Session #03

CMSC 409: Artificial Intelligence

http://

Virginia Commonwealth University,
Fall 2023,
Dr. Milos Manic
(mmanic@vcu. edu)

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CMSC 409: Artificial Intelligence

Topics for today Session # 03

- Announcements
- Previous session review
- History of AI…
  - *from Turing machine to deep learning*
  - *3 waves of AI research*
  - *general intelligence and deep learning*
- What "drives" AI?
  - *"Big" data sets*
- Learning of agents
  - *Brief intro on biological & artificial neurons*
  - *Transfer functions*

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Announcements

Session # 03

- Canvas
  - *New slides posted*
  - *All enrolled should have access – please check*
- Class roster
  - *All of you should be on the Canvas class email list – contact Instructor in case you are not receiving these emails*
- Project #1
  - *Will be posted soon*
- Prereqs
  - *Must have the pre-reqs CMSC 401, MATH 310 (except when approved prior).*
- Subject line and signature
  - *Please use [CMSC 409] Last_Name Question*

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Founder: Zachariah Charles Rodriguez-McDonough

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A few slides on

- ”zeroth” assignment
- forming groups
- Canvas
- Zoom info

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Your "zeroth" assignment (deadline Aug.31)

A: 1. Form a team (team lead + up to 2 members)
2. Provide information in google document
3. Inform Instructor (mmanic@vcu.edu) & TAs
Sandun Bandara (mavikumbureh@vcu.edu),
Victor Cobilean <cobileanv@vcu.edu>
Note: Team lead should always keep team members in cc

B: 1. Send an email to Instructor & TA:
2. Use subject line [CMSC 409] Your Name, Background
3. Describe your professional/academic background (briefly)
4. Describe your interests in AI and course expectations

I receive a large number of emails on daily basis. Please use this subject line so your email ends up in right place in my Inbox. If any urgent matter arises, please append your subject line with " – URGENT".

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A:
1. Form a team (team lead + up to 2 members)
2. Provide information in
https://docs.google.com/spreadsheets/d/1YMPOtcAzOeB4sH9OU4OywX9h3afKOOGn/edit#gid=697412957
3. Inform Instructor (mmanic@vcu.edu) & TAs
Sandun Bandara (mavikumbureh@vcu.edu), Victor Cobilean <cobileanv@vcu.edu>
Note: Team lead should always keep team members in cc

Important: If you are looking for additional team members, please scroll below

Group Name	# team members	First Name	Last Name	Canvas Group Statu
LastName1_LN2_LN3	3	FirstName1	LastName1	Not Created
		FirstName2	LastName2	
		FirstName3	LastName3	
	3			Not Created
	3			Not Created
	3			Not Created
	2			Not Created
	3			Not Created
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	3			Not Created
	2			Not Created
	1			Not Created
	2			Not Created
Name 1, Name 2,...: Looking for a team, plsss contact me if you are looking for another team member (contact email)				Created

<- Populate this document by Aug.31

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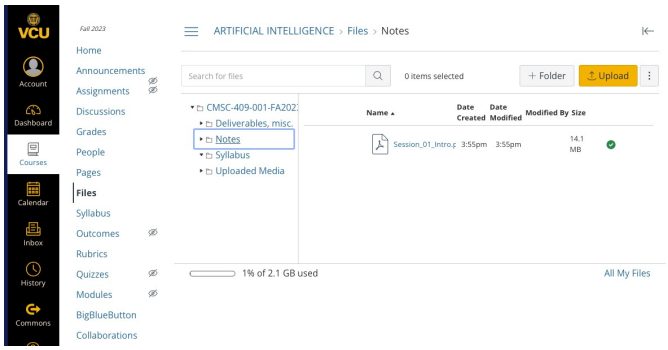
Canvas:



Zoom (office hours)

- Login to https://vcu.zoom.us/ - that activates your zoom account in case you do not have it already
- This is the licensed account

This option is activated => ☑ Only authenticated users can join: Sign in to Zoom

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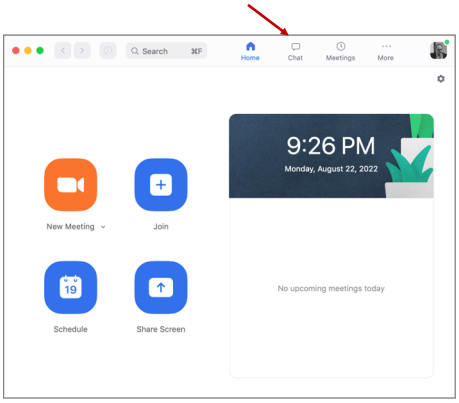
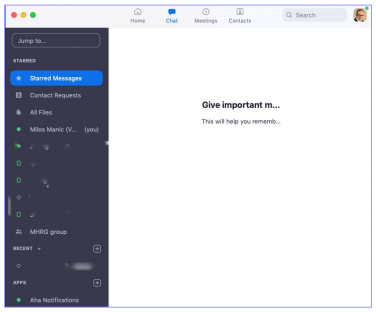
- Zoom Chat (contact me any time)
  - Login to zoom app
  - Start Chat
  - If there is a green dot next to my name, I am not in Zoom call
  - You can "chat me" here during and outside office hours





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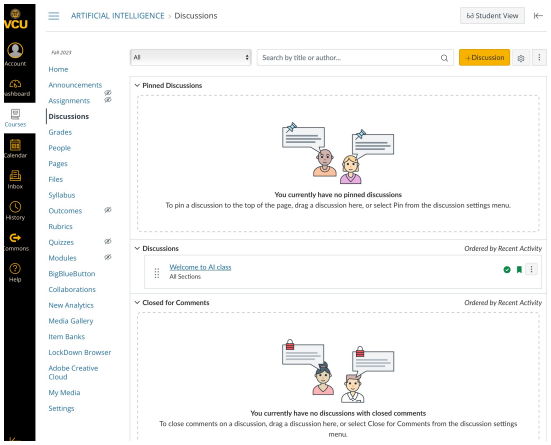
- **Discussions**
  - Welcome thread created
  - Feel free to use it, create new ones…



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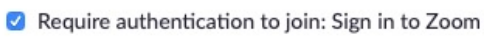
Reminder:

- Office hours - Zoom (please make appointment)
  - https://vcu.zoom.us/j/81934704959, pass: Y9aC9DLL1y
  - https://vcu.zoom.us/j/81934704959?pwd=SEdkaFlyd2NoblN2dVJCWTFVYnZxUT09
- Zoom
  - Login to https://vcu.zoom.us/ - that activates your zoom account
  - All students should have licensed account (contact IT)
  - **Authentication option activated (you must be signed in)**



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History of AI…

From Turing Machine to Deep Learning

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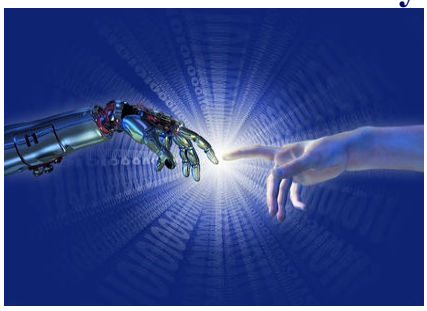
One view of AI history…



From Fantasy and Fact

Artificial intelligence has come far since its inception, both in its practical applications and in the popular imagination.

1950 The mathematician Alan Turing proposes a test for machine intelligence.

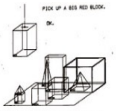
1956 John McCarthy coins the term "artificial intelligence" as the topic of the Dartmouth Conference, the first conference devoted to the subject.

1959 Arthur Samuel's checkers program wins games against the best human players.

1962 First industrial robot company, Unimation, founded.

1967 "HAL" (above) stars in "2001: A Space Odyssey."

1969 Stanford Research Institute: Shakey the Robot demonstrated combining movement, perception and problem solving.



1971 Terry Winograd's Ph.D. thesis (M.I.T.) demonstrated the ability of computers to understand English sentences in a restricted world of children's blocks, in a coupling of his language-understanding program with a robot arm that carried out instructions typed in English.

1977 C3PO and R2D2 star in "Star Wars."

1981 The Fifth Generation Computer Systems project by the Ministry of International Trade and Industry of Japan heralds a generation of intelligent machines.

1985 A Kawasaki robot kills a Japanese mechanic during a malfunction.

1997 I.B.M.'s Deep Blue chess program beats the world chess champion Garry Kasparov in a widely followed match.

2005 Stanley, a robot Volkswagen Touareg, designed by a team of Stanford University engineers, wins the DARPA Grand Challenge award by traveling autonomously for 132 miles through a desert.

The New York Times/Photographs by Associated Press (HAL), Professor Terry Winograd (blocks), 20th Century Fox (Star Wars), Agence France-Presse (Deep Blue), PRNewsFoto (Volkswagen)

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AI, the past and the future…

Artificial Intelligence (AI)…

- Initially for problems w/ formal, math rules
- Humans solve problems intuitively (speech, image recognition)
- Challenge
  - *solve tasks which are easy for people (but hard to describe formally)*
- How about "intuitive" problem solution?
  - *learn from experience, decomposing hierarchy of concepts*
  - *avoid the need to formally specify "the knowledge", instead…*
  - *describe **hierarchy of concepts** via graph with **many layers***

"deep learning" (with many layers)

- Early examples:
  - *IBM's Deep Blue chess-playing (beat Garry Kasparov in 1997)*
  - *Can be described via formal rules (64 rules, 32 pieces, allowable moves)*

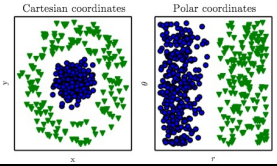
References:

1. Yann LeCun, Yoshua Bengio, Geoffrey Hinton, *Deep learning*, Nature 521, 436–444 (28 May 2015) doi:10.1038/nature14539 (full link: http://www.nature.com/nature/journal/v521/n7553/full/nature14539.html)
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, url=http:/ www.deeplearningbook.org, year=2016.

AI, the past and the future…

Artificial Intelligence (cont.)…

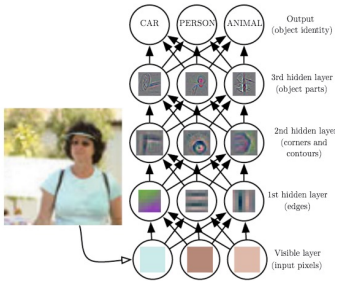
- Abstract/formal tasks most difficult for humans (vs. machine)
- Informal knowledge (humans good at)
  - *Subjective and intuitive knowledge (human)*
  - *How can machine articulate informal knowledge in formal way?*
- Machine learning
  - *Hardcoding knowledge (e.g. pattern matching, or Naïve Bayes for spam filters)*
  - *Data **representation** (using features, not defining features; Arabic vs. Roman numerals)*
  - *Much work goes into designing right **features**, then feeding those to ML*
  - *Char recognition (unique feature vector)*



Goodfellow et. al, Deep Learning, MIT, 2016

AI, the past and the future…

- Deep learning
  - *building complex concepts out of simpler ones*
  - *Multilayer perceptron (MLP)*
    - *complex output function (based on number of simple functions)*
    - *each layer new representation for its input*
  - *building complex concepts out of simpler ones*



Hidden layers (not "visible" in data)

Each layer extracts (higher and higher) abstract features from the system

Visible layer (visible variables)

Goodfellow et. al, Deep Learning, MIT, 2016

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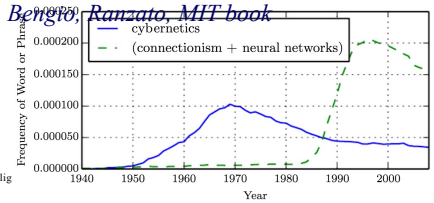
One view of the AI history…

- A new topic?
  - *dates back to 1940s*
  - *"ANNs, one of the names that DL has gone by…" (Goodfellow, et al MIT 2016)*
- According to *Goodfellow, Bengio, MIT book*
  - *freq. of 3 words: "cybernetics", "connectionism", "neural networks"*
  - *three historical waves of ANN research*
  - ***1st wave** - cybernetics, single neuron training:*
    - *1940s-1960s: McCulloch and Pitts 1943, Hebb 1949, Rosenblatt's Perceptron 1958*
  - ***2nd wave** - connectionist approach 1980s-1995:*
    - *EBP (Rumelhart et al 1986, several hidden layers); simple units can achieve intelligent behavior;*
  - ***3rd wave** – deep learning approach 2006-present:*
    - *Hinton, Bengio, Ranzato, MIT book*



According to Google Books
Goodfellow et. al, Deep Learning, MIT, 2016

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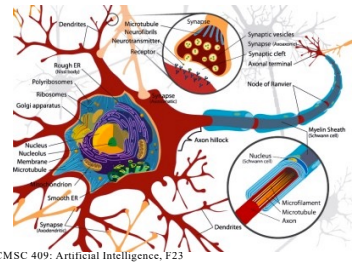
One view of the AI history… (cont.)

- Neural perspective
  - *building intelligence by reverse engineering functionality of brain*
  - *"deeply" interesting to understand brain and human intelligence (ML models)*
- Deep Learning
  - *goes beyond current ML – learning of **multiple levels of composition***
  - ***not necessarily neural inspired***
- ***Why diminished role of neuroscience in DL?***
  - *not enough info about the brain*

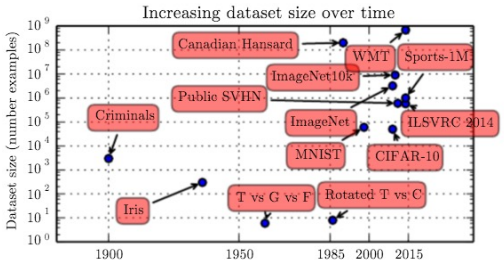


- *The human brain…*
- *100 billion neurons*
- *Each connected to up to 10,000 other neurons*
- *Each up to 1,000 trillion synaptic connections*
- *A computer with 1 trillion bps processor (10^12)*
- *Memory: 1 to 1,000 TB*
- *(19 million volumes in the US Library of Congress represents ~ 10 TB).*

The Human Memory
http://www.human-memory.net/brain_neurons.html

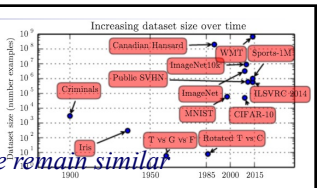
One view of the AI history… (cont.)

- 1990s to 2007 (cont.)…
  - *2006 breakthrough…*
    - *Hinton 2006 – Deep Belief Networks (greedy layer-wise pretraining)*
    - *Bengio, Ranzato 2007 – other kind of DNN, improving generalization*
    - *DNN outperforming competing ML based AI systems*
- **3rd wave**
  - *Continues as of today*
  - *Started with unsupervised learning and DL to generalize from small data sets*
  - *Now older supervised learning and ability of DL large labeled data sets*
- Increasing data sets



Goodfellow et. al, Deep Learning, MIT, 2016

What drives the AI…?



- Increasing data sets *(cont.)*
  - *learning algorithms mimicking human performance remain similar*
  - *1980s toy problems algorithms used today*
  - *BUT models/architectures use very deep architectures today…*
    - *today we can provide resources*
  - *in 2016, rule of thumb:*
    - *DL needs 5,000 labeled examples per category for success*
    - *10M labeled examples to match/exceed human performance*
    - *the age of Big Data…*
  - *Data sets:*
    - *1900s – statisticians working on 100, 100,000 patterns*
    - *1950s-1980s - small synthetic data (letters), Widrow-Hoff 60s, Rumelhart 80s*
    - *1980s-1990s - 10,000 scans of handwritten numbers*
      - *MNIST, LeCun 1998*
    - *2000s –*
      - *CIFAR-10 (Krizhevsky, Hinton 2009), 100,000 – 10Ms like*
      - *SVHN - Street View House Numbers (Netzer et al 2011), ImageNet (Deng et al, 2009), Sports-1M (Karpathy et al 2014)*

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What "drives" the AI…?

- Increasing data sets *(cont.)*
  - *The Street View House Numbers (SVHN) Dataset*
    - *Over 600,000 digit images, coming from a significantly harder, unsolved, real world problem (recognizing digits and numbers in natural scene images)*
    - *Minimal requirement on data preprocessing and formatting*
      - *Labeled data*
      - *Suitable for developing ML, object recognition algorithms*
    - *Real-world image dataset*
      - *obtained from house numbers in Google Street View*
    - *Similar to MNIST*
      - *(images of small cropped digits), but order of magnitude more labeled data*

Format 1: Full Numbers

Format 2: Cropped Digits

http://ufldl.stanford.edu/housenumbers/

Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng Reading Digits in Natural Images with Unsupervised Feature Learning NIPS Workshop on Deep Learning and Unsupervised Feature Learning 2011.

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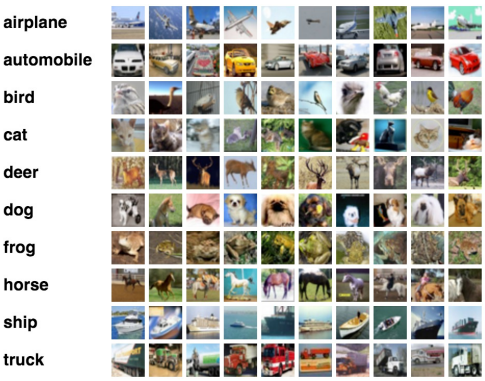
What "drives" the AI…?

- CIFAR-10, CIFAR-100
  - *Labeled subsets of the 80M tiny images*
  - *CIFAR-10 dataset consists of 60,000 32x32 color images in 10 classes*
  - *6,000 images/class; 50,000 training images; 10,000 test images;*

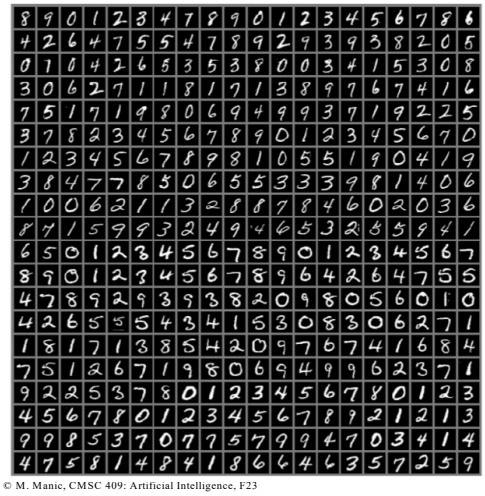


- *CIFAR-10 python version - 163 MB*
- *CIFAR-10 Matlab version - 175 MB*
- *CIFAR-10 binary version - 162 MB*

https://www.cs.toronto.edu/~kriz/cifar.html

What "drives" the AI…?

- Increasing data sets *(cont.)*
  - *MNIST - Modified NIST (National Institute of Standards and Technology)*
    - *training set of 60,000 examples, and a test set of 10,000 examples*



- *Labeled data*
- *Widely used in DL research*

- *Subset of a larger set*
  - *available from NIST who collected data originally*
- *Modified*
  - *data preprocessed for ML*
  - *the digits have been size-normalized and centered in a fixed-size image*

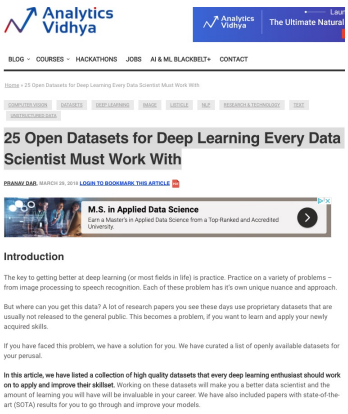
http://yann.lecun.com/exdb/mnist/

The digit images in the MNIST set were originally selected and experimented with by Chris Burges and Corinna Cortes using bounding-box normalization and centering.

Goodfellow et. al, Deep Learning, MIT, 2016

What "drives" the AI…?

- 25 Open Datasets
  - *25 Open Datasets for Deep Learning Every Data Scientist Must Work With*
  - https://www.analyticsvidhya.com/blog/2018/03/comprehensive-collection-deep-learning-datasets/



https://www.analyticsvidhya.com/blog/2018/03/comprehensive-collection-deep-learning-datasets/

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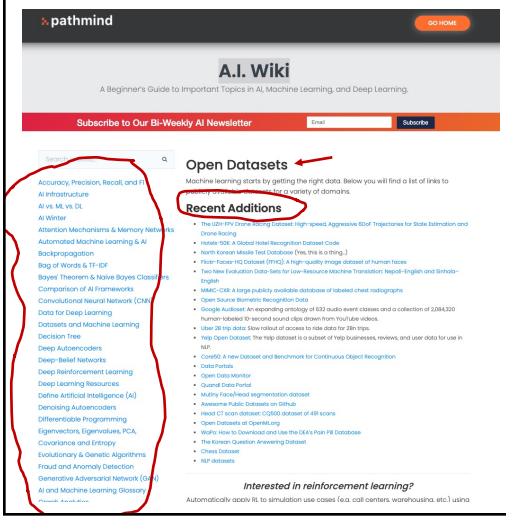
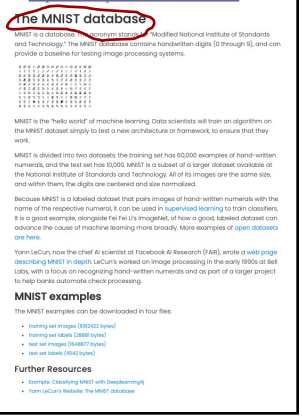
What "drives" the AI…?

- A.I. Wiki
  - *A Beginner's Guide to AI, ML, DL*
  - https://pathmind.com/wiki/open-datasets



https://wiki.pathmind.com/mnist



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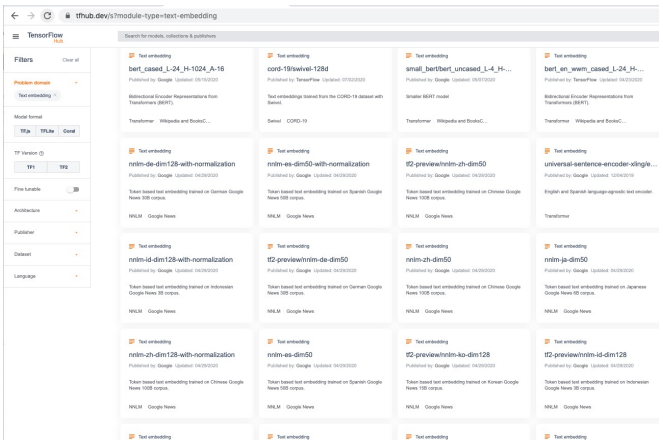
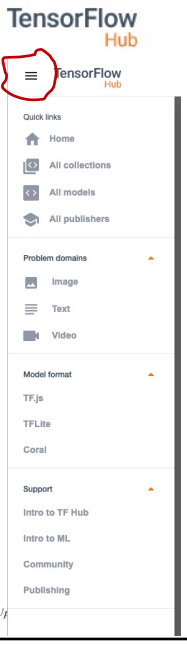
What "drives" the AI…?

- tfhub
  - *TensorFlow Hub (600+ models)*
  - https://tfhub.dev/s?module-typ





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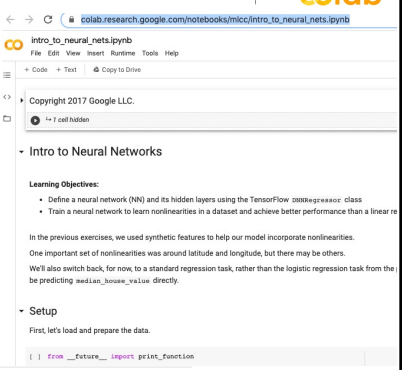
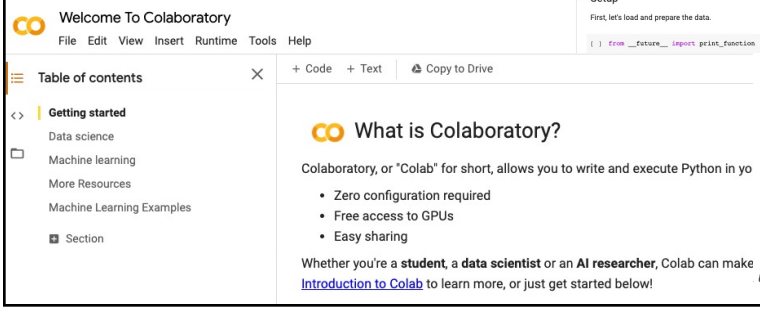
What "drives" the AI…?

- Google's Colab
  - *A hosted Jupyter notebook service*
    - *Requires no setup to use, while providing free access to computing resources including GPUs*
    - *Zero configuration required*
    - *Easy sharing*
  - *You can*
    - *Improve your Python programming language coding skills. develop deep learning applications using popular libraries such as Keras, TensorFlow, PyTorch, and OpenCV*
  - *https://colab.research.google.com/*





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Deep Learning

- "*General intelligence*" capability is here…
  - *building intelligence by reverse engineering functionality of brain*
  - *"deeply" interesting to understand brain and human intelligence (ML models)*
- Deep Learning
  - *goes beyond current ML – learning of* ***multiple levels of composition***
  - ***not necessarily neurally inspired***
- RL is back…
  - *Extension of Reinforcement Learning…*
  - *Learning by trial and error, rewards*
- Companies using DL:
  - *Google, Microsoft, Facebook, IBM, Baidu, Apple, Adobe, Netflix, NVIDIA, NEC*


Computing

Google's AI Masters the Game of Go a Decade Earlier Than Expected

Google achieves one of the long-standing "grand challenges" of AI by building a computer that can beat expert players at the board game Go.

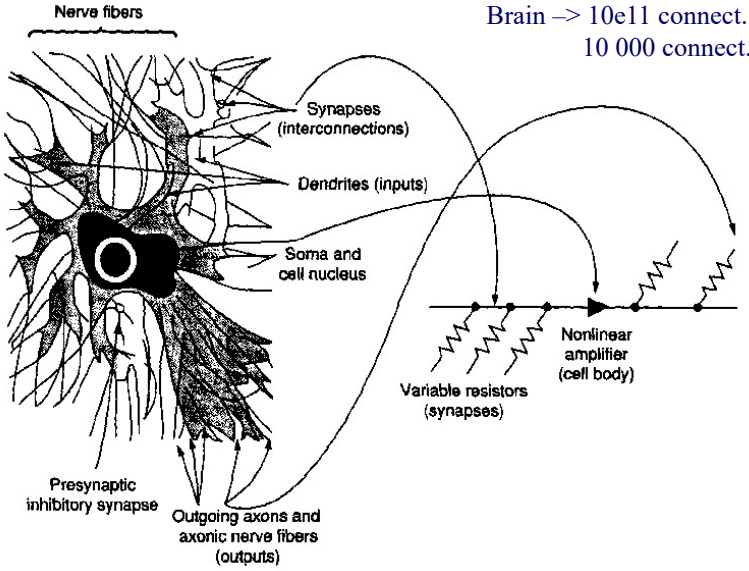
by Will Knight January 27, 2016

Brief Intro on

- ☐Biological & artificial neuron
- ☐McCulloch-Pitts neurons
- ☐Brief historical perspective

BIOLOGICAL NEURON

ANN <-> biological counterparts
Brain –> 10e11 connect. elements,
10 000 connect.per el.



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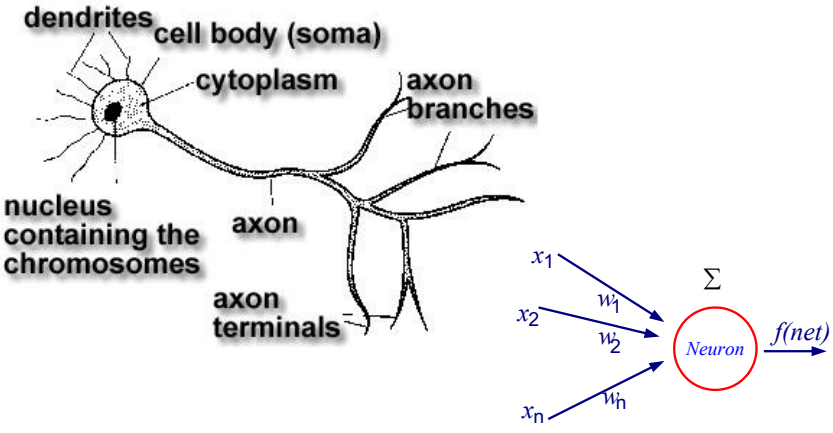
BIOLOGICAL NEURON & LINEAR THRESHOLD DEVICE



Bio-neuron picture taken from: http://www-users.cs.umn.edu/~ginis/5100/ch6/LS5100ch6notes2.htm

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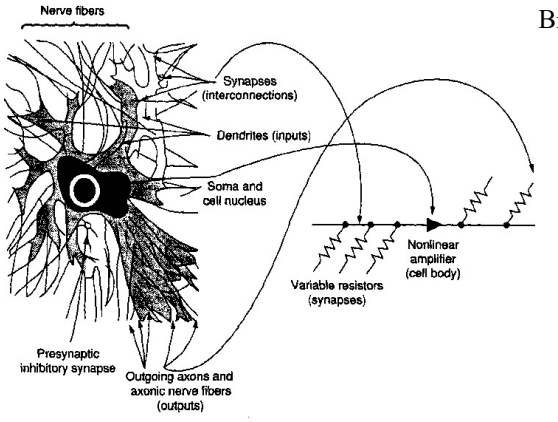
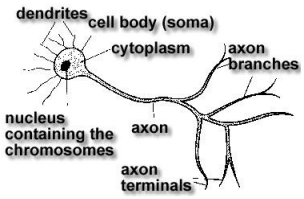
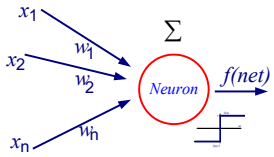
Biological Neuron

ANN <-> biological counterparts
Brain –> 10e11 connect. elements,
10 000 connect.per el.





Artificial neuron



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Learning of Agents
- transfer function

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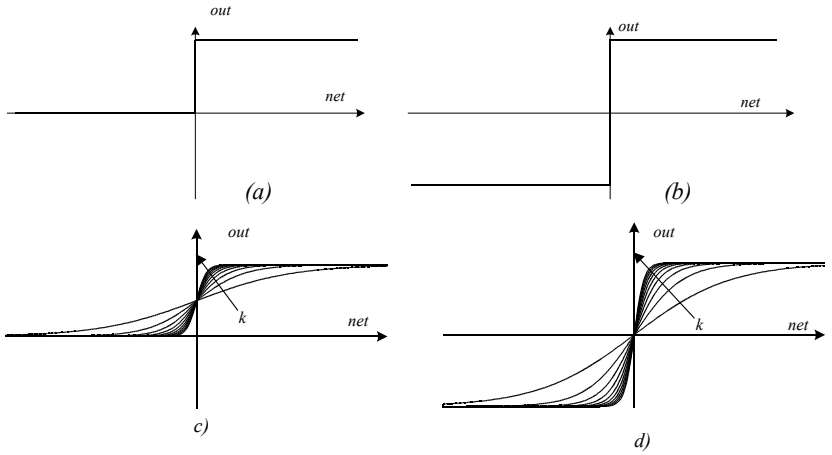
Learning Agents – transfer function

(for now, note the shape of the function only)



$$o = f(knet) = \frac{1}{1 + \exp(-knet)}$$

$$o = f(knet) = \tanh(knet) = \frac{2}{1 + \exp(-2knet)} - 1$$

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Things to remember…

- **What led to explosion of deep learning**
  - *Problems (data) where not so "big" until couple of decades ago*
  - *Machines were not that powerful (GPUs)*
- **Traditional NNs vs. deep learning (DL)**
  - *DL not the only choice, not necessarily "mimicking humans" yet, and cannot necessarily "digest" data without preprocessing. In fact, some ANNs can solve problems without much data preprocessing (example with Japanese char. recognition), and some DL algorithms may require quite a bit of preprocessing.*
- **Threshold**
  - *When net reaches that value, neuron starts "firing"!*
  - *Until then, neuron not active" (remember the lower threshold in biological neurons)*
- **Activation functions**
  - *"hard" activation function*
    - *simple but sufficient for problems that do not warrant a more complicated one (remember which?)*
    - *not uniquely defined, not continuous (differentiable)*
  - *"soft" activation function*
    - *powerful but computationally expensive; differentiable (we'll see why important soon!)*

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