AI and the Pandemic:

When Two Disruptive Forces Meet

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Preamble & Motivations

- Two ongoing **disruptive** forces: AI and the Pandemic (COVID-19)
- The pandemic
  - Changed our life and society in just 10 months
  - Presented immediate and complex challenges
- Many have turned to AI
  - AI as potential solution to cope with the pandemic?
- What lessons have we already learned?
  - Don't let any crisis go to waste

This keynote will offer my viewpoints based on my experiences in teaching AI courses at Harvard and AI research in manufacturing and healthcare

AGENDA

- **Three limitations** of AI exposed by COVID
- **Three goals and visions** in addressing these limitations
- **Concrete next steps**

Exemplar Use of AI for COVID

- **Virus classification**
  - Genomic data as input to track the source of a virus and its mutation
- **Detection of emerging outbreaks**
  - crowd-sourced information
- **Contact tracing and tracking**
  - Complementing social distancing
- **Optimal lockdown strategies**
  - Allowing heterogeneous micro-lockdowns
- **Vaccine development**
  - Research collaboration across AI and biomedical domains

Three Limitations of AI Exposed by COVID-19

AI solutions cannot be developed in real-time

- Virus spread and mutation will not wait

Lack of historical data for novel coronavirus

- Data acquisition is costly and time-consuming

Slow incorporation of rapidly emerging data

- Lots of new data resulting from abrupt changes in user behavior, shift to remote work, and increased use of robots

Goals and Visions for AI-assisted Solutions

Three **Goals**

- Goal 1: Shorten AI Pipeline
- Goal 2: Devise Innovative Domain Methods
- Goal 3: Acquire Domain Expertise

Three **Visions**

- Vision 1: Transform Pipeline Into Single Fully-integrated Process
- Vision 2: Revamp Domain Methods with Ambitious Performance Goals
- Vision 3: Use Data-driven Methods and Expert Tools to Capture Domain Expertise

Goal 1 | Shorten AI Pipeline

Data acquisition → AI model → System deployment

Current pipeline is long, hampering rapid AI solutions

In time : long turnarounds

In space : could span multiple domains under separate management

How to shorten the pipeline?

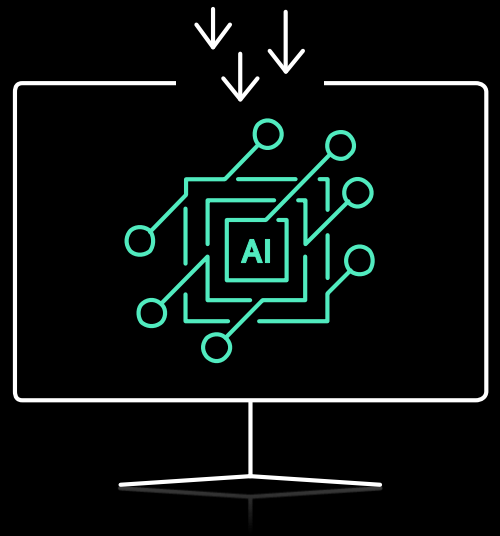
Streamline the pipeline-especially at the two ends especially

(Data acquisition and system deployment)

- They have less automation than AI model development

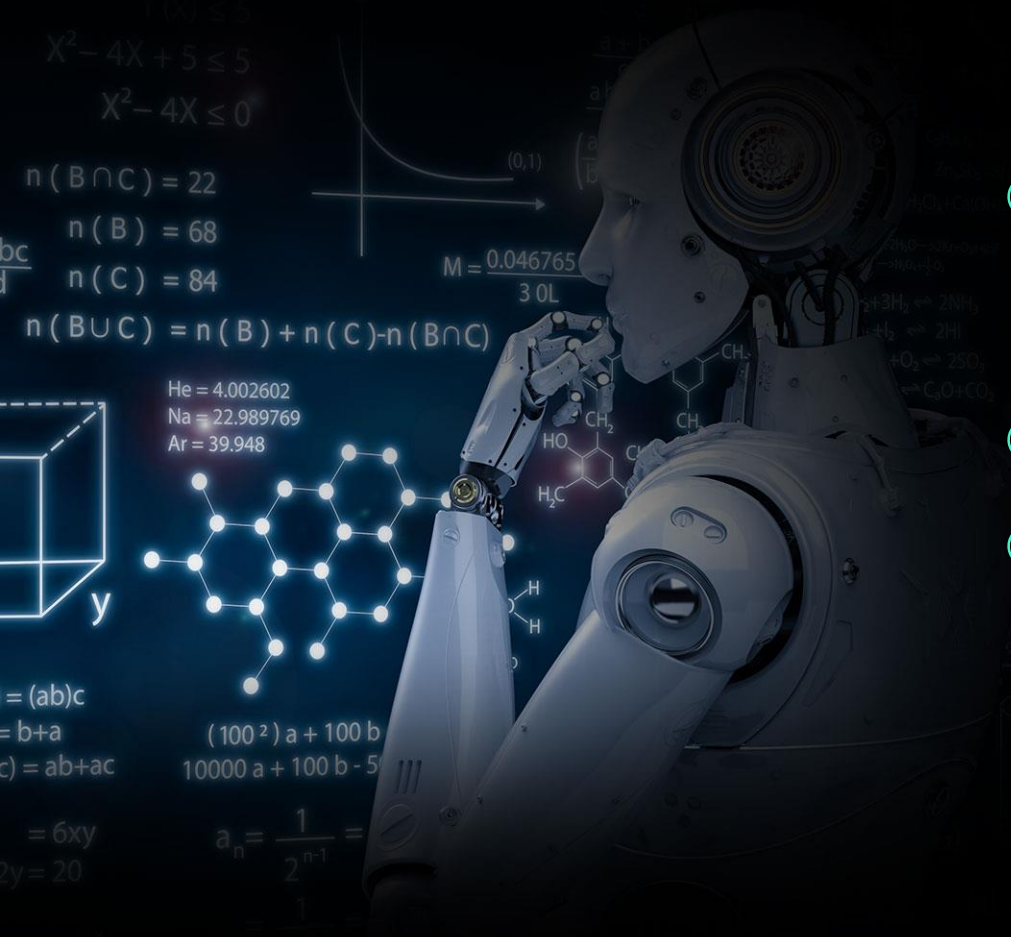
Unify pipeline management and optimization

Vision 1 | Transform an AI Pipeline into Single Fully-integrated Process



- Model training is **continuously** carried out **in-place** & **on-the-fly** alongside data acquisition and model deployment
  This way, AI model can keep pace with new data
- This means **distributed** learning and inference
  E.g., federated learning across different organizations
- Apply **edge-node** optimization and acceleration

Goal 2 | Devise Innovative Domain Methods for AI-assisted Solutions



- **Performance gains from applying AI to standard methods are typically marginal**
  E.g., small % of accuracy gain
- **Small gains don't justify the added cost of using AI**
- **Adopt AI screening**
  We can identify and experiment with new aggressive methods, which can lead to substantially higher performance gains

Vision 2 | Revamp Domain Methods for Ambitious AI Performance Goals

- **Develop a new generation of domain methods that leverage AI assistance**

  E.g., use of “digital twins” in manufacturing and healthcare for substantial performance improvement rather than a few % gain

- **Resulting AI-assisted solutions could have a chance to be disruptive**

  Effective response to new challenges, such as real-time development of AI solutions for COVID

Goal 3 | Acquire Domain Expertise for AI

- **Only domain experts know how to:**
  - Extract useful features—especially nonlinear ones
  - Determine what data to include when training
  - Synthesize data for rare events and corner cases
  - Check model consistency with physical evidence
- **Acquiring expert domain knowledge (logic) can be challenging, and human experts are the most expensive resource**
  - ➡ The art is in minimizing such costs

Vision 3 | Use Data-driven Methods to Capture Domain Knowledge

- **Expert system pipeline is modified to yield outcome as final output**

  Input data → **Expert logic** → Decision → Outcome

- **New data generation process models the following input-output relationship:**

  {Input data, Decision} → Outcome

- **There may still be a data shortage problem**

  → **Again, we rely on domain expertise** (next slide)

Capture Domain Expertise for AI with Expert Tools

Differential equations to device analytical shortcuts without model learning

- E.g., optimal control for micro-lockdowns

Physical simulations to generate synthetic data for rare events such as failure and corner cases

Statistical distribution of real-world data to guide data acquisition as well as model learning

These tools can serve many user in their AI applications, thereby conserving resource demands on domain experts

Concrete Next Steps: AI Faces COVID Challenge

- **Mobile healthcare infrastructure** (low-hanging fruit: a must do)
  - Social networking for distributed, in-place, on-the-fly data acquisition, learning, and deployment Vision 1
  - Leverage 5G-enabled massive, low-latency and high-bandwidth wireless networks Vision 2

- **Joint-decision workflows with operator's cockpit**
  - Human, AI, sensors & other equipment work together
  - To allow easy human control, essential data is automatically presented and collected at an operator's cockpit Vision 3

Conclusions

- The pandemic exposes AI limitations and reveals importance of:
  - Rapid AI solution development (real-time or near real-time)
  - Shortening AI pipeline—especially the two ends (data and deployment)
  - Joint-decision workflows (where rubber meets the road)
- We can minimize the cost of domain experts by capturing their knowledge with data-driven methods and expert tools
- Short-term actions include mobile healthcare infrastructure and operator's cockpit
- The pandemic has demonstrated the urgent need to support all forms of remote operations with AI and related regulatory reform

"Don't let any crisis go to waste"
We have our hands full!

Thank you

Q&A

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