AI Horizon and Landscape Shaping the University

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AI Drives a New Industrial Revolution

AGI is on the horizon!

Artificial General Intelligence (AGI)

Digital Automation and Connectivity

Efficiency Improvement

Muscle Empowerment

1st Rev. Mechanization	2nd Rev. EleAutomation	3rd Rev. Information	4th Rev. Intelligence

1750 1850 1950 2010 2050

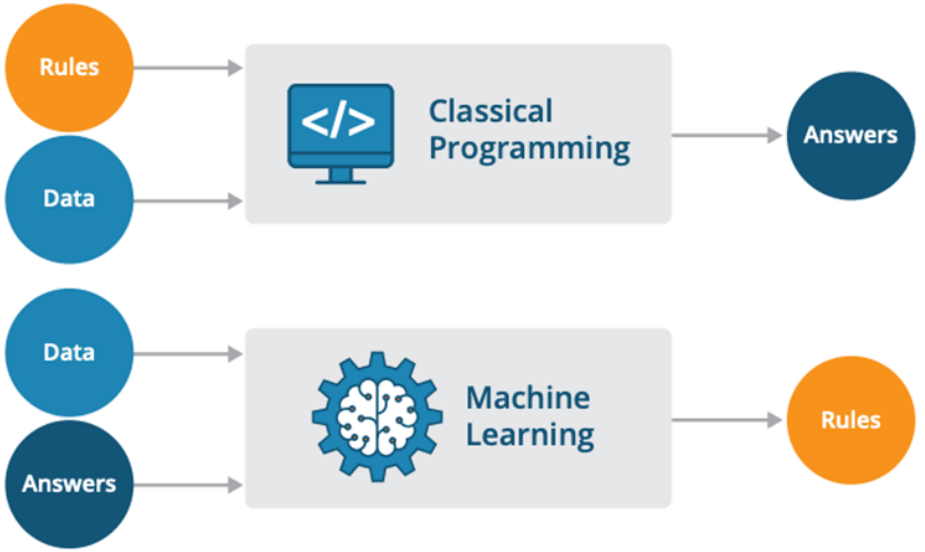
Outline

- **Brief AI History**
- **Key Technologies**
- **AI Lanscape of UM**
- **Emotional AI @ UM**
- **Impacts on Accessibility**

The Birth of AI

- In a Dartmouth meeting in Summer 1956, AI was first defined as a research field in CS:

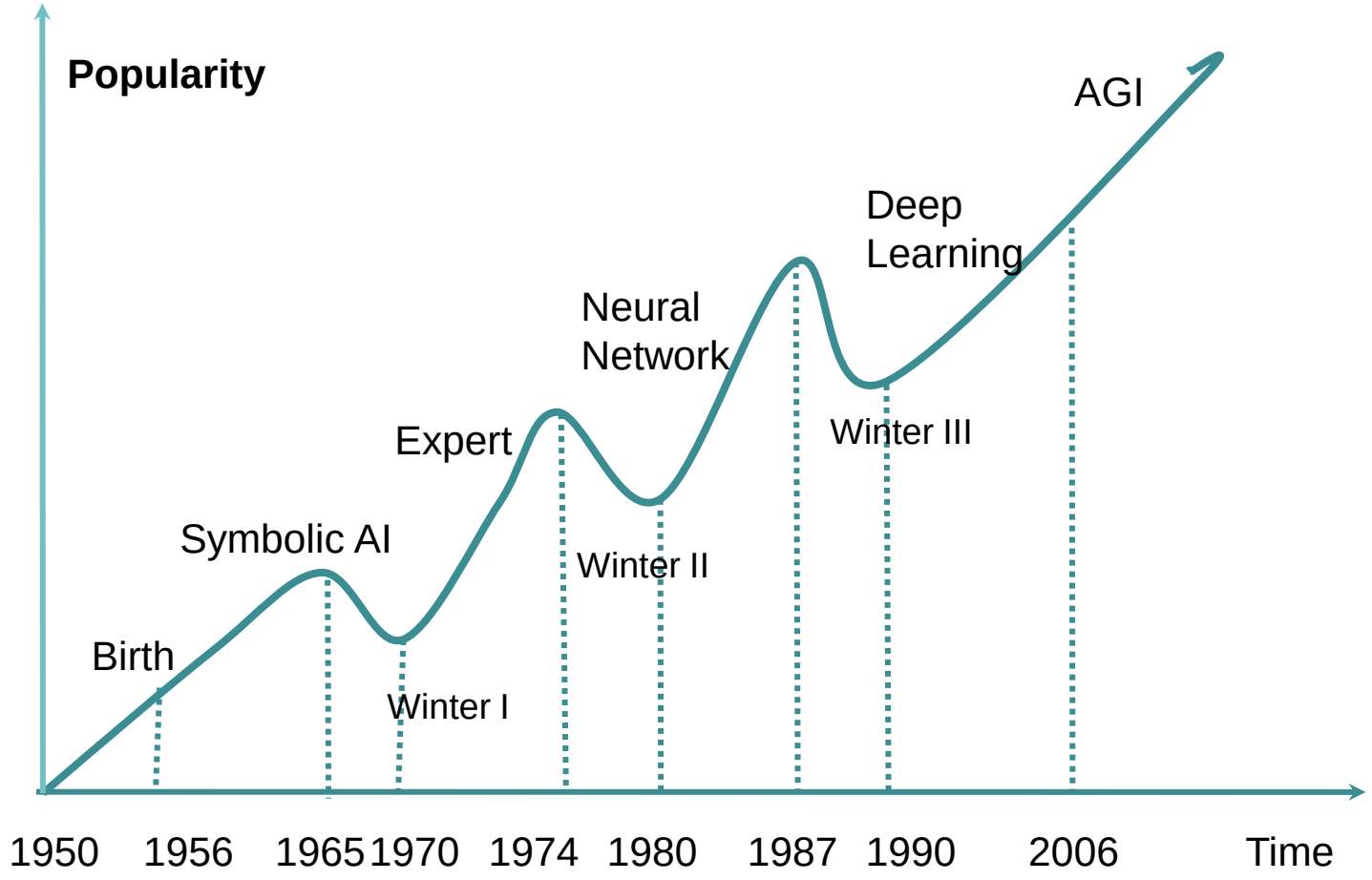
  "Every aspect of learning or any other feature of intelligence should be precisely described so that a machine can simulate it."



Machine Learning:

- given input data and output answer,
- figure out generalizable rules

Learning from History to get Clues about the Future



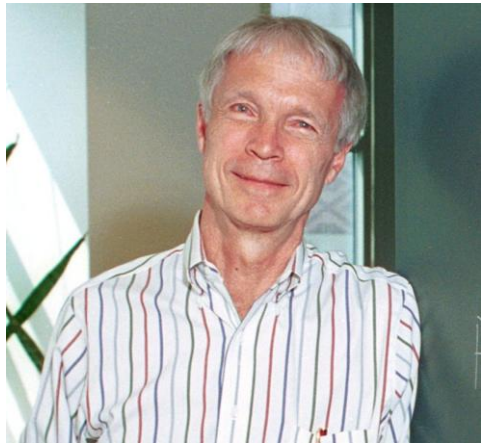
Timeline of AI Development

- **1950s-1960s**: First AI boom - the age of reasoning, prototype AI developed
- **1970s**: AI winter I
- **1980s-1990s**: Second AI boom: the age of Knowledge representation (appearance of expert systems capable of reproducing human decision-making)
- **1990s**: AI winter II
- **1997**: Deep Blue beats Gary Kasparov
- **2006**: University of Toronto develops Deep Learning
- **2011**: IBM's Watson won Jeopardy
- **2016**: Go software based on Deep Learning beats world's champions

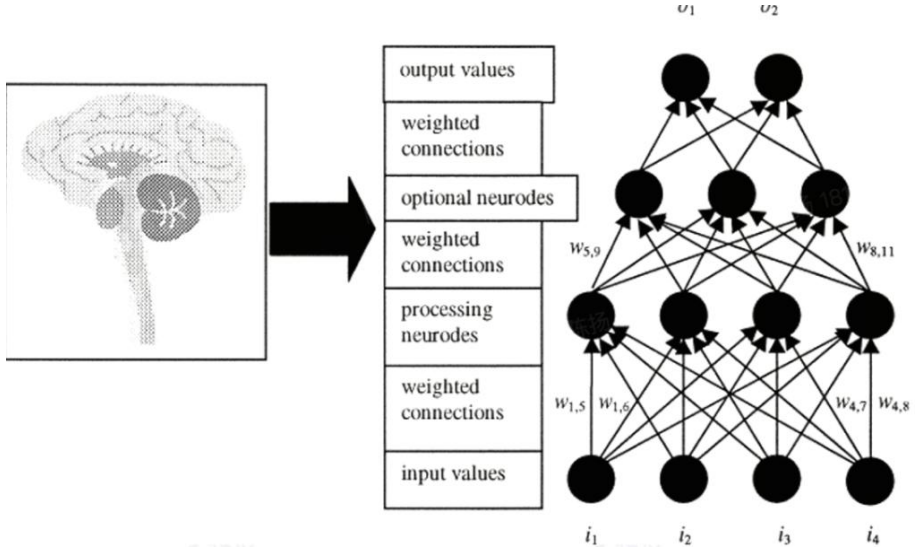
Darkness of Dawn (80-90):

Artificial Neural Networks

- ANN to simulate human brains (structure and operation), using statistical methods to let computers learn from data.
- But, hope dashed,
  - due to hardware limits, the neural network has fewer layers and a relatively simple structure.
  - lacks enough data to fully train the network.

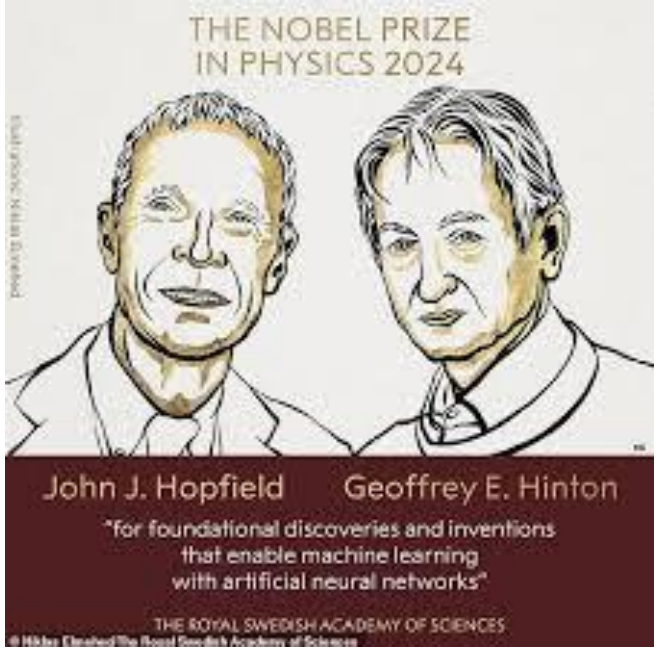


John Hopfield
Physicist, Prof of Princeton, invented ANN in 1982

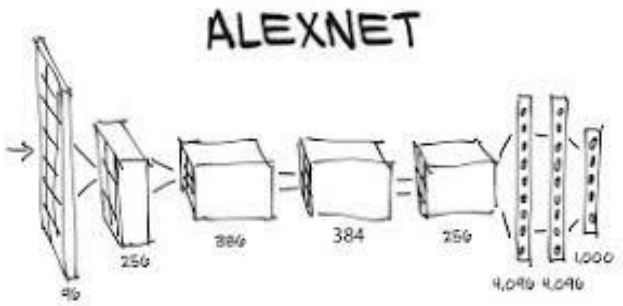


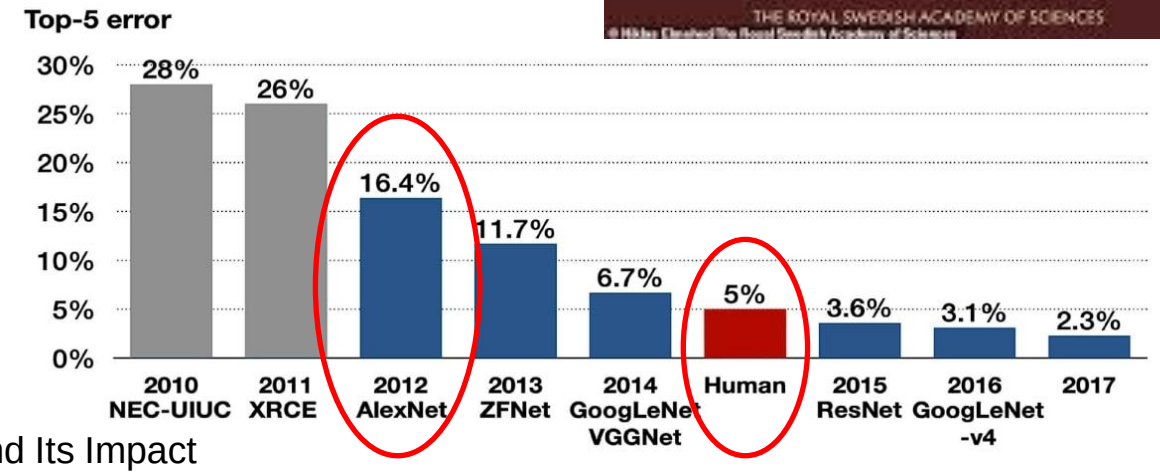
The Birth of Modern AI
Deep Neural Networks for Learning

- Hinton invented AlexNet (2012) and used 8-layer networks and backpropagation techniques to train the model for image classification.
  - Leveraged Nvidia GPU to accelerate model training
  - Tested in ImageNet, millions of labelled images accumulated in Internet age.



Geoffrey Hinton, U. of Toronto





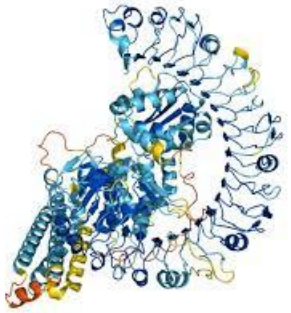
AI Success in Games: AlphaGo Conquered Humans in Go

- DeepMind's AlphaGo beat the world Go champion Lee Sedol in 2016.
  - AlphaGo, based on 30 million human game records + RL (self-play).
- AlphaGo Zero (2017): completely self-play, without human knowledge, achieved superhuman performance

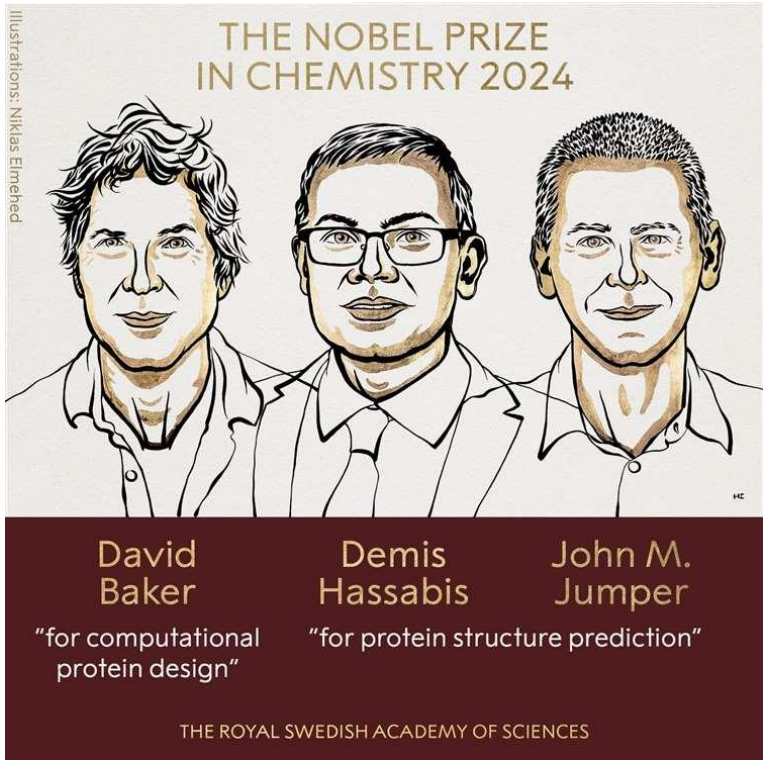
Shocked! It has shifted how we perceive AI and the promise it holds for the future.

Go is hard for AI due to its huge search space, with 10^170 possible positions, far exceeding the number of atoms in the universe.

AI in Science Discovery: AlphaFold



- AlphaFold (2018, 2021): AlphaGo techniques were applied to explore mysteries of life
  - 600 millions protein structure prediction in 2 years, completely revolutionizing protein structure research.
  - Cf. 200K protein structure prediction in 60 years by scientists
- Hassabis and Jumper won 2024 Noble Prize in Chemistry.



ChatGPT for Generative AI in 2022

- Language is a tool for structuring, expanding, and expressing thought, while also shaping perception and cognition.
- ChatGPT enables content generation and creative thinking: not only interact with humans, but also generate creative responses.
- Model war begins, with new IT giants emerged: OpenAI, Anthropic(claude), Deepseek, etc

AI Tools for Productivity and Creativity

AI has come of age

AI for Entertainment

AlphaGo

ALPHAZERO

AI for Science

AlphaFold

AlphaProof for math reasoning, 2025 IMO

The International Mathematical Olympiad

Generative AI

ChatGPT

Midjourney

deepseek

Embodied Intelligence

Self-Driving

Coding with AI

CURSOR

Claude

For Product Designers

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- Brief AI History
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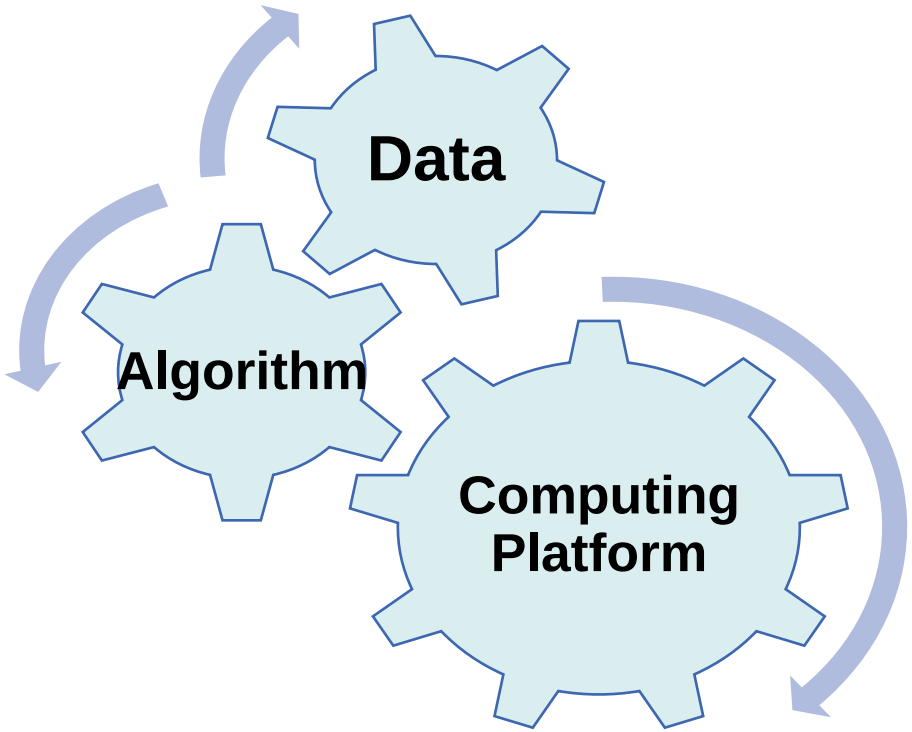
Key Technologies

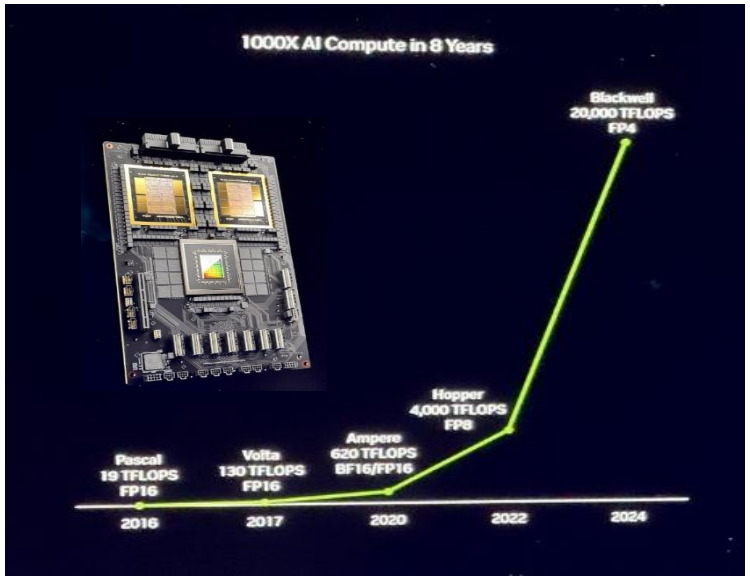
- Algorithms or learning models are the main driving forces behind AI innovation
- Computing power provides the hardware foundation to support massive models
- Data determines the level of AI intelligence.

Data Driven AI



Computing Plarform

- Provide HW support for model training and inference. It is the key to unlock the value of data
  - Nvidea GPU in AlexNet since 2012
- Giga-watts Datacenter Centre (1 GW for about 1 million home)
  - OpenAI Stargate plan for $500B (5 GW)
  - Amazon's plan for 3.5 GW center
  - … …



Increase 23,600% in 2026, cf. 2016

Data: Level of Intelligence

Gigabyte: 2 hours film

Terabyte: Library of Congress (15TB)

Petabyte: 1000 TB

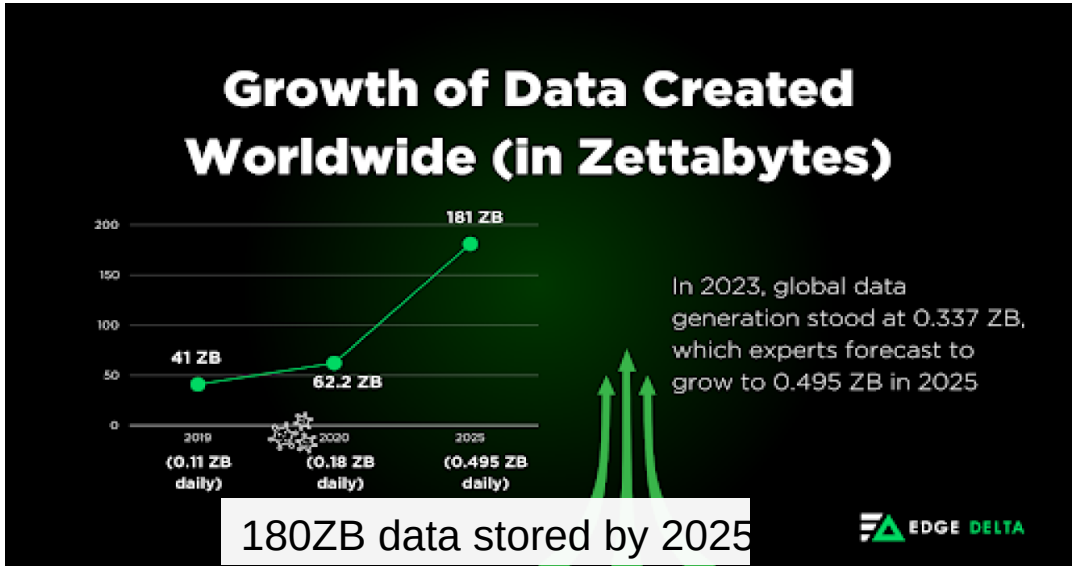
Exabyte: 1000 PB

Zettabyte: 1000EB

245TB

- Latest OpenAI GPT 5 trained on 180,000 GPUs by using 250 TB data
- Exhausting all data in model training
- How about synthetically generated data in physical world model ?

Physical World is compressed into a digital model



180ZB data stored by 2025

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AI Landscape of UM

- **Faculty of Science and Technology (FST)**
- **Institute of AI and Brain Science (founding)**
- **State Key Lab of Internet of Things for Smart City**
- **State Key Lab of Analogy and Mixed-Signal VLSI**

Faculty of Information Science and Computing (FIC)

Academics (Programs)

- Financial Technology
- Robotics

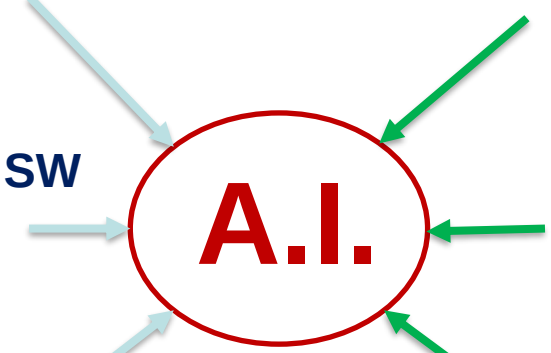
APP

- Computer Science
- Artificial Intelligence

SW

- Electronics Communication
- Microelectronics

HW



Research

- Institute AI and Brain Sciences
- State Key Lab of Internet of Things for Smart City
- State Key Lab of Analog and Mixed-Signal VLSI

Degree Programs

7+3 BSc Programs

- Computer Science, Artificial Intelligence
- Robotics
- Financial Technology
- Electrical and Computer Engineering
- Electromechanical Engineering
- Mathematics (Mathematics and Applications Stream)
- Mathematics (Statistics and Data Science Stream)
- Civil Engineering
- Applied Physics and Chemistry

- ESI: 0.1% in both CS and Engineering

15+1-1 MSc Programs

- Civil Engineering (Hydraulics & Envir Engineering)
- Computer Science
- Electrical and Computer Engineering
- Civil Engineering
- Mathematics
- Electromechanical Engineering
- E-Commerce Technology
- Data Science (offered with other faculties)
- Financial Technology
- Internet of Things
- Coastal Environment & Safety
- Robotics & Autonomous Systems
- Artificial Intelligence
- Construction Project Management
- Smart Ocean Technology
- Smart Power Grid

6 PhD Programs

- Civil Engineering
- Electrical and Computer Engineering
- Electromechanical Engineering
- Computer Science
- Mathematics
- Applied Physics & Materials Engineering (IAPME)

30 years of Microelectronics R&D

UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

SKL AMSV
State Key Laboratory of
Analog and Mixed-Signal VLSI

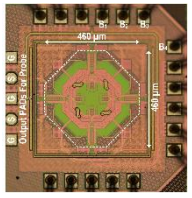
- *34% faculties are trained locally (1 elected IEEE Fellow)*
- *World No. 1 by paper numbers in ISSCC 2023 and 2024*
- *Macau-First National S&T Progress Award and Xplorer Prize*

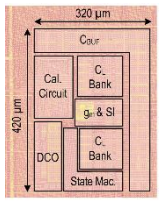
Rui Martins

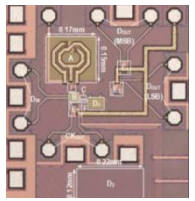
Founder

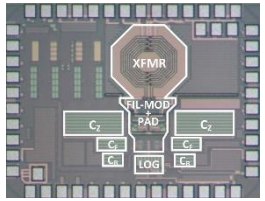
IEEE Fellow, Academician of Portuguese Academy of Sciences

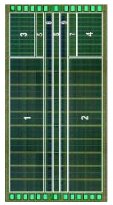
Wireless, Wireline, AI, IoT, Power Management, Signal Processing

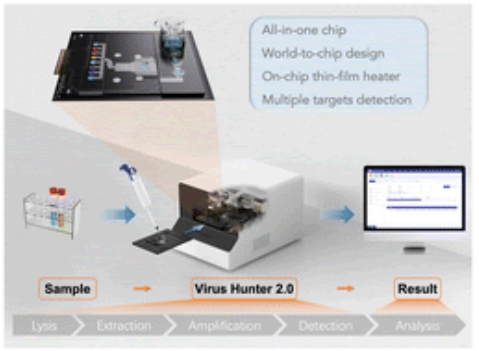












State Key Lab of IoT for Smart City

"1+1+3" Strategic Planning

Advance the development of smart cities nationwide, making substantial contributions to creating a livable, workable, green, and sustainable cities.

Explore the opportunities of AI for Engineering

3 Smart Applications Driving

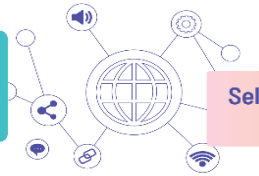
Smart Energy		Intelligent Transportation		Urban Safety and Disaster Prevention	
Smart city carbon neutral path and market mechanism	Clean, efficient and reliable city Integrated energy system	Intelligent transportation system optimization modeling	Intelligent connectivity and autonomous driving	Marine disaster chain in coastal cities under extreme climatic conditions	Smart monitoring and maintenance of infrastructure in coastal cities

1 Smart Brain Empowering

Urban Big Data and Intelligent Technology

- High performance computing system
- Intelligent decision theory
- Knowledge graph reasoning
- Spatiotemporal data modeling
- Multimedia data mining

1 Smart Facility Supporting



Intelligent Sensing and Network Communication

- Self-developed sensor
- Multimodal intelligent environment awareness
- Integrated design
- IoT efficient and secure transmission

Achievements

Major Awards

- Guanghua Engineering Science and Technology Award
- Ho Leung Ho Lee Foundation Award for Scientific and Technological Progress
- Macao Science and Technology Award

Director

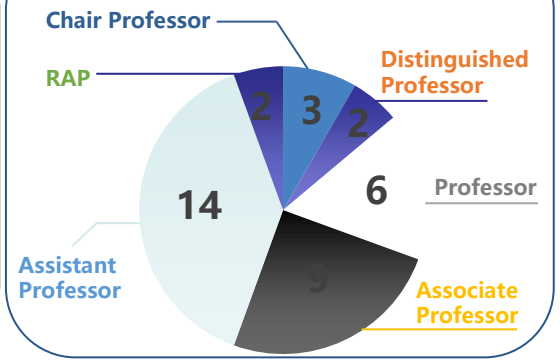
Yonghua SONG

Chair Professor, Foreign mbr of Academia Europaea

IEEE Fellow, RAE Fellow

IOTSC Academic Staff

Total: 36



Autonomous Driving Bus

Smart City Mixed Reality Simulation and Intelligent Decision-Making Platform

Satellite Data Receiving Systems

Health Monitoring for Civil Infrastructure

Super Intelligent Computing Center (SICC)

Urban Flooding Simulation

人工智能与脑科学研究院
Institute of AI and Brain Science

人文
Humanities and Social Sciences

亞太經濟與管理研究所
Asia-Pacific Academy of Economics and Management

澳門研究中心
Centre for Macau Studies

人文社科高等研究院
Institute of Advanced Studies in Humanities and Social Sciences

工商管理學院
Faculty of Business Administration

文學院
Faculty of Arts and Humanities

教育學院
Faculty of Education

社會科學學院
Faculty of Social Sciences

法學院
Faculty of Law

AI研究院
Institute of AI and Brain Science

認知與腦科學研究中心
Centre for Cognitive and Brain Sciences

人工智能與機器人研究中心
Centre for AI and Robotics

數據科學研究中心
Centre for Data Science

科技
Science and Technology

精準醫學
Precision Medicine

先進材料
Advanced Materials

區域海洋
Regional Oceans

科技學院
Faculty of Science & Technology

健康科學學院
Faculty of Health Sciences

微電子研究院
Institute of Microelectronics

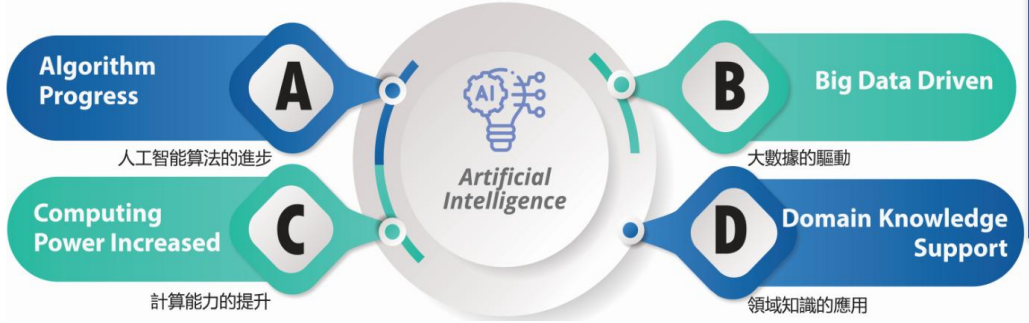
中華醫藥研究院
Institute of Chinese Medical Sciences

應用物理及材料工程研究院
Institute of Applied Physics and Materials Engineering

澳門大學
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

人工智能与脑科学研究院
Institute of AI and Brain Sciences

Centre for AI & Robotics



- Computational intelligence algorithms
- Visual & pattern recognition
- Data intelligent analysis & prediction
- Large Language Models and Machine Translation

- Autonomous Driving and Mobile Robotics
- Intelligent Robotics
- Embodied Intelligence
- Security and Privacy Protection

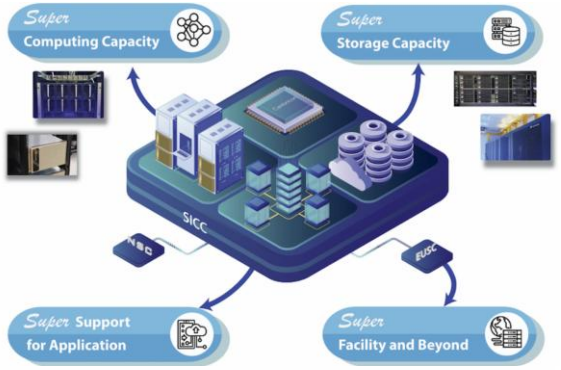
AI algorithms and Systems
AI algorithms and foundations
Systems support for AI
Data analytics for AI

Multimedia and Metaverse
Multimedia processing
Digital Humans and Interactions
Data security and privacy for AI

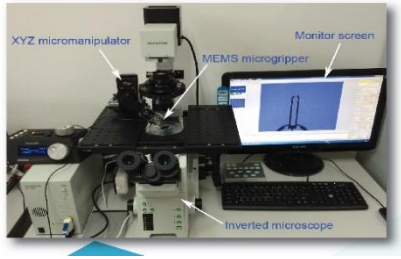
Large Foundation Model
Speech & Language Processing
Multimodal Learning

Robotics & Autonomous Vehicles
Autonomous driving
Intelligent robotics
Embodied AI

Macao's largest intelligent supercomputing center
(Nvidia， Huawei， Cambricon and other heterogeneous computing platforms)



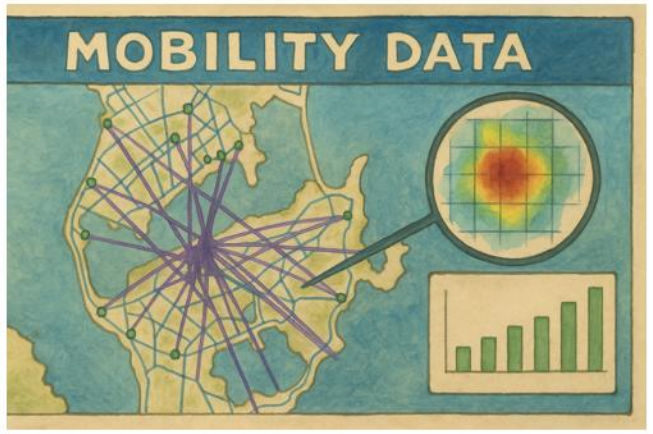
Recognition
- CS:125 (THE)
- CS: 89 worldwide (in CS ranking)
- AI: 41 (USNews)
- Robotics：Asia Top25 (csrankings)
- IEEE Trans. on Robotics: 5篇 2024-2025（CUHK: 6）



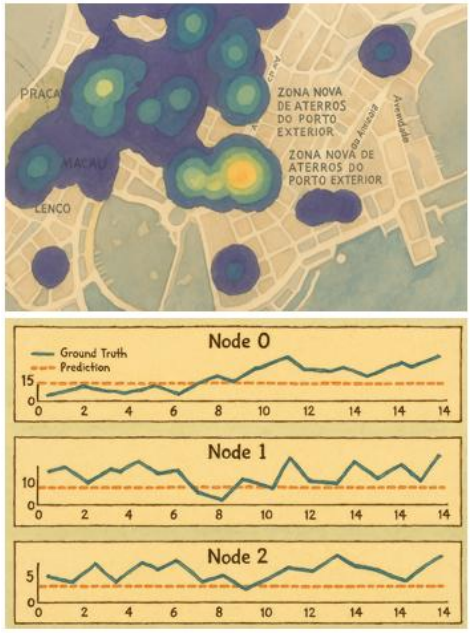
人工智能与脑科学研究院
Institute of AI and Brain Science

Centre for Data Science

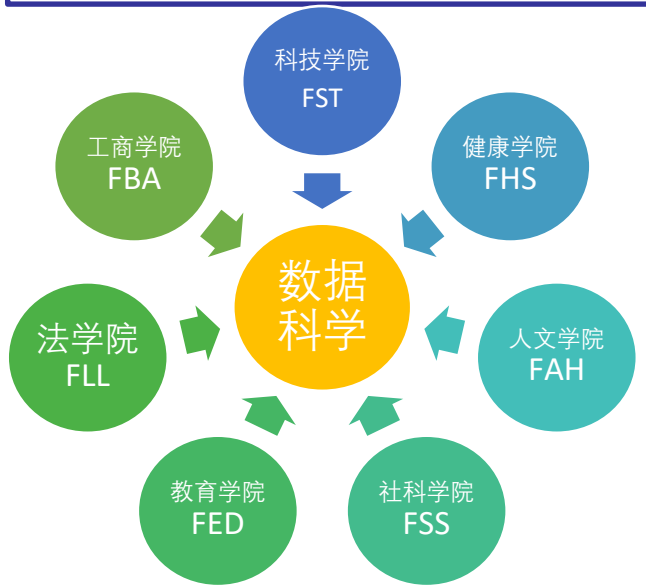
Data is the cornerstone of the digital economy, enabling industrial transformation and refined social governance. Research into key technologies and applications such as data acquisition, integration, and analytical mining, aligning with industry needs.



以移動數據為核心，研究深合區與澳門的城市融合程度。



結合人工智能與數據處理技術，有效進行評估與預測。



In collaboration with 7 faculties of UM, CDS offers a MSc in Data Science with 8 specializations, fostering the development of data science in Macao.

Precision Medicine
精準醫學
Computational Linguistics
計算語言學
Analytics in Teaching and Learning
教學分析
Data Strategy and Compliance
數據戰略與合規管理
Artificial Intelligence Applications
人工智能應用
Smart Governance
智慧政務
Financial Technology
金融科技
Marketing Analysis
市場營銷分析

MSc in Data Science
- 2024 admission: 229/1269 （18%）
- 2025 admission: 255/1515 （16.8%）

澳門大學
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

人工智能与脑科学研究院
Institute of AI and Brain Science

Centre for Cognitive and Brain Sciences

CCBS is dedicated to enhancing interdisciplinary cognitive and brain sciences and translating discoveries into solutions for health and society. It aims at becoming a leading research and education institution in cognition ar sciences in the Greater Bay Area.

01 腦干預平台 BRAIN INTERVENTION CORE

02 腦影像平台 NEUROIMAGING CORE

03 認知與行為測查平台 COGNITION AND BEHAVIORAL DATA COLLECTION CORE

Focus on 4 Key Research Areas

- Addiction and Decision Making
- Brain and Language Cognition
- Child Development, Cognitive Aging and Brain Disorders
- **Emotional AI**

- Of the 12 core members, 6 are non-Chinese professors from the US, Germany, UK, the Netherlands, Denmark

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MoEAI: Macao Emotional AI

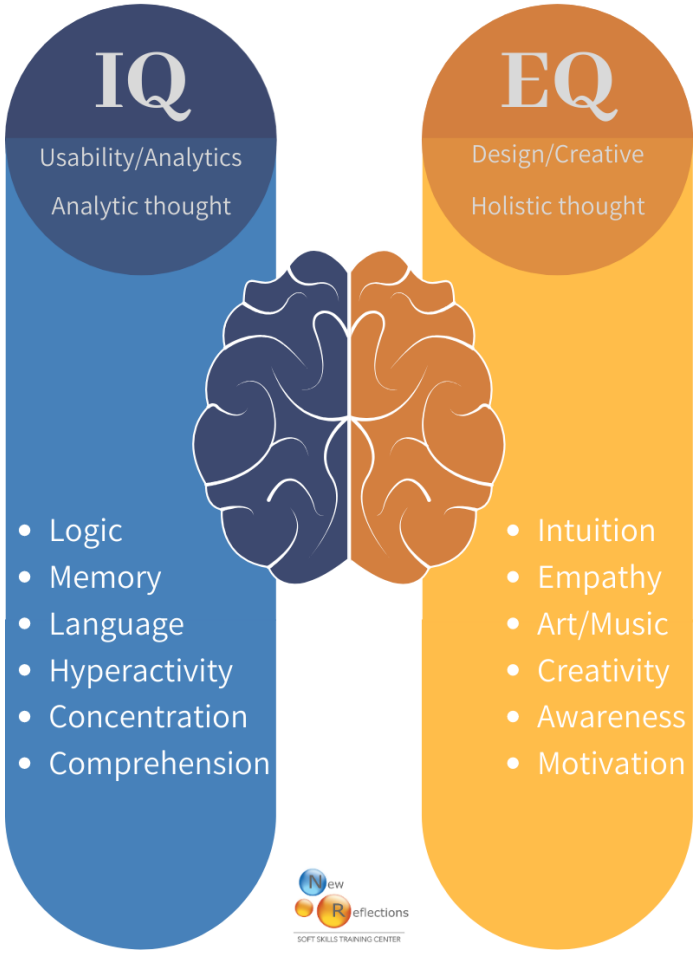
Empowering AI Agent with Emotions

Institute of AI and Brain Science

MoEAI: Background

- AI advance is mainly on IQ; its learning and reasoning (and artistic creativity) capabilities are approaching human level intelligence.
- Future Human-Machine Synergy in SocioTechnical organization: AI agents (social robotics) needs EQ, in addition to IQ

AI Agent =
Nature (Intelligence) +
Social Attribute



Goal of MoEAI

Develop key emotional AI technologies for human-machine synergy and train students for future sociotechnical environments

1. Advance understanding of emotional intelligence
2. Read emotions and translate to texts
3. Empower AI agents with capability of regulating human's emotion
4. Emotion-aware AI agents and robotics in elderly caring and autonomous driving applications

Scenario I: Robots for Elderly Care

Consider AI agent providing personalized accompanying services to elderlies

1. The agent would understand emotions of elderly through speech/text or facial video detection
2. The agent needs to respond to the emotion by interact to the elderly accordingly
3. If needed, the agent would proactively initiate interaction to regulate the emotion

Scenario II: Autonomous Driving

- Autonomous vehicles become moving robots.
- Consider a AV robot running on the street, it may need to interact with passengers and surrounding walking traffic
- Consider a passenger sitting such a AV robot, he/she needs to communicate to the robot to express her emotions

Launched in 2020.10 @ U Macau

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How to Survive in the Era of AI?

Innovation

Innovation:

- From Simple to Complex, from Closed env to Open, from Deterministic to Uncertainty;
- From IQ to EQ-related Emotion, Consciousness, Empathy

Knowledge Discovery

- *Problem Definition (Hypothesis)*
- *Solutions*

Knowledge Diffusion

- *Learning*
- *KN access*

Knowledge Transfer

- *Appl-Oriented KN Integration*

Info Access in the Era of AI

- AI is reshaping how info is retrieved, curated, and utilized, moving libraries toward "smart" services.
  - Internet: transform info access from centralized to distributed repository
  - AI: transform access from a passive repository to a personalized, dynamic and intelligent knowledge ecosystem.

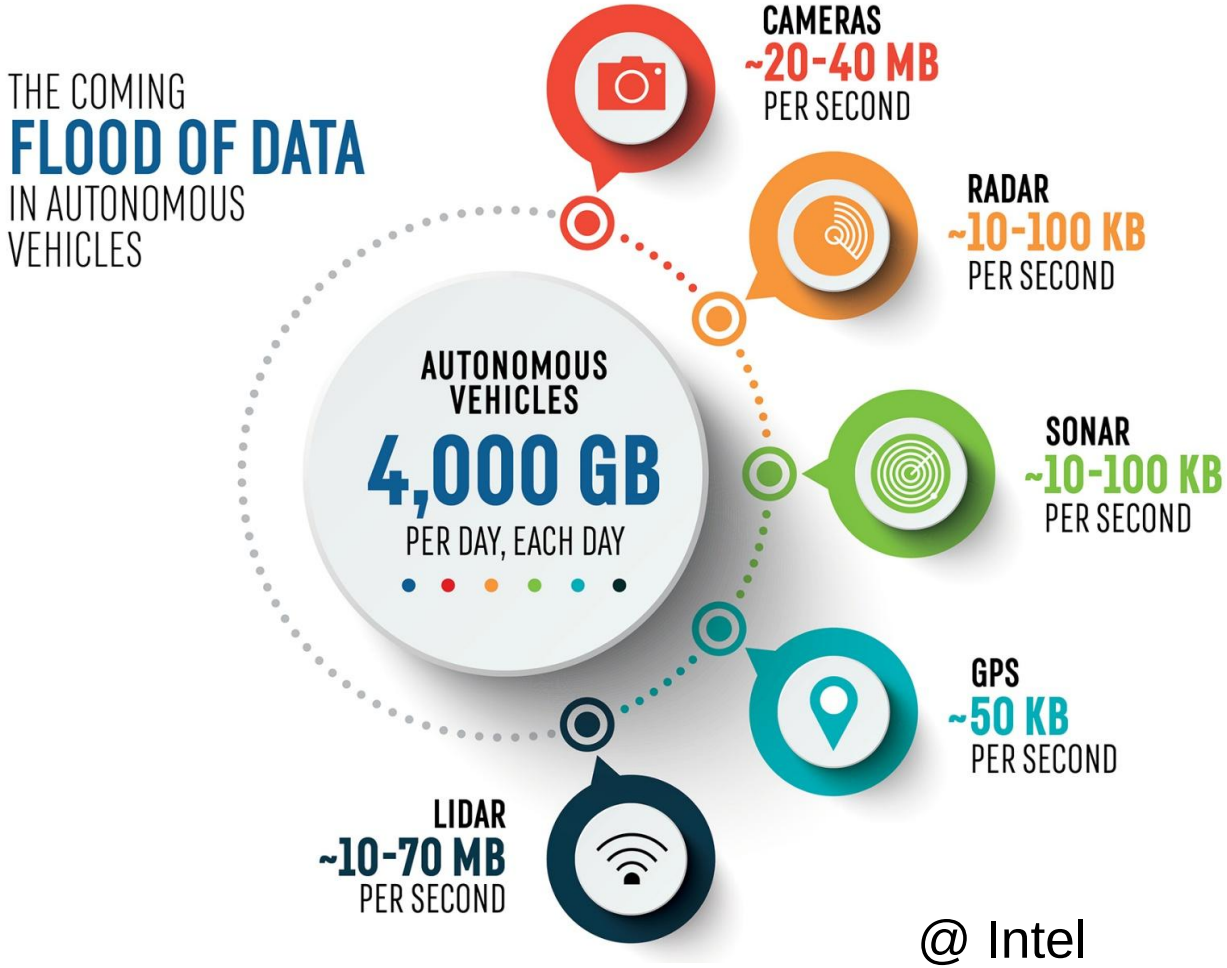
Library would play more active roles in institutional learning

AI Horizon and Landscape Shaping the University

Chengzhong Xu（须成忠）
Faculty of Science and Technology
Institute of AI and Brain Science (Founding)
University of Macau
https://fst.um.edu.mo/personal/czxu

Backup

Data Generated by Self-Driving Vehicles



@ Intel

Algorithms: Machine Learning

- ML builds a model that learns from data and uses it to make predictions or decisions. The model must be generable, so that it can is applied to new scenarios.
- E.g. Deep NN, Reinforcement Learning, etc