Machine Learning for Modern Artificial Intelligence

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About Me

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Learning from Data

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NTU-Coursera MOOCs
ML Foundations/Techniques

research goal: making machine more realistic
Outline

ML for (Modern) AI

ML Research for Modern AI: A Personal Story

ML for AI in Reality

ML for Future AI
intelligence: thinking and acting smartly
- humanly
- rationally

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

humanly ≈ smartly ≈ rationally
—are humans rational? 😊
Humanly versus Rationally

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\text{intelligently} \approx\text{rationally}

My Definition

intelligently \approx\text{easily}

is your smart phone ‘smart’? 😊

modern artificial intelligence

=\textbf{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
ML for (Modern) AI

AI Milestones

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

**reason of winters**: expectation mismatch

H.-T. Lin (NTU)
What’s Different Now?

More Data
- cheaper storage
- Internet companies

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

Faster Computation
- cloud computing
- GPU computing

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 and AI

Easy-to-Use

Acting Humanly

Acting Rationally

Machine Learning

**machine learning**: core behind modern (data-driven) AI
Machine Learning Connects Big Data and AI

From Big Data to Artificial Intelligence

big data  \(\rightarrow\) ML  \(\rightarrow\) artificial intelligence

ingredient  \(\rightarrow\) tools/steps  \(\rightarrow\) 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**

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

- 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
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
- ConvNet (deep learning) with polar rotation invariance
- Better than current system & 'production-ready'
- (Chen et al., KDD '18; Chen et al., Weather & Forecasting '19)

ML for Modern AI
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ML for Future AI
What is the Status of the Patient?

By DataBase Center for Life Science; licensed under CC BY 4.0 via Wikimedia Commons

• a classification problem
—an 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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<td>0</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?
Our Works

<table>
<thead>
<tr>
<th></th>
<th>binary</th>
<th>multiclass</th>
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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 (Tu and Lin, ICML 2010)
- cost-sensitive one-versus-one (Lin, ACML 2014)
- cost-sensitive deep learning (Chung et al., IJCAI 2016)

why are people not using those cool ML works for their AI? 😊
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>LM</th>
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issue 2: is cost-sensitive classification really useful?
Cost-Sensitive vs. Traditional on Bacteria Data

Are cost-sensitive algorithms great?

Cost-sensitive algorithms perform better than regular algorithm

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? 😊
Issue 3: Error Rate of Cost-Sensitive Classifiers

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>
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<th>Error</th>
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<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

See Page 16 of the Slides for Sources of the Pictures
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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.
Two Axes on 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**.
Sophisticated Model for AI

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

- **(big) data**
  - gathering
  - cleaning
  - storing
  - ...

- **machine learning**
  - modeling
  - computation
  - non-ML tech.
  - ...

- **artificial intelligence**
  - evaluation
  - deployment
  - scalability
  - ...

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

suggest improvement opportunities

data
hint preparation steps

techniques
assist model/tech. choices

usage
define acceptance goals

tip: always start with reasonable & measurable criteria to describe prioritized AI goal
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AI: Now and Next

2010–2015: AI becomes promising, e.g.
- initial success of deep learning on ImageNet
- mature tools for SVM (LIBSVM) and others

2016–2020: AI +
AI becomes competitive, e.g.
- super-human performance of alphago and others
- all big technology companies become AI-first

2021–:
AI becomes necessary
- “You’ll not be replaced by AI, but by humans who know how to use AI”
  (Sun, Chief AI Scientist of Appier, 2018)
Needs of ML for Future AI

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

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

- more interactive
  - win human heart
  - e.g. my student’s work (w/ DeepQ) 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