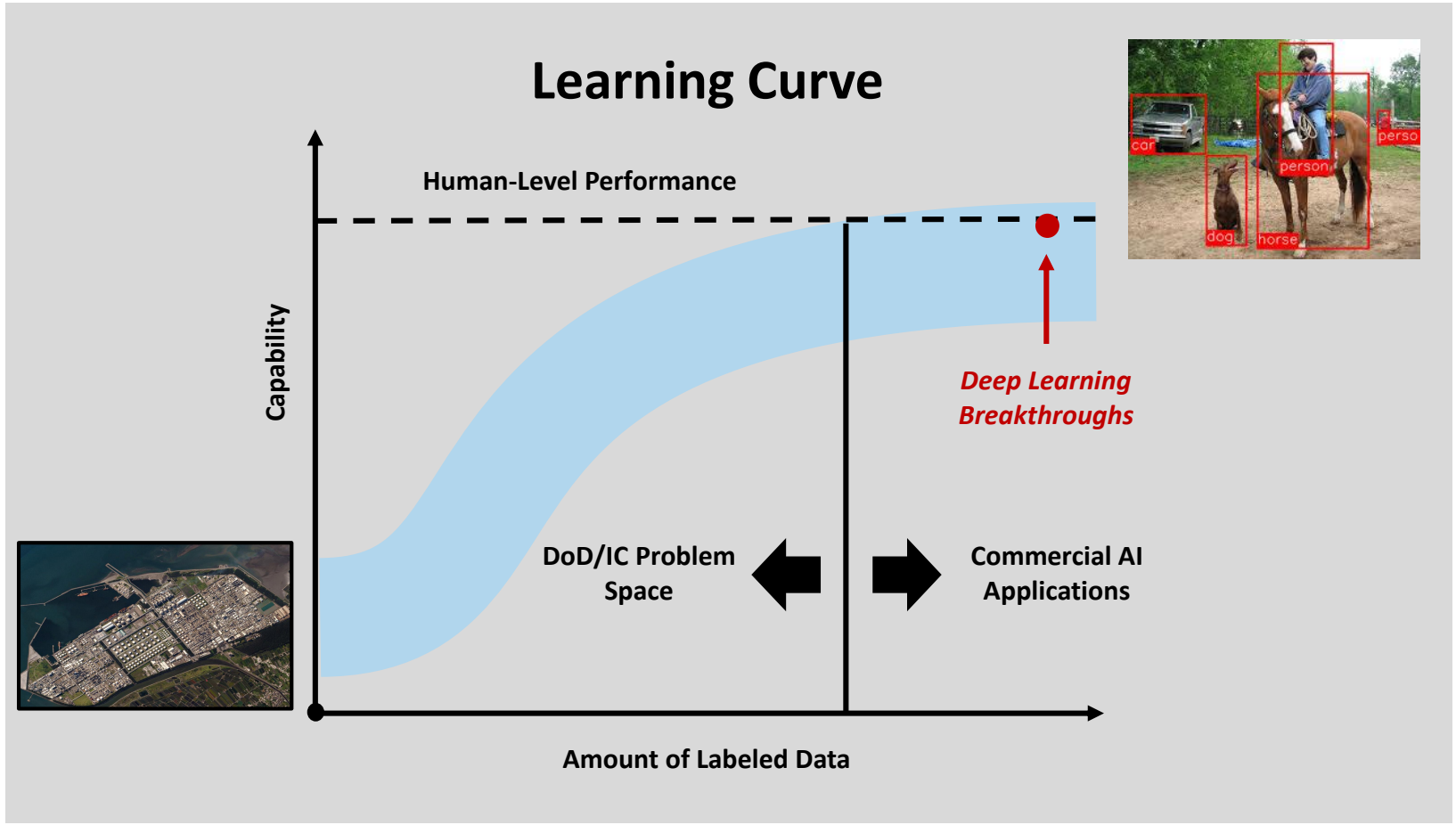




Commercial Space is Data Rich

- Data is easy to collect
- Labels are free or crowd source
- Rich datasets like ImageNet, COCO, and others.

Applying AI to National Security

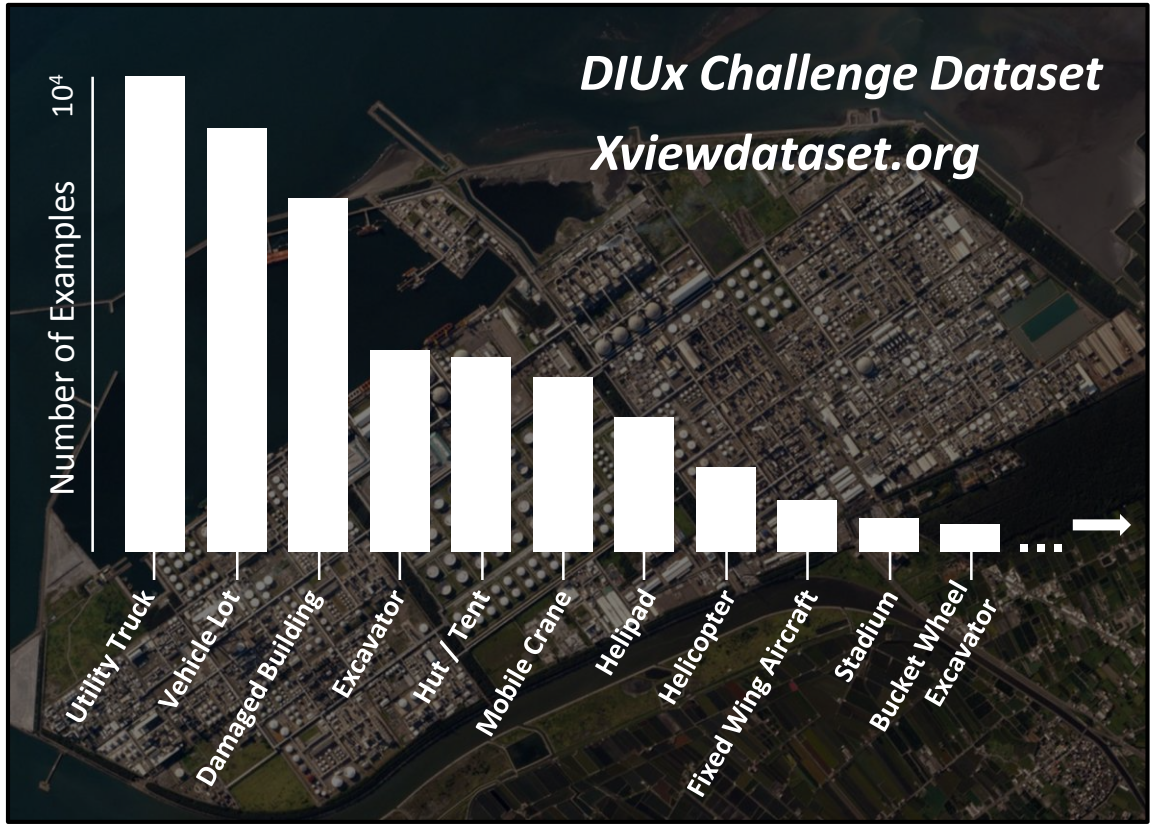


DoD Problem Space is Data-Starved

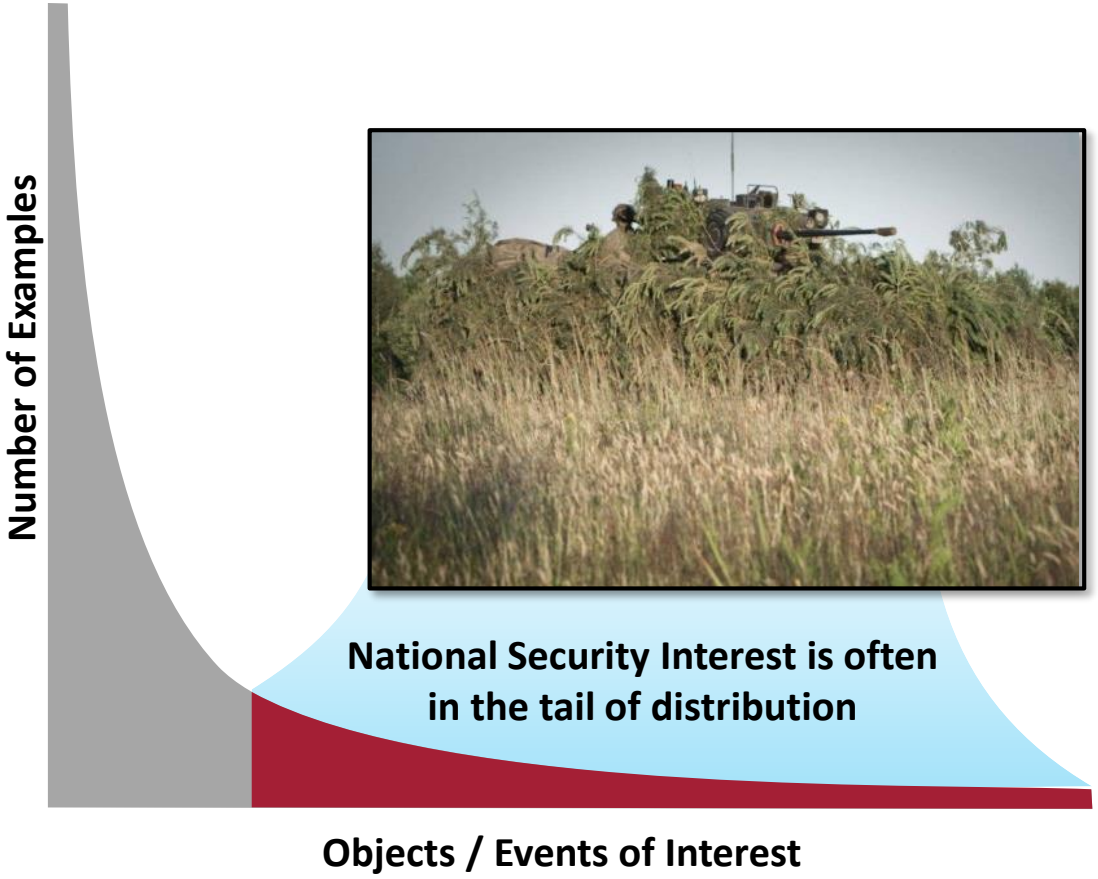
- Data has not been labeled
- Data is difficult to collect because content of interest is rare or adversary makes it hard

Data Starved AI Challenges

Not Enough Labeled Data



Not Enough Data

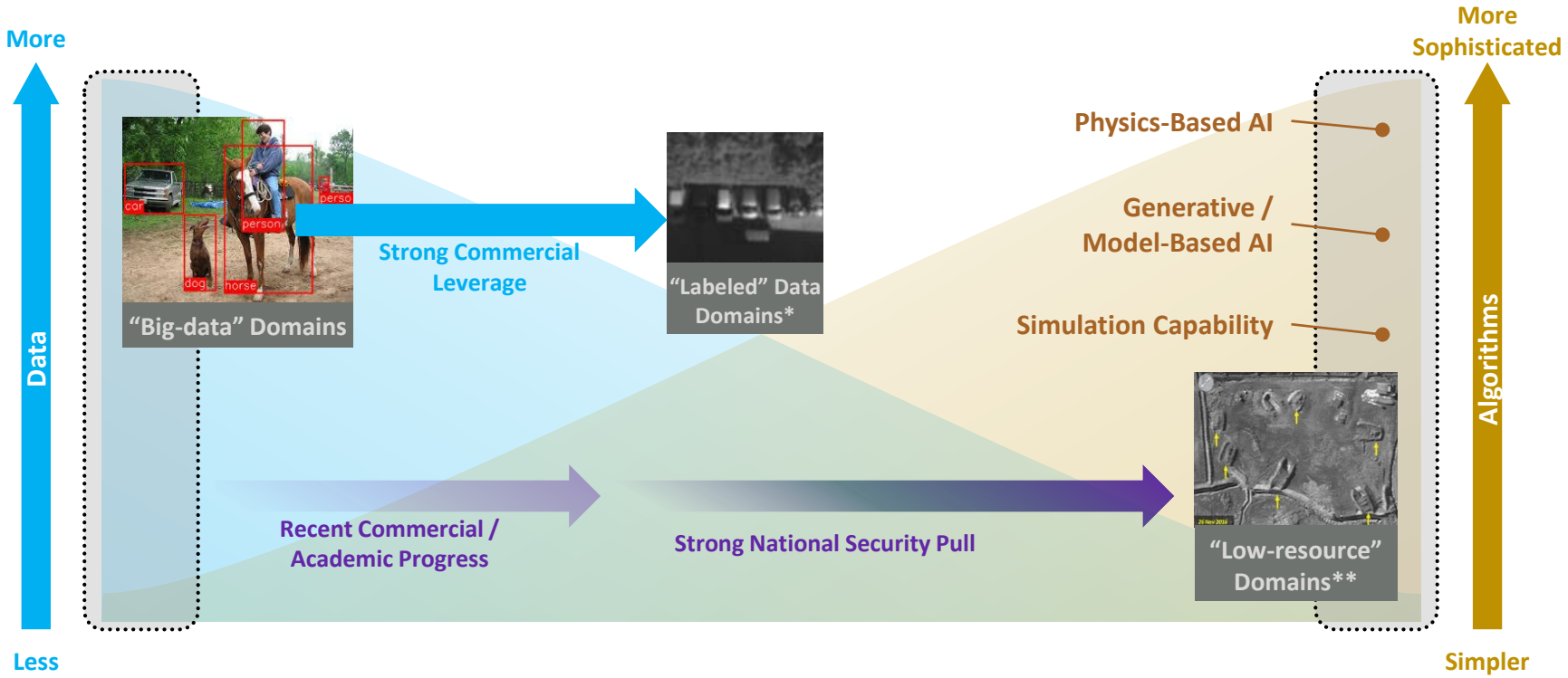


Applying AI to National Security

Data Rich
- Data is easy to collect
- Labels are free or crowd source

Data-Starved
- Insufficient labeled data

Data-Starved
- Data is difficult to collect
- Content of interest is rare



Example Research Thrusts

1. Develop Gold-standard datasets
2. Efficient data labeling at scale
3. Develop algorithms that require less training data
4. Pursue Cognitive Science research to inform machine learning
5. Hybrid learning that merges deep learning with model-based learning

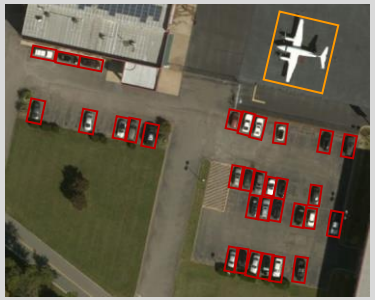
More sophisticated algorithms are needed in a data-starved environment

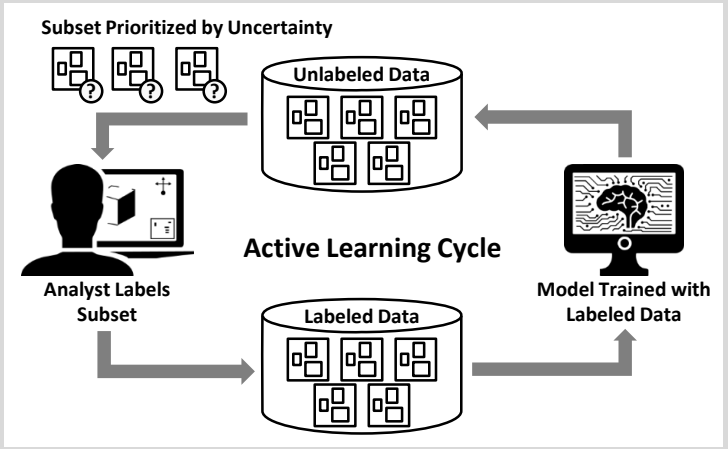
*Vehicle detection in low-res FMV; an example of AI applied to data-rich military domain
** Identification of camouflaged military targets: an example of a low-resourced and adversary-countered AI task

Data-Starved AI Session Talks

Computer Vision

Object Detection



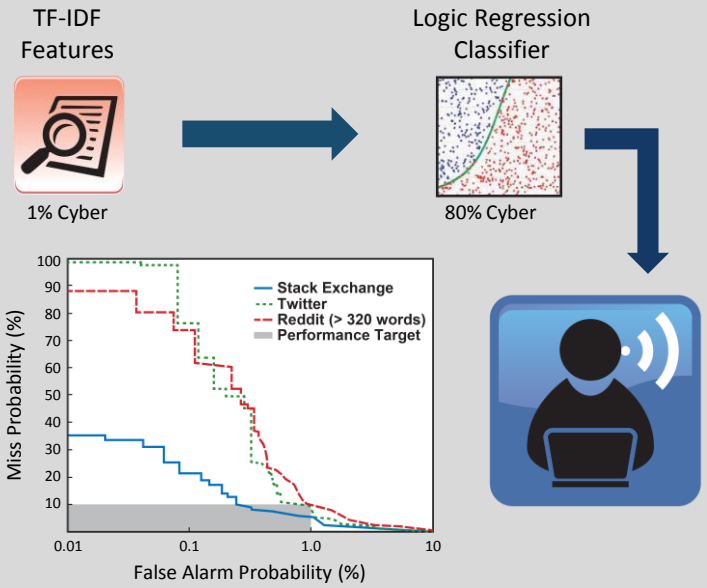


AI for Imagery Analysis in Low Resource Domains

Cyber Warrior

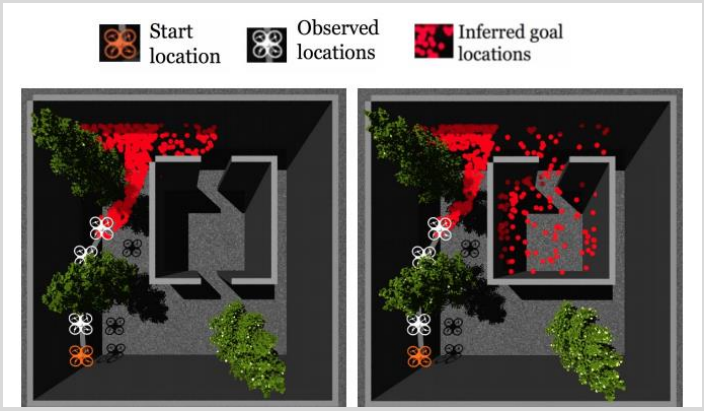
CHARIOT

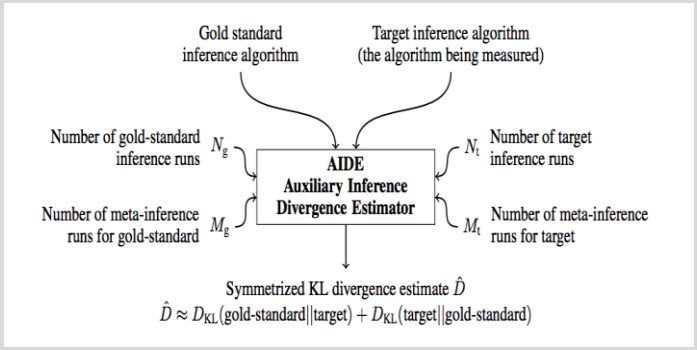
Detecting Online Cyber Discussions



AI to Aid Rapid Response to Cyber Attacks

Inferencing

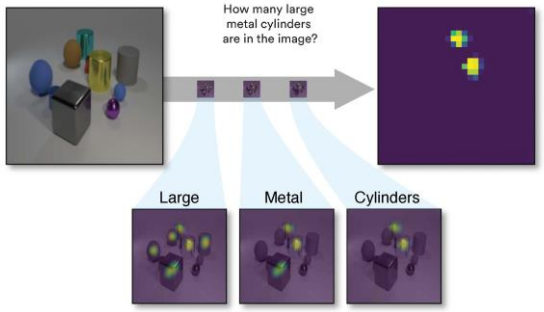


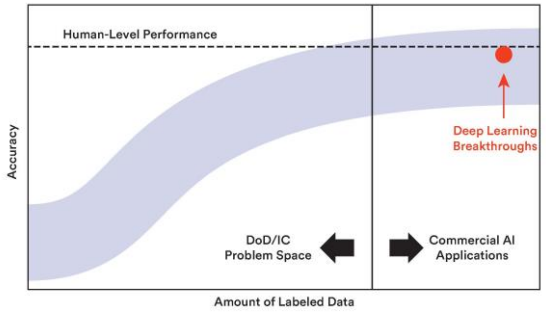


Probabilistic Computing for Data-Starved AI

Data-Starved AI Session Posters

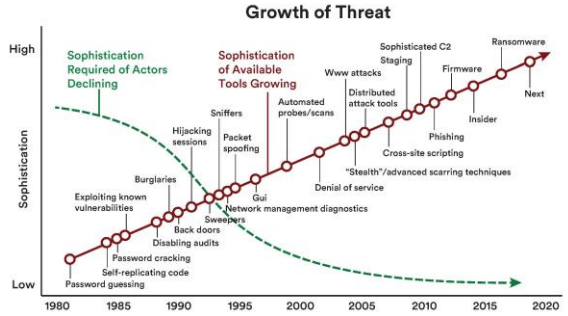
Computer Vision in Low Resource Environments

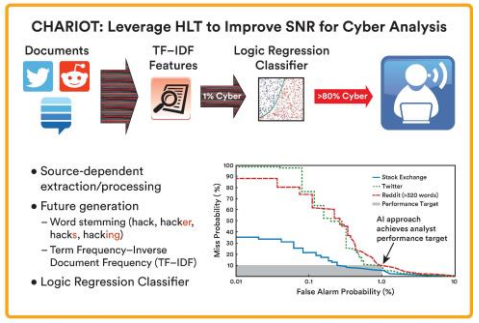




Mr. David Mascharka, MIT Lincoln Laboratory

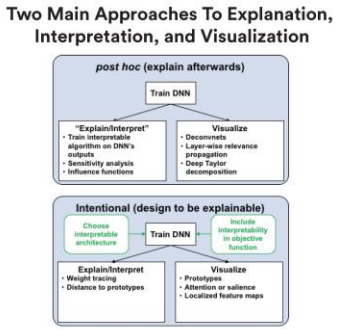
Teaming with the AI Cyber Warrior

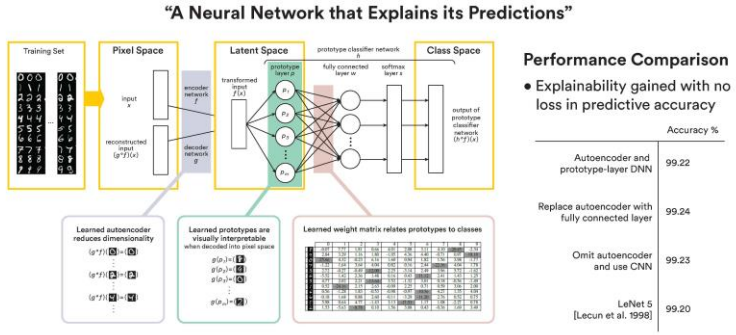




Dr. William Streilein, MIT Lincoln Laboratory

Interpretable Machine Learning





Performance Comparison

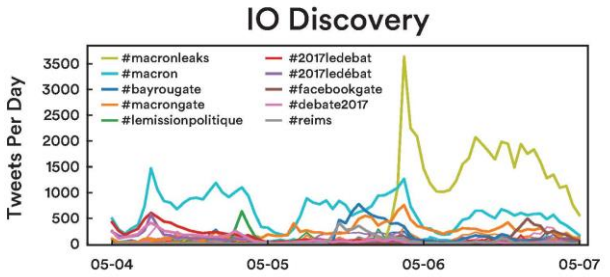
- Explainability gained with no loss in predictive accuracy

	Accuracy %
Autoencoder and prototype-layer DNN	99.22
Replace autoencoder with fully connected layer	99.24
Omit autoencoder and use CNN	99.23
LeNet 5 [Lecun et al. 1998]	99.20

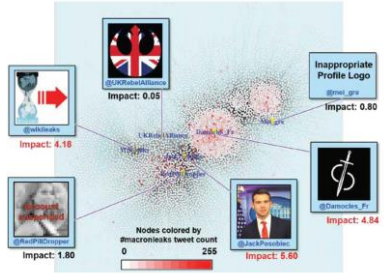
Dr. Jonathan Su, MIT Lincoln Laboratory

Threat Network Detection:

Countering Weaponization of Social Media



Estimation Problem: Influence



Dr. Olga Simek, MIT Lincoln Laboratory

Keynote: Prof. Antonio Torralba

Professor
CSAIL
Dept. of Electrical Engineering and Computer Science
Massachusetts Institute of Technology

Research Interests

- **Building systems that can perceive the world like humans do. A system able to perceive the world through multiple senses might be able to learn without requiring massive curated datasets.**

MIT-IBM Watson Lab

- **The Lab is focused on advancing four research pillars: AI Algorithms, the Physics of AI, the Application of AI to industries, and Advancing shared prosperity through AI**

Summary

- **Recent advances in hardware, algorithms, and the availability of large training data have led to machines approaching or exceeding human performance in some domains**
- **Challenge in applying AI for National Security: *How do we gain understanding of the world to enable time-critical decisions in an environment that is adversarial and data starved.***
- **Advances in data-starved AI are needed to meet national needs**
  - **MIT Lincoln Laboratory is actively working in this area**
  - **Looking forward to collaborating with you to improved the state of the art**