Phil's A.I. Whiteboards

Phil Parker, INSEAD

H.R.

Phil Parker's view of Artificial General Intelligence (S)= Sci fi (for now)

Artificial Intelligence = happening now ~ "AI effect"

Weak = W_i

Strong = $S = \sum_{i}^{\infty} W_i$

Robotics/Mech

- Mechanical Engineering
- Electrical Engineering
- Computer Engineering

Industrial

- Material Science
- Industrial Design
- Art

Home

⇓

Applied Physics + Engineering + Computer Science

Symbolic Learning
Cognitive Computing

- Business
- Philosophy
- Real Mathematics
- Set theory
- Graph theory
- Game theory
- Economics
- Sociology
- Network theory
- Musicology
- Physiology
- Medicine
- Linguistics

+ Computer Science

Modern Machine Learning

Computational (ML)

- Statistics
- Marketing Science
- Management Science
- Computational Quantum Chemistry, etc

+ Computer Engineering Applied Physics + Applied Mathematics

+ Computer Science

Control (MLC)

- Operations Research
- Industrial Engineering
- Applied Mathematics
- Geography (GIS)
- Decision Sciences

+ Computer Engineering

+ Computer Science

Foundations

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Robotics/Machines

F = m*a	Force
S = d/t	Speed
V = d/t	Velocity
a = Δv/t	Acceleration
g = 10m/s²	Gravity
Fg = mg = W	Weight
F = kx	Springiness
Ek = 1/2mv²	Kinetic Energy
Ep = mhg	Gravitational potential energy
Ep = Ek(mgh=1/2mv²)	Conservation of energy (falling body)
W = Fd	Work
W = Δ E	Change in kinetic Or potential energy

+

Equations specifically for
- Robot Kinematics
- Kinematic influence coefficients
- Inverse Kinematics
- Foundations (linear equations, polynomial interpolation, nonlinear equations, computational geometry, differential geometry)

Symbolic Learning
Cognitive Computing

$y = a + b x_1 + cx_2^2$

dependent

Intercept

Slope

settings

Power, Order, exponent

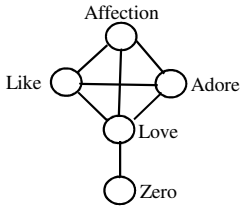
Predictors explanatory independent

a = b; b = c;

$\Rightarrow$ a = c

y' = b + 2cX

y" = 2c



Nodes
Cliques
Edges

$Y_1 = \{X_1, X_2, X_3, X_4\}$

$Y_2 = \{X_2, X_3, X_5, X_9\}$

Computational (ML)

$\begin{bmatrix} 1 \\ 2 \\ 1 \\ 5 \end{bmatrix} \sim \begin{bmatrix} a \\ b \\ c \end{bmatrix} \sim \begin{bmatrix} 4 \\ 10 \\ 12 \end{bmatrix}$

Vectors

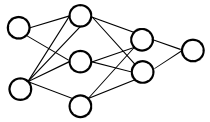
Tensor w/ Rank Dimension Row x column MxN

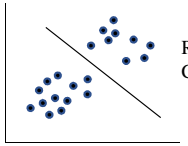
$y = a + bx_1 + cx_1^2$

output bias weights inputs

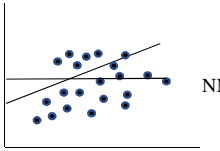
Hyperparameters

$\Rightarrow$ settings





Regression v. Classification



NN

Modern Machine Learning

Control (MLC)

Objective

Max $Y = f(X_1, X_2)$

(min)

Subject to "constraints"

X_1 = f (P's of marketing)

X_2 = f (material costs)

Min~ C^T_x etc…

st. Ax < b

and x ≥ 0

$$\max \boldsymbol{\pi} = \sum\sum\sum \int_0^T e^{-rt}[(P - MC) - F]dt$$

s.t.

U = f (4 P's)

MC = f (BCG curve)

F = f ($\sum\sum\sum$, tech)

Applications

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Robotics/Mech

- Sensors
- Sex dolls/ puppets
- Conveyors
- Welders
- Material handling
- Player piano
- Calculators
- R2D2-CP30
- "Nouvelle"= insects
- Readers (punch cards)
- Automobiles
- Backhoes
- Rovers

Q: What's the trick?
A: What do humans hate doing or can't in the physical world?

Symbolic Learning
Cognitive Computing

- Chat bots/ recommend engines
- Quiz winners
- Poetry
- Factsheets
- Music
- Books
- Academic Articles
- Search/Sorting Engines
- Trading Recommendations
- Translation Engines (small problems)
- Expert Systems

Q: What's the trick?
A: There is no such thing as a book!!

Modern Machine Learning

Computational (ML)

- Segmentation
- Positioning
- Product design
- Product Pricing
  - Hotels
  - Aircraft
  - Travel
- Recommendations
- Predictions
- Image Identification
- Credit Scoring
- Stock picking
- Machine translation
- Forecasting trends
- Classifying things

Q: What's the trick?
A: Know what type of data you have and how much!

Control (MLC)
Linear Programming

- Which crops to grow
- Aero: foil shape optimization
- Airlines: price/seat optimization
- Manufacturing: supply chain orders
- Energy: power system design

Other

- HVAC
- Autopilots
- Navigators
- ATC alerts
- Route Planning
- Cloud computing (minimize cost)
- Sensors ⟷ Action

Q: What's the trick?
A: Know what you want and what will never work!

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Types

< Weak = W_i

Strong = S = $\sum_{i}^{\infty} W_i$

Industrial

Robotics/Machines
- Articulated
- Cartesian (x,y,z)
- Cylindrical
- Polar
- Scara
- Delta

Home
- Simplex/Duplex
- Autonomous
- Mobile/Fixed

Etc.

Retail
- ATM//Dispense
- Vending Machines//Dispense
- Servers//Comfort Q & A

Symbolic Learning

Cognitive Computing

Translation (e.g. tts, stt)
- Dictionary
- Statistical
- Grammatical
- Seg 2 Sequence →

NLP
- By order
- + by POS
- + by Corpora

NLG
- By Genre
- * Sub Genre

Speculation
- By interpolation w/in exceptions

Curiosity
- By depth of search

Creativity
- By licence
- Explore across graphs or methods

Machine Learning

Computational (ML)

Unsupervised (x_1, x_2)
- Cluster Analysis
  - Partitioning
  - Hierachical
  - Fuzzy
  - Density-based
  - Model-based

  Pop: K-means
  DBSCAN
- Data Reduction
  - Factor Analysis/PCA
  - SVD (singular value decomposition)
  - LDA (Latent Dirichlet Allocation)

Supervised ($y = f(x_1, x_2)$)
- Classification < a, b, c
  - Neural Nets
  - Logistic Regression
  - Naïve Bayes
  - SVM (support vector machine)
  - Decision Tree
- Regression < 1, 26, 114
  - Neural Nets
  - Regression + Time Series (ARIMA, etc.) < Trends, ETS, ARIMA, Etc., Bass Models
  - Decision Trees
  - Conjoint
- Ensemble (boosting/forests)
- Reinforcement ($y = f(X_1, X_2)$)/g(R)) = Loop on reward

Control

Linear Programming
Mixed Integer Prog.
Quadratic Prog.
Shortest Route
Dynamic Prog.
Stochastic Prog.
Optional Control Theory
Geometric Programming
etc.

Resume signals

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Robotics/Machines
CPU/RAM

- C++
- Python
- Matlab
- Lua
- Rust (Nphysics)
- C
- Assembly

+

specialty by application

Symbolic Learning
Cognitive Computing
CPU/RAM

- Excel (VBA)
- Ms Access (VBA)
- MySql/Sqlite(.net)
- Solr Lucene

R Python

Redis

- Net/C#/VBA/JS

+

C++, Python

$\neq Assembly, Javascript, or\ Java\ but\ cool$!!

$\approx MEL, exotic\ languages$

(*LUA* Go)

Modern Machine Learning

Computational (ML)
CPU/GPU/RAM

- Python
- R
- Excel (VBA, .net. C#)

… SAS, SPSS. STATA, Open NN

- Redis
- Solr/Lucene
- MySql/Sqlite
  - MS Access
- Mongo DB
  - Word
  - Pdf

Oracle, SAP, etc.
AWS, Azure, iCloud,
Google Cloud

Control

- Matlab
- Mathematica/Wolfram Alpha
- Python
- R
- Maxima
- Octave
- GNU Scientific Library
- PSPP

math

OR : SAS/OR ($)
COIN-OR, NCSS ($)
Gnumeric
GLPK
Goblin
Openforecast
Flopc++
Zimpl
Cliquer

Old school!!

Libraries (e.g.Python)

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Robotics/Mech

General
- PythoRobotics

Dynamics Simulation
- Bullet
- Chrono: Engine
- DART
- Idyntree
- Klampt
- MARS
- MRPT
- MuJoCo
- OpenRave
- Pinocchio
- Py Dy
- RBDL
- RBDyn
- Robopy
- Siconos
- Trep

Inverse Kinematics
- IKBT

Optimization
- Ipsolvers
- qpsolvers

Symbolic Learning
Cognitive Computing

NLP
- NLTK
- Gensim, Spacy
- custom

Data Mining/Scraping
- Scrapy
- Statsmodels
- Custom

Math Computer Algebra Systems (CAS)
- MAXIMA
- WOLFRAM ($)
  - Mathematica
- MATLAB ~ Mathworks
- SymPy (Python)
- GAP (combinatories)

Translation/Stat/ML/NN

Apertium	Tensorflow/G
Phrasal	Open NMT/H
Moses	Nematus/E
Travatar	Sockeye/AM
Joshua	Fairseq/FB

Visuals
- Highcharts
- D3.js

Modern Machine Learning

Computational

"Deep Learning"

See Wikipedia "Comparison of Deep Learning Software"

…Tensorflow
- Keras/ Dist- Keras
- Caffe
- Theano
- MxNet
- Lasagne
- Nolearn
- Sklearn-theano
- Pytorch

ML
- Numpy
- SciPy
- Pandas
- Scikit-learn, XG Boost, Eli5

Visuals
- Matplotlib
- Seaborn
- Bokeh, Plotly, Pydot

Control

Python
- MIDACO
- Open MDAO
- SciPy
- APMonitor
- IMSL Numerical Libraries

Other
- Search by method

Key Concepts

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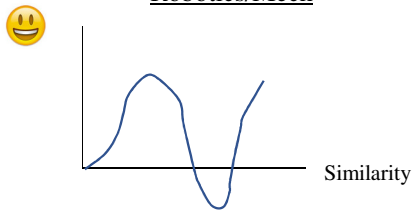
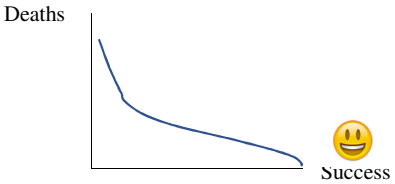
Robotics/Mech



- Pain points w/ repetition + cost/benefit
- Ninja! ⇒ Six Sigma
- Kiss
  - ➢ Find simplest solution
  - – Auto drivers w/ or w/o image recognition
  - – v. tracks w/o danger
- Experiment!!!
- Validate w/ People!

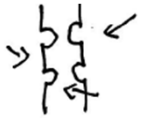


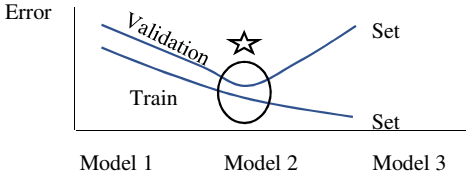
Symbolic Learning
Cognitive Computing

- PLOT the DATA!!
- Underfitting (too simple)
  - – Error due to bias (bad training)
- Overfitting (over complicating)
  - – Error due to variance
  - – Great on training set

⇒ Need good training + testing sets!

Add Exception Rules

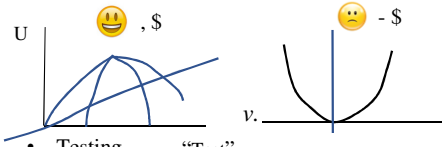
- Add theory/laws/rules
  - – "Diminishing Returns"
- Clean, clean, clean the data
-  Multiple perspectives
- Find/mimic the formulas used by people/ others…
- Experiment!!
- Validate w/ Experts! ⇒Vetting



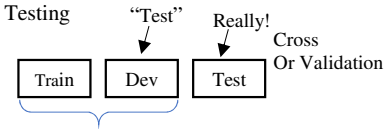
Modern Machine Learning

Computational

- Plot the data!!!!
- Kiss
  - – Classics can beat new stuff!
  - – Experiment!!!
  - – People are expensive not python, not hardware ∴ Kaggle; starving students, etc…
- Loss Functions



- Testing



- Confusion Matrix ~ add $ or ג

	Predick sick	Predict healthy	
Sick	True +	False -	ok = high precision
healthy	False +	True -	

ok = recall

- Accuracy = (True/All)
- Precision = $\frac{Tr^t}{Tr^t + F^t}$ Recall = $\frac{Tr^t}{Tr^t + F^-}$
- F1 ≠ $\frac{P+R}{2}$; $F_1 = \frac{2PR}{P+R}$ = harmonic mean; F_β → $F_{.05}$ = prec., F_2 = recall

Control

- Plot the Data!!!
- Closed form
- Not closed form
- Simulations
- Brute Force
- Heuristics
- Quantum computing to the rescue?
- Objectives (goal)
- Constraints (but..)
- P= polynomial time
  - 2x +3 = Fast Sorting
  - + - ÷ x
- NP= non-deterministic polynomial
  - – Travelling Sales Route

Bummer, recursion!!

- NP Hard
  - ~ not verifiable?
  - ~ not solvable?
- NP + NP Hard

Complete – can check!