Room change, so we will start a bit late!

EE392B Industrial AI

https://web.stanford.edu/class/ee392b/

Daniel O’Neill
Dimitry Gorinevsky

REV 2

Instructors

- Daniel O'Neill, Adjunct Professor in EE
  - Generative Models (cloud-AIOps, genomics, energy)
  - Sr. Dir. @ Microsoft, TI, SUN, CEO @2 startups, VC Partner
  - PhD Stanford, MBA UC Berkeley
  - http://www.stanford.edu/~dconeill
- Dimitry Gorinevsky, Adjunct Professor in EE
  - Industrial AI in several industries
  - Analytical applications across several industries
  - www.stanford.edu/~gorin

Class Mechanics

- Sequence of Talks
- Weekly on Tuesday's
  - Many remote speakers on ZOOM
  - Check out class website at ee392b.stanford.edu
- 1 unit graded CR/NC
  - No formal pre-requisites
  - Attendance and participation
  - Term paper: one page report/summary in the end
    - Will post formal requirements

Let's Ask ChatGPT About EE392B?

EE392b at Stanford University is a graduate-level course called "Industrial AI: Applications and Practice." The course covers the fundamentals of AI and machine learning, with an emphasis on applications in industry. Topics covered may include deep learning, natural language processing, computer vision, reinforcement learning, and AI-driven optimization. The course is designed to give students hands-on experience with industrial AI applications, using real-world case studies and examples. Students may also have the opportunity to work on a project related to industrial AI.

Definition?

It's worth noting that course offerings and content can change over time, so this information may not be up-to-date if you are looking at this course in the future.

Hedge?

For the one pager: Can you guess the source?

Today's Agenda

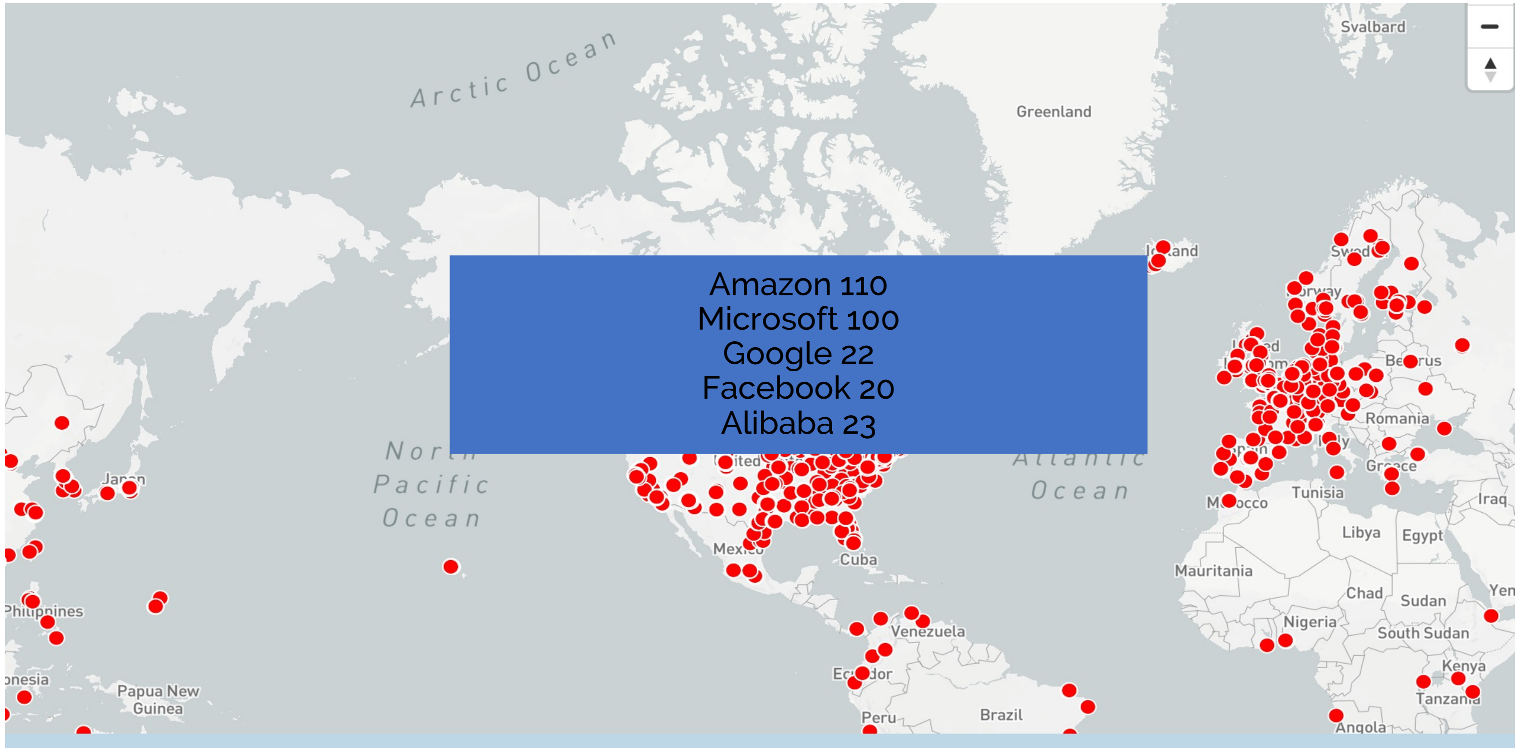
- I-AI applications
- I-AI infrastructure
- Current industry trends
- Challenges and opportunities
- This quarter's speakers!

Examples and characteristics

Example One: AIOps

- Cloud based web sites run continuously, but can experience anomalies in subtle ways
- Degradation is $$
- Outages are critical
- Needed: AI to monitor distributed operational data, detect anomalies, automatically respond and solve problem

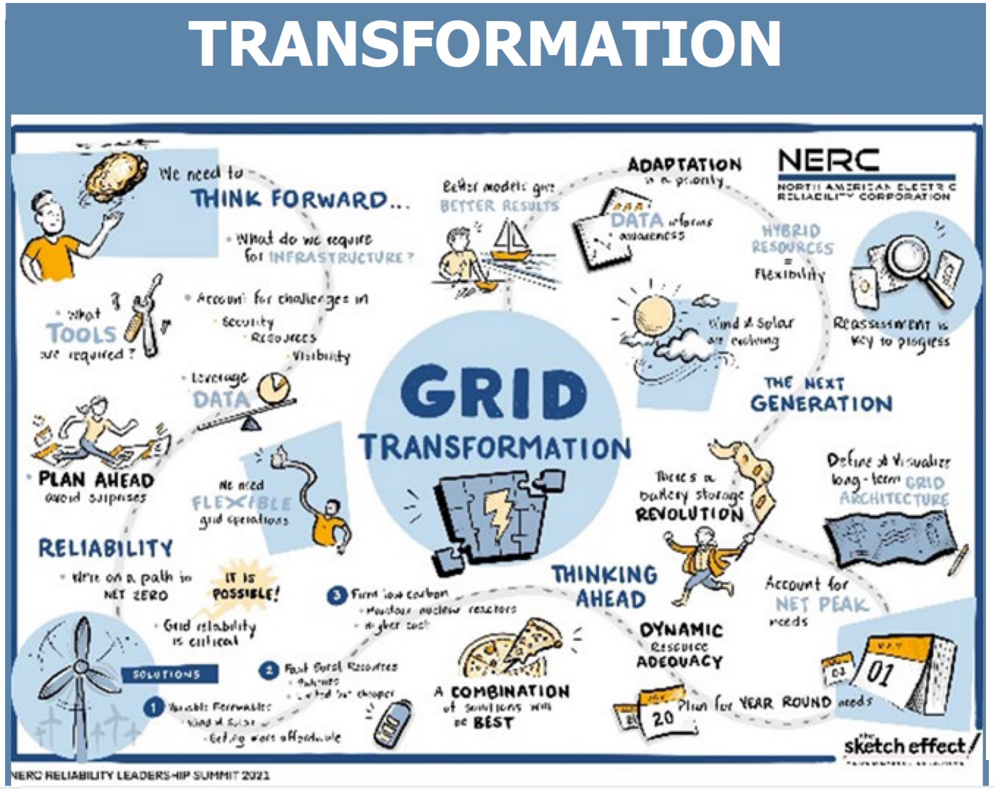
Cloud Complexity and AIOps

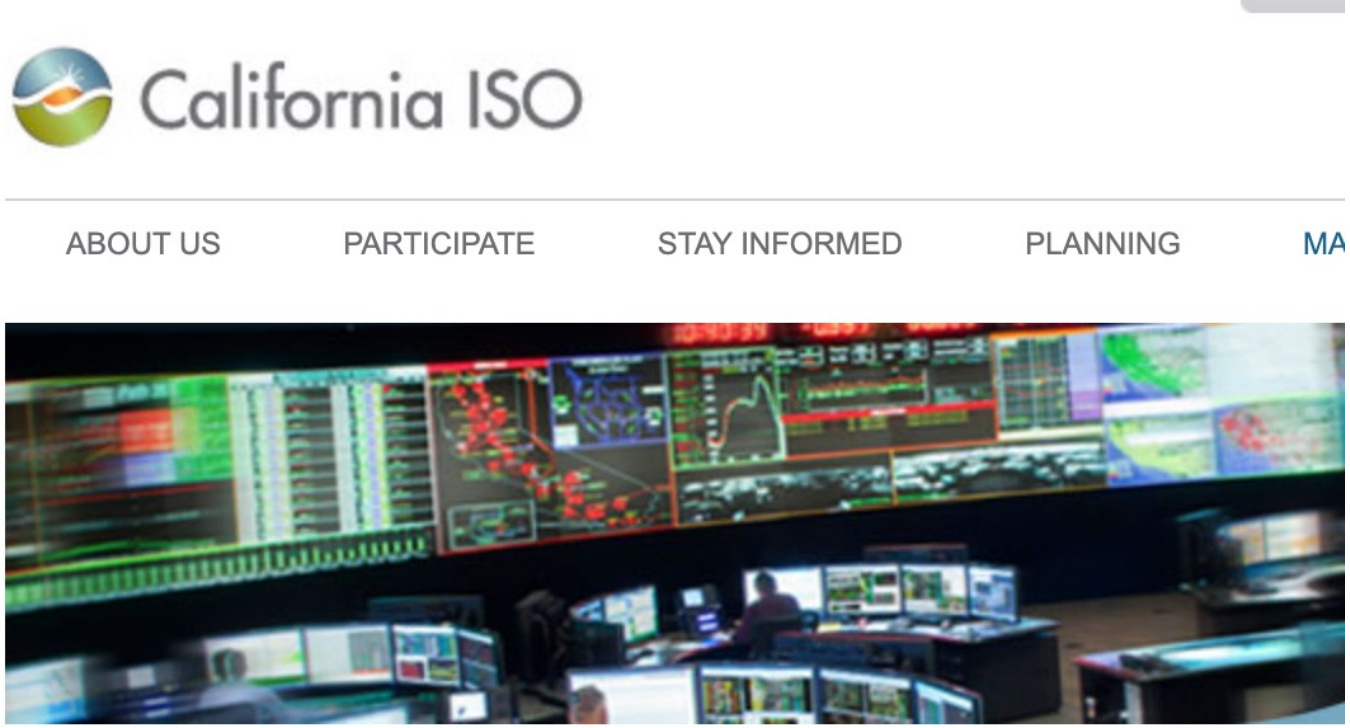


Example Two: Energy

- Large scale, real-time system
- Recent blackouts!
- Errors have large downside
- Needed: AI to understand real-time distributed data, automatically solve problems

US Electrical Grid Is A Mixture of Systems





Example 3: Maintenance Supply Chain

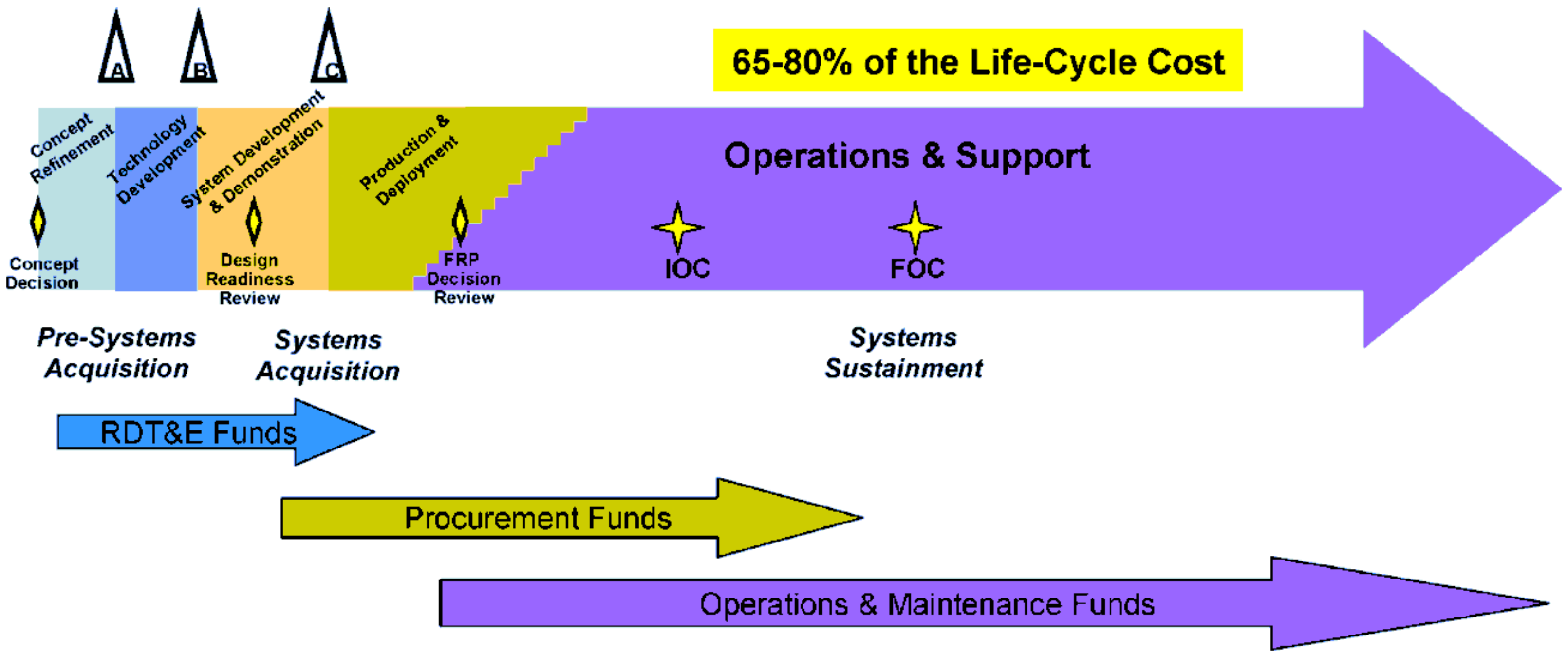
- Maintenance makes over half of aircraft OpEx
- US Air Force aircraft currently have mission readiness at 70%
- Very expensive assets might be inoperational because needed maintenance parts are not there
- CBM promises to predict failures and the need for replacement parts in advance, using AI

US Air Force CBM

Condition Based Maintenance

Operations and Support

- Engineering and manufacturing
  - 10-15% of the lifecycle cost
- Operations and supply chains
  - 65-80% of the lifecycle cost



Industrial AI Applications are Very Broad

- AI for computer management
- AI for energy automation
- AI for aircraft maintenance (ops)

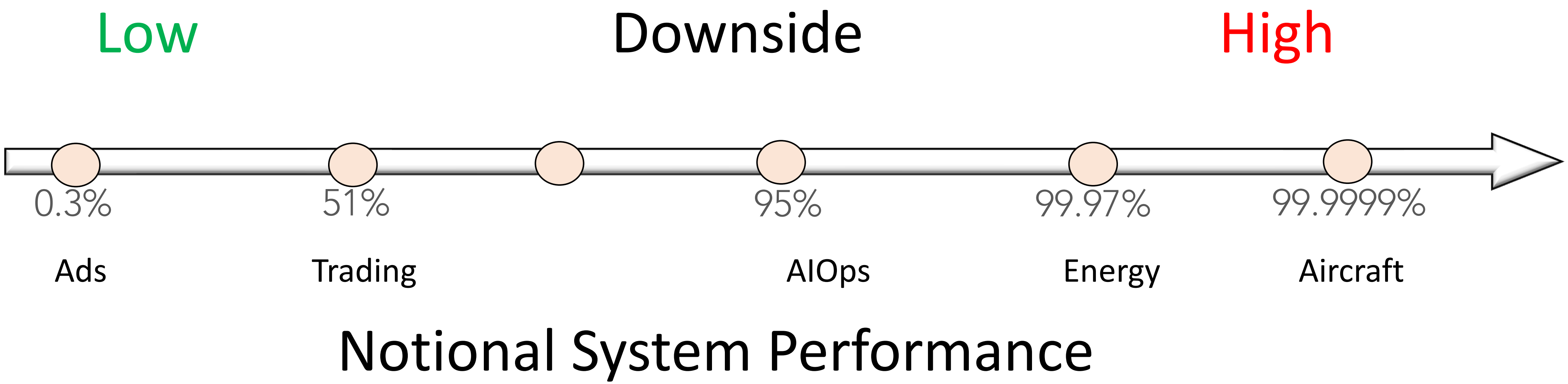
- AI for supply chain optimization
- AI for human training (ops and UX)
- AI for transportation management
- AI for genetic testing (ops)

Mission Critical

Characteristics of Industrial AI

- Mission Critical
  - Large downside to mistakes
  - Trusted / Reliable
- Often, time limited
- Often, distributed
- Usually, involves new or different human interactions
- Requires new infrastructure paradigms

Mission Critical



I-AI => Changing Infrastructure

- New SW paradigms
  - Convergence
  - New Algorithms
- New HW paradigms
  - Exponential growth in compute
  - Distributed intelligence
- New UX paradigms (Training and Operations)

Center for
Research on
Foundation
Models

Software Convergence

Example of SW Convergence

What is the use of AI in process control?

Instead of requiring engineers to explicitly program complex control laws that are based on physics or chemistry, AI is used to learn those control laws or learn the model with a process of machine learning out of historical data that describes the way a product has responded to different conditions or different ... Jun 6, 2022

FE Food Engineering Magazine
https://www.foodengineeringmag.com › articles › 100...

D pytroch for regression using nn.Module

‹ 3 / 3 › Sure, here's an example code for building a simple regression model using PyTorch's `nn.Module`:

python Copy code

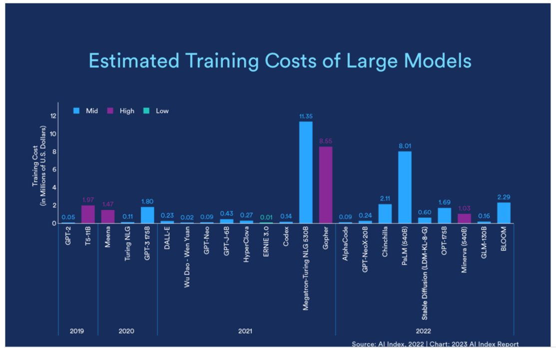
```python
import torch
import torch.nn as nn

# Define the network architecture
class SimpleRegression(nn.Module):
    def __init__(self, input_size, hidden_size, output_size):
        super(SimpleRegression, self).__init__()
        self.fc1 = nn.Linear(input_size, hidden_size)
        self.relu = nn.ReLU()
        self.fc2 = nn.Linear(hidden_size, output_size)

    def forward(self, x):
```

Regenerate response

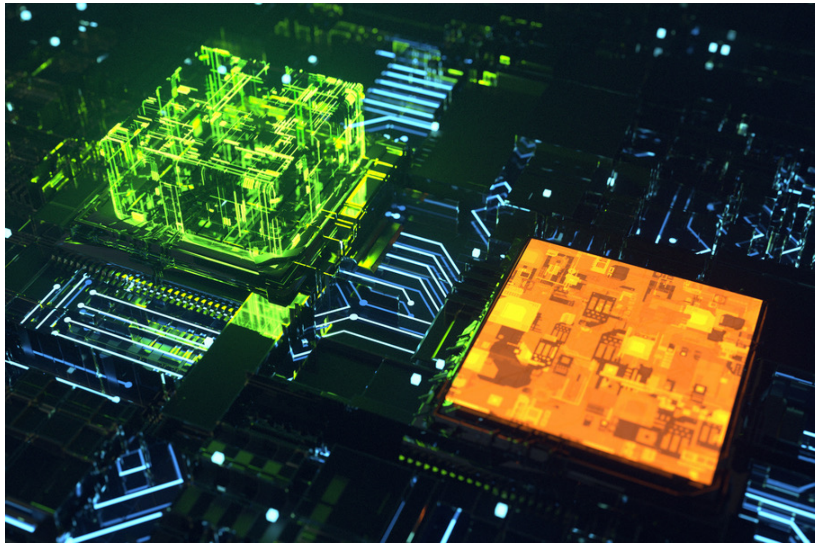
Compute Costs



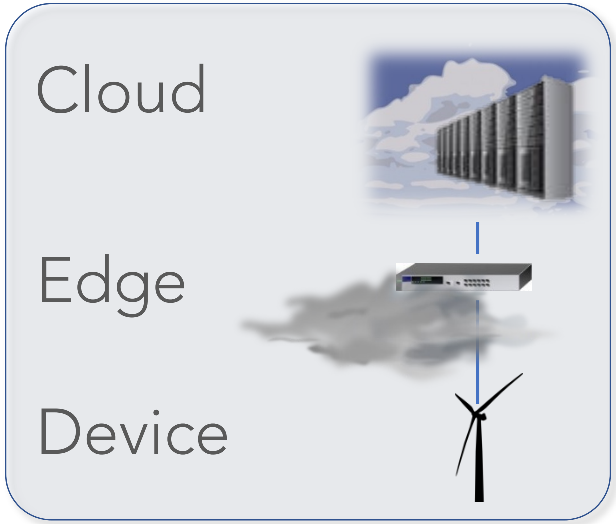
- GPT-1 $50K
- GPT-3 Tens of millions $

Stanford University
Human-Centered
Artificial Intelligence

Hardware **Transformation**



Exponential Compute demands:
CPU's, GPU's, Wafer Scale, Quantum?



Distributed Data (Federated)
Distributed Compute

OpenAI's CTO Brockman

Let’s Ask ChatGPT about I-AI

> Industrial AI, also known as AI in Industry or Industrial Automation, refers to the use of artificial intelligence (AI) technologies in industrial and manufacturing processes. This involves the use of machine learning, deep learning, computer vision, and other AI

More chatting yields additional information:

- SW algorithms – Transformers, NLP, CNN,GNN, VAE’s, Generative Models, Reinforcement Learning
- Data at scale or in real-time
- New SW Tools – PyTorch, SciPy, AlphaFold, Dall-E, BERT, GPT,…
- New compute – to support the SW

Current Industry I-AI Trends

- Digital Transformation
  - Industry 4.0
  - Digital (SW) twins
    - Simplifications (do it in SW)
  - Automated
    - Monitoring and management
    - Maintenance
    - Performance updates
    - Safety measures

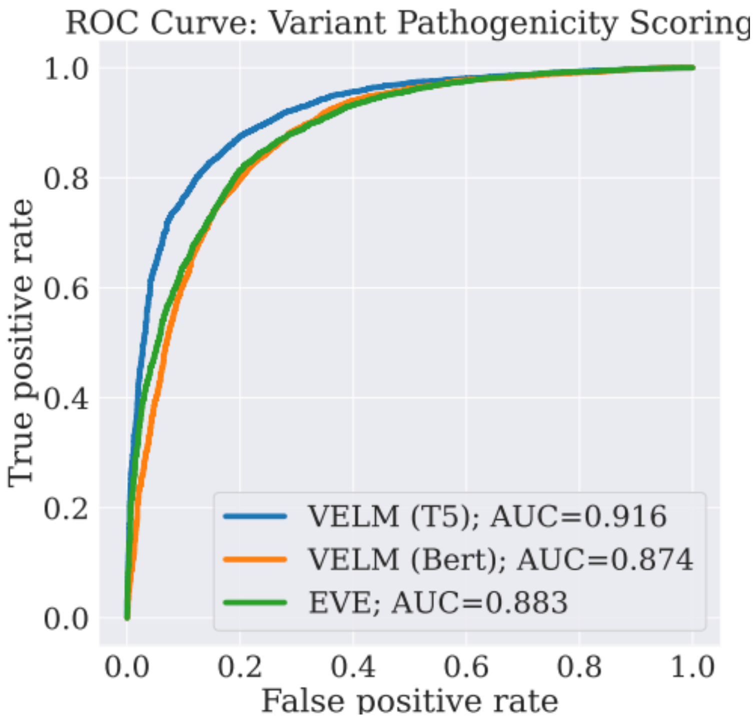
- Internet of Industrial Things
  - The electrical grid
  - Supply chains
  - AIOps for various compute clouds
  - Smart cities
  - Smart transportation
  - Automated maintenance

New I-AI Opportunities

- Security / *Authentication*
- *Training people to work with I-AI*
- *Genomics*
- Transparent customization
- Real time medical management
- *Synthetic Data*

Difficult or impossible without AI/ML enabled I-AI methods

Opportunity in Genetic Testing



- Steps:
  1. Blood test
  2. Sequence genome
  3. Apply AI to detect anomaly

Someday a blood test for cancer

Generative model using only the encoder and self supervision

Backup: Genetic Testing

NeurIPS 2022

Unsupervised language models for disease variant prediction

Allan Zhou* Stanford University

Nicholas C. Landolfi* Stanford University

Daniel C. O'Neill Stanford University

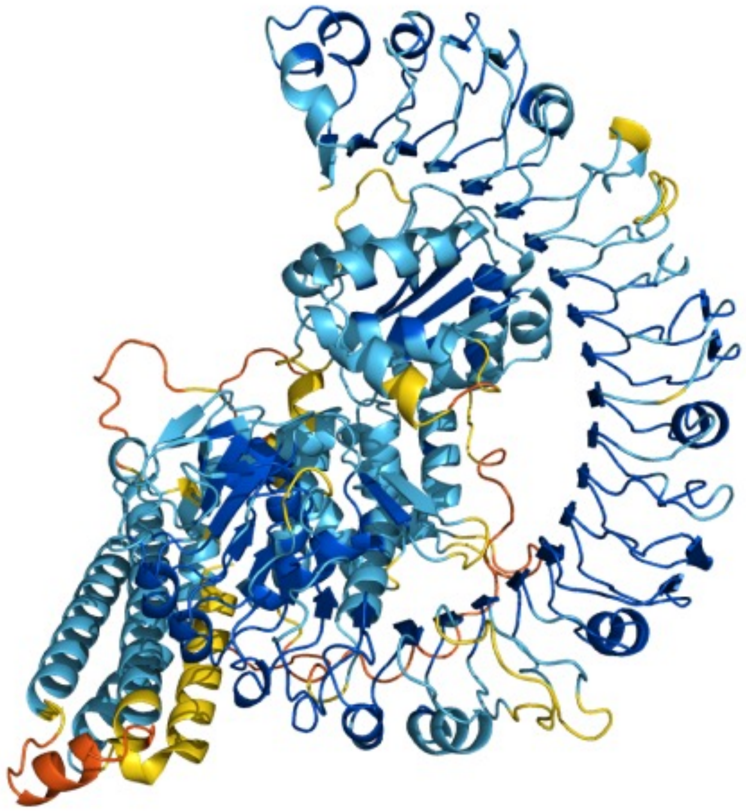
Abstract

There is considerable interest in predicting the pathogenicity of protein variants in human genes. Due to the sparsity of high quality labels, recent approaches turn to *unsupervised* learning, using Multiple Sequence Alignments (MSAs) to train generative models of natural sequence variation within each gene. These generative models then predict variant likelihood as a proxy to evolutionary fitness. In this work we instead combine this evolutionary principle with pretrained protein language models (LMs), which have already shown promising results in predicting protein structure and function. Instead of training separate models per-gene, we find that a single protein LM trained on broad sequence datasets can score pathogenicity for any gene variant zero-shot, without MSAs or finetuning. We call this unsupervised approach **VELM** (Variant Effect via Language Models), and show that it achieves scoring performance comparable to the state of the art when evaluated on clinically labeled variants of disease-related genes.

AlphaFold2:
Today a Research Tool, Tomorrow ?

AlphaFold is an AI system developed by DeepMind that predicts a protein's 3D structure from its amino acid sequence. It regularly achieves accuracy competitive with experiment.

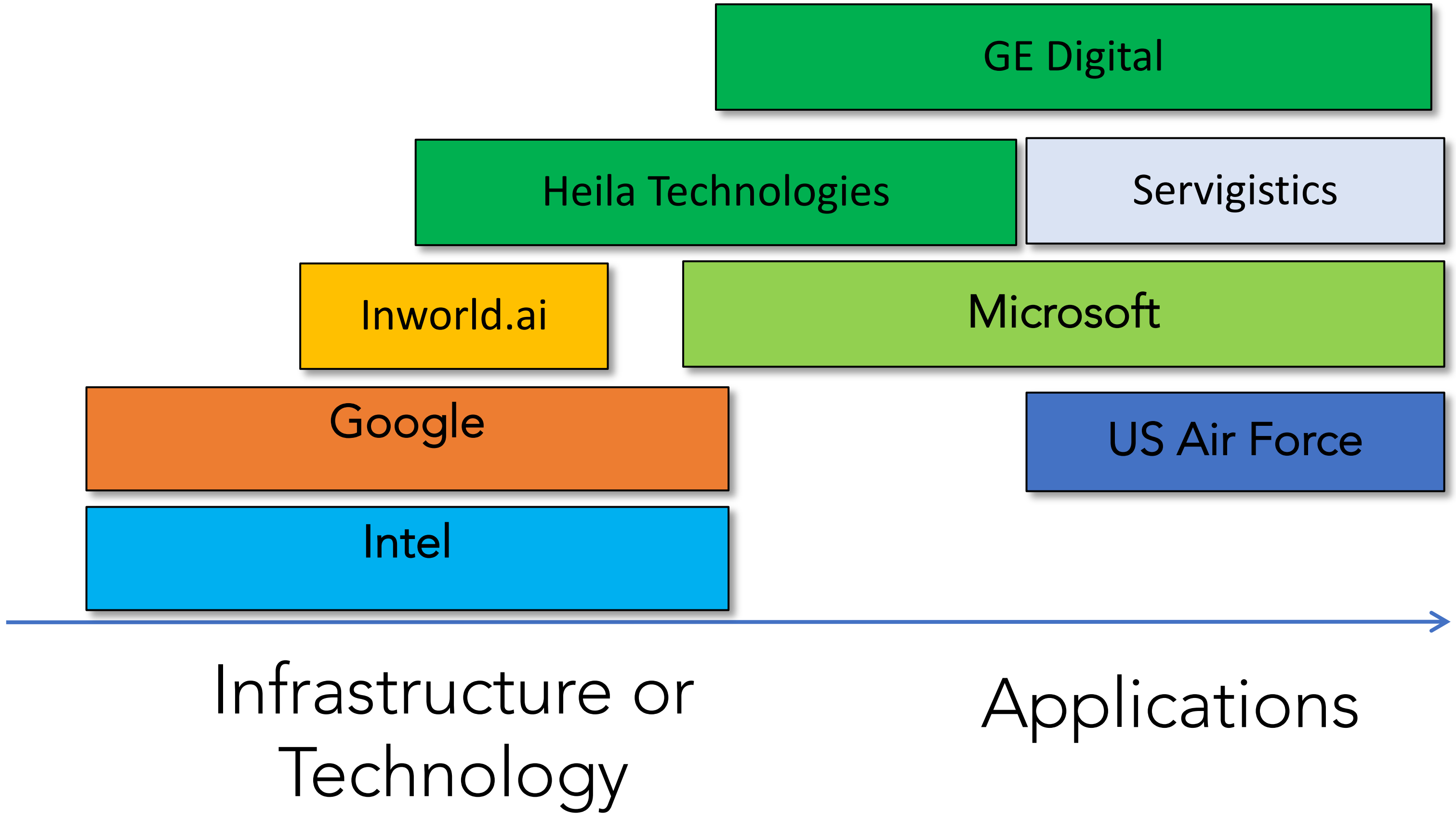
Also used to generate "synthetic data" !



Lots of Challenges

- Data
  - Who owns the data?
  - Generated synthetic data?
- I-AI safety in mission critical uses
  - Unexpected behavior
  - Errors
  - Data drift
- Interpretability of I-AI methods
- Scale of infrastructure
- Working with I-AI systems

I-AI Lecture Map



Speakers

Date	AREA	Speaker
April 4	Industrial AI Introduction	Profs Dan ONeill and Dimitry Gorinevsky
April 11	AI for Sustainable Energy	Achalesh Pandey, VP for Artificial Intelligence and Digital Transformation, GE Digital
April 18	AI and Optimization of Large-Scale Service Supply Chains	Leslie Paulson, Division VP and GM, PTC Servigistics
April 25	AI for Condition Based Maintenance of Aircraft	Lt Col Michael Lasher, Deputy Chief of Logistics, US Air Force RSO
May 2	Next Gen AI for I-AI	Gadi Singer, VP, Intel AI Research at Intel Lab
May 9	AI UX for Training and Industry	Kylan Gibbs, VP, Inworld.ai
May 16	AI for IT Operations - AIOps	Allison Jones, GPM, Product Management, Azure AIOps, Microsoft
May 23	Quantum Computing and AI	Ryan Babbush, Head of Quantum Algorithms, Google
May 30	AI for Power Systems	Trudie Wang, VP of Innovation, Heila Technologies

Questions?

End of Deck

Electricity Production in USA

Energy source	Billion kWh	Share of total
Total - all sources	4,243	
Fossil fuels (total)	2,554	60.2%
Natural gas	1,689	39.8%
Coal	828	19.5%
Petroleum (total)	23	0.6%
Petroleum liquids	16	0.4%
Petroleum coke	7	0.2%
Other gases[3]	12	0.3%
Nuclear	772	18.2%
Renewables (total)	913	21.5%
Wind	435	10.2%
Hydropower	262	6.2%
Solar (total)	146	3.4%

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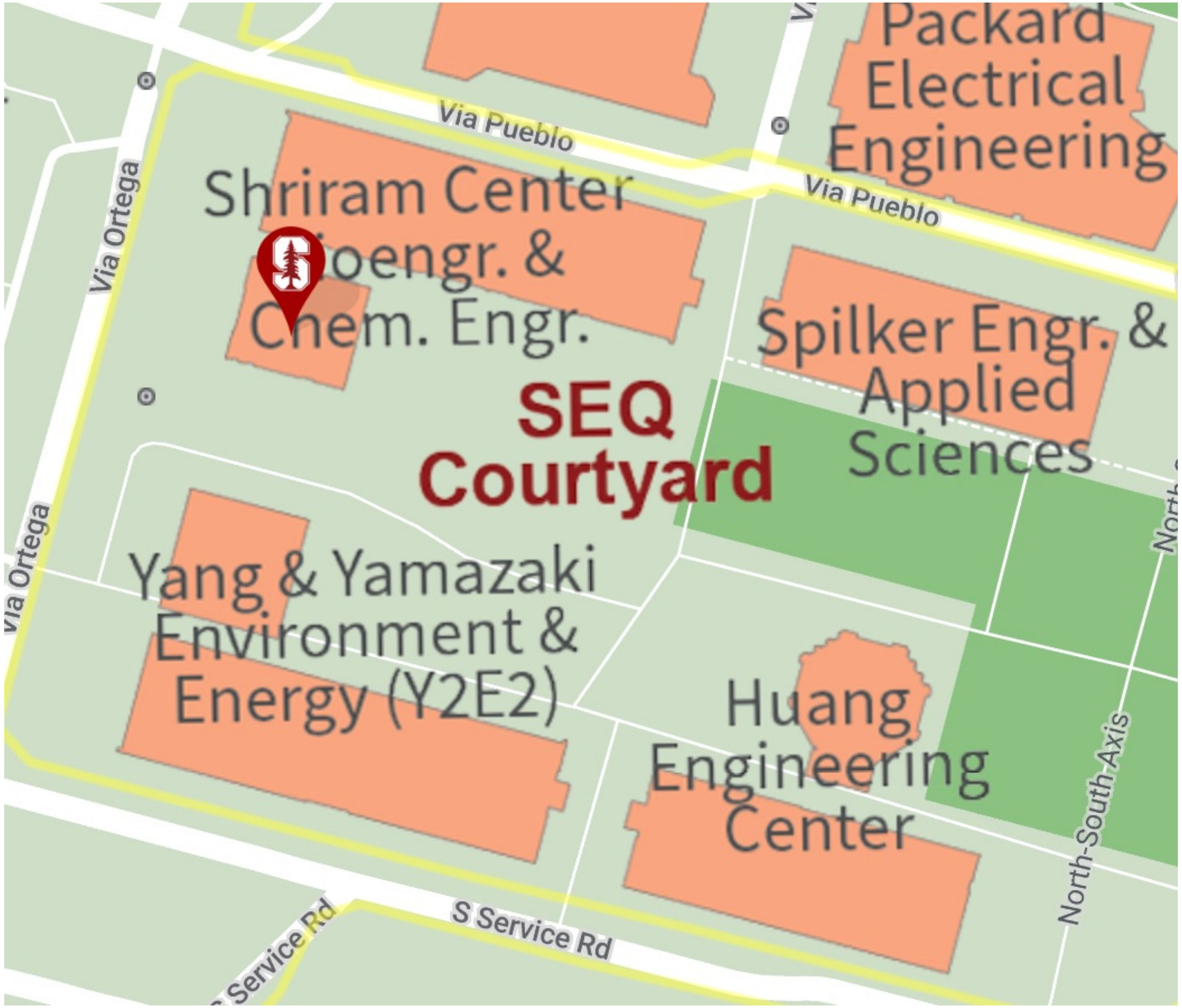
June 6	TBD	

EE392B Industrial AI Has Moved to

Shriram Center for Bioengineering & Chemical Engineering, Room 104



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