Room change, so we will start a bit late!

EE392B
Industrial AI

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

Daniel O’Neill
Dimitry Gorinevsky
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
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.

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.

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

Amazon 110
Microsoft 100
Google 22
Facebook 20
Alibaba 23
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

Notional System Performance

Low
0.3%
Ads

Downside
51%
Trading

High
95%
AIOps
99.97%
Energy
99.9999%
Aircraft
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)
Software Convergence

Self Supervised Models
Generative Models
Transformers

Process Control Models
Simulink Models
Business Intelligence

Federated Models
Foundational Models

Real time Streaming Data
Distributed data
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

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

• GPT-1 $50K
• GPT-3 Tens of millions $
Hardware **Transformation**

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

OpenAI’s CTO Brockman

Distributed Data (Federated)  
Distributed Compute
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 1-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
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

Infrastructure or Technology

- Intel
- Google
- Heila Technologies
- Inworld.ai
- Servigistics
- Microsoft
- GE Digital
- US Air Force

Applications
<table>
<thead>
<tr>
<th>Date</th>
<th>AREA</th>
<th>Speaker</th>
</tr>
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<tbody>
<tr>
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<td>AI for Condition Based Maintenance of Aircraft</td>
<td>Lt Col Michael Lasher, Deputy Chief of Logistics, US Air Force RSO</td>
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<td>May 2</td>
<td>Next Gen AI for I-AI</td>
<td>Gadi Singer, VP, Intel AI Research at Intel Lab</td>
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<td>AI UX for Training and Industry</td>
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Questions?
End of Deck
## Electricity Production in USA

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<thead>
<tr>
<th>Energy source</th>
<th>Billion kWh</th>
<th>Share of total</th>
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<tbody>
<tr>
<td>Total - all sources</td>
<td>4,243</td>
<td></td>
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<tr>
<td>Fossil fuels (total)</td>
<td>2,554</td>
<td>60.2%</td>
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<tr>
<td>Natural gas</td>
<td>1,689</td>
<td>39.8%</td>
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<tr>
<td>Coal</td>
<td>828</td>
<td>19.5%</td>
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<tr>
<td>Petroleum (total)</td>
<td>23</td>
<td>0.6%</td>
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<tr>
<td>Petroleum liquids</td>
<td>16</td>
<td>0.4%</td>
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<tr>
<td>Petroleum coke</td>
<td>7</td>
<td>0.2%</td>
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<tr>
<td>Other gases(^3)</td>
<td>12</td>
<td>0.3%</td>
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<tr>
<td>Nuclear</td>
<td>772</td>
<td>18.2%</td>
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<tr>
<td>Renewables (total)</td>
<td>913</td>
<td>21.5%</td>
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<tr>
<td>Wind</td>
<td>435</td>
<td>10.2%</td>
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<tr>
<td>Hydropower</td>
<td>262</td>
<td>6.2%</td>
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<td>Solar (total)</td>
<td>146</td>
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EE392B
Industrial AI
Has Moved to
Shriram Center for Bioengineering & Chemical Engineering, Room 104