Machine Learning for Modern Artificial Intelligence

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beBit TECH

Outline

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 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

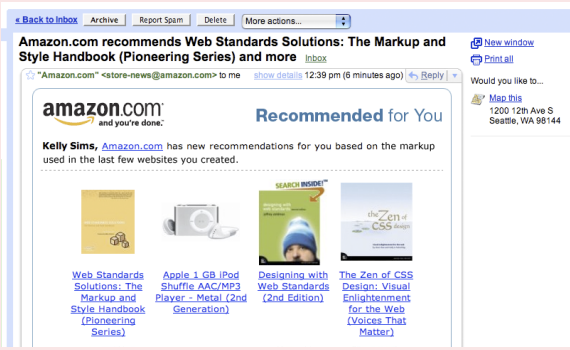
Siri

By Bernard Goldbach [CC BY 2.0]

iRobot

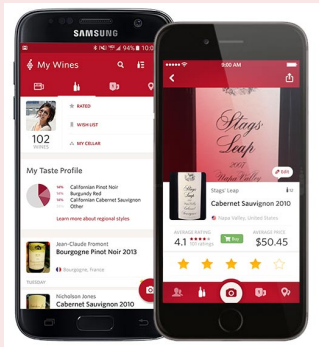
By Yuan-Chou Lo [CC BY-NC-ND 2.0]

Amazon Recommendations



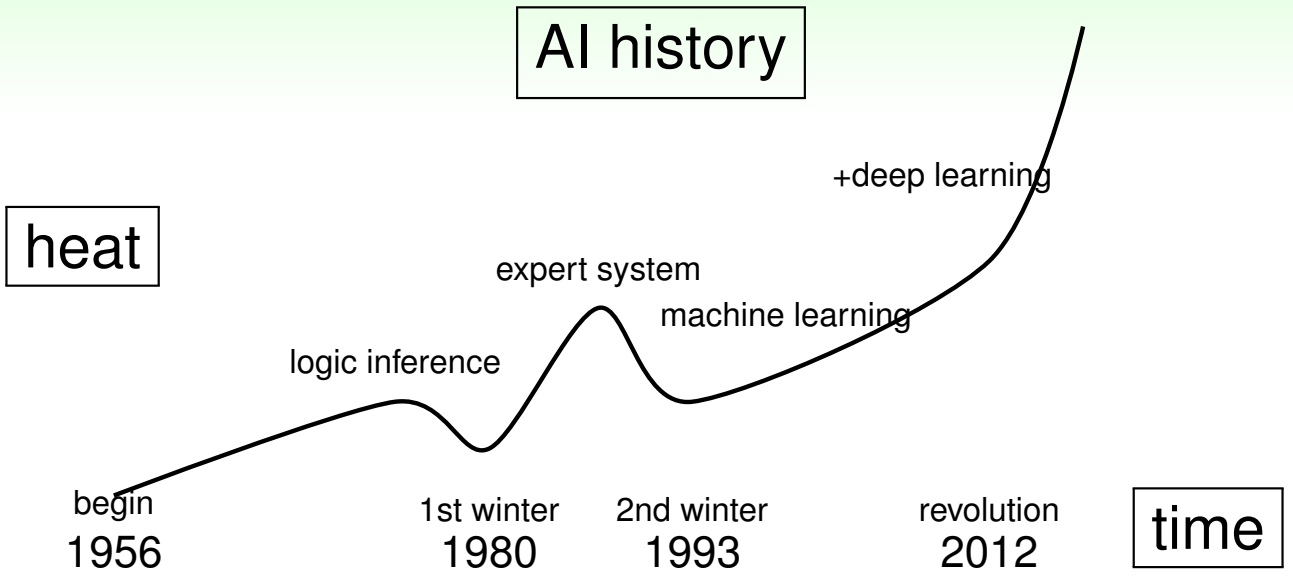
By Kelly Sims [CC BY 2.0]

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

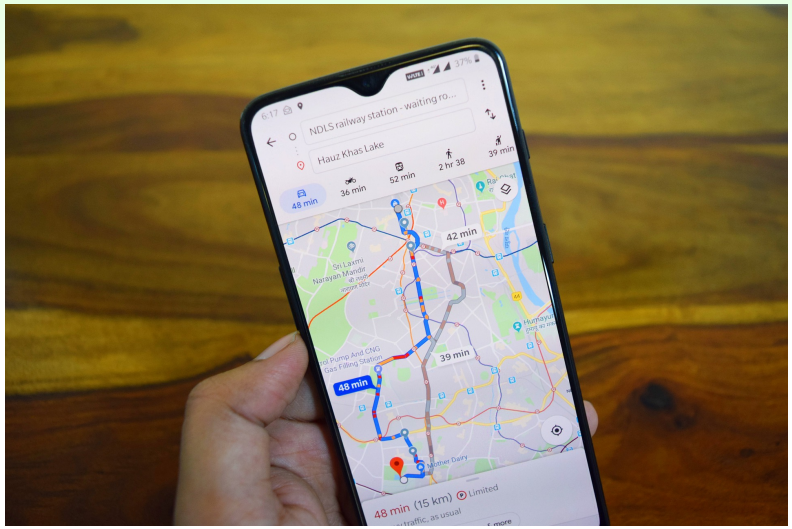
- cloud computing
- GPU computing

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 Connects Big Data and AI

From Big Data to Artificial Intelligence

big data → ML → artificial intelligence

ingredient → tools/steps → dish

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 $\approx$ ⟦recent strength of student $>$ 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

AlphaGo

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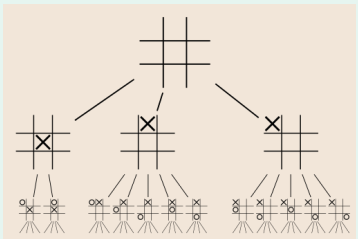
Non-ML Techniques

Monte C. Tree Search ≈ move simulation in brain



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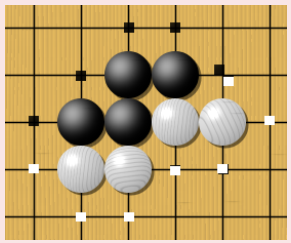
ML Techniques

Deep Learning ≈ board analysis in human brain



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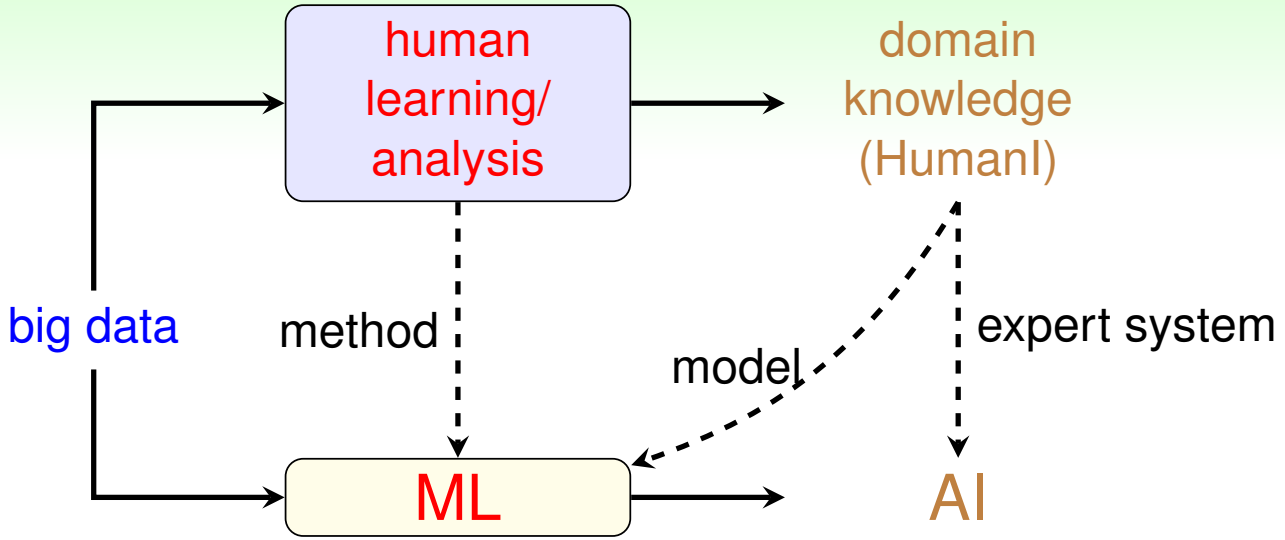
Reinforcement Learn. ≈ (self)-practice in human training

(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

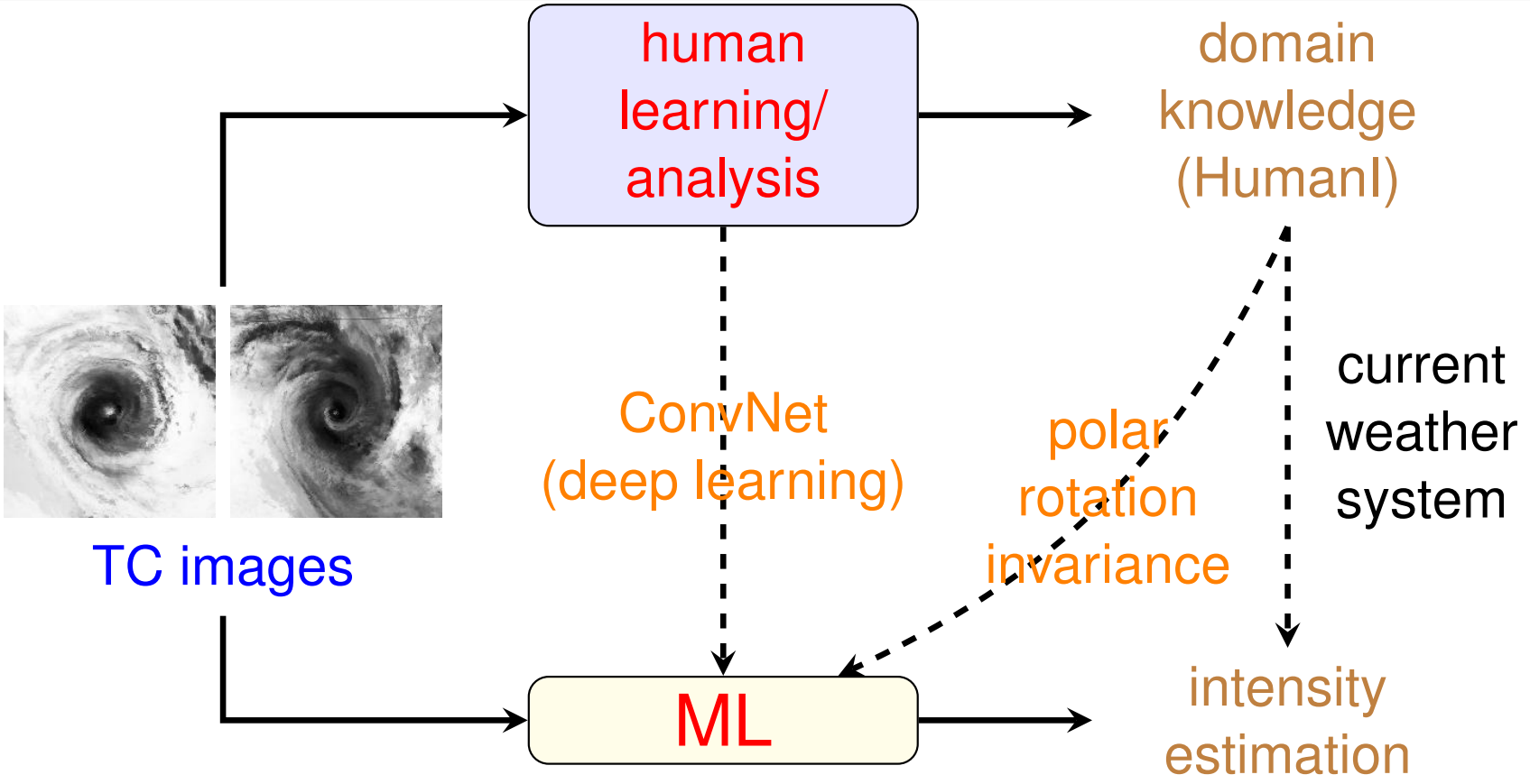
Machine Learning

- objective
- leverage computing power
- continuous improvement

tip: use humans as much as possible first before going to machines

Example: Tropical Cyclone Intensity Estimation

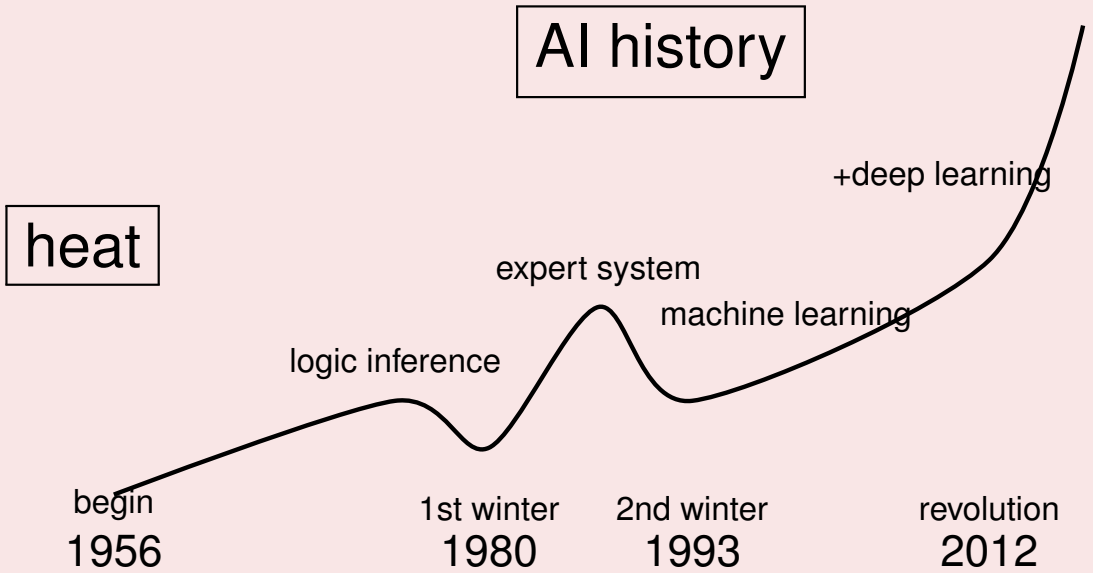
meteorologists can 'feel' & estimate TC intensity from image



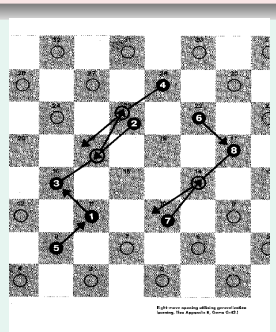
better than current system & 'production-ready'

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

History: From Checkers to Go

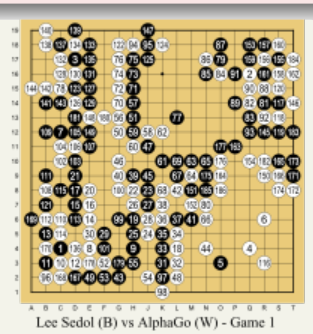


(Samuel, 1959) Some studies in machine learning using the game of checkers



Picture extracted from the original paper of Samuel for educational purposes

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



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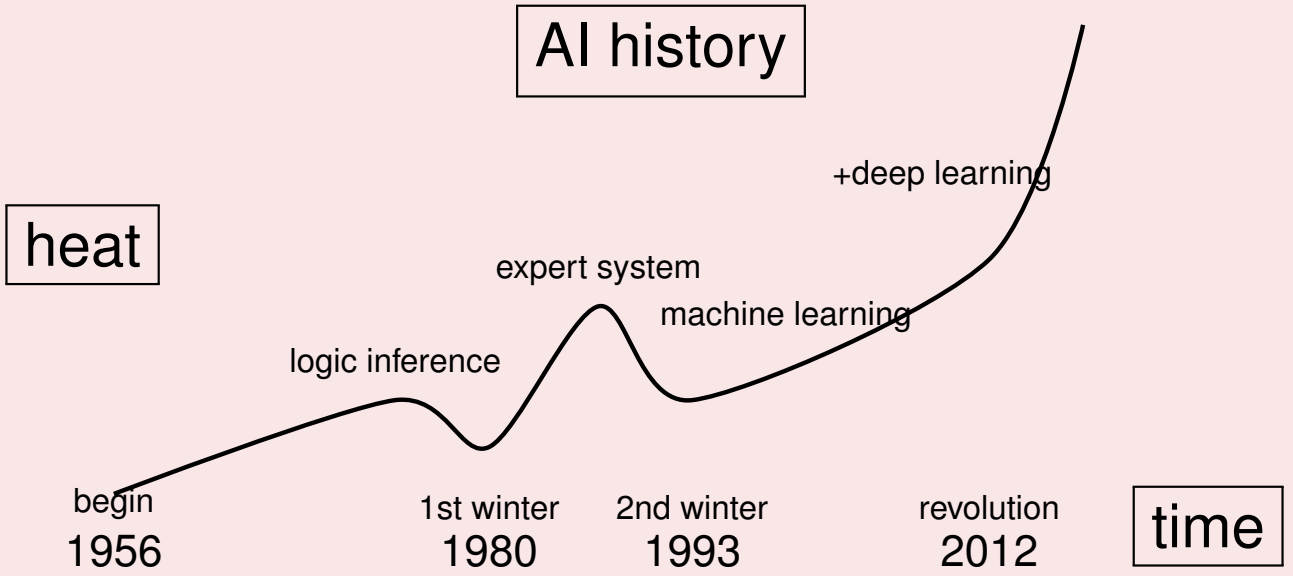
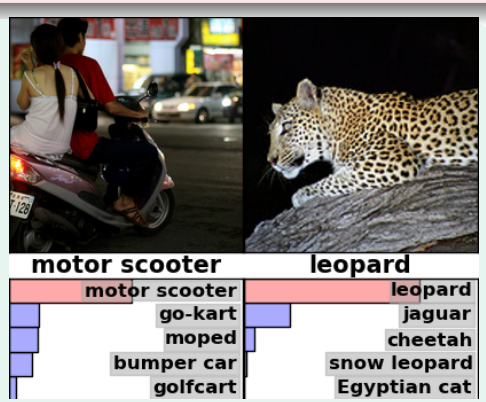
machine learning witnesses the rise of board-game AI throughout the years

History (?): From Recognition to Generation

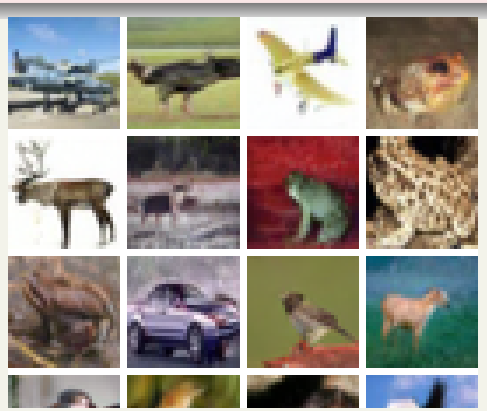


(Krizhevsky et al., 2012) ImageNet classification with deep convolutional neural networks



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

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



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

deep learning speeds up realizing modern AI

Generative Artificial Intelligence (Machine Learning)

Recognitive ML

Listen/Read/Watch

Generative ML

Speak/Write/Draw

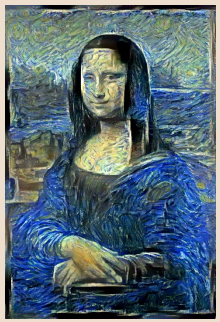
Two Properties of Generative ML

variation (creativity)

(Pictures Extracted from Ho et al.

for educational purposes)

complexity (structure)



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Generative ML :
complex outputs with variations

Outline

What is the Status of the Patient?

By DataBase Center for Life Science;

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?

COVID19

cold

healthy

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- 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?

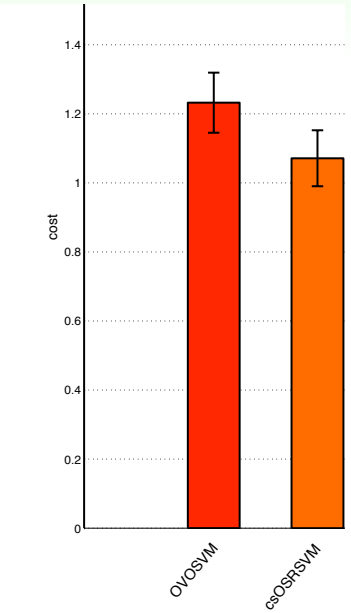
A Real Medical Application: Classifying Bacteria

- by human doctors: different treatments $\Longleftrightarrow$ 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

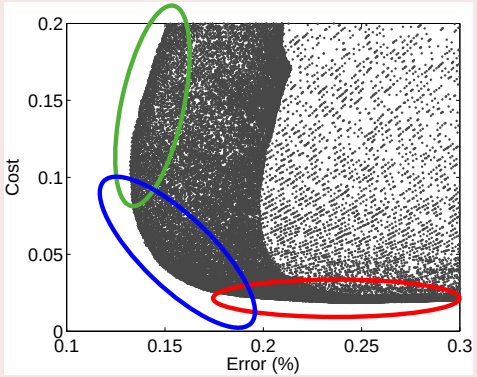


(Jan et al., BIBM 2011)

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

Outline

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.

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

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

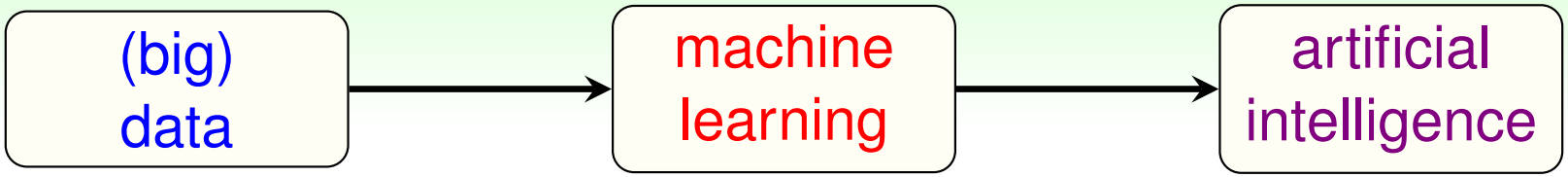
I don't know. ☺

New Me

I know one key factor!

let's see what the key factor is

Todos in AI Project



data

- gathering
- cleaning
- storing
- . . .

techniques

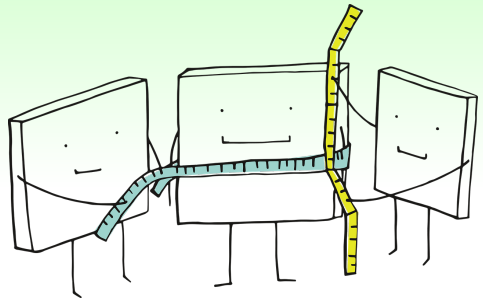
- modeling
- computation
- non-ML tech.
- . . .

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

Outline

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. 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 diagonsis

(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?