INTRODUCTION

INT301 Bio-computation, Week 1, 2025

Lecturers in INT301

- Module leader:
  Dr. Rui Yang (SD529)
  - Email: R.Yang@xjtlu.edu.cn
  - Teaching weeks: 1-6
  - Office hour: Tue 2pm-4pm

- Co-Lecturer
  Dr. Shan Liang (SC565)
  - Email: Shan.Liang@xjtlu.edu.cn
  - Teaching weeks: 8-13
  - Office hour: Wed 10am-12pm

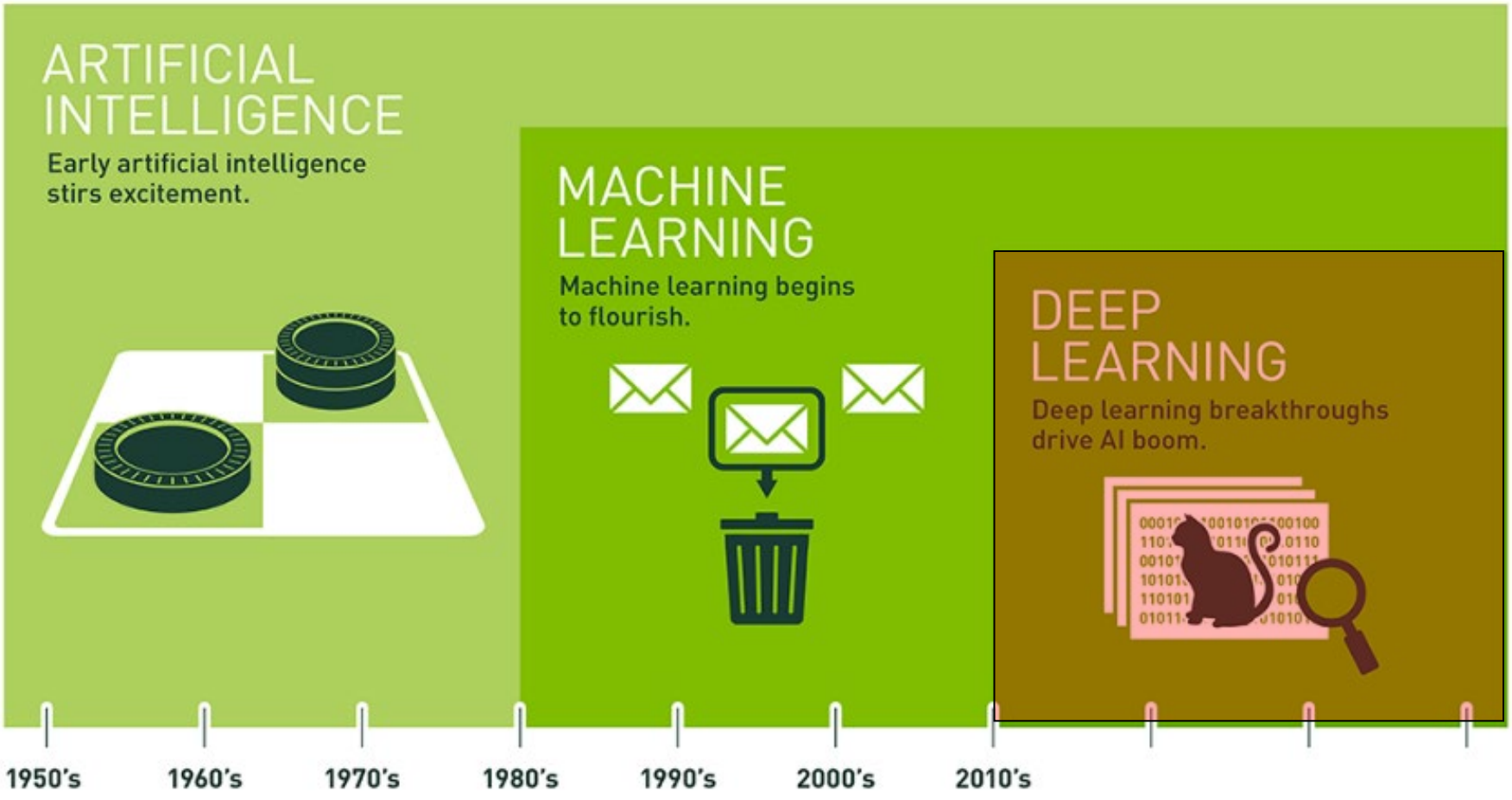
- Lectures/Tutorials:
  - EB138 Thu (9:00-10:50)
  - EB138 Thu (11:00-11:50)
- Labs:
  - SD554 Tue (9:00-9:50)
  - SD554 Tue (10:00-10:50)
  - SD554 Tue (11:00-11:50)
- Assessments:
  - 1 In-Class Test: Week 6 (10%)
  - 1 In-Class Test: Week 13 (10%)
  - 1 Final Exam (80%)

In Lecture Theatre

What INT301 is about?

- Bio-computation: a field devoted to tackling complex problems using computational methods modeled after principles encountered in **Nature**.
- **Goal:** to produce informatics tools with enhanced robustness, scalability, flexibility and reliability.
- A multi-disciplinary field strongly based on Biology, Computer Science, Informatics, Cognitive Science, and Robotics.
- The main content is **Artificial Neural Networks**.

Artificial intelligence (AI), deep learning, and neural networks



Artificial intelligence (AI), deep learning, and neural network

AI- any technique which enables computer to mimic human behavior

ML- subset of AI techniques which use statistical methods to enable machines to improve with experience

Neural network -- also known as "artificial" neural network -- is one type of machine learning that's loosely based on how neurons work in the brain

DL- subset of ML which makes the computation of multi-layer neural network feasible

ANN: a brief history

- Some early researchers explored the idea of neuron models for AI. When the limits of *Classic AI* became clear, ANN with new models and algorithms started proving useful.

- Artificial neural networks (ANNs) was created over 50 years ago when very little was known about how real neurons worked.

- Since then, neuroscientists have learned a great deal about neural anatomy and physiology, but the basic design of ANNs has changed very little. Therefore, despite the name neural networks, the design of ANNs has little in common with real neurons.

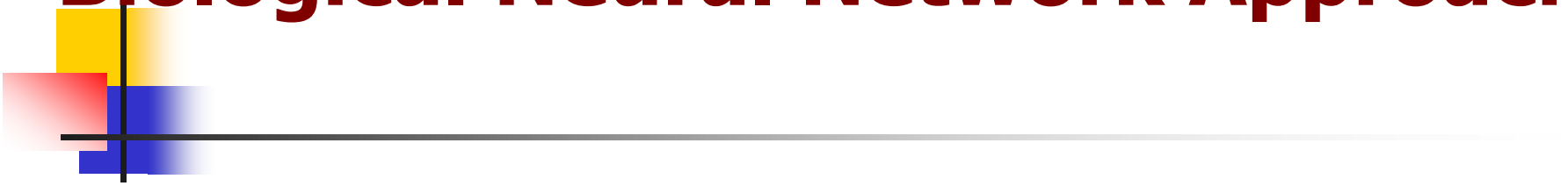
ANN: a brief history

- Instead, the emphasis of ANNs moved from biological realism to the desire to learn from data. Consequently, the big advantage of *Simple Neural Networks* over *Classic AI* is that they learn from data and don't require an expert to provide rules.

- Today ANNs are part of a broader category of machine learning which includes other mathematical and statistical techniques.

- Machine learning techniques, including ANNs, look at large bodies of data, extract statistics, and classify the results.

Biological Neural Network Approach



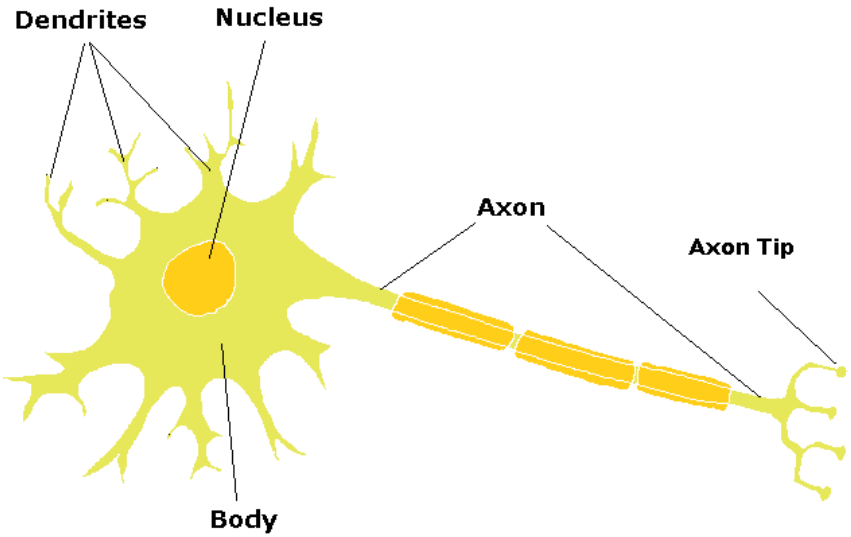
- Human brain is an intelligent system. By studying how the brain works we can learn what intelligence is and what properties of the brain are essential for any intelligent system.

- Other essential attributes include that *memory* is primarily a sequences of patterns, that behavior is an essential part of all learning, and that learning must be continuous.

- In addition, biological neurons are far more sophisticated than the simple neurons used in the simple neural network approach.

Biological Neural Networks Overview

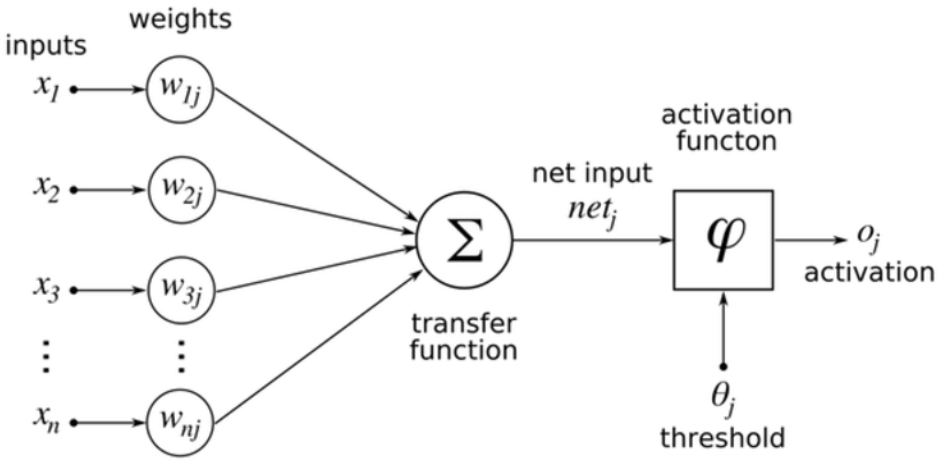
- The inner-workings of the human brain are often modeled around the concept of *neurons* and the networks of neurons known as *biological neural networks*.
  - It's estimated that the human brain contains roughly 100 billion neurons, which are connected along pathways throughout these networks.



- At a very high level, neurons communicate with one another through an interface consisting of *axon terminals* that are connected to *dendrites* across a gap (*synapse*)

Abstract neuron

- In plain English, a single neuron will pass a message to another neuron across this interface if the sum of weighted input signals from one or more neurons (summation) into it is great enough (exceeds a threshold) to cause the message transmission.
- This is called activation when the threshold is exceeded and the message is passed along to the next neuron.



Further on Simple Neural Network

- Neural networks are mathematical models *inspired* by the human brain.

- Neural networks, and machine learning in general, engage in two different phases.
  - First is the ***learning phase***, where the model trains to perform a specific task. It could be learning how to describe photos to the blind or how to do language translations.
  - The second phase is the ***application phase***, where the finished model is used.

Neural Network

- In a biological system, learning involves adjustments to the synaptic connections between neurons
  - ➔ same for artificial neural network (ANN)

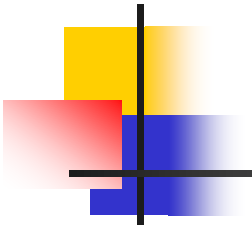
- Neural networks are configured for specific applications, such as **prediction** or forecasting, **pattern recognition** or data classification, through a **learning process**

Then, What is Machine Learning

- Webster's definition of "**to learn**"
  "To gain **knowledge** or **understanding** of, or **skill** in **by study**, **instruction** or **experience**"

- Simon's definition of **"machine learning"**
  "Learning denotes **changes** in the system that are **adaptive** in the sense that they enable the system to do the same task or tasks drawn from the same population **more effectively the next time"** -- Machine Learning I, 1993, Chapter 2.

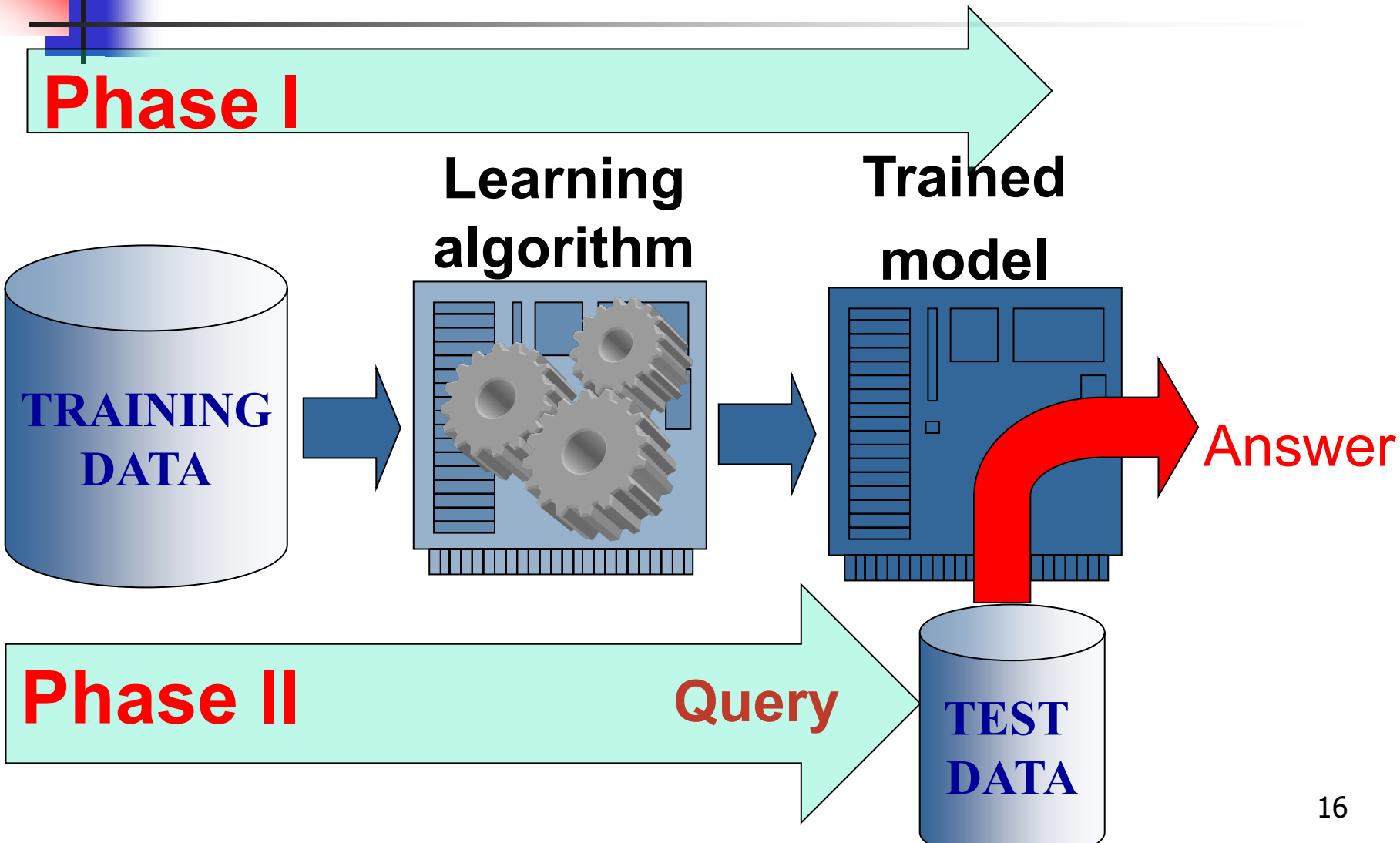
Why "Learn" ?



- **Machine learning:** programming computers to *optimize a performance criterion using example data* or past experience.
  - There is no need to "learn" to calculate payroll

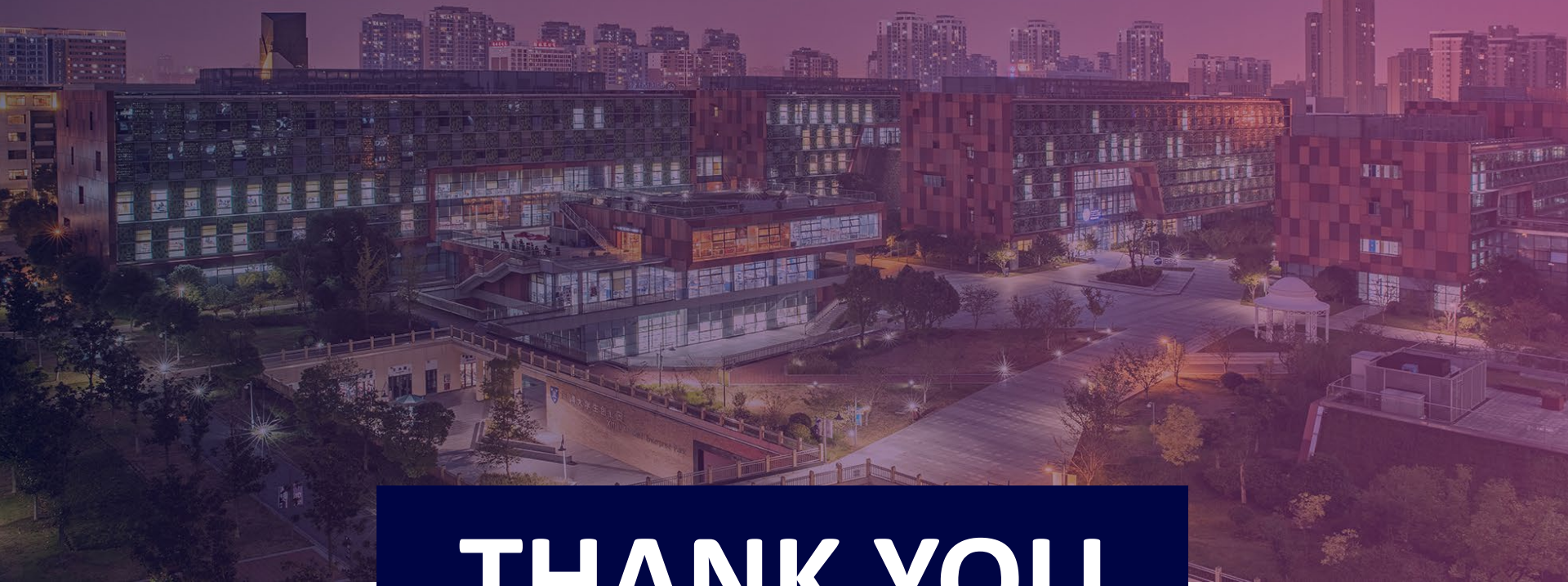
- **Learning is used when:**
  - Human expertise does not exist (e.g.,navigating on Mars),
  - Humans are unable to explain their expertise (e.g., speech recognition)
  - Solution changes in time (e.g., forecasting stock market)
  - Solution needs to be adapted to particular cases (e.g., user biometrics)

General Illustration of Machine Learning



Typical Learning Machines

- Basic ML
  - Models from statistics for regression and classification
  - Decision trees
  - Bayesian networks
  - **Artificial neural networks (focus of INT301)**
  - Support vector machines
  - Latent variable models
  - Unsupervised learning
  - Manifold learning
  - Reinforcement learning
  - Transfer learning



THANK YOU

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