

This is not an ADB material. The views expressed in this document are the views of the author/s and/or their organizations and do not necessarily reflect the views or policies of the Asian Development Bank, or its Board of Governors, or the governments they represent. ADB does not guarantee the accuracy and/or completeness of the material's contents, and accepts no responsibility for any direct or indirect consequence of their use or reliance, whether wholly or partially. Please feel free to contact the authors directly should you have queries.

From Intelligence to Superintelligence: Shaping the Future with AI

Professor Javen Qinfeng Shi

September 2024

What is Intelligence?

The background features a dark blue gradient with a field of small, light blue stars. On the right side, there are several technical diagrams: a large circular gauge with a scale from 80 to 210, a smaller circular gauge with a scale from 100 to 140, and a dashed circular arrow pointing clockwise. In the bottom left corner, there is a partial view of a circular arrow pointing counter-clockwise.

Knowledge alone is not intelligence

- hard drives, books, or libraries are NOT intelligent
- A person, who memorises a lot, can be dumb

Creativity is the spark in intelligence

- Simple neural networks, like Multi-Layer Perceptrons (MLPs) already have creativity
 - Vector embedding allows to predict previously **unseen** examples
 - Won't blindly believe the data and can **outsmart** the teacher by a lot (MNIST example)
- Model based Reinforcement Learning (RL) agent
 - Learns a world model
 - Learns strategies (called policies) to act to achieve goals **without a teacher**
- Large Language Models (LLMs) are based on transformers (a type of neural nets) and RL
- Still a **Narrow AI**, the world desires **Artificial General Intelligence (AGI)**, why?

The background is a dark blue gradient with faint, glowing technical graphics. On the right side, there are several concentric circular patterns resembling radar or data visualization, with numerical labels like 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, and 200. There are also dashed lines and arrows pointing in various directions, suggesting a complex system or data flow.

Are LLMs the only path to AGI?

Why tech giants (MS, Meta, Tesla/xAI etc) invest aggressively in LLMs (and GPUs) with billions?

LLMs are seen (by many) as the **surest and quickest** path to **AGI**
(though may not be the cheapest)

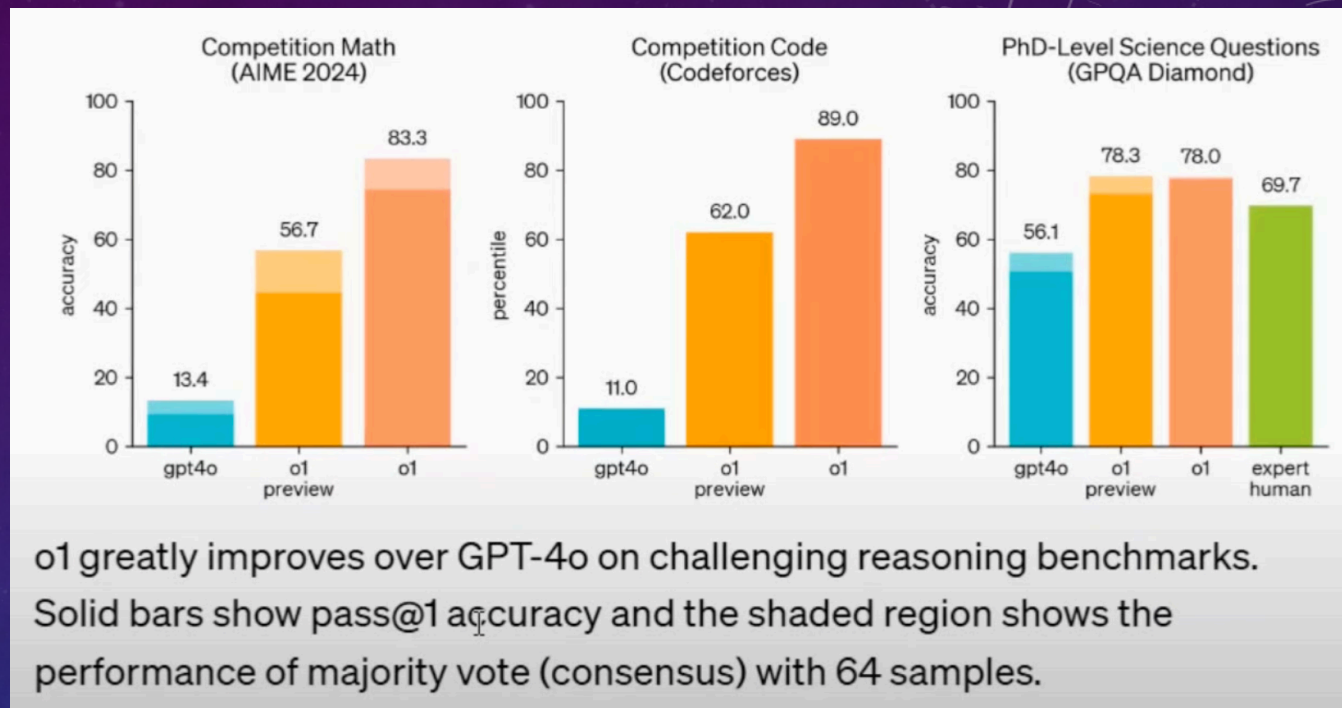
The background is a dark blue gradient with a starry space pattern. On the right side, there are several technical diagrams, including a large circular gauge with numerical markings from 80 to 210 and a smaller circular diagram below it. On the left side, there are faint circular diagrams, one of which is partially visible at the bottom left.

A problem can be solved by money (if you can afford) is
no longer a problem

Too risky to be left behind in the new industry revolution

Just a year ago, skepticism surrounded LLMs' ability to achieve AGI, as critics claimed they merely predicted the next token.

Today, the latest LLMs are nearing human-level AGI (e.g. GPT-o1 with reasoning capability far surpasses GPT-4o), with aspirations shifting towards creating **Superintelligence (SI)**



Safe Superintelligence (SSI), newly co-founded by Ilya Sutskever, has raised **\$1 billion** with only 10 employees

Why LLMs work and what's next?

Compression distills and elevates knowledge, and expands creativity

Best compression, over data and tasks of sufficient changes, would inevitably capture and utilise the mechanism of changes (i.e. causality)

Causality + LLMs may lead to AGI or even SI

Causality is the way of change

Causality is the way of change is disguised as cause-and-effect

Change is inevitable. All forms are non-stable and forever changing

Reichenbach's Common Cause Principle: if A correlates with B, then

- $A \rightarrow B$,
- Or $A \leftarrow B$,
- Or $A \leftarrow C \rightarrow B$, where C is the common **cause**.

Do **NOT** trust a decision derived from correlation alone, even if the data are distortion-free and noise-free

- Spurious correlation & Simpson's paradox (medical examples)

No need to remove all correlation (partial causation can be ok)

Causality as Structural Causal Models (SCMs)

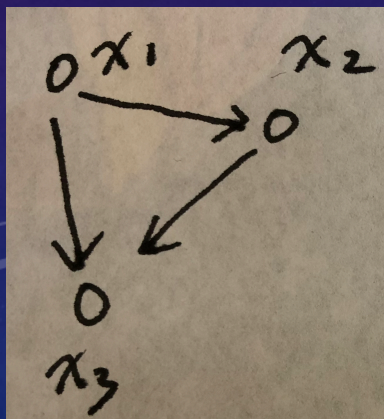
A SCM example

$$X_1 = N_1$$

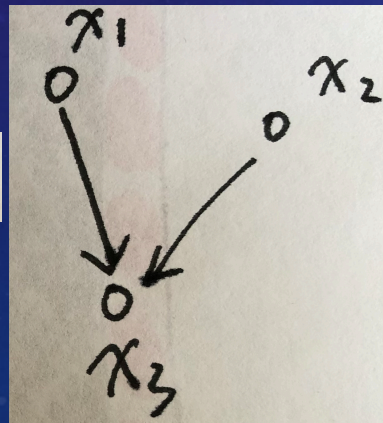
$$X_2 = 2X_1^2 + N_2$$

$$X_3 = 3X_2 + 2X_1 + N_3$$

Intervention



$do(X_2=2)$



Counterfactual

Observe $(X_1, X_2, X_3) = (-1, 3, 8)$
What X_3 would have been had X_1 been 2?

Recover $(N_1, N_2, N_3) = (-1, 1, 1)$

$$X_1 = 2$$

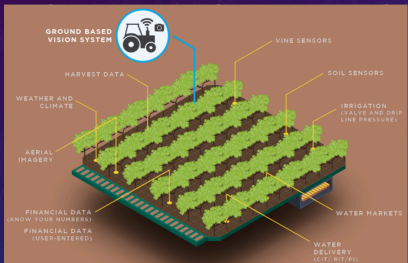
$$X_2 = 2 \times 4 + 1 = 9$$

$$X_3 = 3 \times 9 + 2 \times 2 + 1 = 32$$

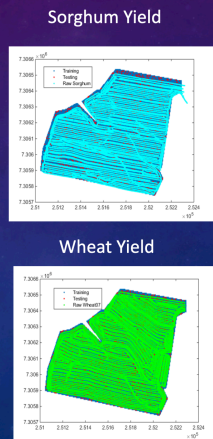
Causality brings

- **A Deeper Truth:** Beyond Mere Correlation
 - Find **(root) causes** (explainability & accountability)
 - Reveal the **Right choice** (amidst spurious correlation & Simpson's paradox)
 - Uncover **hidden variables & mechanism**
- **Proactive Change:** Shaping, Not Just Adapting
 - It offers how to change/**intervene to achieve** specific outcomes (rather than merely adapting to survive)
- **A Holistic View:** Oneness and Evolution
 - See diverse data, tasks and domains as **one**
 - Naturally evolve to **long term optimal** with ease (free of fear, and anxiety)

Viticulture&Wine (VitiVisor)



Crop Yield & Soil Variability



Predict Adjusted Yield via Genotype

Australian Grains Technologies (AGT)

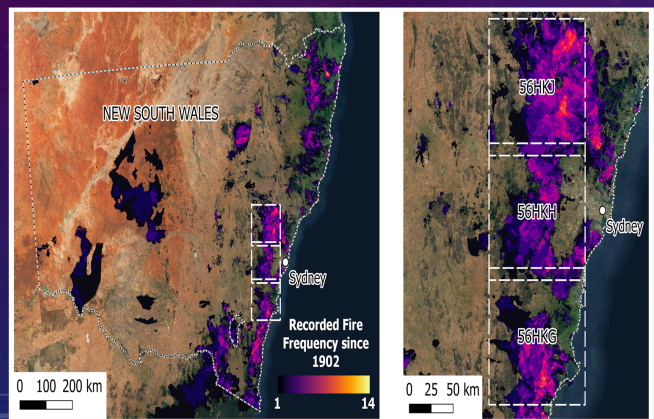
300,000 gene varieties (called lines)

- > 6 billion marker data points

We achieved

- Using only 302 genetic markers (others use 17k markers) beating the current STOA
- ~ 7% testing error on the predicted adjusted yield

Predict bushfire burn areas/fire scars



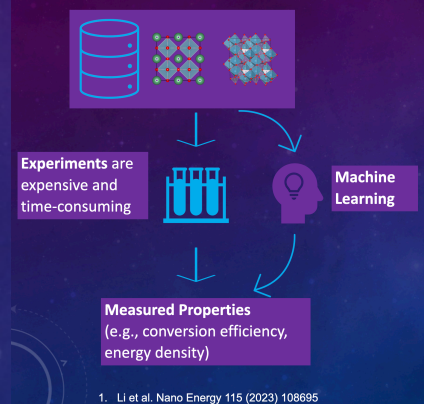
Fuel load & risk assessment mobile app



AI's Impact on Society: Inspirational AI Successes

- Agricultural productivity
- Disaster response
- Energy material discovery& Decarbonization
- Wave and wind energy harvesting
- Mining exploration
- Health
- ...

ENERGY-MATERIAL DISCOVERY & DECARBONIZATION



- Few-atom catalysts for CO2 recycling¹
- High-entropy alloys for lithium batteries
- Perovskite solar cells

1. Li et al. Nano Energy 115 (2023) 108695

WAVE AND WIND ENERGY HARVESTING

Wave energy harvesting via continuous action RL and optimization (Carnegie Clean Energy)

Short-term wind speed forecasting

Wind Turbine Power output Prediction

https://scienceexchange.caltech.edu/topics/sustainability/wind-energy-advantages-disadvantages

Predict Where to Drill

Unearthed OZ Explorers Challenge Congratulations DeepSightX!

2nd Prize Winners (US\$200,000)
Dong Geng, Jinxin Guifeng Shi, Zifeng Wu, Hao Zhang, Ehsan Akbarnejad, Lingqiao Liu, Anton van den Hengel, Kai Hornum and John Alexander Anderson

The diagram shows the DeepSightX architecture. It takes 'Input Data' (Sensory data, Mineral Estimation, Drill hole Extraction) and processes it through a 'Sensory data Extraction Network', 'Mineral Estimation Network', and 'Drill hole Estimator Network' to produce 'Number in drill'.

Predict newborn survival and leading causes

Women's and Children's Hospital

https://www.wch.sa.gov.au
https://www.abc.net.au/news/2022-09-27/new-womens-and-childrens-hospital-to-be-at-thebarton-barracks/101476264

The diagram compares two methods for predicting newborn survival. The 'Traditional method' uses an MLP (three dense layers) and Attributes Sorting (GradCAM) to predict a death category (32.78%). The 'Our method' uses causal discovery (DirectINGAM) to create a Causal Graph, which is then used with an MLP (three dense layers) and Attributes Sorting (GradCAM) to predict a death category (99.98%).

AI's Impact on Society: The Future of Work?

- Will AI and robotics replace jobs?
- Are humans needed for production in the era of AGI?
- If not, do we need to incentivise humans to work for production then?
- If not, why link income with production (via jobs)? Break the link
- The Future of Life

Take home msg

- Knowledge alone is not intelligence
- Even a simple MLP exhibits creativity and can outsmart a flawed teacher
- LLMs, seen as a surest and quickest way to reach AGI
- Compression is more than memorising, and best compression over changes leads to causality
- Causal LLMs may lead to AGI or SI
- Causality is the way of change and change is inevitable
- Changes are not your enemy. They can help you discover unknowns and better adapt
- Why adapt to survive, when you can proactively change and flourish?
- When production is done by AGI, humans do not need to work for income. You will be free to live a life, not forced to work for a living
- A mysterious question to ponder ...