Machine Learning for Modern Artificial Intelligence

Hsuan-Tien Lin
林軒田

Professor, National Taiwan University

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beBit TECH
Outline

ML for (Modern) AI

ML Research for Modern AI: A Personal Story

ML for AI in Reality

ML for Future AI
From Intelligence to Artificial Intelligence

intelligence: thinking and acting **smartly**
- humanly
- rationally

artificial intelligence: computers (thinking and) acting **smartly**
- humanly
- rationally

**humanly** ≈ **smartly** ≈ **rationally**
—are humans rational? 😊
What if your self-driving car decides one death is better than two—and that one is you? (The Washington Post http://wpo.st/ZK-51)

You’re humming along in your self-driving car, chatting on your iPhone 37 while the machine navigates on its own. Then a swarm of people appears in the street, right in the path of the oncoming vehicle.

**Car Acting Humanly**
- to save my (and passengers’) life, stay on track

**Car Acting Rationally**
- avoid the crowd and crash the owner for minimum total loss

Which is smarter?—depending on where I am, maybe? 😊
Traditional vs. Modern [My] Definition of AI

**Traditional Definition**

humanly \(\approx\) intelligently \(\approx\) rationally

**My Definition**

intelligently \(\approx\) easily

is your smart phone ‘smart’? 😊

modern artificial intelligence

\[= \text{application intelligence}\]
Examples of Application Intelligence

**Siri**
By Bernard Goldbach [CC BY 2.0]

**iRobot**
By Yuan-Chou Lo [CC BY-NC-ND 2.0]

**Amazon Recommendations**
By Kelly Sims [CC BY 2.0]

**Vivino**
From nordic.businessinsider.com
AI Milestones

- **first AI winter**: AI cannot solve ‘combinatorial explosion’ problems
- **second AI winter**: expert system failed to scale

**reason of winters**: *expectation mismatch*
## What’s Different Now?

### More Data
- cheaper storage
- Internet companies

### Faster Computation
- cloud computing
- GPU computing

### Better Algorithms
- decades of research
- e.g. deep learning

### Healthier Mindset
- reasonable wishes
- key breakthroughs

**data-enabled AI: mainstream nowadays**
Bigger Data Enable Easier-to-use AI

By deepanker70 on https://pixabay.com/

past  
best route by shortest path

present  
best route by current traffic

future  
best route by predicted travel time

big data can make machine look smarter
Machine Learning Connects Big Data and AI

From Big Data to Artificial Intelligence

big data → ML → artificial intelligence

ingredient → tools/steps → dish

Photos Licensed under CC BY 2.0 from Andrea Goh on Flickr

many possibilities when using the right tools
Example of ML-based AI Application: Education

- **data**: students’ records on quizzes on a Math tutoring system
- **AI**: predict whether a student can give a correct answer to another quiz question

**A Possible ML Solution**

\[
\text{answer correctly} \approx \left[ \text{recent strength of student} > \text{difficulty of question} \right]
\]

- give ML 9 million records from 3000 students
- ML determines (reverse-engineers) strength and difficulty automatically

key part of the world-champion system from National Taiwan Univ. in KDDCup 2010
Good AI Needs Both ML and Non-ML Techniques

Non-ML Techniques
Monte C. Tree Search
≈ move simulation in brain

ML Techniques
Deep Learning
≈ board analysis in human brain

Reinforcement Learn.
≈ (self)-practice in human training

good AI: important to use the right techniques—ML & others, including human

H.-T. Lin (NTU)
Full Picture of ML for Modern AI

Human Learning
- subjective
- produce domain knowledge
- fast basic solution

Machine Learning
- objective
- leverage computing power
- continuous improvement

tip: use humans as much as possible first before going to machines
Example: Tropical Cyclone Intensity Estimation

Meteorologists can ‘feel’ & estimate TC intensity from image

- TC images
- ML
- ConvNet (deep learning)
- Polar rotation invariance
- Current weather system
- Domain knowledge (HumanI)
- ML
- Better than current system & ‘production-ready’
  (Chen et al., KDD ’18; Chen et al., Weather & Forecasting ’19)
History: From Checkers to Go

(Samuel, 1959) Some studies in machine learning using the game of checkers

(Silver et al., 2016) Mastering the game of Go with deep neural networks and tree search

machine learning witnesses the rise of board-game AI throughout the years
ML for (Modern) AI

History (?): From Recognition to Generation

- Logic inference
- Expert system
- Machine learning
- Deep learning

Begin 1956
1st winter 1980
2nd winter 1993
Revolution 2012

Deep learning speeds up realizing modern AI

(Krizhevsky et al., 2012)
ImageNet classification with deep convolutional neural networks

(Ho et al., 2020)
Denoising diffusion probabilistic models

Picture extracted from the original paper of Krizhevsky et al. for educational purposes

Picture extracted from the original paper of Ho et al. for educational purposes
Generative Artificial Intelligence (Machine Learning)

Recognitive ML
Listen/Read/Watch

Generative ML
Speak/Write/Draw

Two Properties of Generative ML

variation (creativity)

complexity (structure)

(Pictures Extracted from Ho et al. for educational purposes)

(Pictures Licensed under CC0 on Wikipedia)

Generative ML:
complex outputs with variations
ML Research for Modern AI: A Personal Story
What is the Status of the Patient?

- a classification problem
  —grouping ‘patients’ into different ‘status’

- are all mis-prediction costs equal?
Patient Status Prediction

**error measure = society cost**

<table>
<thead>
<tr>
<th>actual</th>
<th>predicted</th>
<th>COVID19</th>
<th>cold</th>
<th>healthy</th>
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<tr>
<td>healthy</td>
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</table>

- COVID19 mis-predicted as healthy: **very high cost**
- cold mis-predicted as healthy: **high cost**
- cold correctly predicted as cold: **no cost**

*human doctors consider costs of decision; how about computer-aided diagnosis?*
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<tr>
<td>regular</td>
<td>well-studied</td>
<td>well-studied</td>
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<tr>
<td>cost-sensitive</td>
<td>known (Zadrozny et al., 2003)</td>
<td>ongoing (our works, among others)</td>
</tr>
</tbody>
</table>

**selected works of ours**

- cost-sensitive SVM \( (\text{Tu and Lin, ICML 2010}) \)
- cost-sensitive one-versus-one \( (\text{Lin, ACML 2014}) \)
- cost-sensitive deep learning \( (\text{Chung et al., IJCAI 2016}) \)

**why are people not using those cool ML works for their AI? 😊**
Issue 1: Where Do Costs Come From?

A Real Medical Application: Classifying Bacteria

- by human doctors: different treatments $\iff$ serious costs
- cost matrix averaged from two doctors:

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<th>KP</th>
<th>LM</th>
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<th>GBS</th>
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issue 2: is cost-sensitive classification really useful?
Are cost-sensitive algorithms great?

Cost-sensitive algorithms perform better than regular algorithms.

Jan et al. (Academic Sinica)

Cost-Sensitive Classification on SERS

October 31, 2011 15 / 19

(Jan et al., BIBM 2011)

(cost-sensitive better than traditional; but why are people still not using those cool ML works for their AI? 😊)
The Problem

- cost-sensitive classifier: low cost but high error rate
- traditional classifier: low error rate but high cost
- how can we get the blue classifiers?: low error rate and low cost

cost-and-error-sensitive: more suitable for real-world medical needs
### Improved Classifier for Both Cost and Error

(Jan et al., KDD 2012)

<table>
<thead>
<tr>
<th><strong>Cost</strong></th>
<th><strong>Error</strong></th>
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<tr>
<td>wine</td>
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<tr>
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<tr>
<td>ecoli</td>
<td>ecoli</td>
</tr>
<tr>
<td>soybean</td>
<td>soybean</td>
</tr>
</tbody>
</table>

**now, are people using those cool ML works for their AI? 😊**
Lessons Learned from Research on Cost-Sensitive Multiclass Classification

1. more realistic (generic) in academia
   ≠ more realistic (feasible) in application
   e.g. the ‘cost’ of inputting a cost matrix? ☺

2. cross-domain collaboration important
   e.g. getting the ‘cost matrix’ from domain experts

3. not easy to win human trust
   —humans are somewhat multi-objective
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ML for Future AI
What is the best AI project for (my precious big) data?

**My Polite Answer**

good start already 😊, any more thoughts that you have in mind?

**My Honest Answer**

I don’t know.

or a slightly longer answer:
if you don’t know, I don’t know.
A Similar Scenario

What is the best AI project for (my precious big) data?

how to find a research topic for my thesis?

My Polite Answer
good start already 😊, any more thoughts that you have in mind?

My Honest Answer
I don’t know.

or a slightly longer answer:
I don’t know, but perhaps you can start by thinking about motivation and feasibility.
Finding AI Projects ≈ Finding Research Topics

- **motivation**: what are you interested in?
- **feasibility**: what can or cannot be done?

### motivation
- something publishable? oh, possibly just for people in academia 😊
- something that improves xyz performance
- something that inspires deeper study
—helps generate questions

### feasibility
- modeling
- computational
- budget
- timeline
—helps filter questions

**tip**: important for first AI project to be of high success possibility
What is the best machine learning model for (my precious big) data and AI?

My Polite Answer
the best model is data-dependent, let’s chat about your data first

My Honest Answer
I don’t know.

or a slightly longer answer:
I don’t know about best, but perhaps you can start by thinking about simple models.
What is the best machine learning model for (my precious big) data and AI?

What is the most sophisticated machine learning model for (my precious big) data and AI?

- myth: my AI works best with most sophisticated model
- sophisticated model:
  - time-consuming to train and predict
  - difficult to tune or modify
  - hard to “simplify” nor “analyze”

sophisticated model shouldn’t be first choice
What is the first machine learning model for (my precious big) data and AI?

simple model first:
- efficient to train and predict
- easy to tune or modify
- somewhat “analyzable”
- little risk

tip: KISS Principle
—Keep It Simple, Stupid Safe
How to Get my AI Project Started?

**Old Me**
I don’t know. 😊

**New Me**
I know one key factor!

let’s see what the key factor is
Todos in AI Project

- **data**
  - gathering
  - cleaning
  - storing
  - ...

- **techniques**
  - modeling
  - computation
  - non-ML tech.
  - ...

- **usage**
  - evaluation
  - deployment
  - scalability
  - ...

**key first step:** set up evaluation criteria
Evaluation Criteria Guide AI Project Planning

Suggest improvement opportunities

Tip: Always start with reasonable & measurable criteria to describe prioritized AI goal

Data
- Hint preparation steps

Techniques
- Assist model/tech. choices

Usage
- Define acceptance goals
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## AI: Now and Next

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>AI becomes promising, e.g.</td>
<td>AI becomes competitive, e.g.</td>
<td>AI becomes necessary</td>
</tr>
<tr>
<td>• initial success of deep learning on ImageNet</td>
<td>• super-human performance of alphaGo and others</td>
<td>• “You’ll not be replaced by AI, but by humans who know how to use AI” (Sun, Chief AI Scientist of Appier, 2018)</td>
</tr>
<tr>
<td>• mature tools for SVM (LIBSVM) and others</td>
<td>• all big technology companies become AI-first</td>
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Needs of ML for Future AI

- **more generative**
  - win human *respect*
  - e.g. our work on design matching clothes
  - (Shih et al., AAAI 2018)

- **more explainable**
  - win human *trust*
  - e.g. our work on automatic bridge bidding
  - (Yeh et al., IEE ToG 2018)

- **more interactive**
  - win human *heart*
  - e.g. our work on efficient disease diagnosis
  - (Peng et al., NeurIPS 2018)
Summary

• ML for (Modern) AI: tools + human knowledge ⇒ easy-to-use application

• ML Research for Modern AI: need to be more open-minded —in methodology, in collaboration, in KPI

• ML for AI in Reality:
  • motivated/feasible project with measurable criteria
  • human and/or simple model first

• ML for future AI: knowing how to use is important

Thank you! Questions?