Deep Reinforcement Learning Live Training

Superhuman Performance on Complex Problems with Deep Learning

The Pomodoro Technique

-- Francesco Cirillo, 1980s

Today's Training Structure:

1. three pomodoros (25 minutes + 5 minute break)
2. bonus five-minute break
3. three further pomodoros

Questions typically handled at break end

POLL

Where are you?

- The Americas
- Europe / Middle East / Africa
- Asia-Pacific
- Extra-Terrestrial Space

POLL

What are you?

- Developer / Engineer
- Scientist / Analyst / Statistician / Mathematician
- Combination of the Above
- Other

Deep Reinforcement Learning

1. The Foundations of Artificial Intelligence
2. Deep Q-Learning Networks
3. Advanced Deep Reinforcement Learning Agents

Deep Reinforcement Learning

1. **The Foundations of Artificial Intelligence**
   - The Contemporary State of A.I.
   - Applications of Deep Reinforcement Learning
   - Review of Prerequisite Deep Learning Theory
2. Deep Q-Learning Networks
3. Advanced Deep Reinforcement Learning Agents

Dig Deeper (“*reference RL LiveLessons*”)

Search *“Deep Reinforcement Learning and GANs”* or *“Jon Krohn”* in Safari

Deep Learning for NLP

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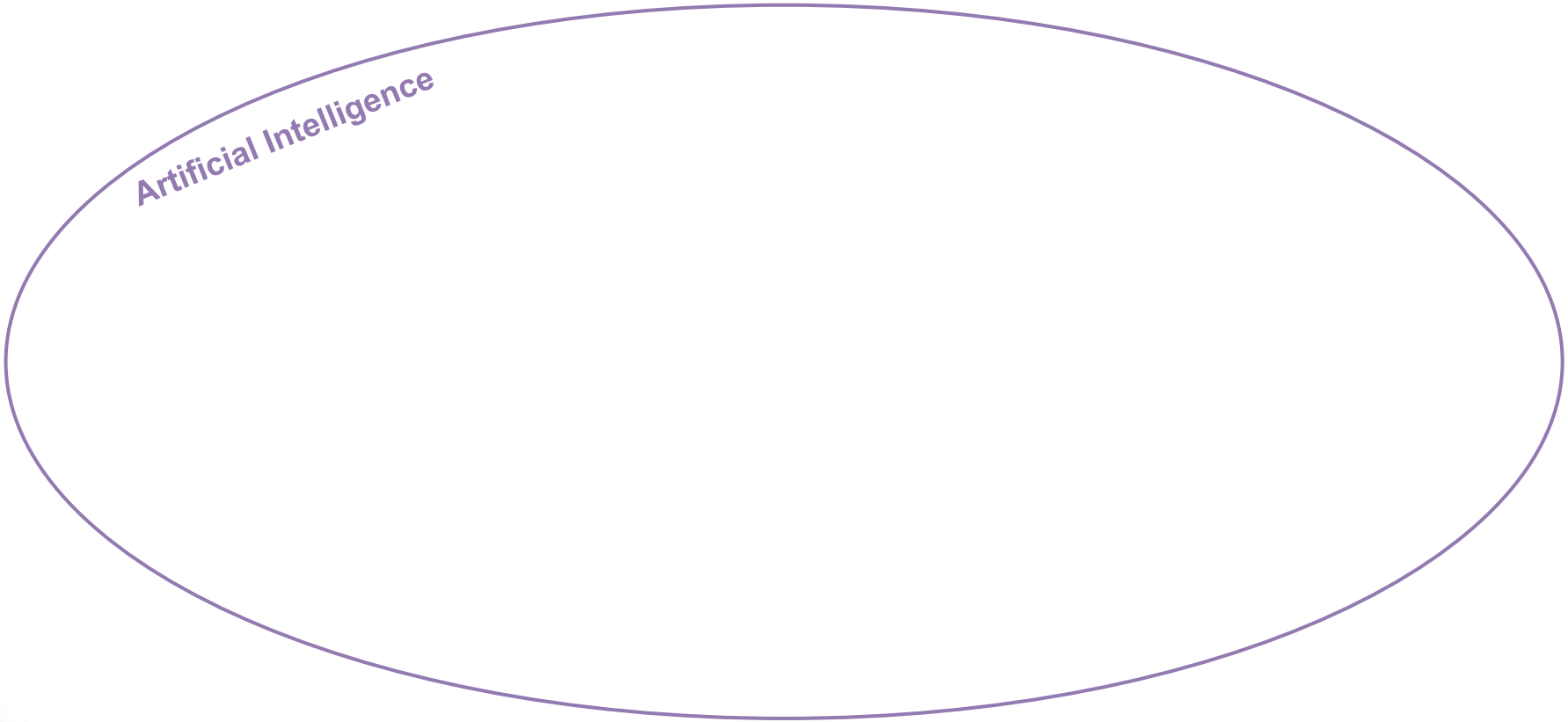
The Contemporary State of A.I.



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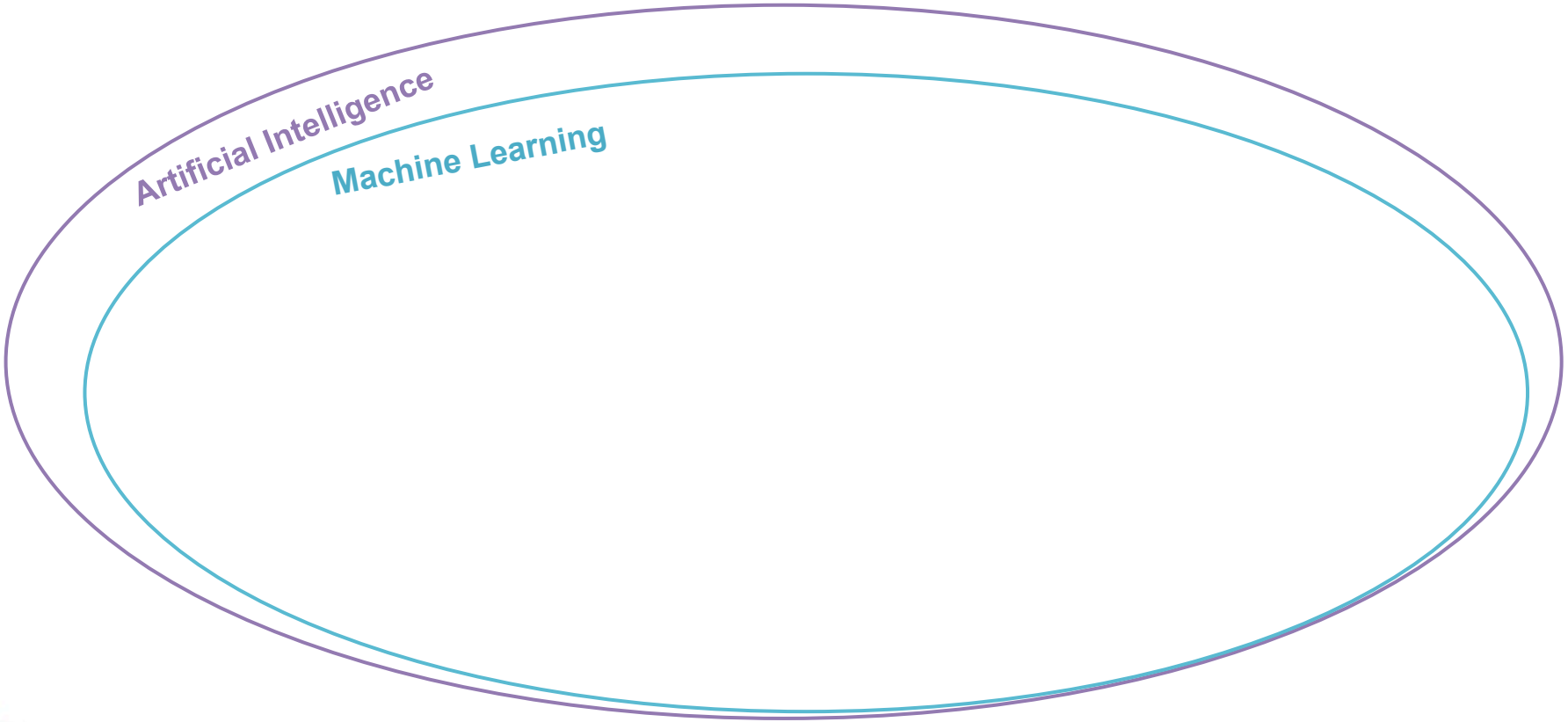

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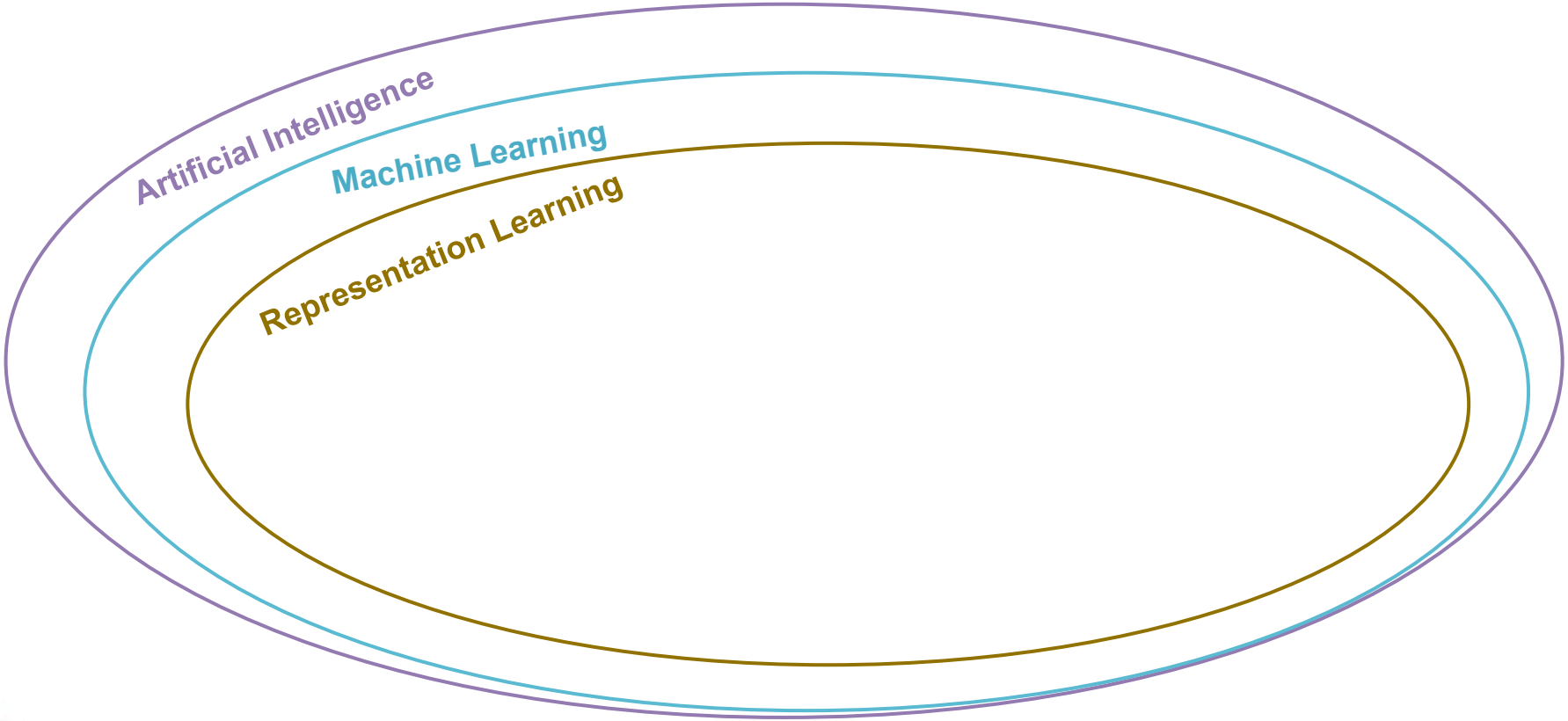

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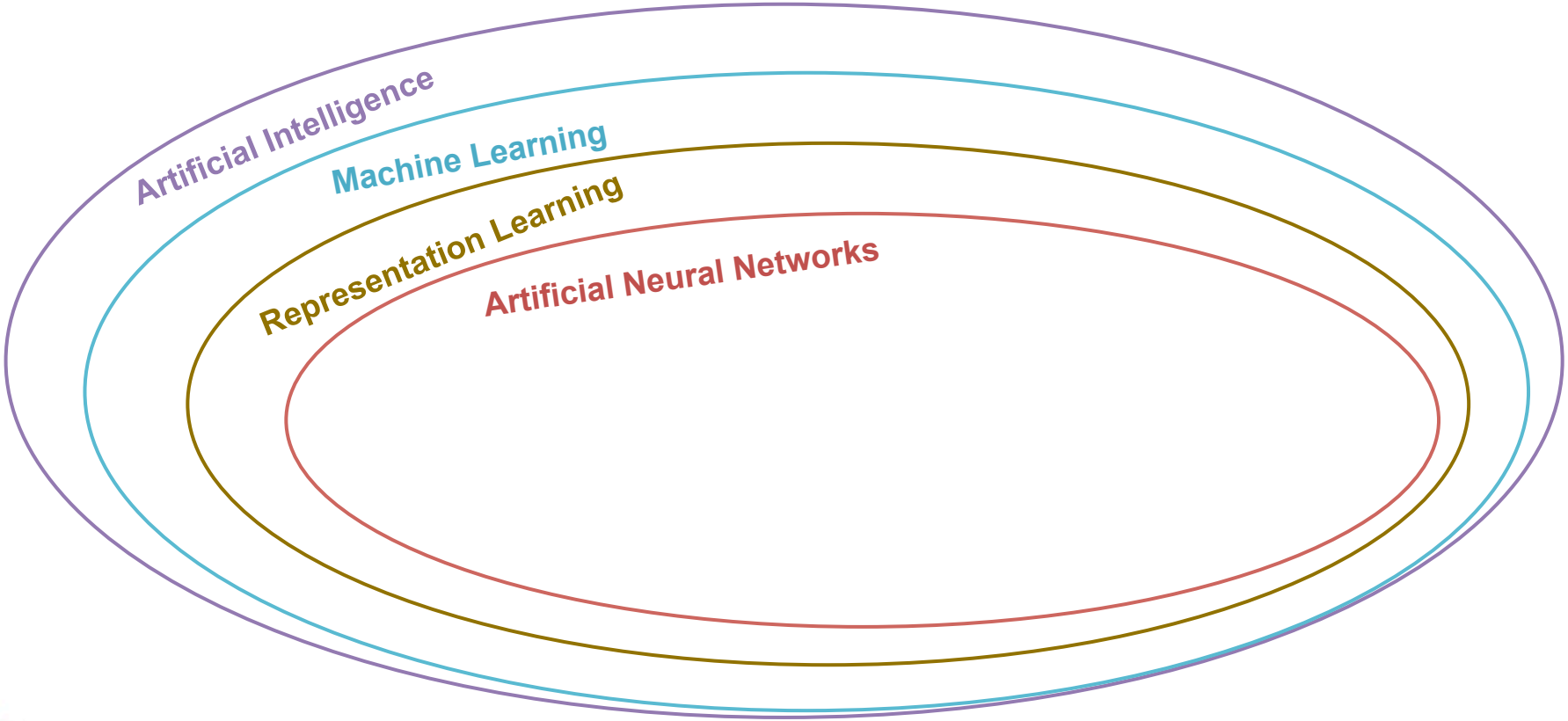

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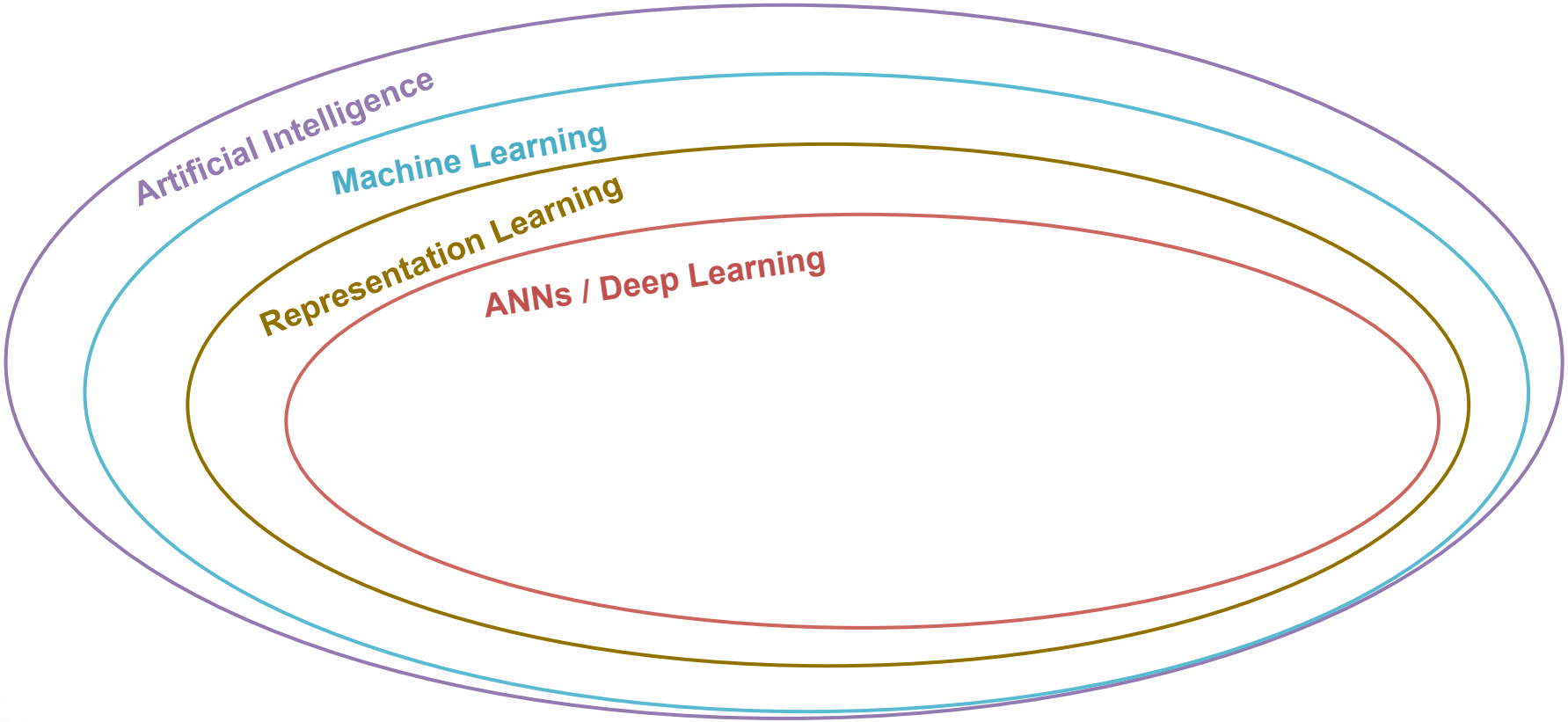
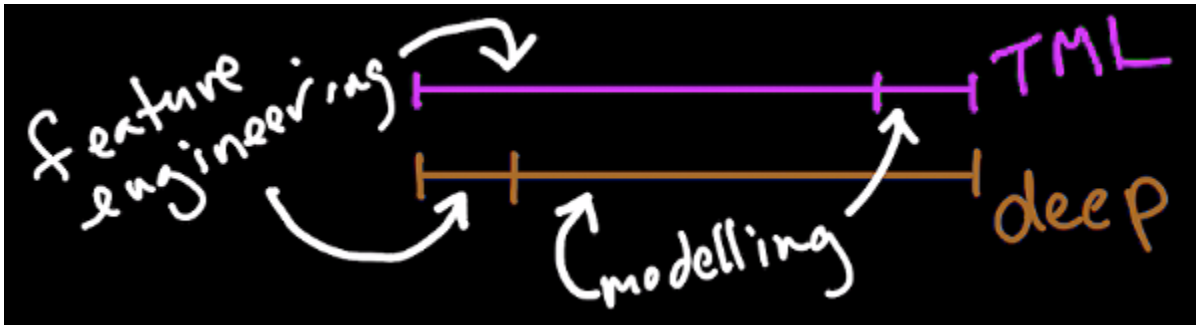
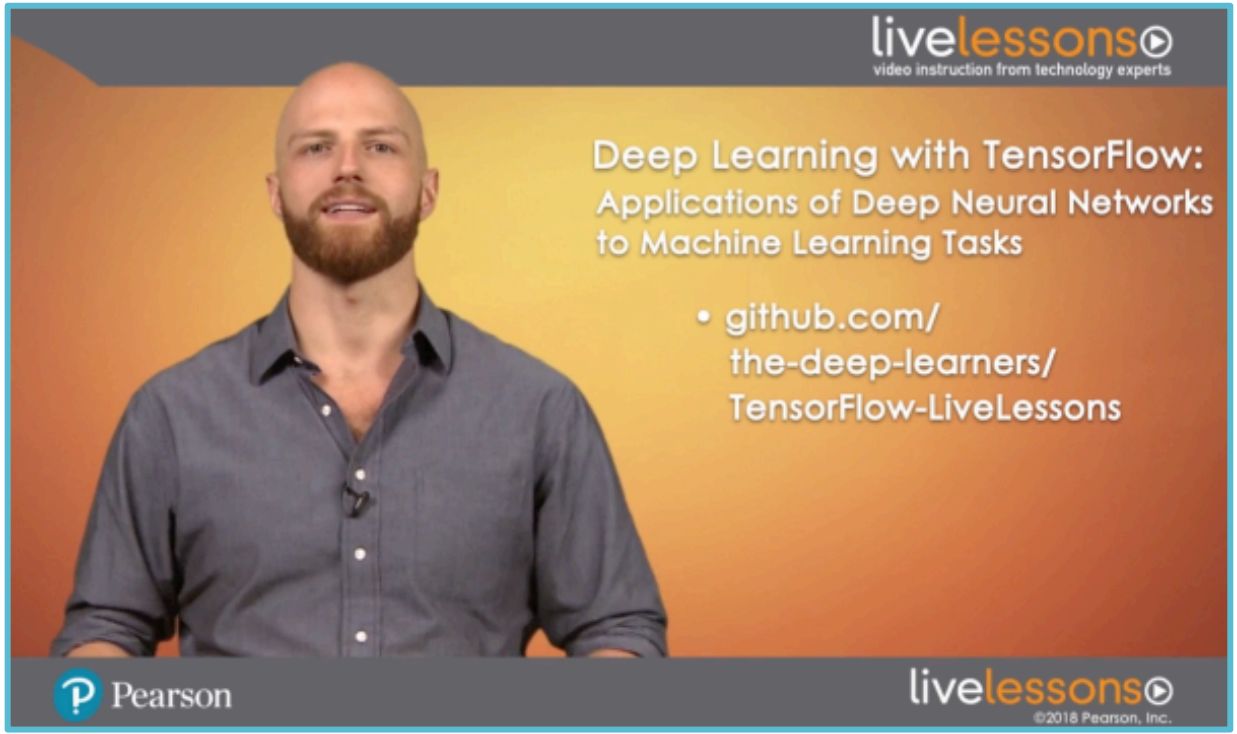


Traditional ML vs Deep Learning



Dense Networks

unsplash.com/photos/ij5_qCBpIVY



Search *"Deep Learning with TensorFlow"* or *"Jon Krohn"* in Safari

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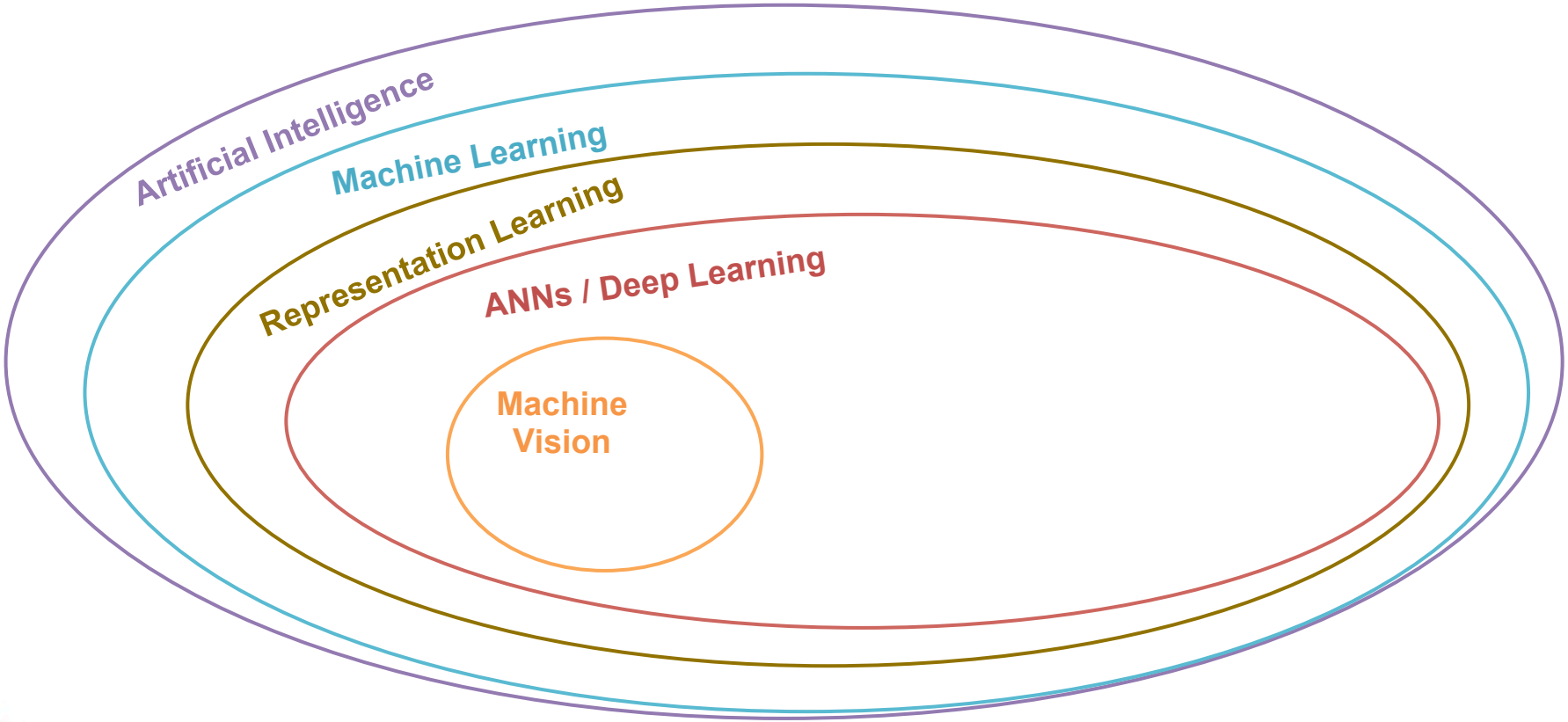

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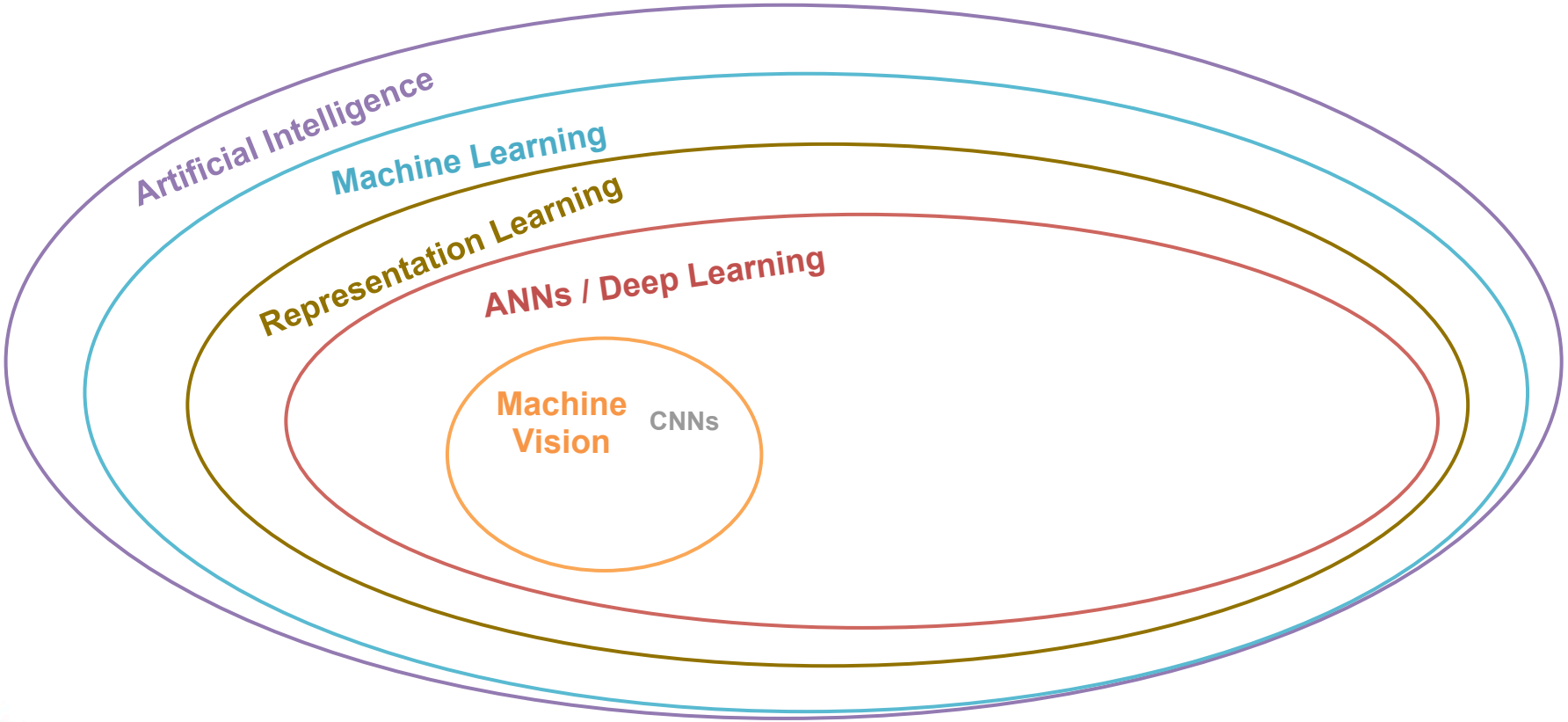
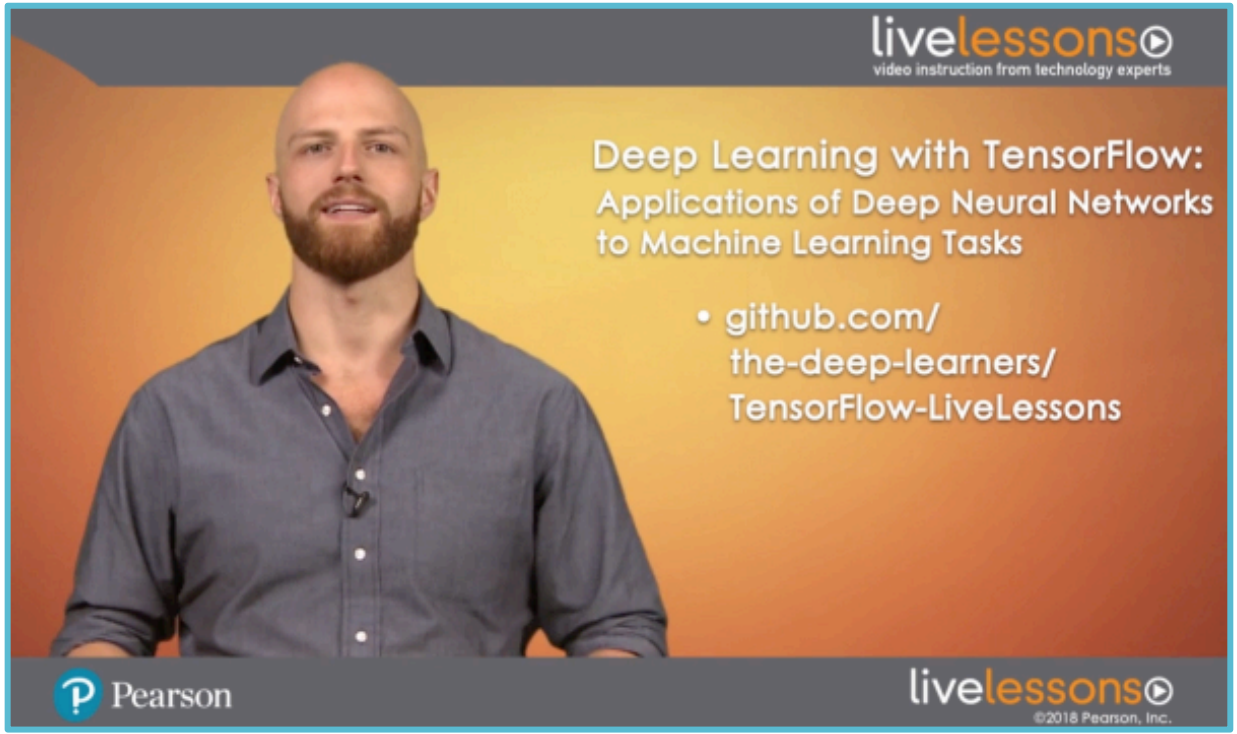


Pearson

ConvNets: Convolutional Networks

unsplash.com/photos/b8p8nqFshyY



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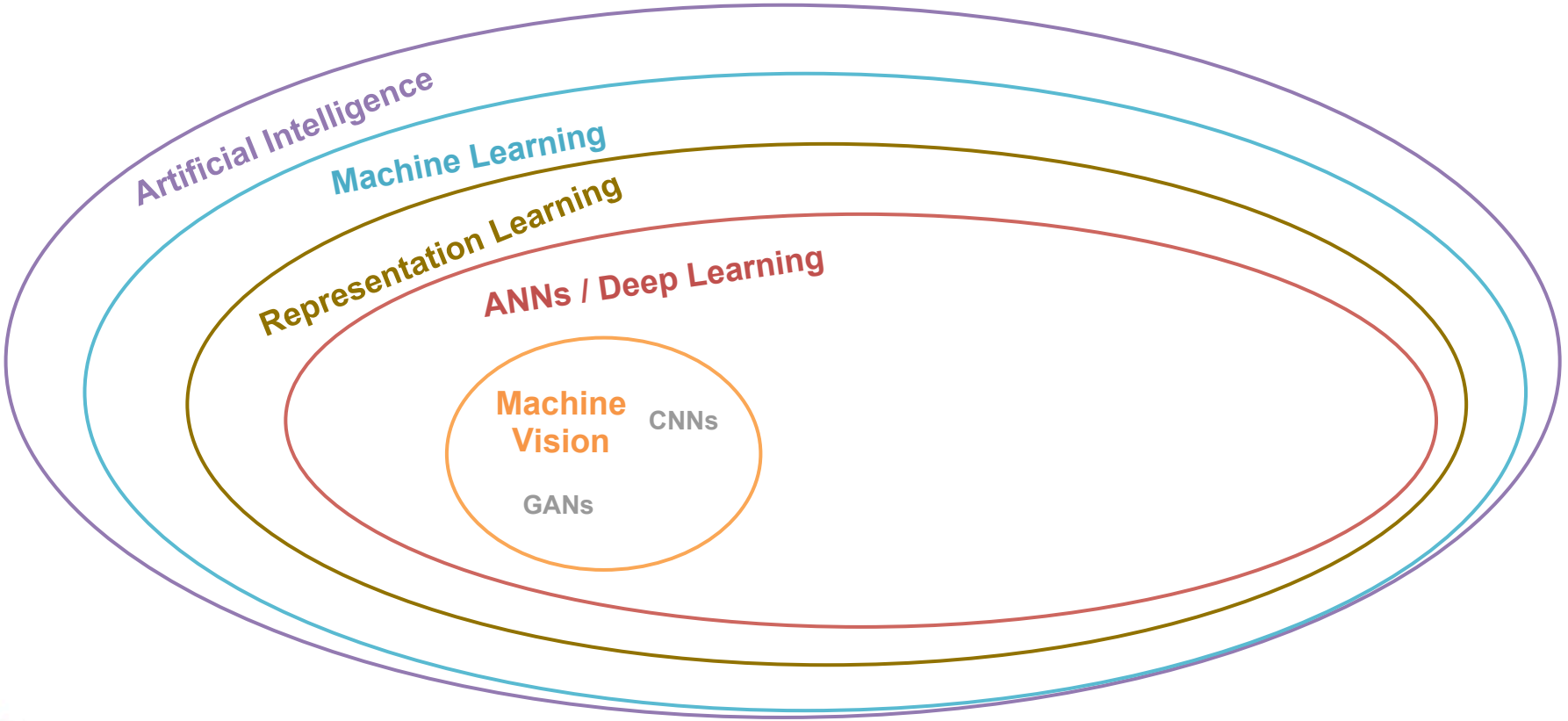

Pearson

GANs: Generative Adversarial Networks

unsplash.com/photos/FwF_fKj5tBo

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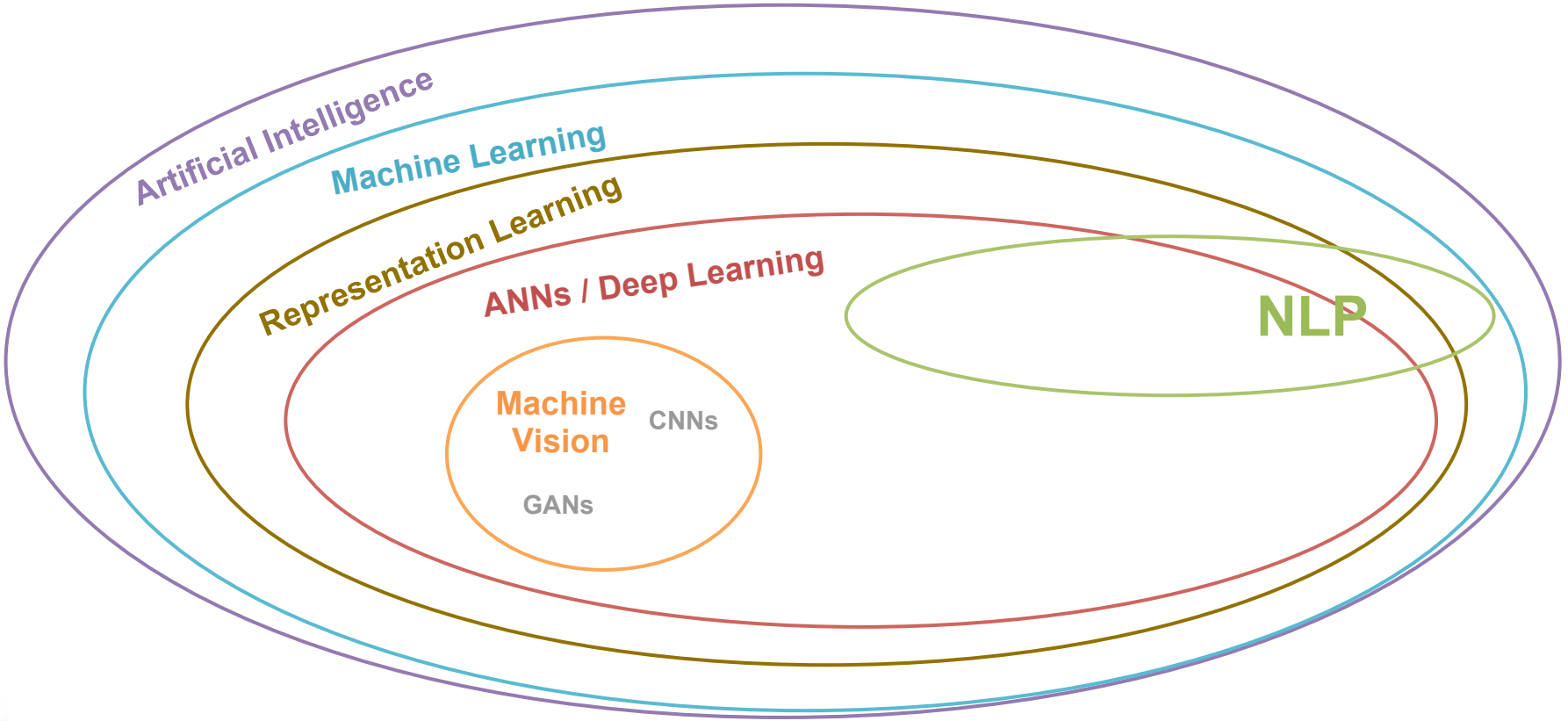

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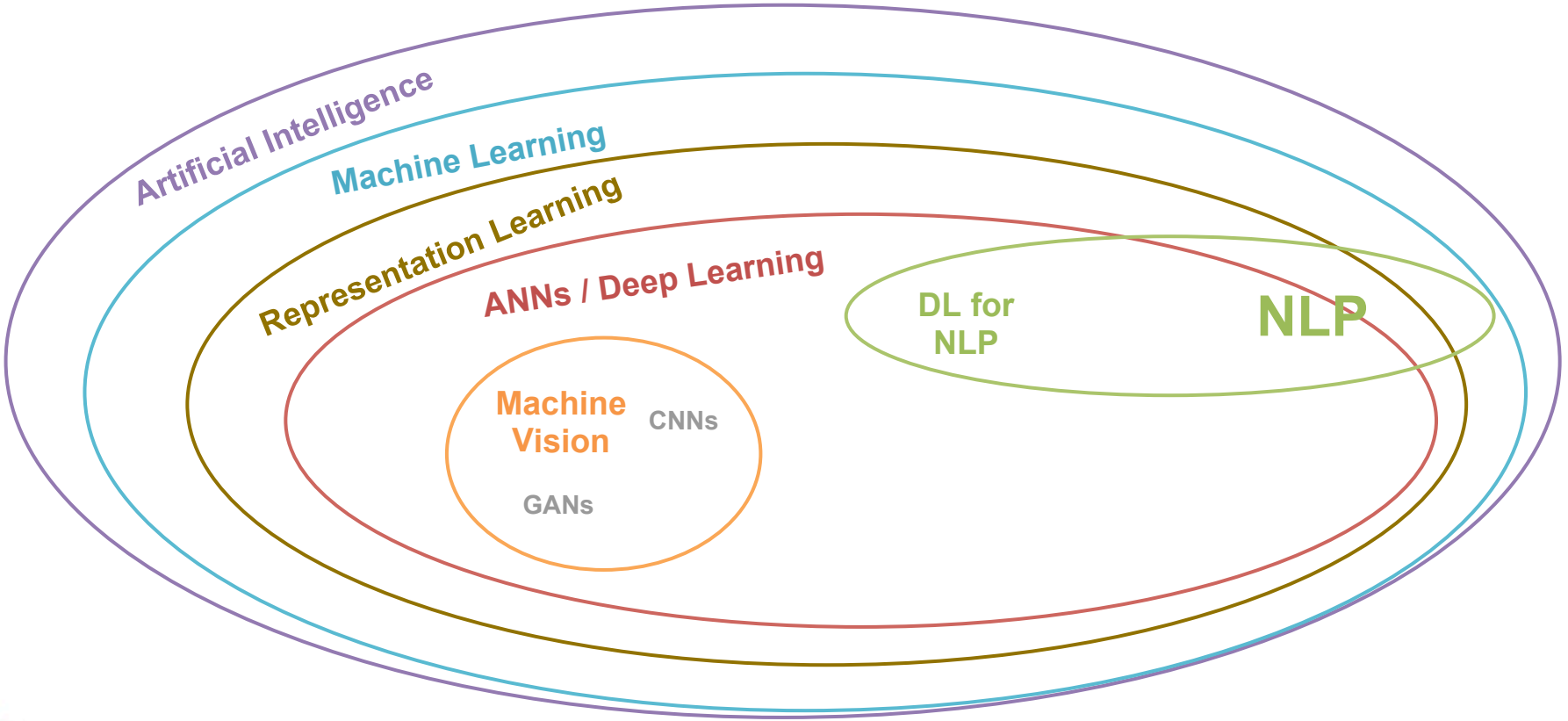

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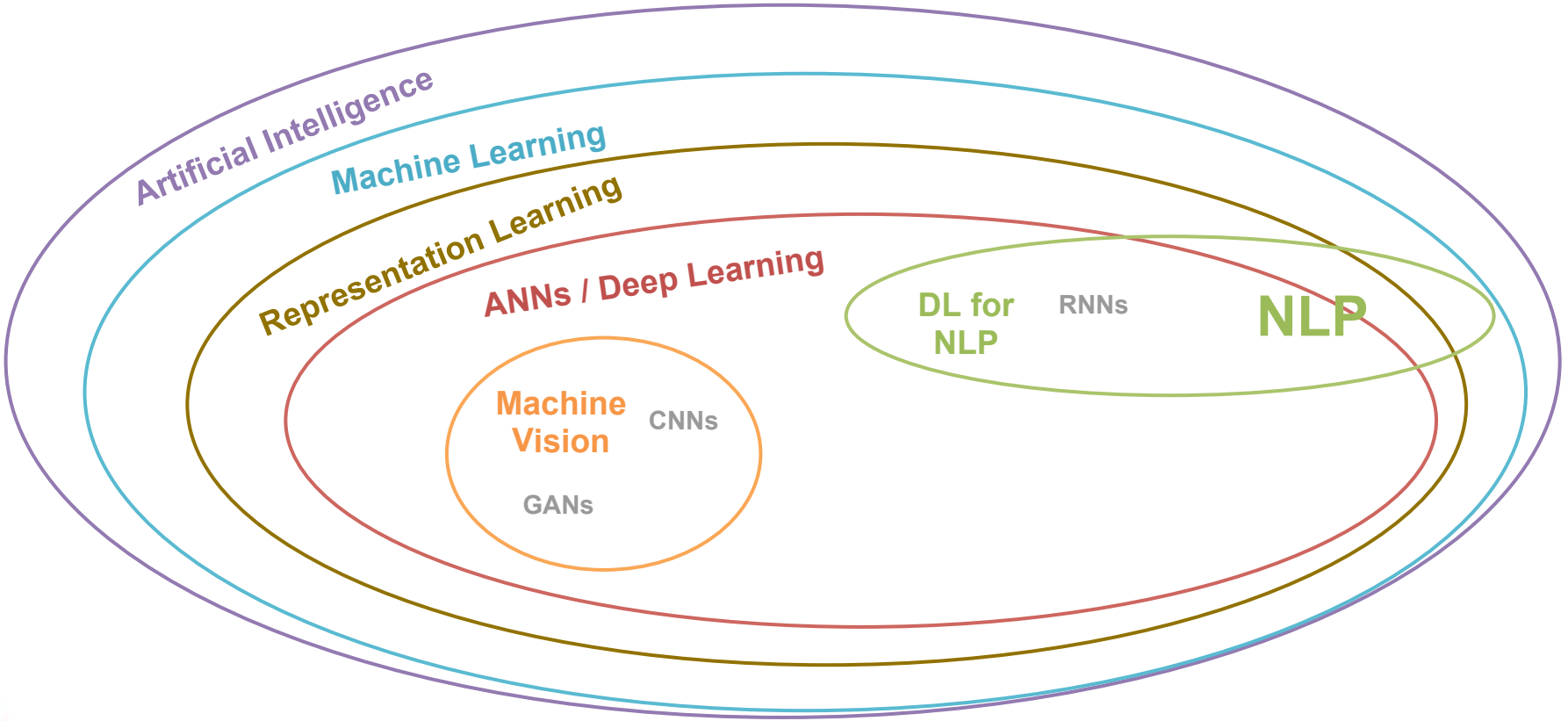

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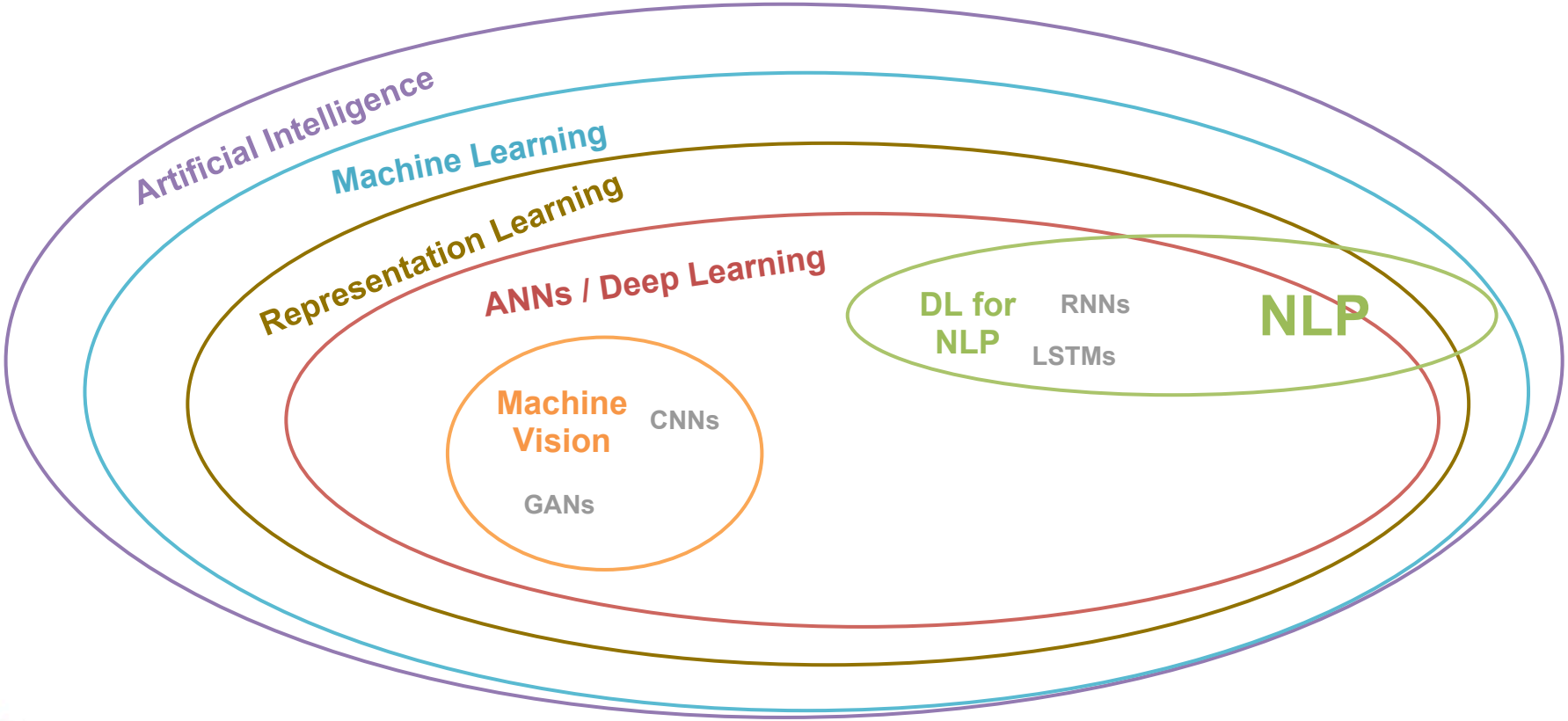
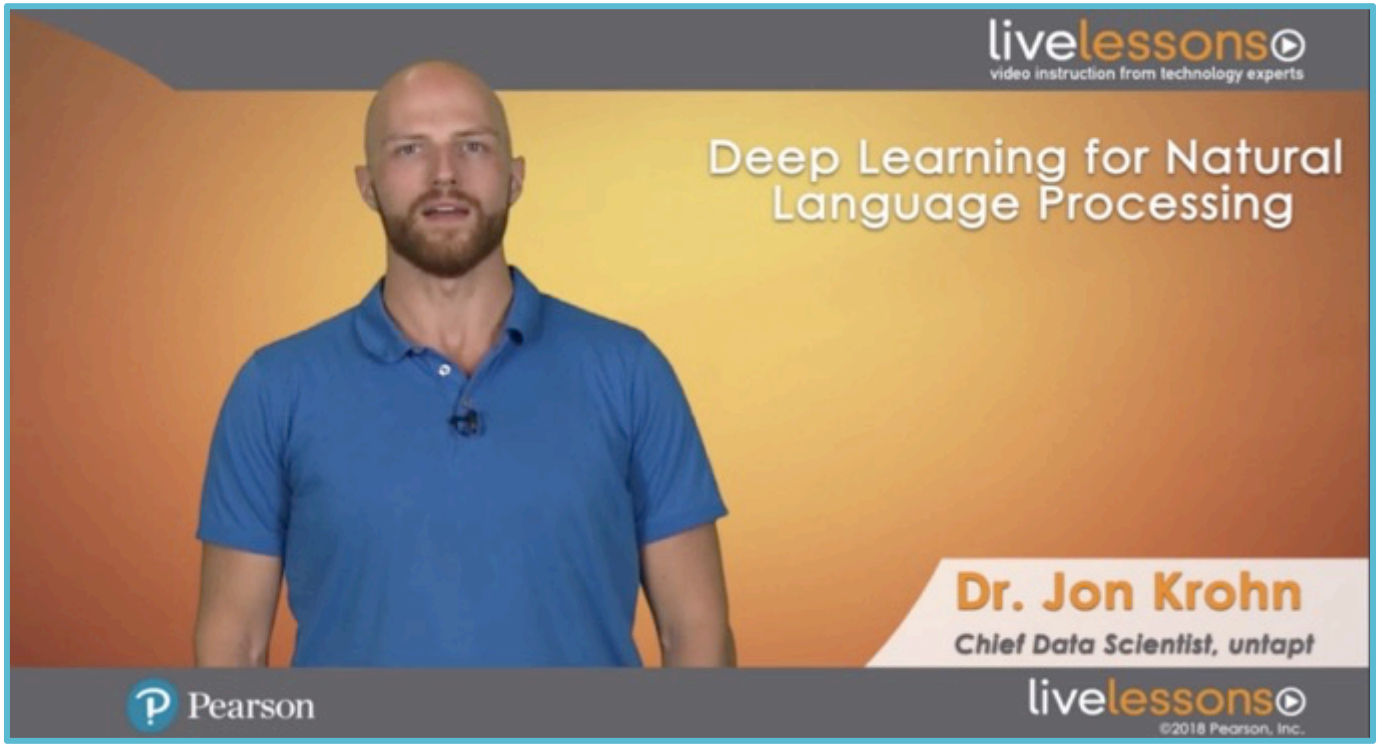


RNNs: Recurrent Neural Networks

unsplash.com/photos/cZhUxIQjILg



Search *"Deep Learning for Natural Language Processing"* or *"Jon Krohn"* in Safari

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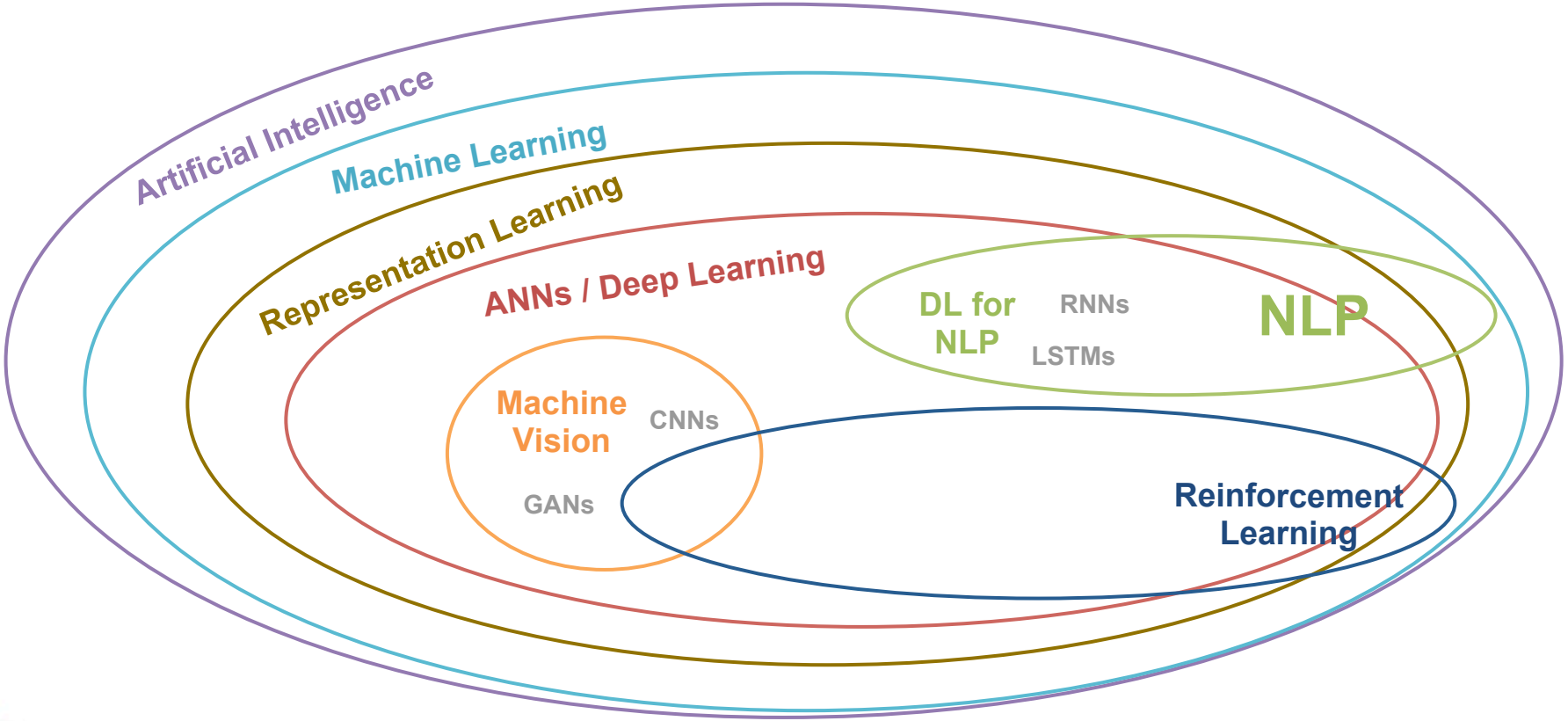

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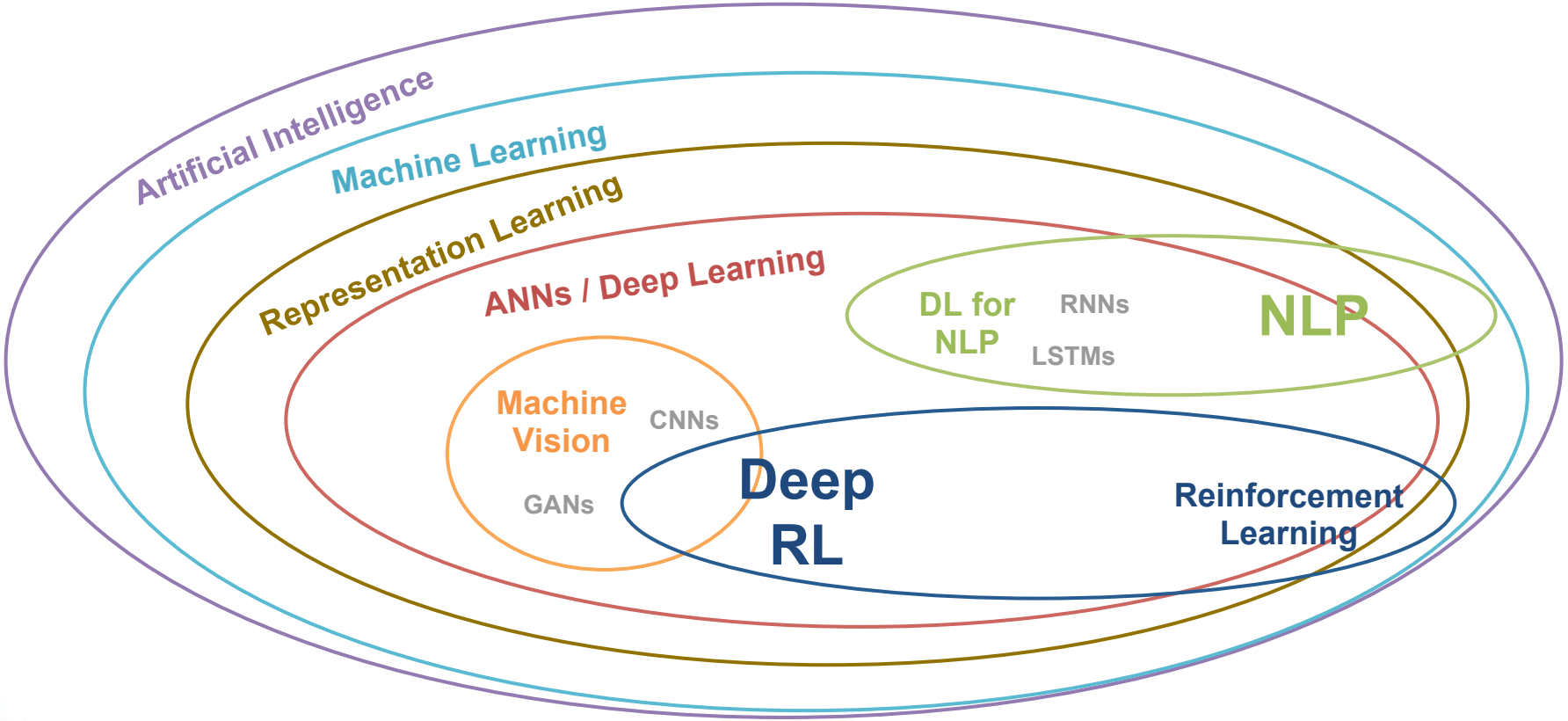

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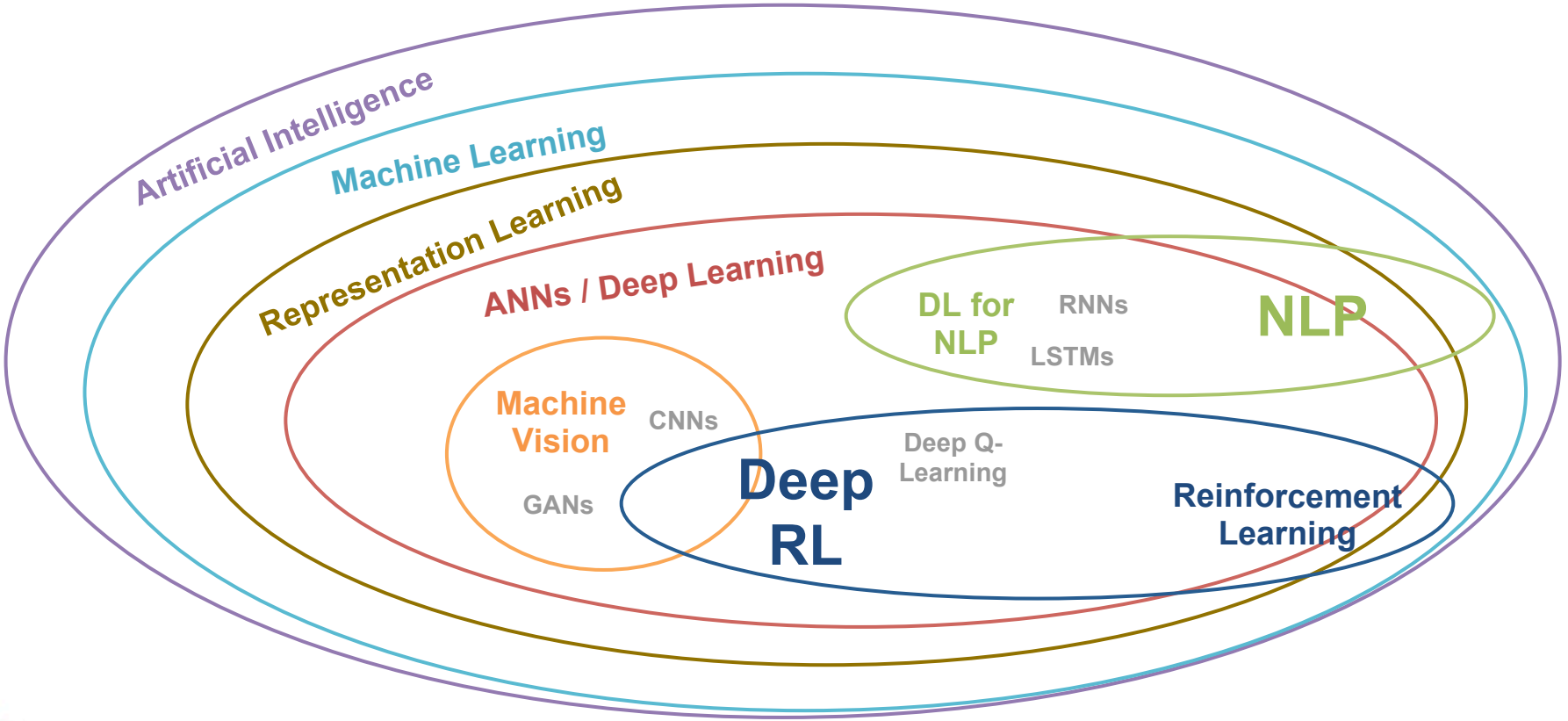

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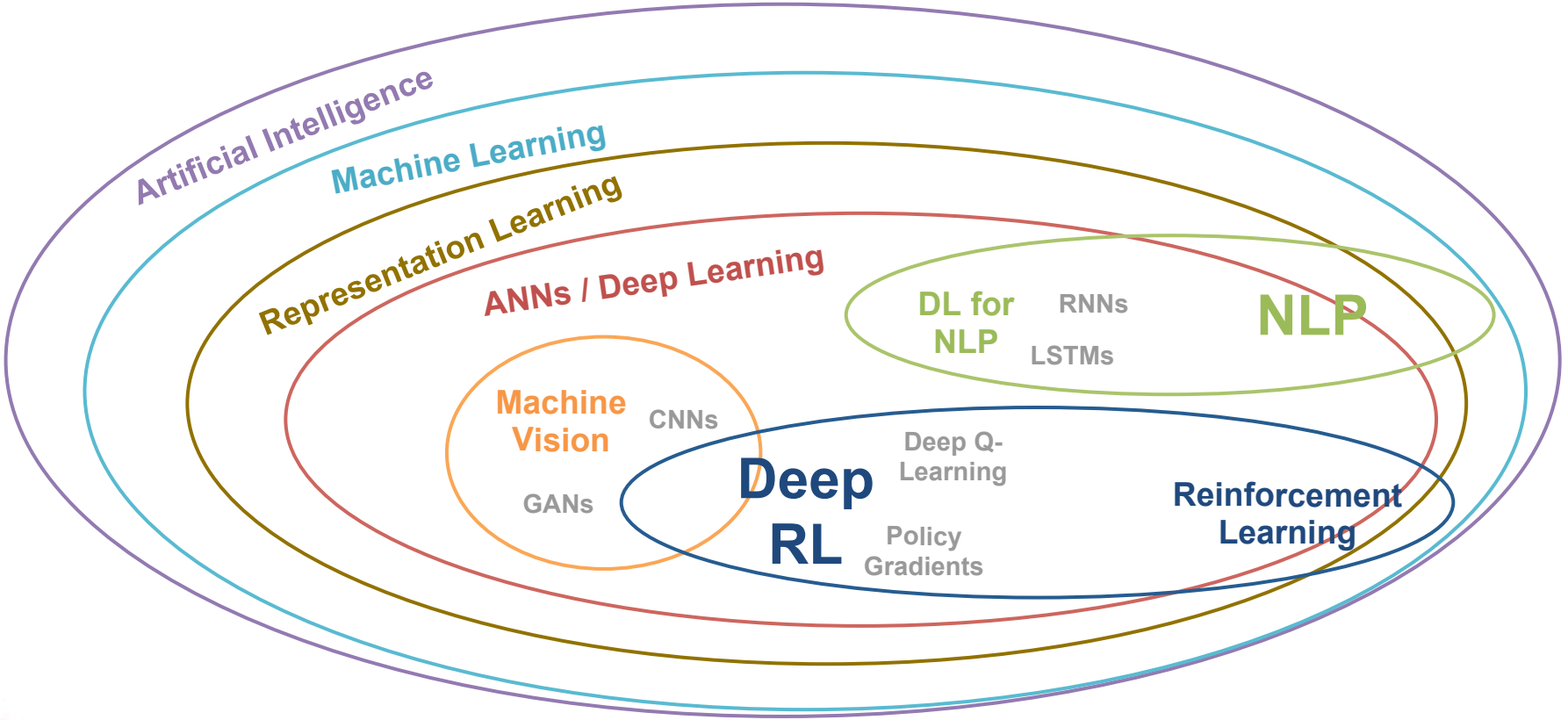

Deep Reinforcement Learning

unsplash.com/photos/pxnDA177rVg

Categories of Artificial Intelligence

1. ANI: *Narrow*

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2. AGI: *General*

Categories of Artificial Intelligence

1. ANI: *Narrow*
2. AGI: *General*
3. ASI: *Super*

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Broad Categories of ML Problems

1. Supervised Learning

Broad Categories of ML Problems

1. Supervised Learning
2. Unsupervised Learning

Broad Categories of ML Problems

1. Supervised Learning
2. Unsupervised Learning
3. Reinforcement Learning

Supervised Learning

- have *x* and *y*

Supervised Learning

- have *x* and *y*
- goal: learn function that uses *x* to approximate *y*

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- examples:
  - classification
    - MNIST digits
    - movie-review sentiment

Supervised Learning

- have *x* and *y*
- goal: learn function that uses *x* to approximate *y*
- examples:
  - classification
    - MNIST digits
    - movie-review sentiment
  - regression
    - sales of a product
    - future value of an asset

Unsupervised Learning

- have *x* only -- no *y* labels available

Unsupervised Learning

- have *x* only -- no *y* labels available
- goal: learn hidden, underlying structure of data *x*

Unsupervised Learning

- have *x* only -- no *y* labels available
- goal: learn hidden, underlying structure of data *x*
- examples:
  - word vectors
  - GANs

Reinforcement Learning

- an *agent* takes **action** in an *environment*
- environment returns:
  - **reward** at timestep *t*
  - **state** at timestep *t*+1
- repeat!

Deep Reinforcement Learning

An RL algo that incorporates (Deep) ANN layers:

- *Deep* NN can process complex sensory input
  - visual
  - sound
- *RL* can select action from complex possibilities

“Playing Atari with Deep RL”

- Mnih et al. (2013)
  - NIPS and arXiv paper
  - DeepMind (acquired by Google in 2014)

arXiv: 1312.5602

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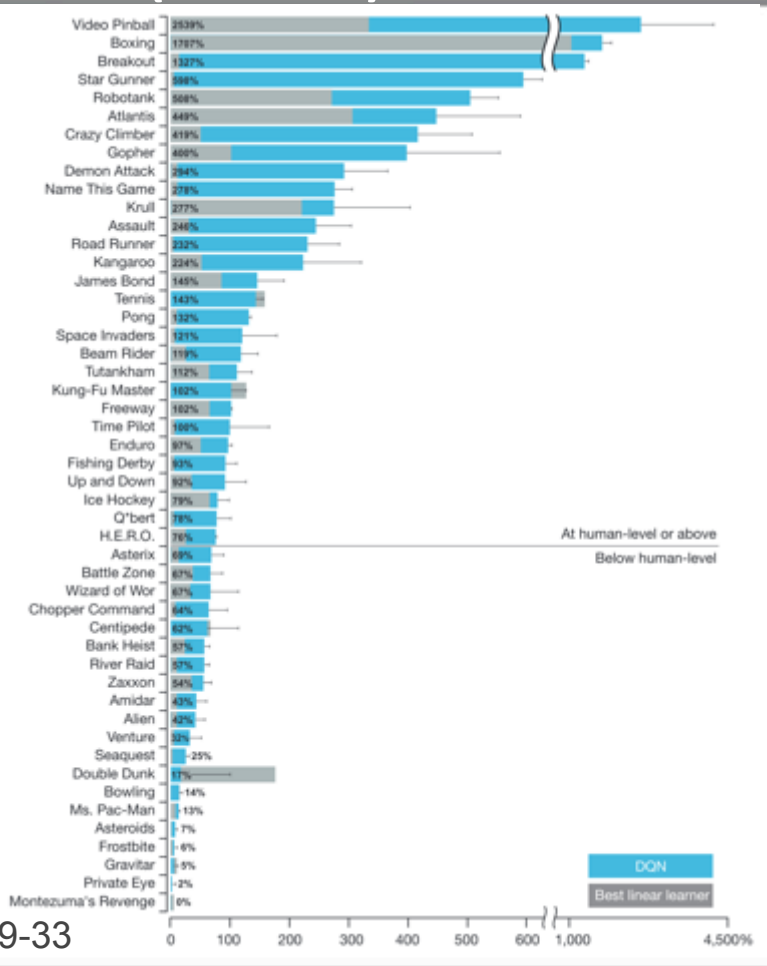
  - beat previous ML approaches on six
  - beat human expert on three

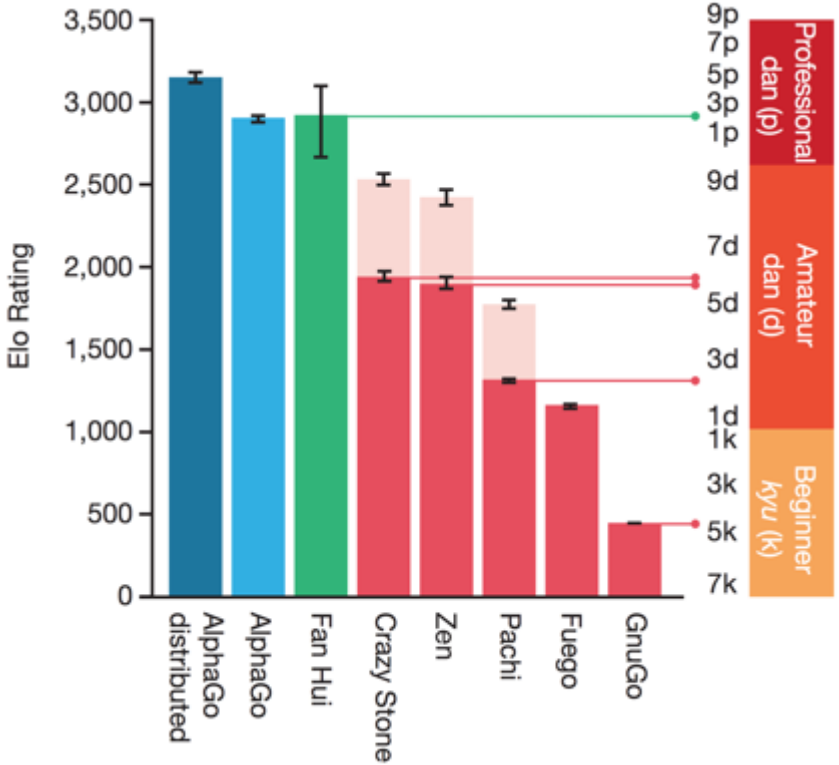
arXiv: 1312.5602

Mnih et al. (2015)



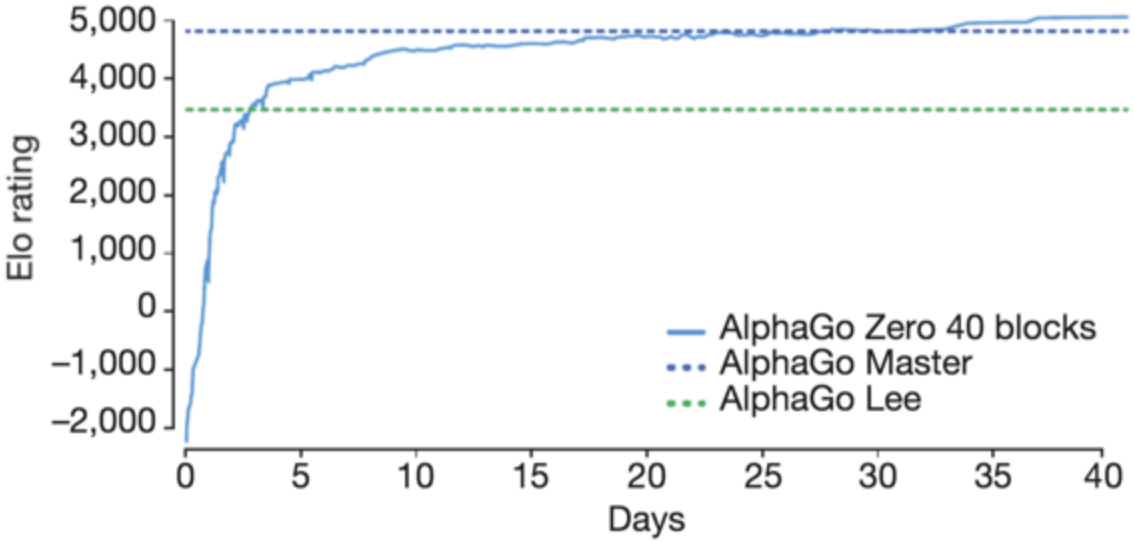
Nature 518: 529-33

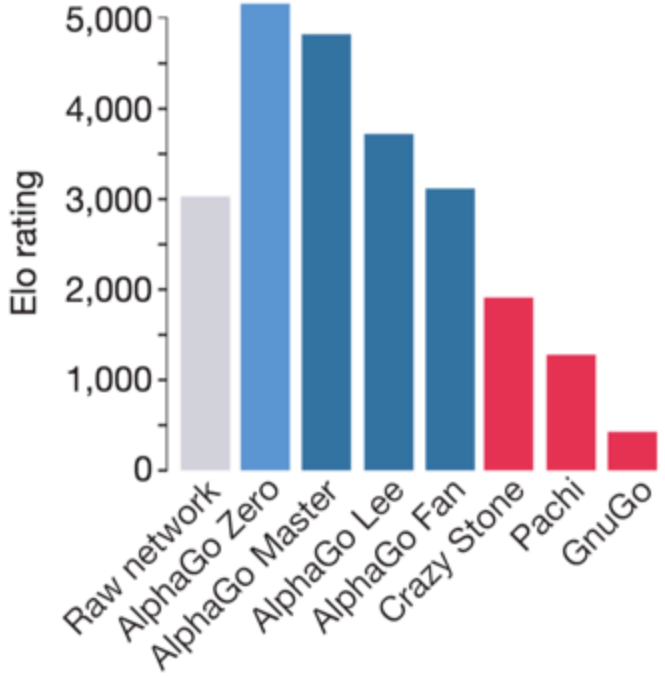
AlphaGo (Silver et al., 2016)



Nature 529: 484-9

AlphaGo Zero (Silver et al., 2017)





Nature 550: 354-9

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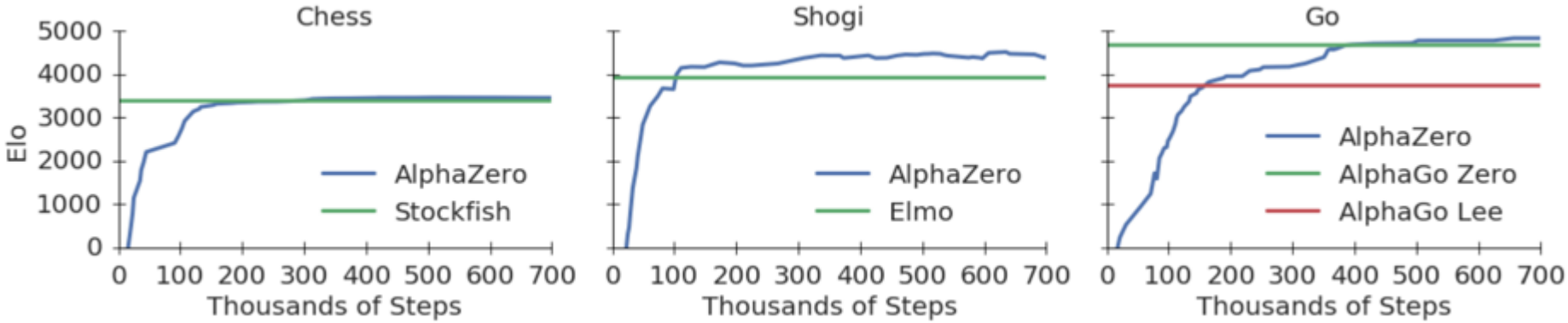
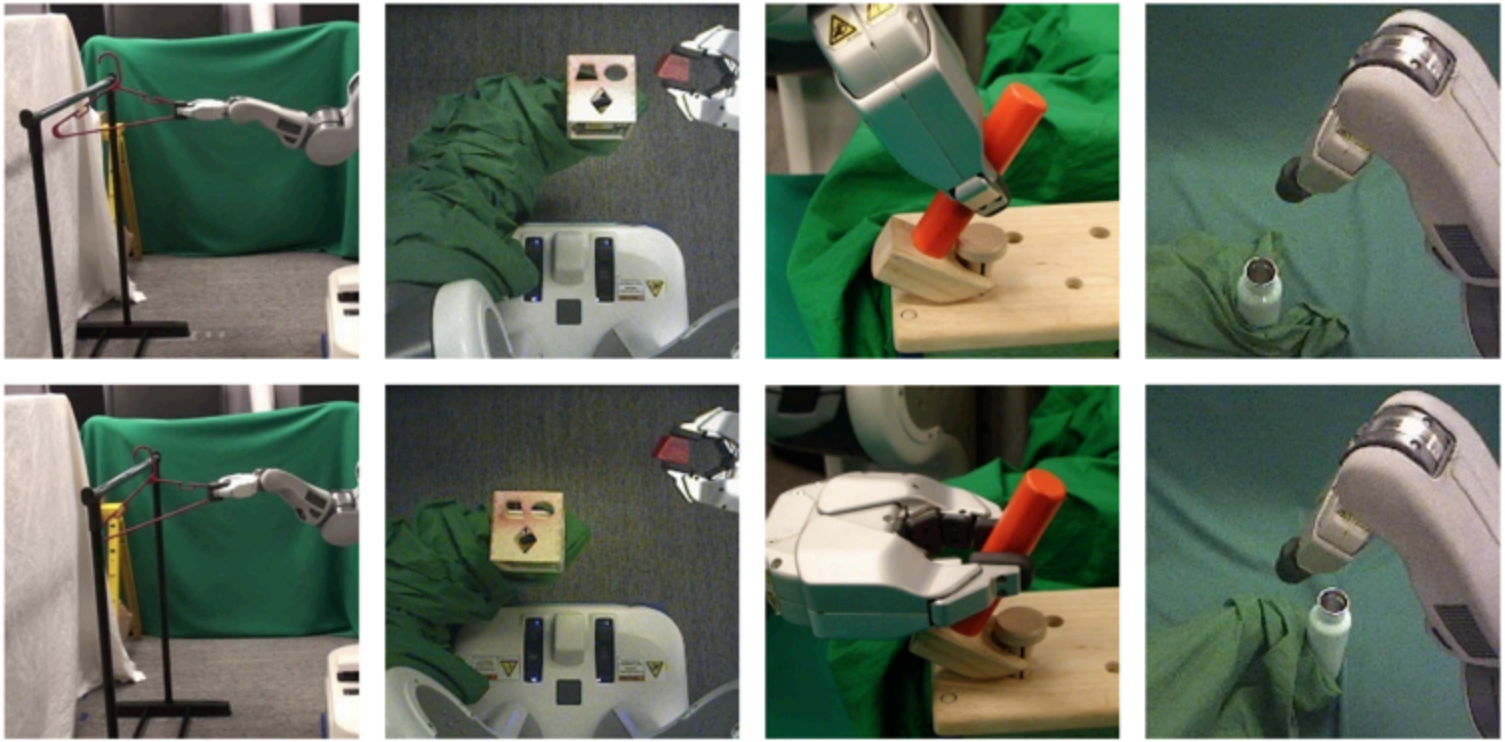


arXiv: 1712.01815

Levine et al. (2016)



(a) hanger (b) cube (c) hammer (d) bottle

Journal of Machine Learning Research 17: 1-40

Popular Deep RL Environments

1. OpenAI Gym: `github.com/openai/gym`

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3. Unity: `github.com/Unity-Technologies/ml-agents`

The Cart(pole) Before the Horse

Interactive Jupyter(Hub) Demo:

`cartpole_dqn.ipynb`

More Cart(pole) Before the Horse

Local Jupyter Demo:

`cartpole_dqn.ipynb`

1. run `jupyter notebook` outside of Docker container
2. uncomment `env.render()`

Rendering OpenAI Gym

- not necessary… *but fun!*
- not easily done within Docker container
- may vary by machine; my process was:
  a. install as at `github.com/openai/gym`
  b. install as at `anaconda.com`
  c. (`pip install gym[atari]`)
  d. `pip uninstall pyglet`
  e. `pip install pyglet==1.2.4`
  f. run `jupyter notebook` in `TensorFlow-LiveLessons` directory

Deep Reinforcement Learning

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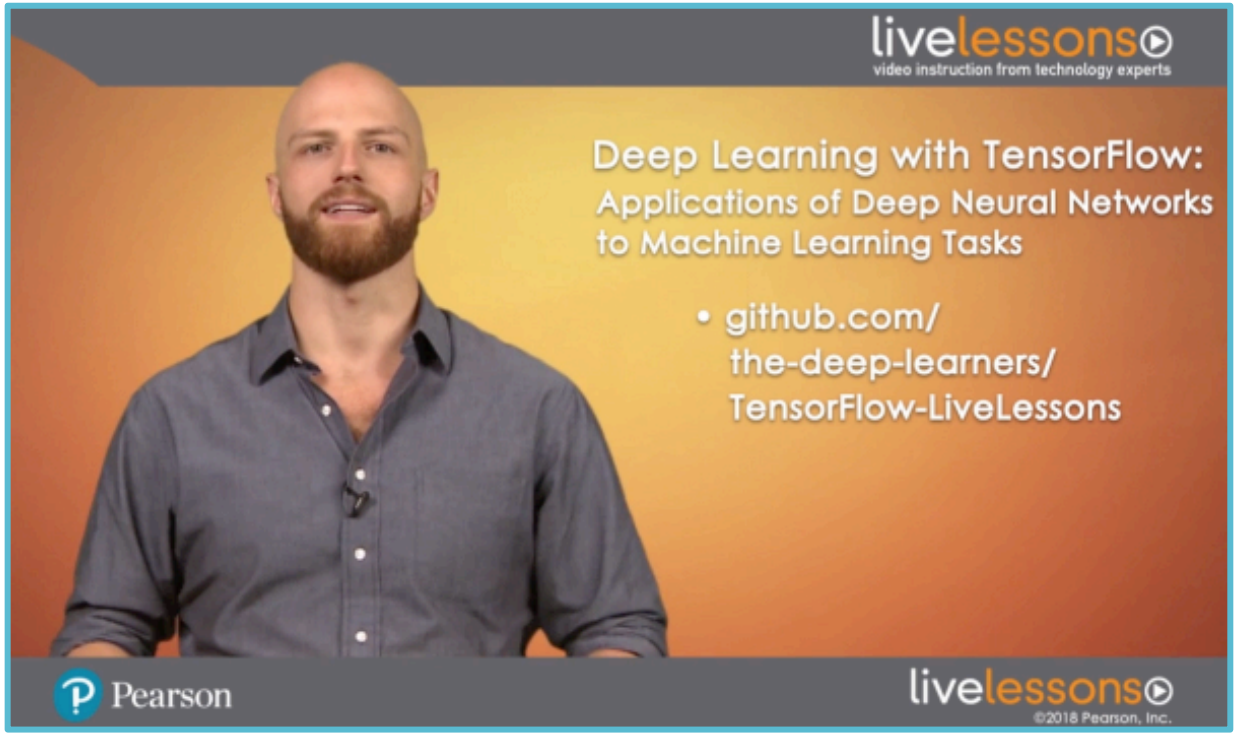
Deep Learning Fundamentals (assumed)



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Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Your Arsenal

Neurons

- sigmoid
- tanh
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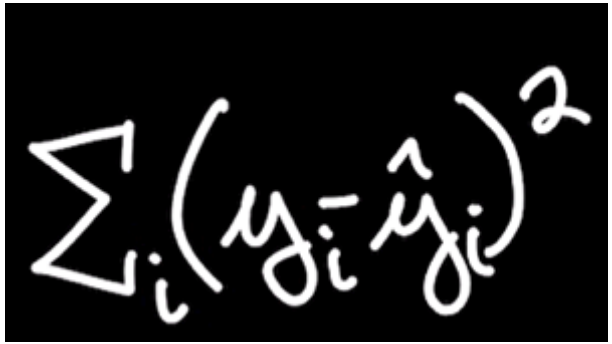
Cost Functions

- quadratic cost



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***Stochastic* Gradient Descent**

- mini-batch size
- learning rate
- second-order, e.g., Adam

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Layers

- dense / fully-connected

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***Stochastic* Gradient Descent**

- mini-batch size
- learning rate
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Backpropagation

Layers

- dense / fully-connected
- convolutional (*if we were detecting pixels from, e.g., Atari*)

Deep Reinforcement Learning

1. The Foundations of Artificial Intelligence
2. **Deep Q-Learning Networks**
   - The Cartpole Game
   - Essential Deep Reinforcement Learning Theory
   - Defining a DQN Agent
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Deep Reinforcement Learning

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The Cartpole Game

Environment States:

1. Cart Position
2. Cart Velocity
3. Pole Angle
4. Pole Angular Velocity

Actions:

1. Move Cart Left
2. Move Cart Right

Deep Reinforcement Learning

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   - **Essential Deep Reinforcement Learning Theory** *(reference RL LiveLessons sections 3.2 and 3.3)*
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Essential Deep RL Theory

Reference:

`deep_RL_theory.pdf`

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Defining a DQN Agent

Interactive Jupyter(Hub) Demo:

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Interacting with OpenAI Gym

Return to Interactive Jupyter(Hub) Demo:

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Deep Reinforcement Learning

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3. **Advanced Deep Reinforcement Learning Agents**
   - OpenAI Lab for Agent Experimentation and Optimization
   - Policy Gradients: the REINFORCE and Actor-Critic Algorithms
   - Software 2.0
   - Approaching Artificial General Intelligence

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OpenAI Lab

Interactive Demo of:

`github.com/kengz/openai_lab`

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Popular Deep RL Agents

1. Deep Q-Learning Network (DQN)

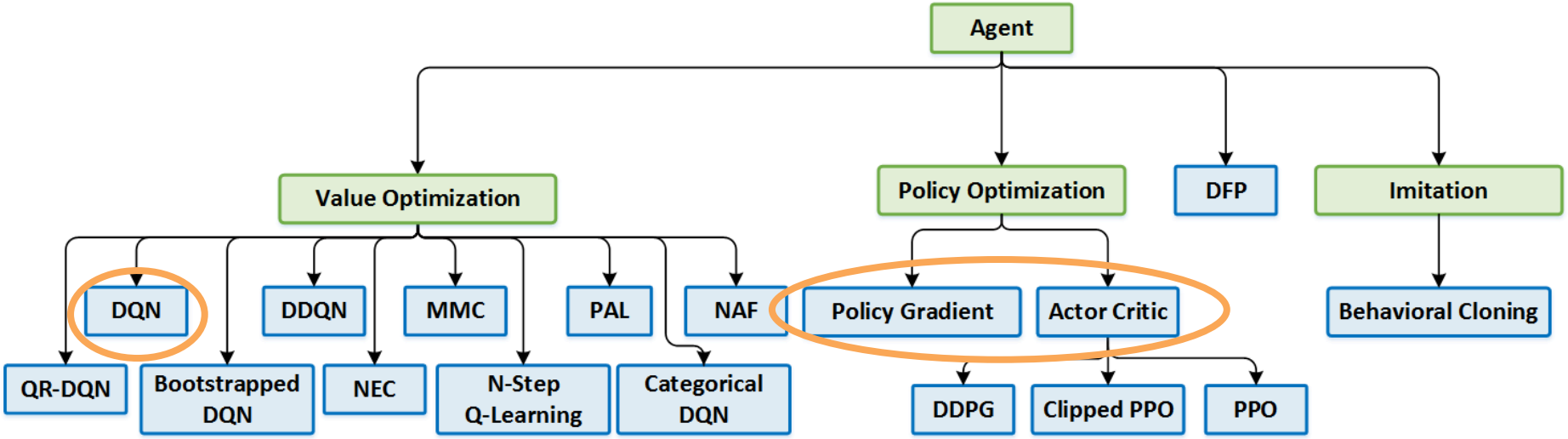
Popular Deep RL Agents

1. Deep Q-Learning Network (DQN)
2. REINFORCE

Popular Deep RL Agents

1. Deep Q-Learning Network (DQN)
2. REINFORCE
3. Actor-Critic

Popular Deep RL Agents

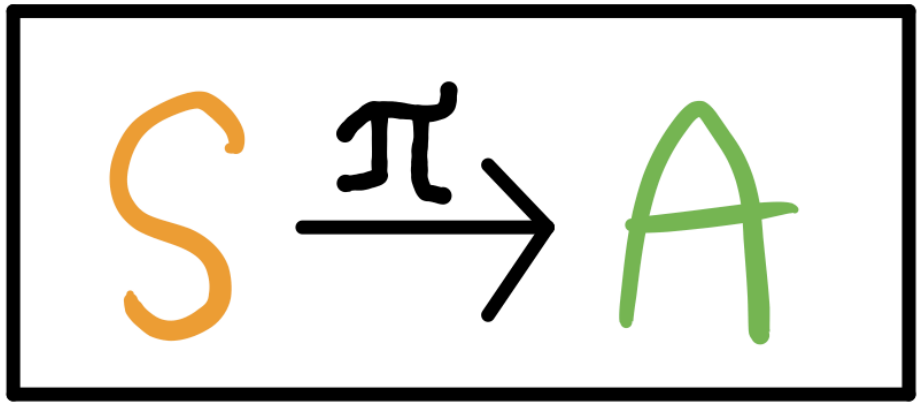


github.com/NervanaSystems/coach

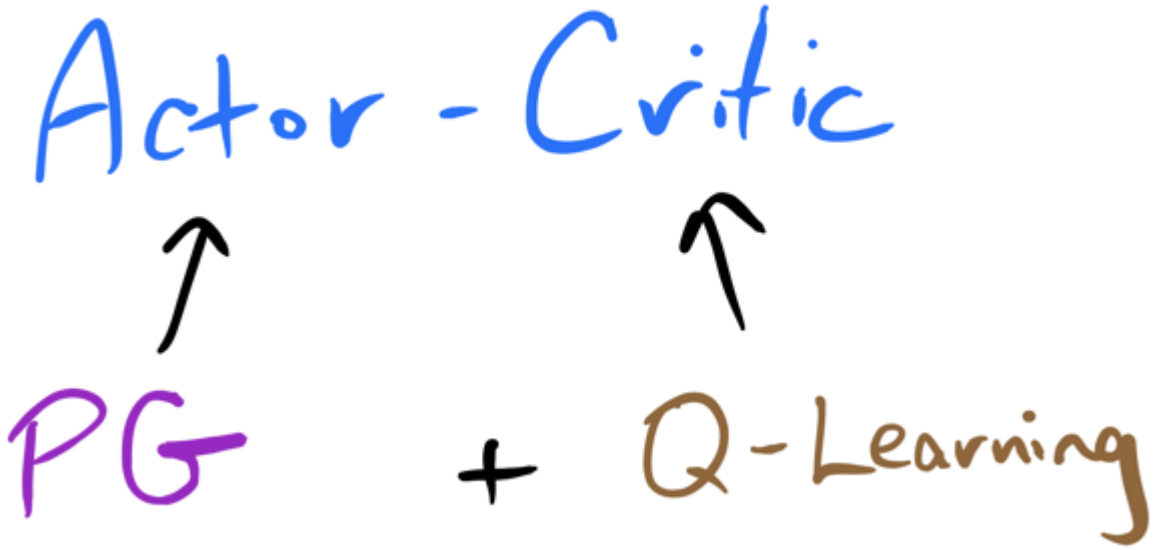
Reinforcement Learning Resources

1. UC Berkeley CS294-112 *Deep Reinforcement Learning*
2. Sutton & Barto (2017) *Reinforcement Learning: An Introduction*

Policy Gradients & REINFORCE



Actor-Critic Algorithm



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Software 2.0

Software 2.0 Pros

1. Computational Homogeneity

Software 2.0 Pros

1. Computational Homogeneity
2. Constant Running Time

Software 2.0 Pros

1. Computational Homogeneity
2. Constant Running Time
3. Constant Memory Use

Software 2.0 Pros

1. Computational Homogeneity
2. Constant Running Time
3. Constant Memory Use
4. Portable Across Devices

Software 2.0 Pros

1. Computational Homogeneity
2. Constant Running Time
3. Constant Memory Use
4. Portable Across Devices
5. Easy

Software 2.0 Pros

1. Computational Homogeneity
2. Constant Running Time
3. Constant Memory Use
4. Portable Across Devices
5. Easy
6. Superior

Deep Reinforcement Learning

1. The Foundations of Artificial Intelligence
2. Deep Q-Learning Networks
3. **Advanced Deep Reinforcement Learning Agents**
   - OpenAI Lab for Agent Experimentation and Optimization
   - Policy Gradients: REINFORCE and Actor-Critic
   - Software 2.0
   - **Approaching Artificial General Intelligence** *(reference RL LiveLessons section 5.4)*

Categories of Artificial Intelligence

1. ANI: *Narrow*
2. AGI: *General*
3. ASI: *Super*

Factors Driving A.I.

Tim Urban's non-technical introduction:

`waitbutwhy.com/2015/01/`
`artificial-intelligence-revolution-1.html`

Factors Driving A.I.

1. Data

Factors Driving A.I.

1. Data
2. Computing Power

Factors Driving A.I.

1. Data
2. Computing Power
3. Algorithms

Factors Driving A.I.

1. Data
2. Computing Power
3. Algorithms
4. Infrastructure

Deep Learning AGI Barriers

Deep Learning AGI Barriers

1. Requires Training on Many, Many Samples

Deep Learning AGI Barriers

1. Requires Training on Many, Many Samples
2. Black Box

Deep Learning AGI Barriers

1. Requires Training on Many, Many Samples
2. Black Box
3. Doesn't Leverage Knowledge of the World

Deep Learning AGI Barriers

1. Requires Training on Many, Many Samples
2. Black Box
3. Doesn’t Leverage Knowledge of the World
4. Correlation = Causation

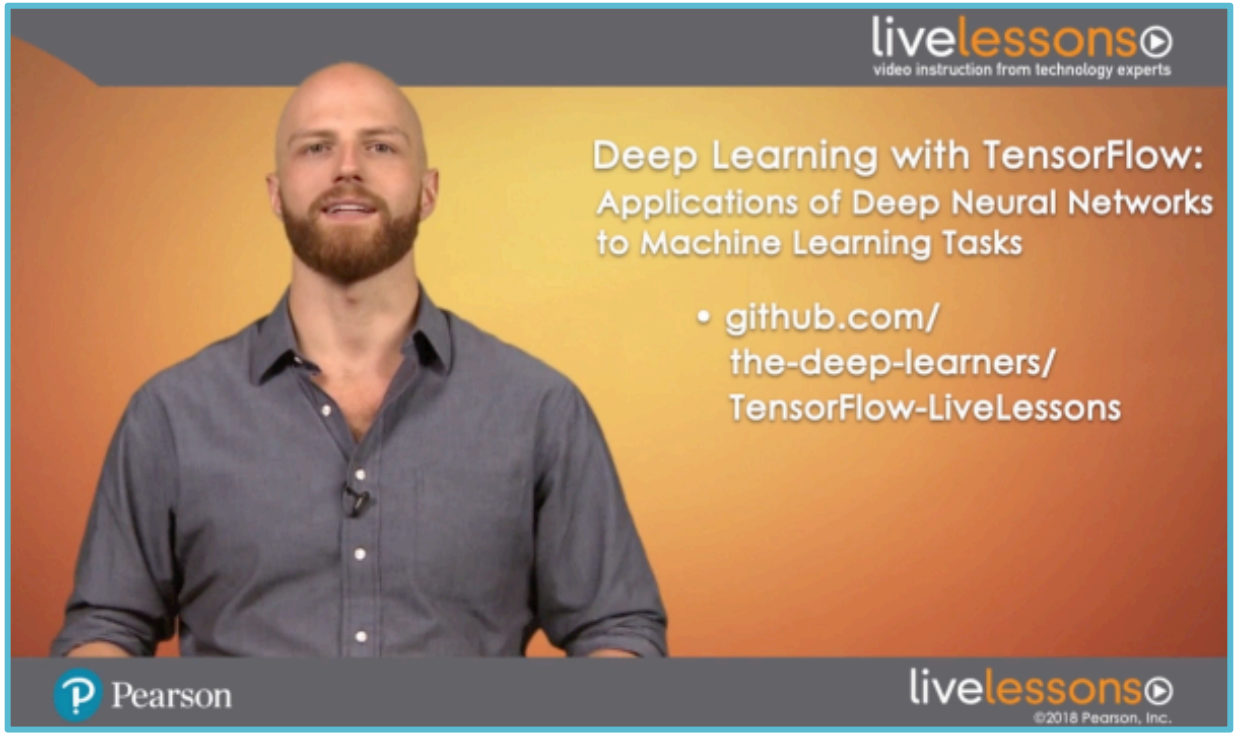
Deep Learning AGI Barriers

1. Requires Training on Many, Many Samples
2. Black Box
3. Doesn't Leverage Knowledge of the World
4. Correlation = Causation
5. Unintuitive / Embarrassing / Adversarial Failures

POLL

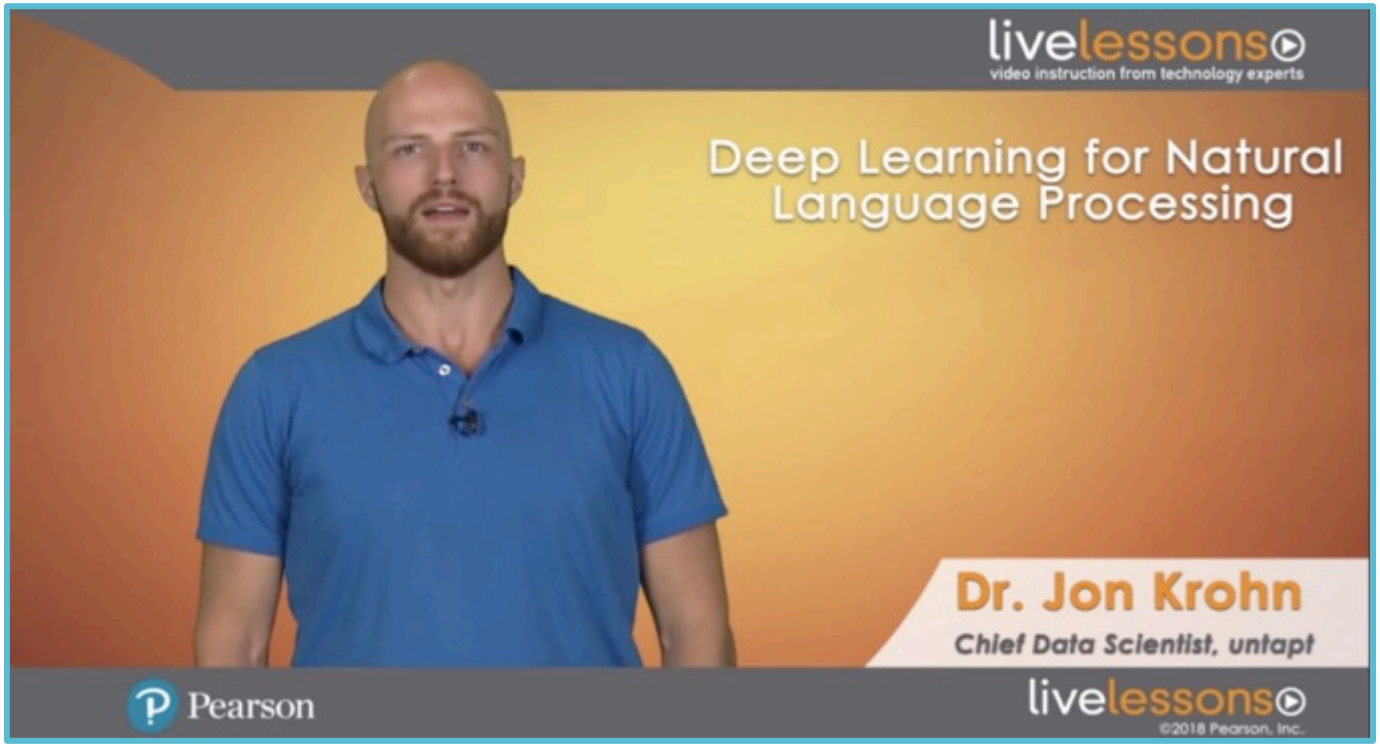
What other Deep Learning topic interests you most?

- Detail on Policy Gradients
- Natural Language Processing
- CNNs and Machine Vision
- Generative Adversarial Networks
- TensorBoard
- Something Else



Search *"Deep Learning with TensorFlow"* or *"Jon Krohn"* in Safari

Search *"Deep Reinforcement Learning and GANs"* or *"Jon Krohn"* in Safari



Search *"Deep Learning for Natural Language Processing"* or *"Jon Krohn"* in Safari

Staying in Touch

twitter.com/JonKrohnLearns

medium.com/@jonkrohn

linkedin.com/in/jonkrohn

(with message mentioning today's Live Training)

PLACEHOLDER FOR:

5-Minute Timer

PLACEHOLDER FOR:

10-Minute Timer