Machine Learning

Introduction to the Course

Nevin L. Zhang
lzhang@cse.ust.hk

Department of Computer Science and Engineering
The Hong Kong University of Science and Technology

This set of notes is based on internet resources.

What is Machine Learning?

- Arthur Samuel (1959): Machine learning is a "field of study that gives computers the ability to **learn without being explicitly programmed**".

What is Machine Learning?

- Arthur Samuel (1959): Machine learning is a "field of study that gives computers the ability to **learn without being explicitly programmed**".
- Machine learning is the science of getting machines to learn and act in **a similar way to humans** while also autonomously **learning from real-world interactions** and sets of **training data** that we feed them.

What is Machine Learning?

- Arthur Samuel (1959): Machine learning is a "field of study that gives computers the ability to **learn without being explicitly programmed**".
- Machine learning is the science of getting machines to learn and act in **a similar way to humans** while also autonomously **learning from real-world interactions** and sets of **training data** that we feed them.
- Machine learning is an application of artificial intelligence (AI) that provides systems the ability to **automatically learn and improve from experience without being explicitly programmed**. Machine learning focuses on the development of computer programs that can **access data and use it** learn for themselves.

What is Machine Learning?

- Machine Learning is the science of making computer artifacts **improve their performance** with respect to a **certain performance criterion** using example **data or past experience**, **without requiring humans** to program their behavior explicitly.

What is Machine Learning?

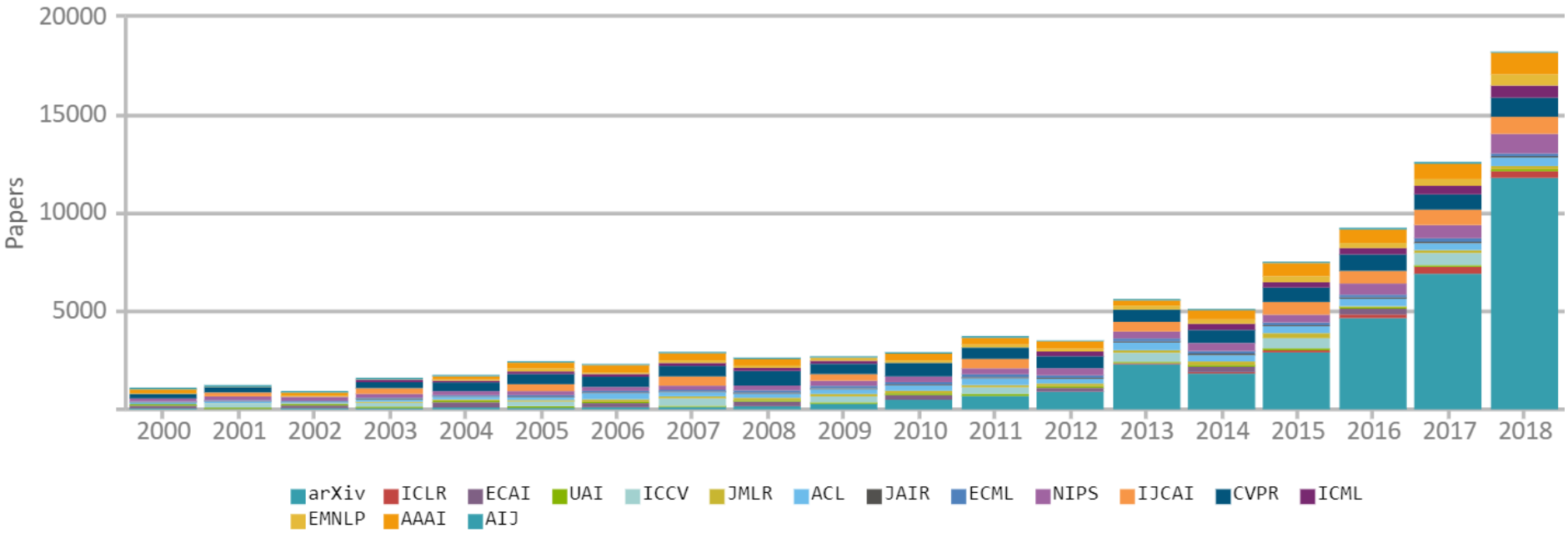
- Machine Learning is the science of making computer artifacts **improve their performance** with respect to a **certain performance criterion** using example **data or past experience**, **without requiring humans** to program their behavior explicitly.
- Machine Learning is a set of methods that automatically **detect patterns in data**, **use the uncovered patterns** to for prediction or decision making.

Machine Learning (and AI) is Very Hot

Countries and companies invest heavily in ML and AI.

Machine Learning (and AI) is Very Hot

The number of research papers on AI and Machine Learning has been increasing sharply in the past few years.



`http://aipano.cse.ust.hk/`

Overview of topics: `http://home.cse.ust.hk/ lzhang/topic/ai-tree.pdf`

Coverage of this Course

Deployment	**Adversarial Attack (Security)**	**XAI (Trust)**	Meta-learning (Learn to Learn)	Federated Learning (Privacy)	
	General Issues	**Supervised**	**Self-Supervised**	**Unsupervised**	**Reinforcement**
Deep Learning	Dropout Normalization Optimizers	Feedforward NN Convolutional NN	Recurrent NN Transformer BERT	VAE GAN	DQN Policy gradient Actor-critic
Machine Learning	Overfitting Bias, variance Regularization Validation	Linear Regression Logistic Regression Generative models SVM		Finite Mixtures	Q-learning
Foundation Principles Algorithms	**Probability Theory** Likelihood, Bayes theorem	**Information Theory** Cross entropy Divergence	**Optimization Theory** Gradient Descent Newton Primal-dual		

Objective: Quickly bring students with little background to the forefront of research, while covering all important topics in between.

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.
4. Why can it achieve its goal? [Theoretical guarantees] (Theoretician)

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.
4. Why can it achieve its goal? [Theoretical guarantees] (Theoretician)

We will **focus mostly on the first three questions**.

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.
4. Why can it achieve its goal? [Theoretical guarantees] (Theoretician)

We will **focus mostly on the first three questions**. We will **explain the math behind the objective functions and how the steps are derived from principles**.

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.
4. Why can it achieve its goal? [Theoretical guarantees] (Theoretician)

We will **focus mostly on the first three questions**. We will **explain the math behind the objective functions and how the steps are derived from principles**. So, we will do a fair amount of math derivations.

Depth of this Course

Questions about an ML Algorithm:

1. What does it do? [Inputs and Outputs] (User)
2. How does it work? [Steps] (Programmer)
3. Why does it work the way it does? (Algorithm Designer)
   - Ideas behind the steps.
   - Pros and cons w.r.t alternatives.
4. Why can it achieve its goal? [Theoretical guarantees] (Theoretician)

We will **focus mostly on the first three questions**. We will **explain the math behind the objective functions and how the steps are derived from principles**. So, we will do a fair amount of math derivations. Hands-on experiences are to be gained via self-practice, programming assignment and term project.