

Machine Learning for Modern Artificial Intelligence

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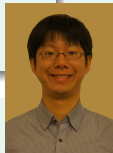
About Me

Professor
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Chief Data Science Consultant
(former Chief Data Scientist)
Appier Inc.

The logo for Appier Inc., consisting of the word "Appier" in a blue, sans-serif font.



Co-author
Learning from Data



Instructor
NTU-Coursera MOOCs
ML Foundations/Techniques



research goal: making machine more realistic

Outline

ML for (Modern) AI

ML Research for Modern AI: Some Personal Stories

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 \approx **smartly** \approx **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) Artificial Intelligence

Thinking Humanly

- cognitive modeling
—now closer to Psychology than AI

Thinking Rationally

- formal logic—now closer to Theoreticians than AI practitioners

Acting Humanly

- dialog systems
- humanoid robots
- computer vision

Acting Rationally

- recommendation systems
- cleaning robots
- character recognition

acting humanly or rationally:
more academia/industry attention nowadays

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
= **application** intelligence

Examples of Application Intelligence

Siri



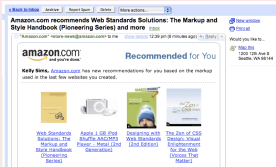
By Bernard Goldbach [CC BY 2.0]

iRobot



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

Amazon Recommendations



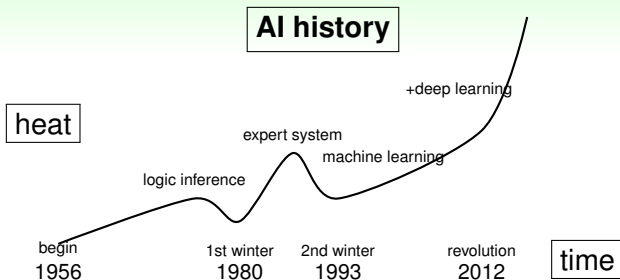
By Kelly Sims [CC BY 2.0]

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

Better Algorithms

- decades of research
- e.g. deep learning

Faster Computation

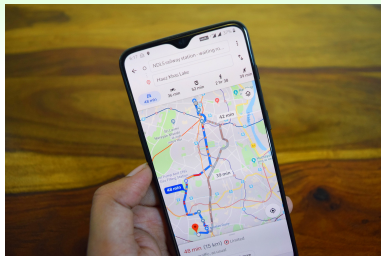
- cloud computing
- GPU computing

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

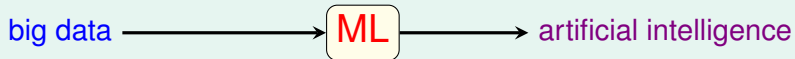
Acting Rationally

Machine Learning

machine learning: core behind
modern (data-driven) AI

Machine Learning Connects Big Data and AI

From Big Data to Artificial Intelligence



ingredient



tools/steps



dish



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many possibilities when
using the right tools

ML-based AI Applications (1/4): Medicine



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for computer-assisted diagnosis

- data:
 - **patient status**
 - **past diagnosis from doctors**
- **AI**: dialogue system that **efficiently identifies disease of patient**

my student's earlier work
as intern @ HTC DeepQ

ML-based AI Applications (2/4): Communication



By JulianVilla26;

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for 4G LTE communication

- **data**:
 - **channel information** (the channel matrix representing mutual information)
 - **configuration** (precoding, modulation, etc.) that reaches the highest throughput
- **AI**: predict **best configuration to the base station** in a new environment

my student's earlier work as intern @ MTK

ML-based AI Applications (3/4): 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 \llbracket recent **strength** of student $>$ **difficulty** of question \rrbracket

- 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

ML-based AI Applications (4/4): Security



original picture by F.U.S.I.A. assistant and derivative work by Sylenius via Wikimedia Commons

face recognition

- data: **faces and non-faces**
- AI: predict **which boxes contain faces**

mature **ML technique**, but often need **tuning**
for different **application intelligence** needs

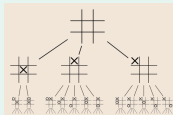
Good AI Needs Both ML and Non-ML Techniques



(Public Domain, from Wikipedia; used here for education purpose; all other rights still belong to Google DeepMind)

Non-ML Techniques

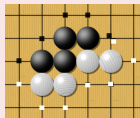
Monte C. Tree Search
 \approx **move simulation** in brain



(CC-BY-SA 3.0 by Stannered on
 Wikipedia)

ML Techniques

Deep Learning
 \approx **board analysis** in human brain



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 Wikipedia)

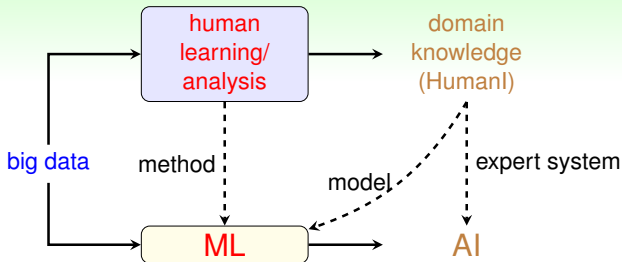
Reinforcement Learn.
 \approx **(self)-practice** in human training



(Public Domain, from Wikipedia)

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

Full Picture of ML for Modern AI



Human Learning

- subjective
- produce domain knowledge
- fast basic solution

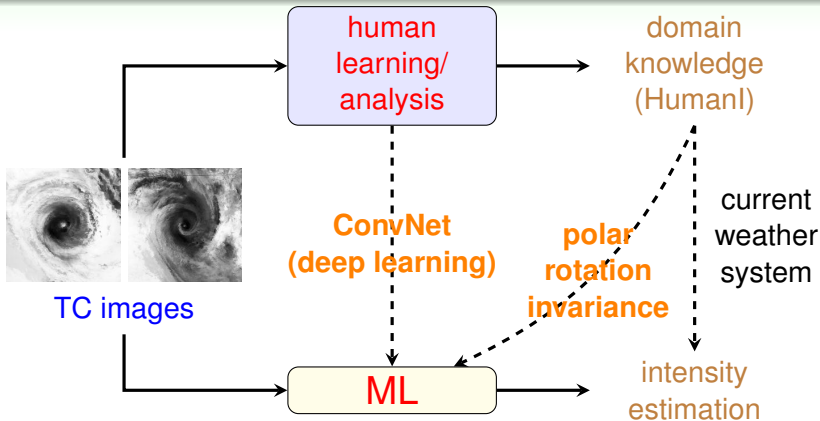
Machine Learning

- 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



better than current system &
'production-ready'
 (Chen et al., KDD '18; Chen et al., Weather & Forecasting '19)

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Cost-Sensitive Multiclass Classification

What is the Status of the Patient?



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?



COVID19



cold



healthy

Pictures Licensed under CC BY-SA 3.0 from 1RadicalOne on Wikimedia Commons

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

are all mis-prediction costs equal?

Patient Status Prediction

error measure = society cost

actual \ predicted	COVID19	cold	healthy
COVID19	0	1000	100000
cold	100	0	3000
healthy	100	30	0

- 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

	binary	multiclass
regular	well-studied	well-studied
cost-sensitive	known (Zadrozny et al., 2003)	ongoing (our works, among others)

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?** 😊

Issue 1: Where Do Costs Come From?

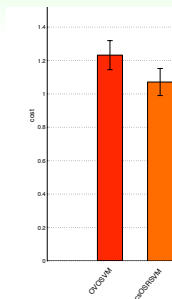
A Real Medical Application: Classifying Bacteria

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

	Ab	Ecoli	HI	KP	LM	Nm	Psa	Spn	Sa	GBS
Ab	0	1	10	7	9	9	5	8	9	1
Ecoli	3	0	10	8	10	10	5	10	10	2
HI	10	10	0	3	2	2	10	1	2	10
KP	7	7	3	0	4	4	6	3	3	8
LM	8	8	2	4	0	5	8	2	1	8
Nm	3	10	9	8	6	0	8	3	6	7
Psa	7	8	10	9	9	7	0	8	9	5
Spn	6	10	7	7	4	4	9	0	4	7
Sa	7	10	6	5	1	3	9	2	0	7
GBS	2	5	10	9	8	6	5	6	8	0

issue 2: is cost-sensitive classification
really useful?

Cost-Sensitive vs. Traditional on Bacteria Data

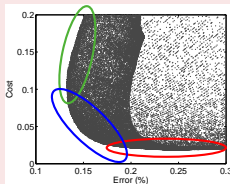


(Jan et al., BIBM 2011)

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)

Cost	
iris	≈
wine	≈
glass	≈
vehicle	≈
vowel	○
segment	○
dna	○
satimage	≈
usps	○
zoo	○
splice	≈
ecoli	≈
soybean	≈

Error	
iris	○
wine	○
glass	○
vehicle	○
vowel	○
segment	○
dna	○
satimage	○
usps	○
zoo	○
splice	○
ecoli	○
soybean	○

now, **are people using those cool ML works for their AI?** 😊

Lessons Learned from Research on Cost-Sensitive Multiclass Classification



?



COVID19



cold



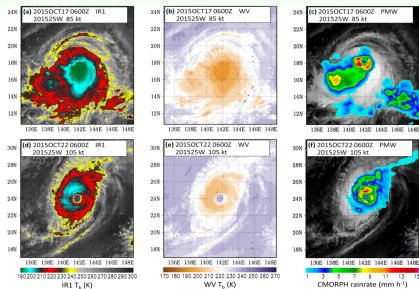
healthy

See Page 16 of the Slides for Sources of the Pictures

- 1 more realistic (generic) in academia
 \neq **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**

Tropical Cyclone Intensity Estimation

Experienced Meteorologists Can 'Feel' and Estimate Tropical Cyclone Intensity from Image



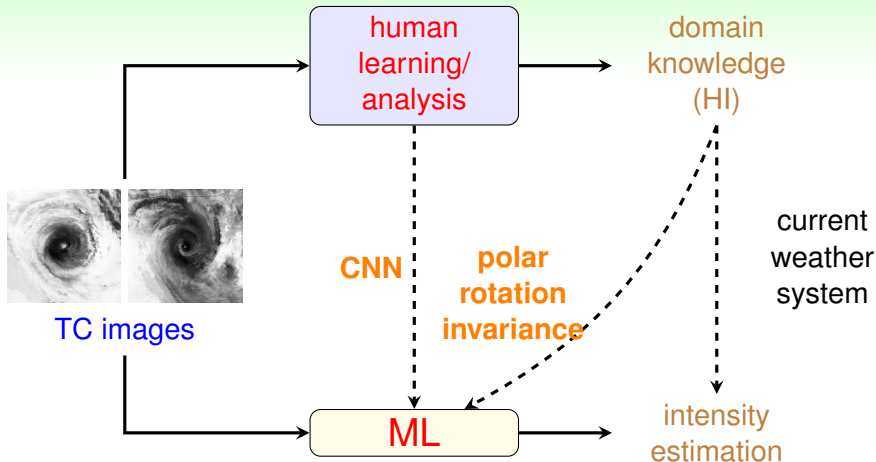
Can ML do the same/better?

- lack of **ML-ready datasets**
- lack of **model that properly utilizes domain knowledge**

issues addressed in our latest works

(Chen et al., KDD '18; Chen et al., Weather & Forecasting '19)

Recall: Flow behind Our Proposed Model



is proposed **CNN-TC** better than current weather system?

Results

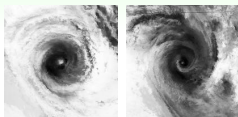
RMS Error

ADT	11.75
AMSU	14.40
SATCON	9.66
CNN-TC	9.03

CNN-TC much better than current weather system (SATCON)

why are people **not**
using this **cool ML model?** 😊

Lessons Learned from Research on Tropical Cyclone Intensity Estimation



- 1 again, **cross-domain collaboration** important
e.g. even from 'organizing data' to be ML-ready
- 2 not easy to claim **production ready**
—can ML be used for '**unseenly-strong** TC'?
- 3 good AI system requires **both human and machine learning**
—still an 'art' to blend the two

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Frequently Asked Questions of ML for AI (1/3)

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 \approx 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

Frequently Asked Questions of ML for AI (2/3)

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**

Simple First

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

Taught in ML Foundations on NTU@Coursera

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*

Frequently Asked Questions of ML for AI (3/3)

How to Get my AI Project Started?

Old Me

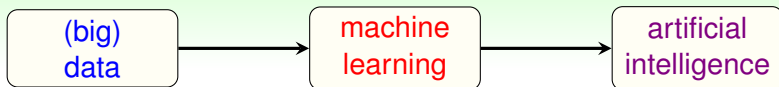
I don't know. 😊

New Me

I know one key factor!

let's see what the key factor is

Todos in AI Project



data

- gathering
- cleaning
- storing
- ...

techniques

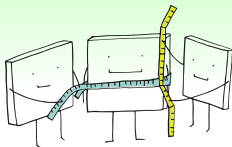
- modeling
- computation
- non-ML tech.
- ...

usage

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

key first step: set up **evaluation criteria**

Evaluation Criteria Guide AI Project Planning



(free image by Manfred Steger from Pixabay)

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 |

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 ×

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., AAI 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 \Rightarrow **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?