



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

untapt

Deep Reinforcement Learning

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

Deep Learning for NLP

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”)

The screenshot shows a video player interface. On the left, there is a portrait of a man with a beard and short hair, wearing a dark blue button-down shirt. He is smiling and looking towards the camera. The background behind him is a gradient from orange to yellow. At the top right of the video frame, the "livelessons" logo is displayed, with the tagline "video instruction from technology experts" underneath. To the right of the video frame, the title "Deep Reinforcement Learning and GANs LiveLessons" is written in white. Below the title, there is a bullet point followed by a URL: "• github.com/the-deep-learners/TensorFlow-LiveLessons". At the bottom left of the video frame, the Pearson logo is visible, which consists of a stylized 'P' inside a teal circle. At the bottom right, the "livelessons" logo appears again with the copyright notice "©2018 Pearson, Inc."

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

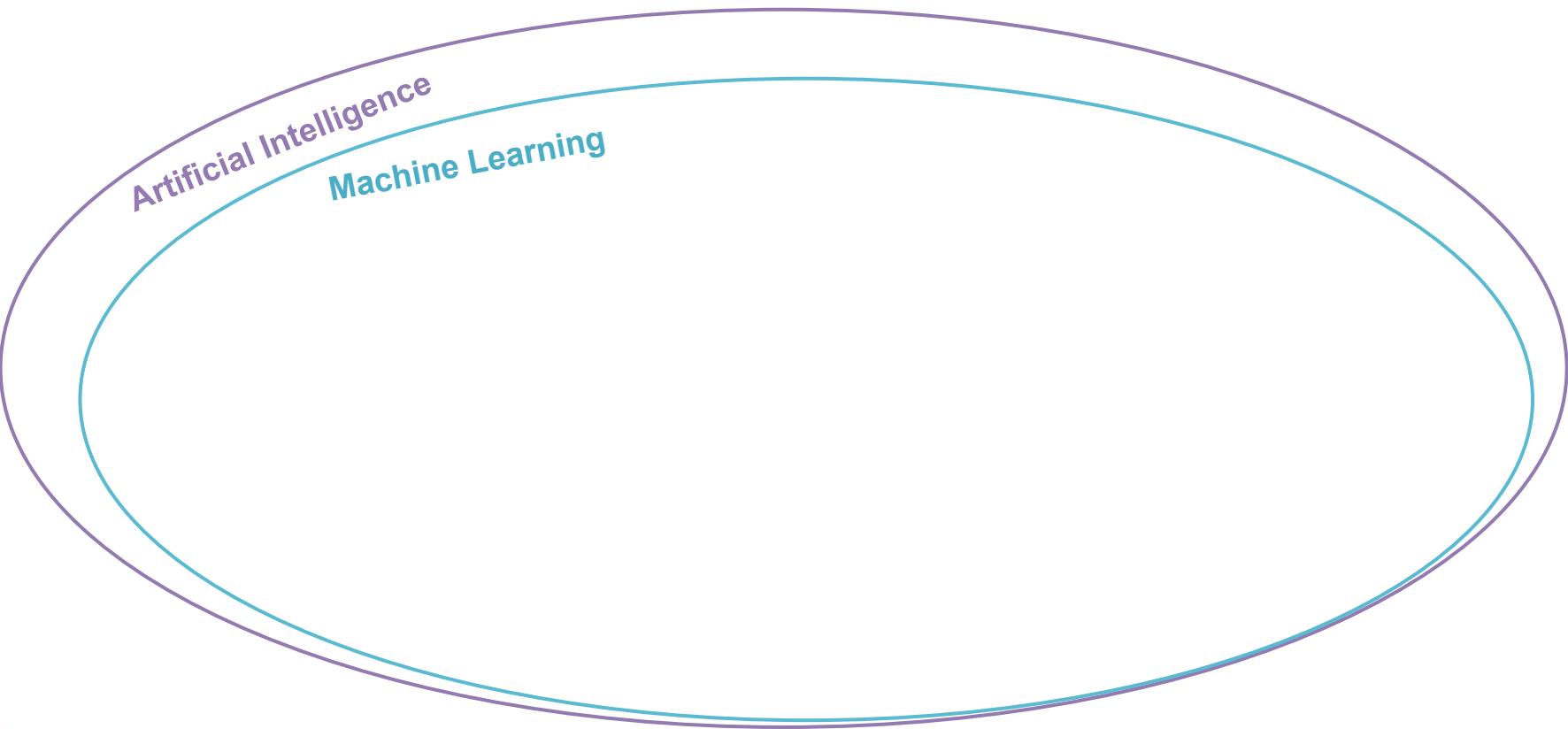
Deep Learning for NLP

1. **The Foundations of Artificial Intelligence**
 - **The Contemporary State of A.I.** (*reference RL LiveLessons section 1.1*)
 - Applications of Deep Reinforcement Learning
 - Review of Prerequisite Deep Learning Theory
2. Deep Q-Learning Networks
3. Advanced Deep Reinforcement Learning Agents

The Contemporary State of A.I.

Artificial Intelligence

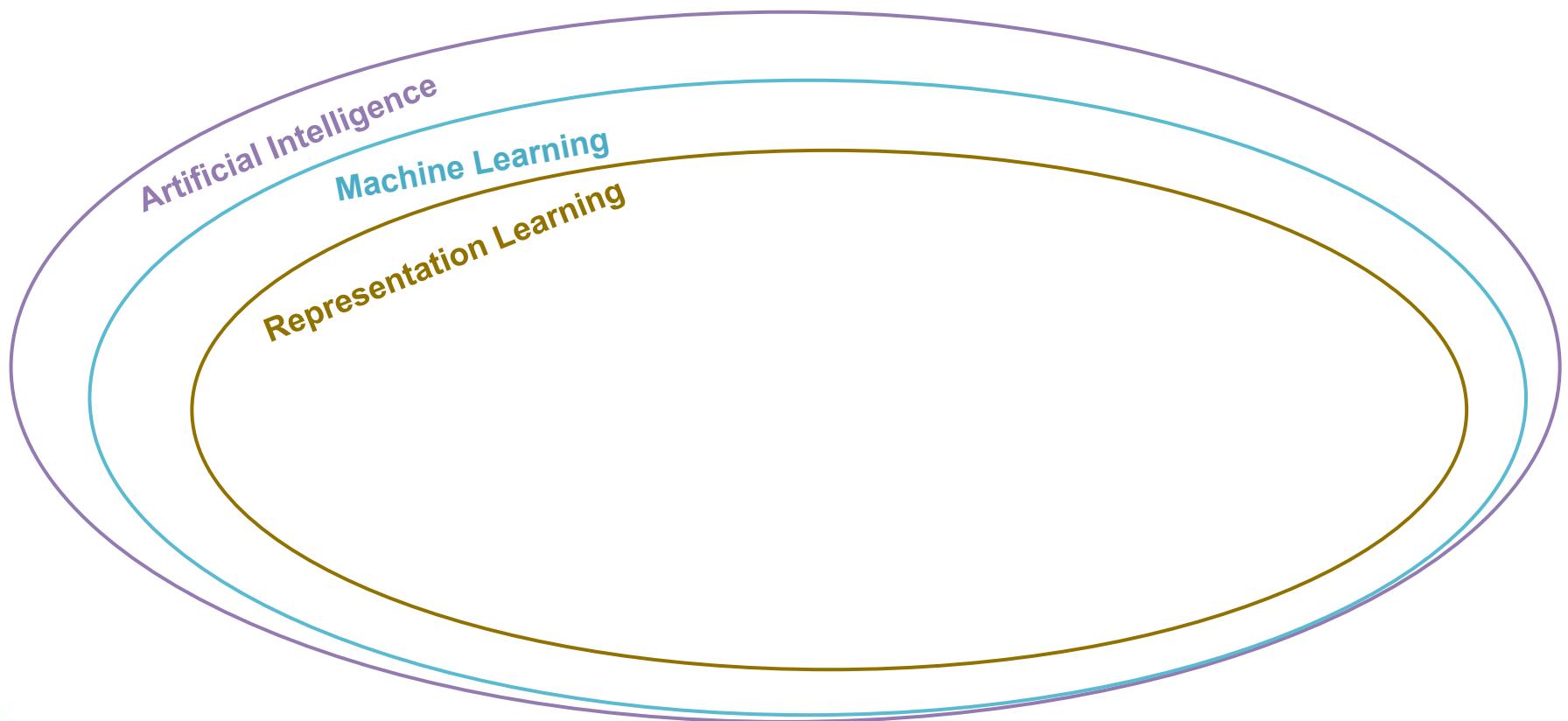
The Contemporary State of A.I.



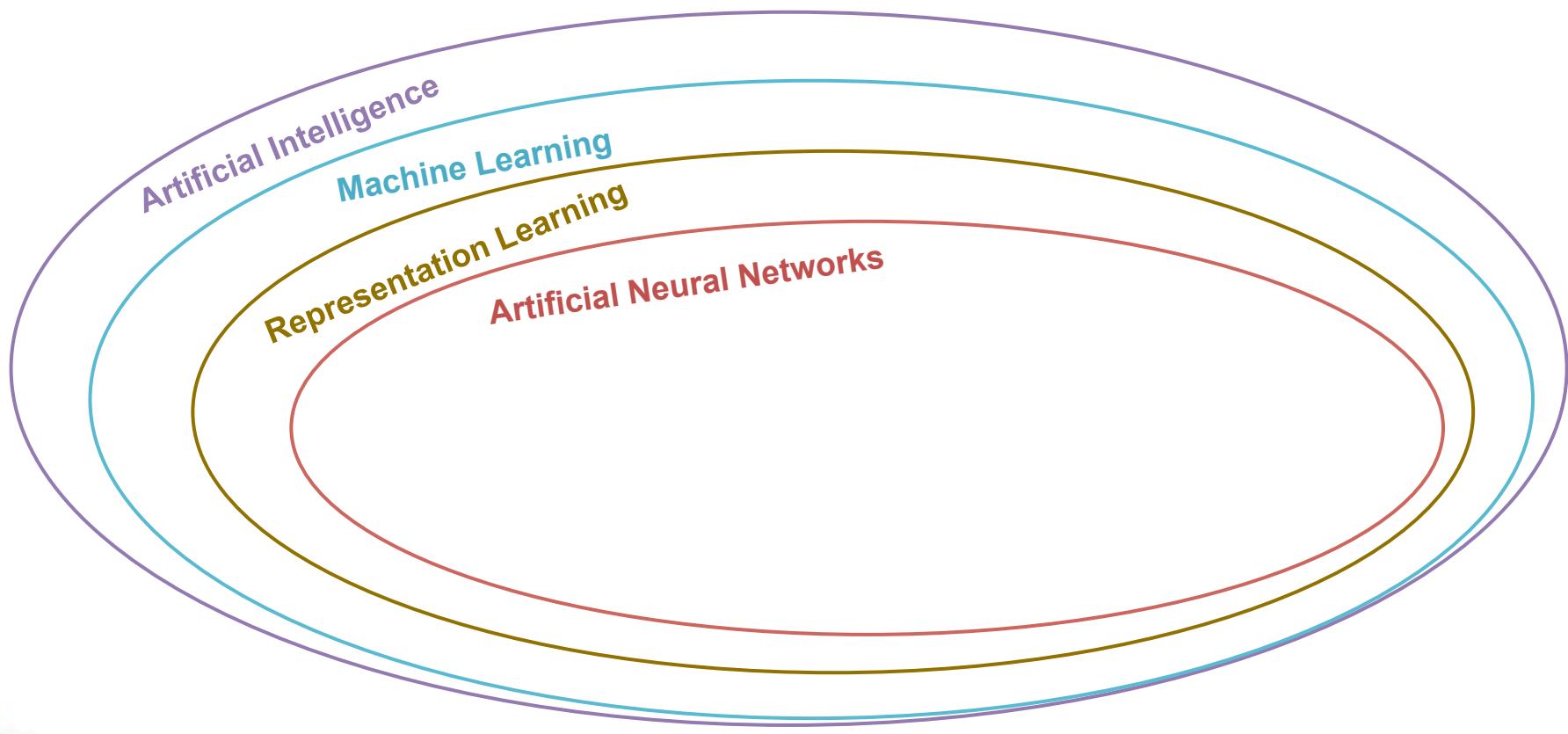
Artificial Intelligence

Machine Learning

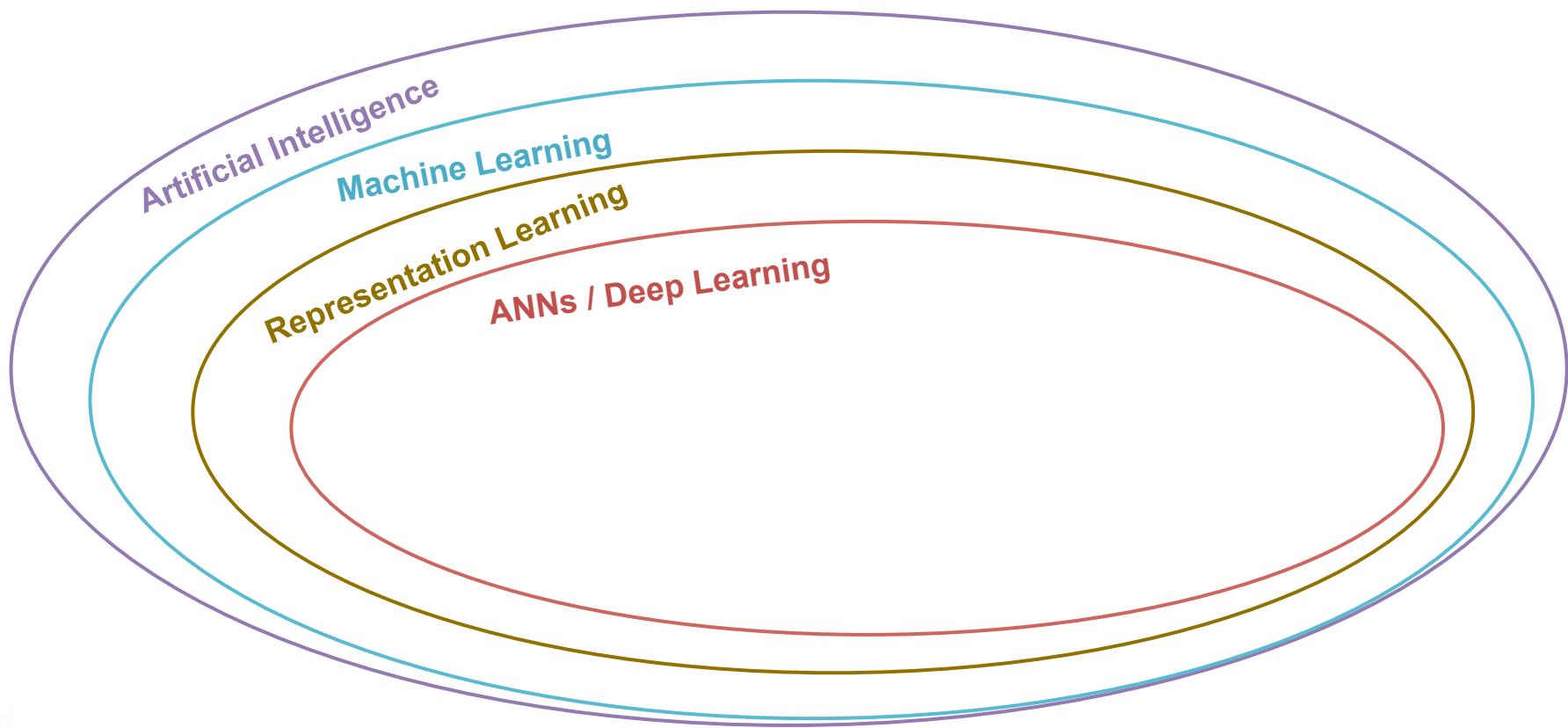
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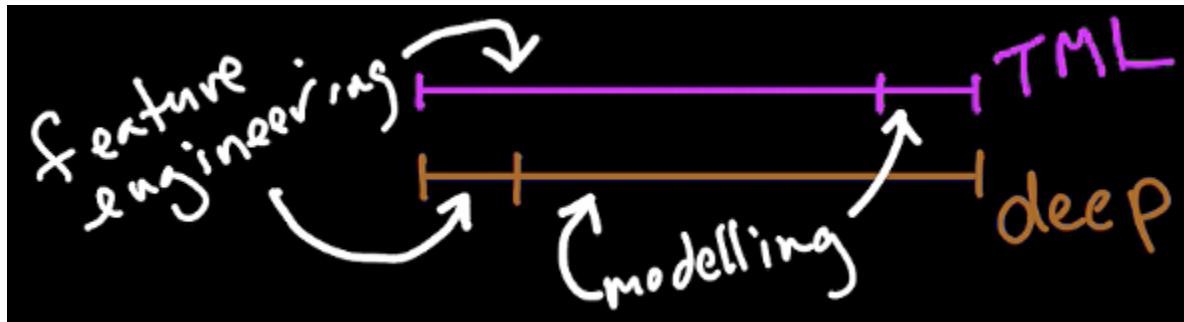
The Contemporary State of A.I.



The Contemporary State of A.I.



Traditional ML vs Deep Learning



Dense Networks



unsplash.com/photos/ij5_qCBpIVY

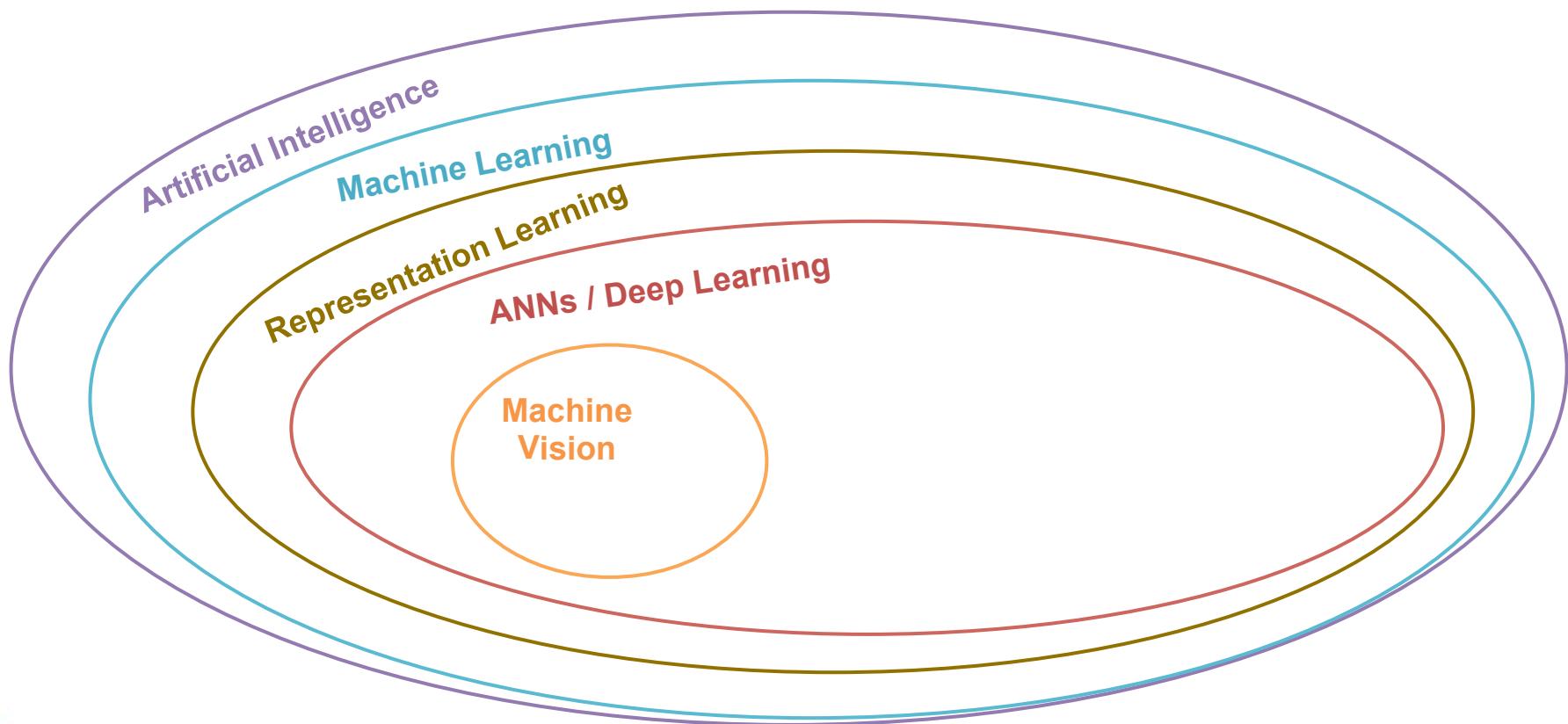


Deep Learning with TensorFlow:
Applications of Deep Neural Networks
to Machine Learning Tasks

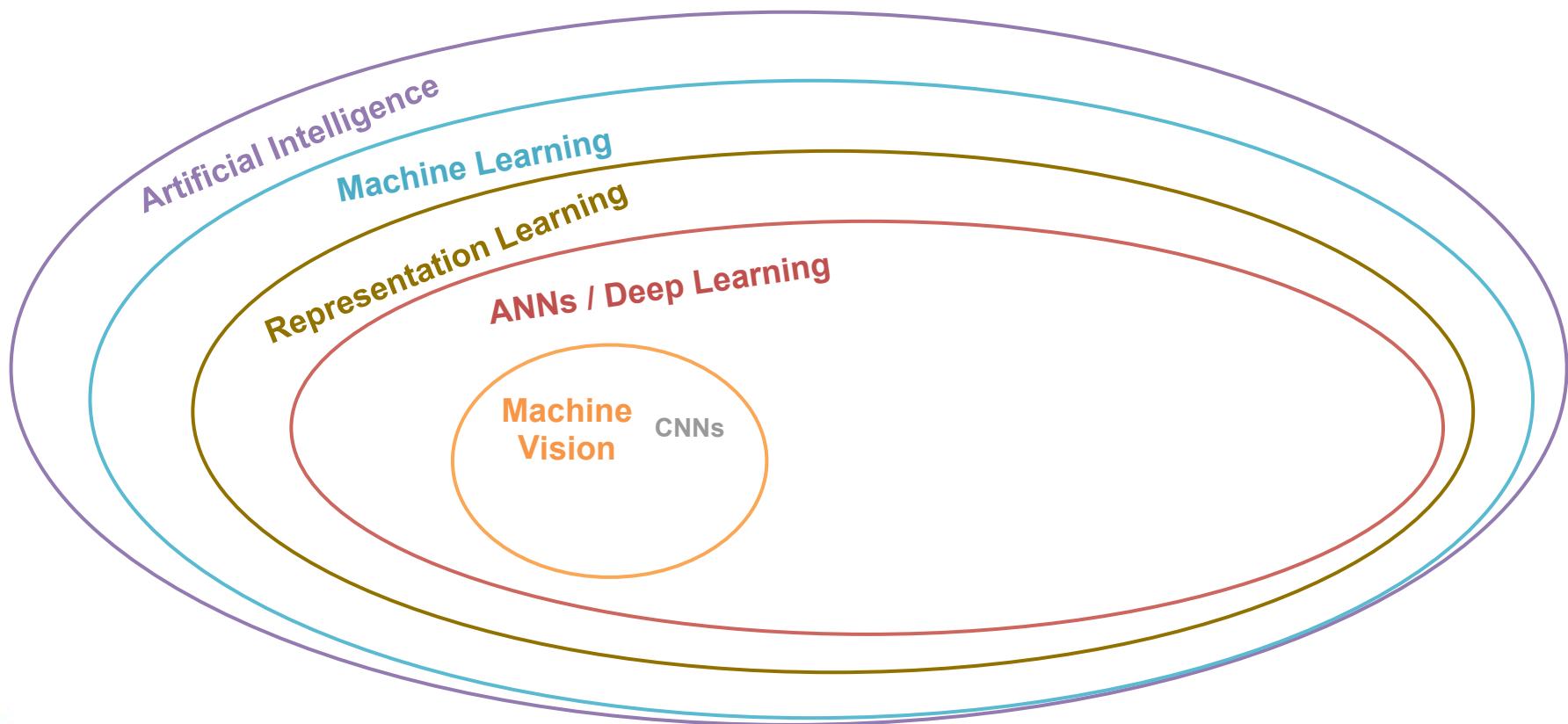
- [github.com/
the-deep-learners/
TensorFlow-LiveLessons](https://github.com/the-deep-learners/TensorFlow-LiveLessons)

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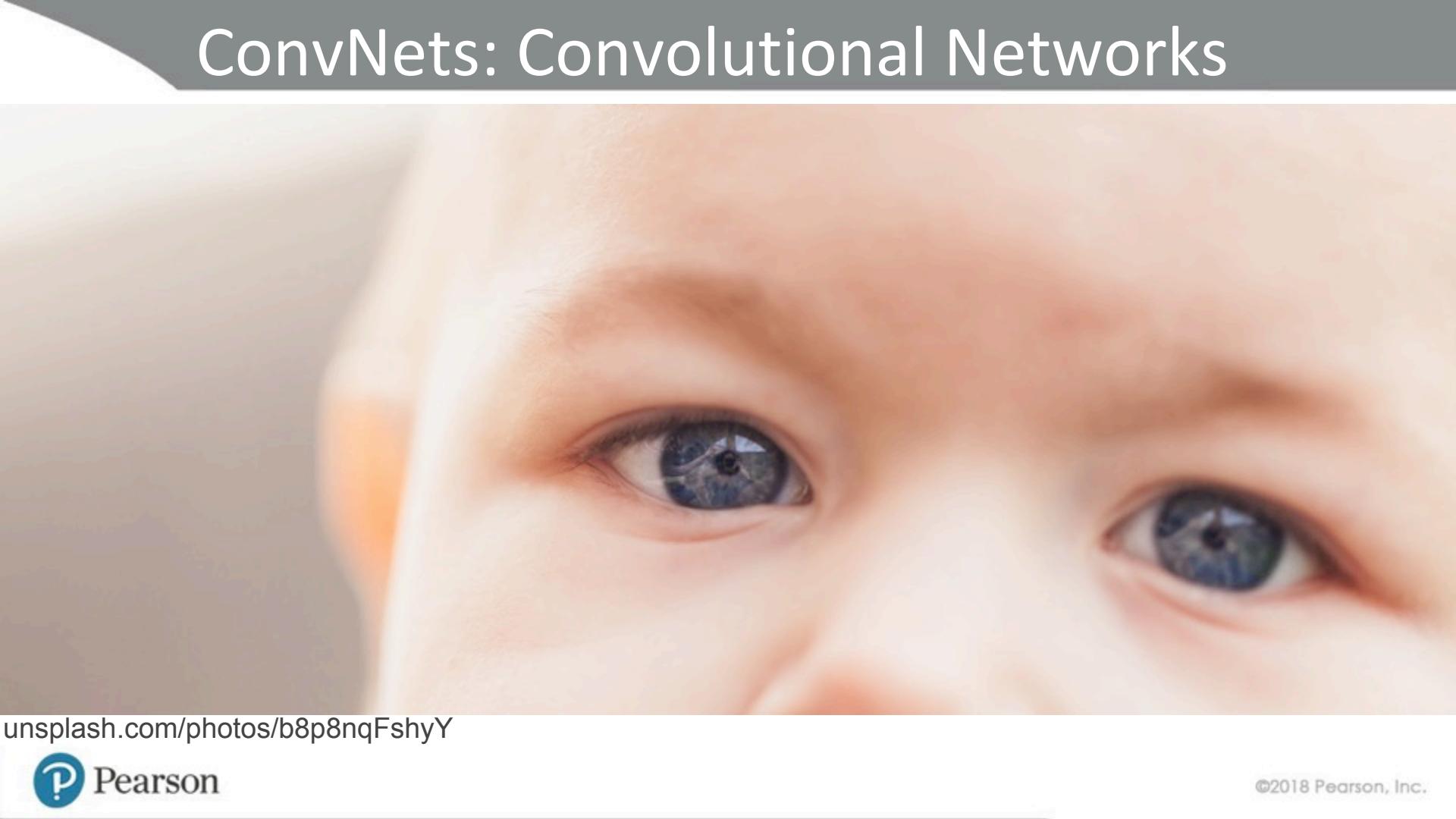
The Contemporary State of A.I.



The Contemporary State of A.I.



ConvNets: Convolutional Networks

A close-up photograph of a young child's face, focusing on the eyes. The child has light-colored hair and blue eyes. The background is blurred, showing a soft, warm color palette.

unsplash.com/photos/b8p8nqFshyY

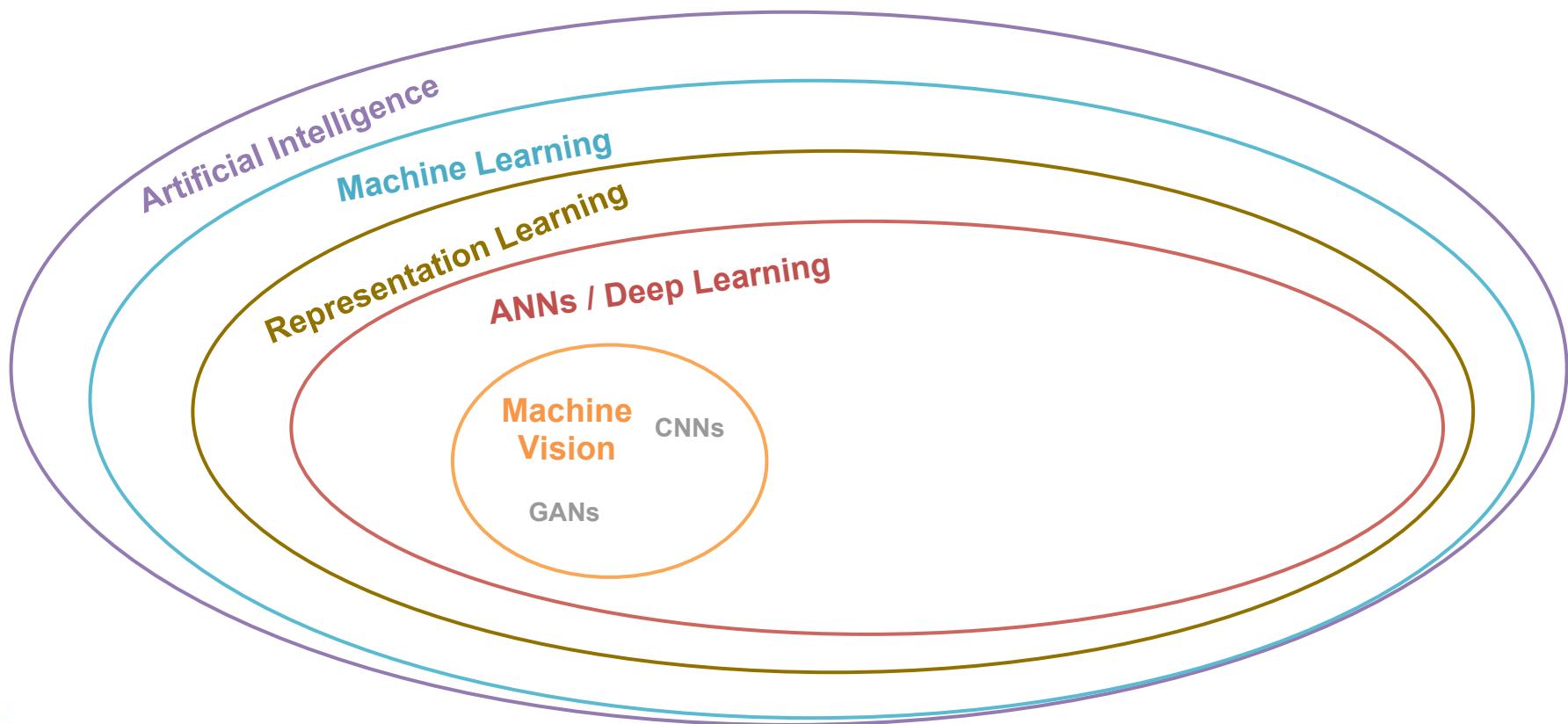


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- [github.com/
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The Contemporary State of A.I.



GANs: Generative Adversarial Networks



unsplash.com/photos/FwF_fKj5tBo

Deep Reinforcement Learning and GANs LiveLessons

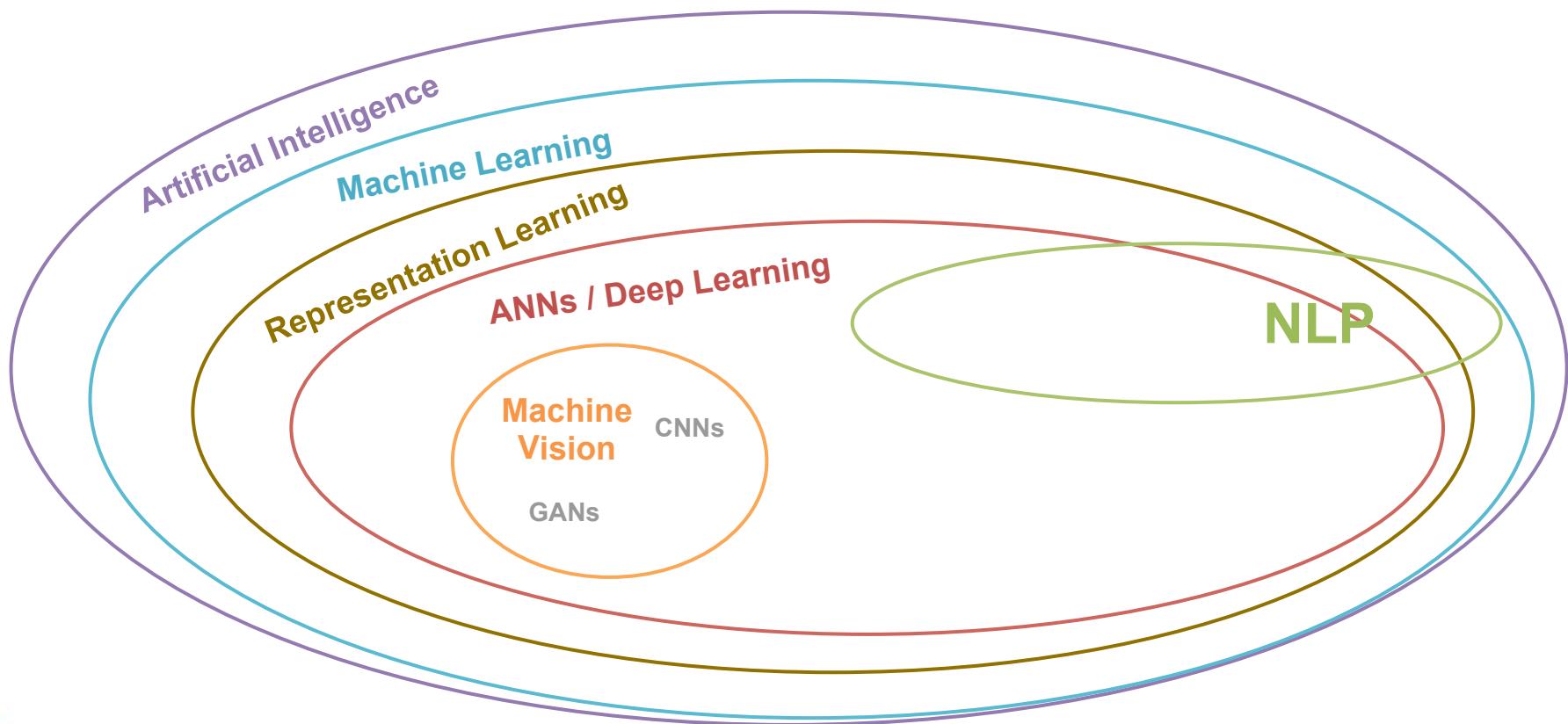
- github.com/the-deep-learners/TensorFlow-LiveLessons



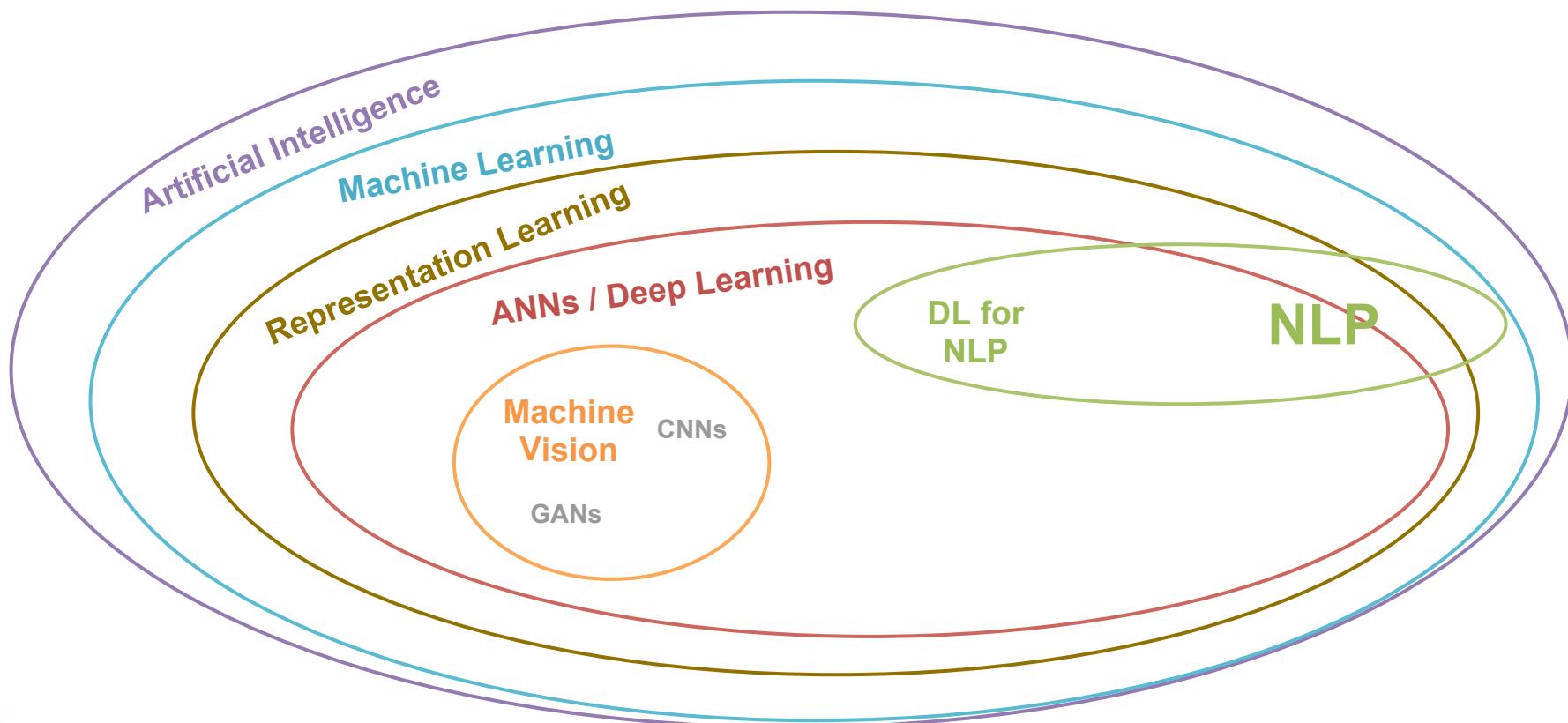
Pearson

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

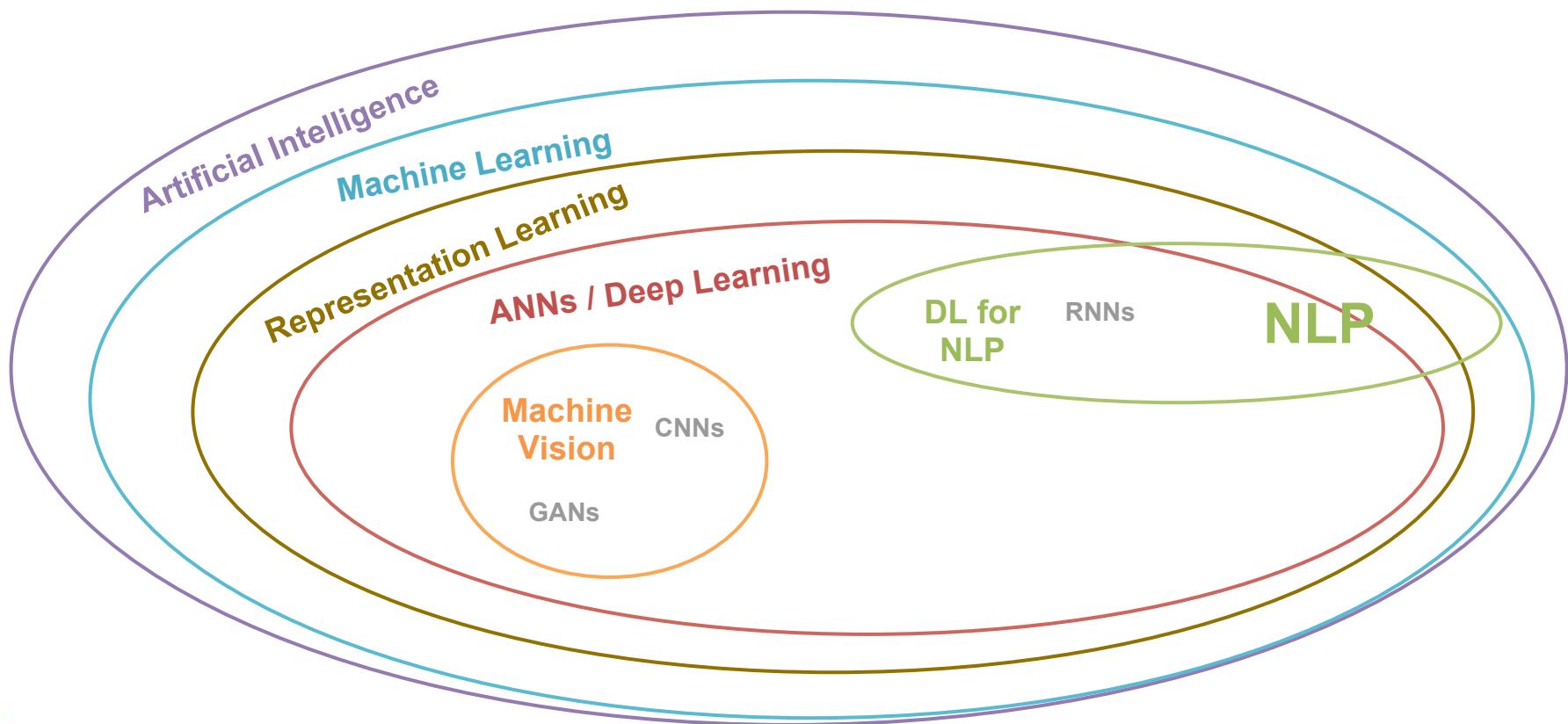
The Contemporary State of A.I.



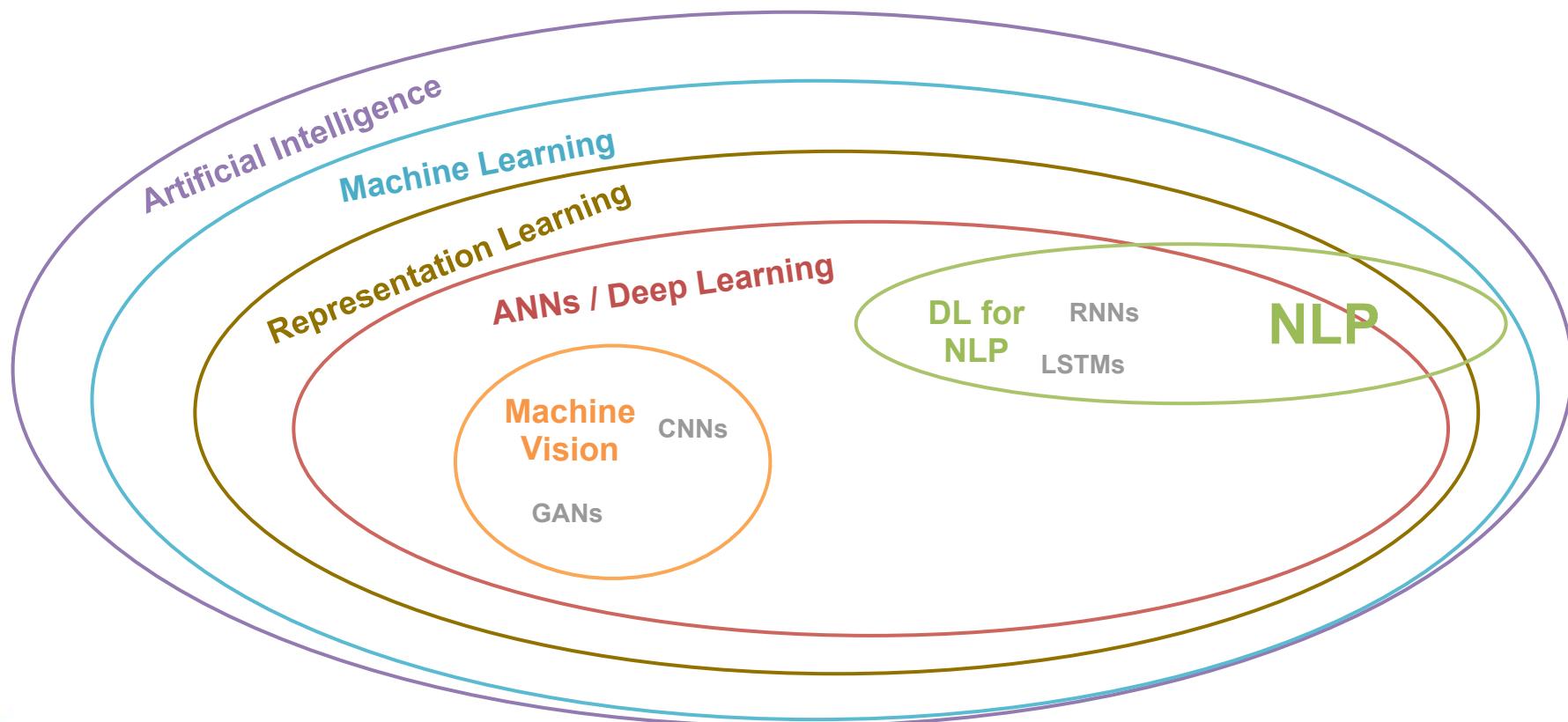
The Contemporary State of A.I.



The Contemporary State of A.I.



The Contemporary State of A.I.



RNNs: Recurrent Neural Networks



unsplash.com/photos/cZhUxIQjILg

Deep Learning for Natural Language Processing



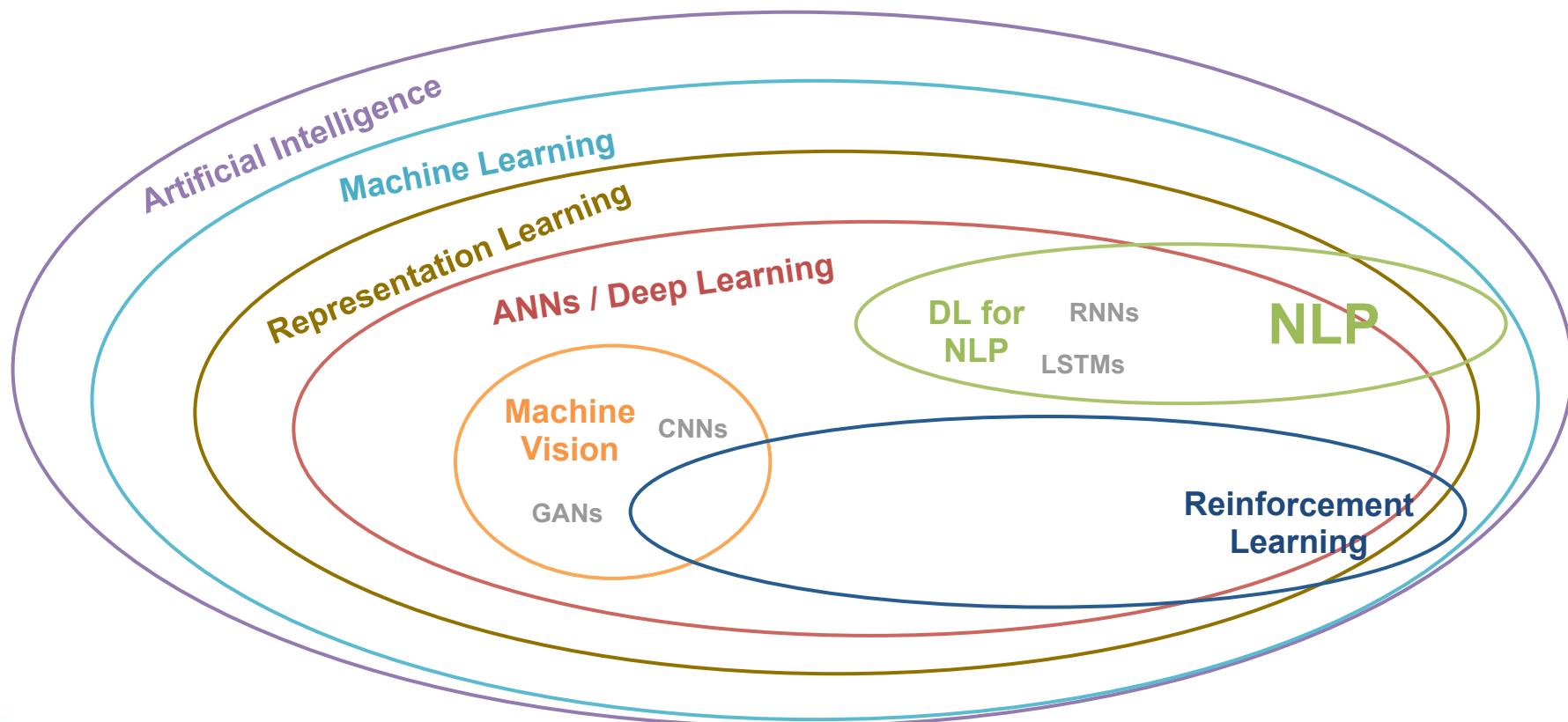
Dr. Jon Krohn
Chief Data Scientist, untapt



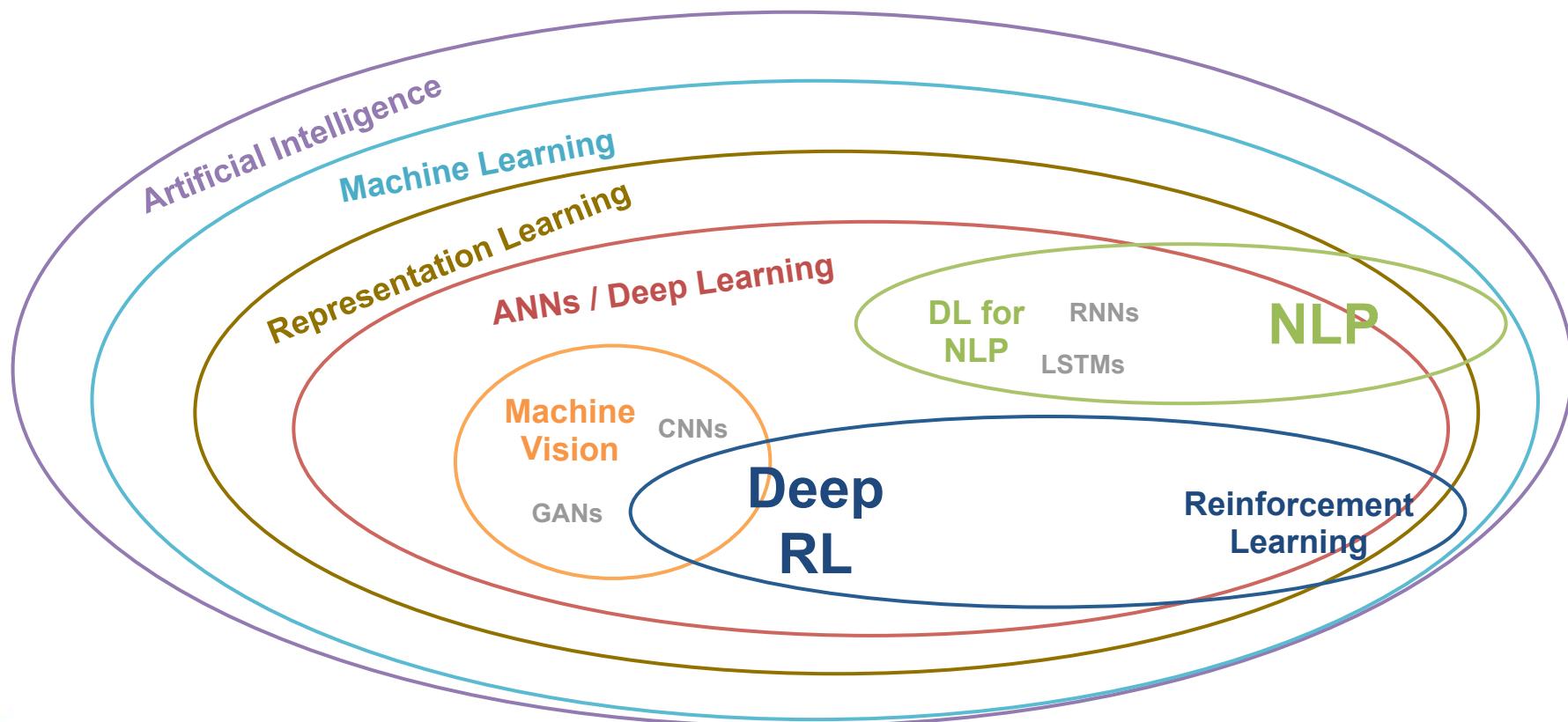
Pearson

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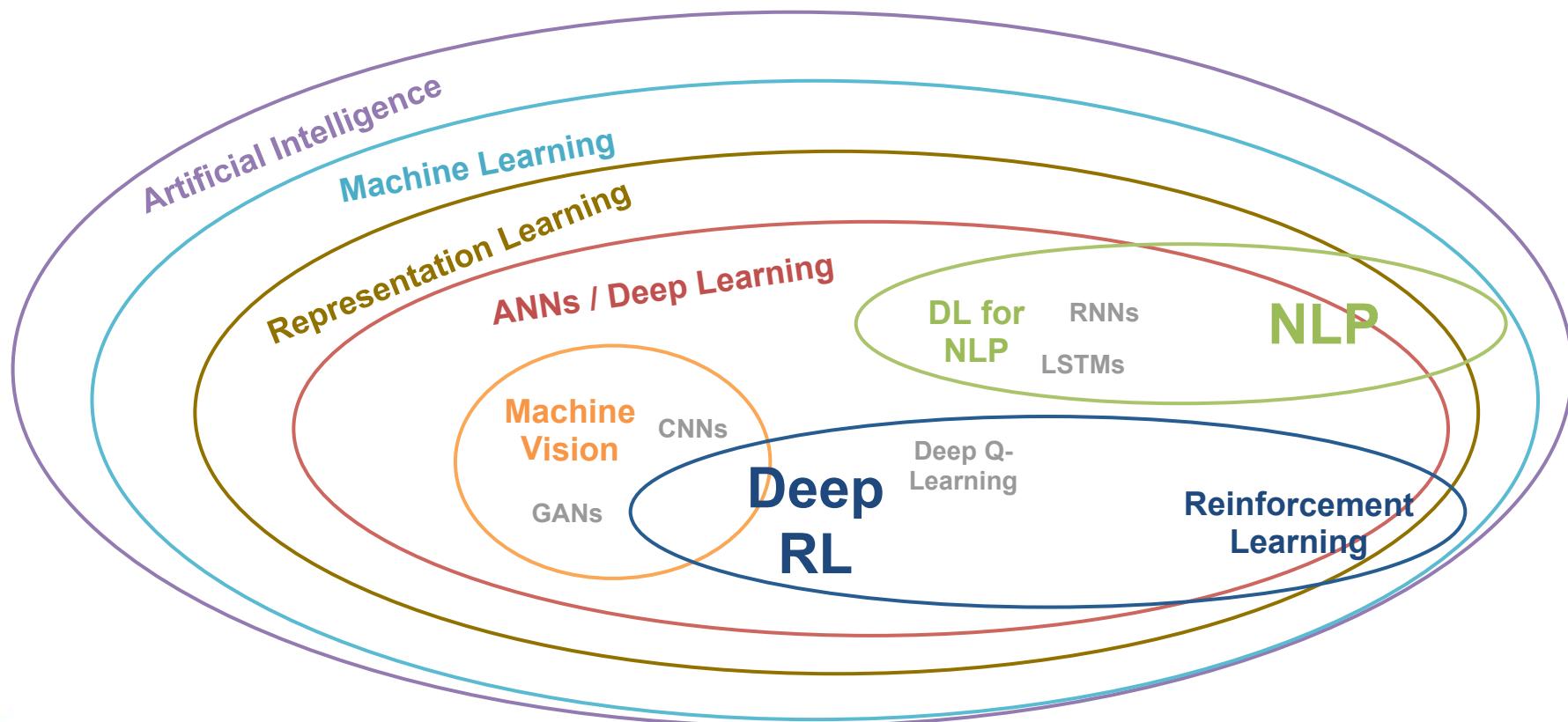
The Contemporary State of A.I.



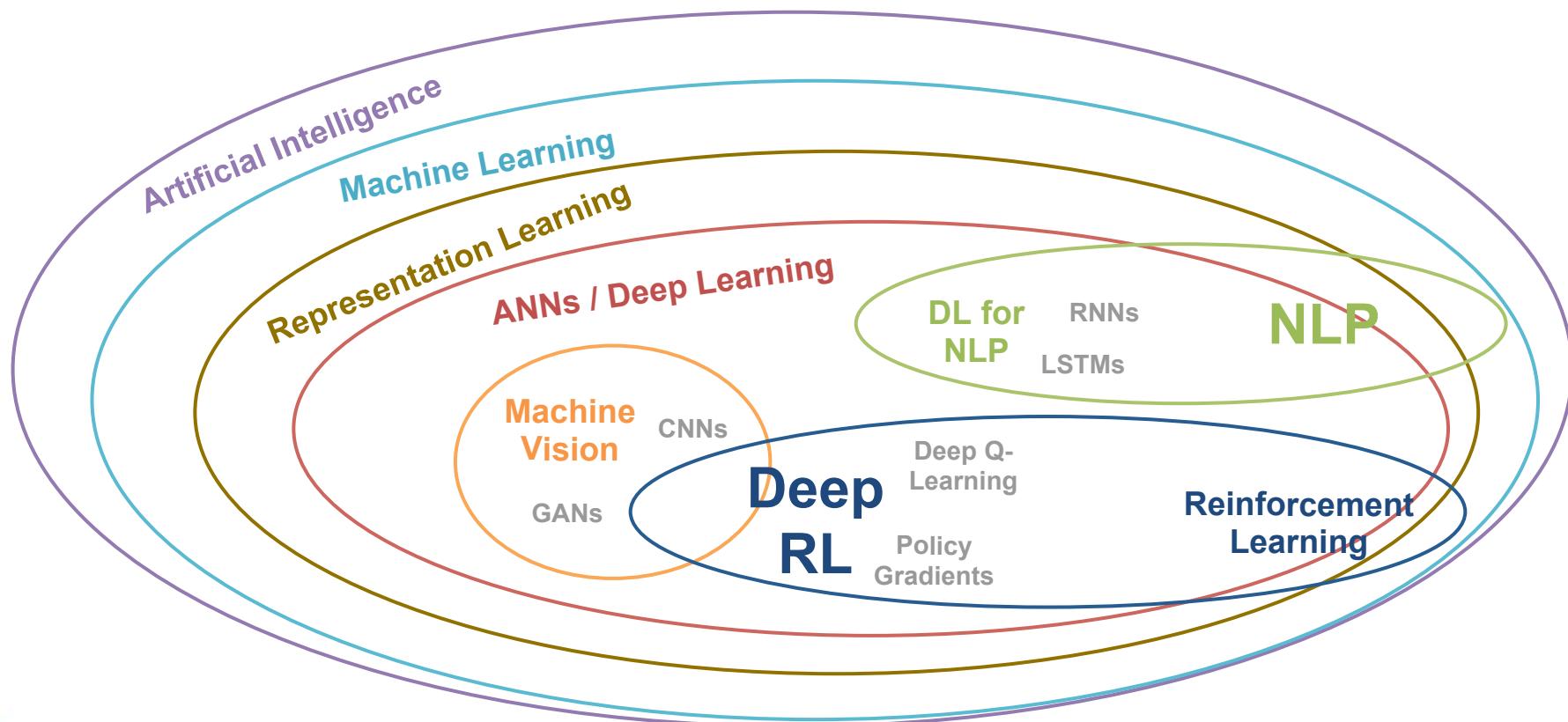
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The Contemporary State of A.I.



The Contemporary State of A.I.



Deep Reinforcement Learning



unsplash.com/photos/pxnDAT77rVg

Categories of Artificial Intelligence

1. ANI: *Narrow*

Categories of Artificial Intelligence

1. ANI: *Narrow*
2. AGI: *General*

Categories of Artificial Intelligence

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

Deep Reinforcement Learning

1.

The Foundations of Artificial Intelligence

- The Contemporary State of A.I.
- **Applications of Deep Reinforcement Learning**
(reference RL LiveLessons section 1.3)
- Review of Prerequisite Deep Learning Theory

2.

Deep Q-Learning Networks

3.

Advanced Deep Reinforcement Learning Agents

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

Supervised Learning

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

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 - played seven Atari 2600 games

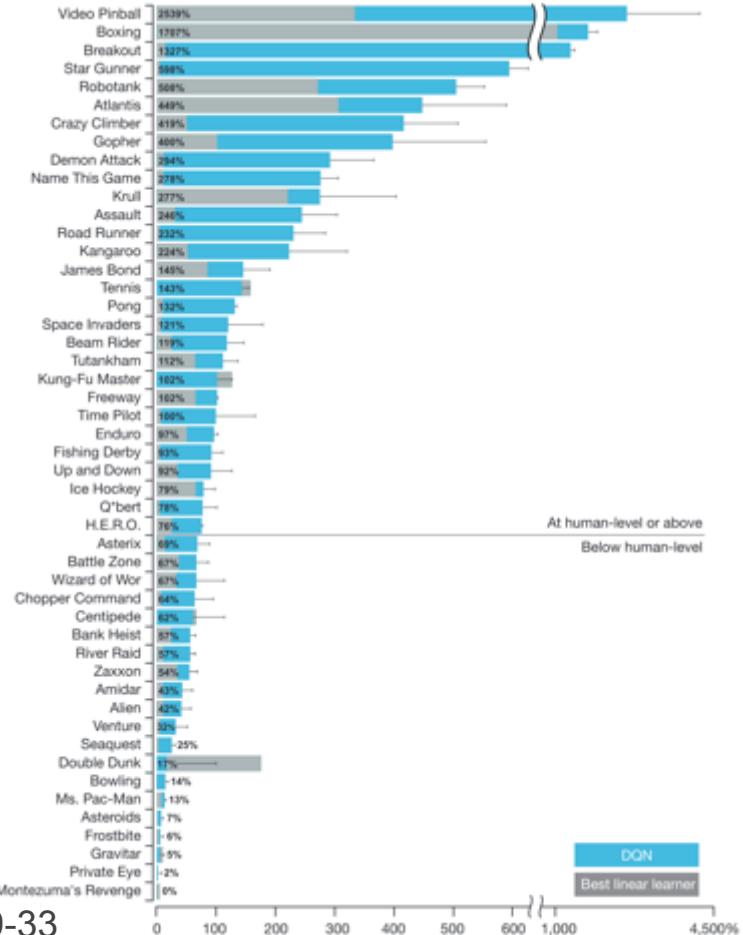
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 - DeepMind (acquired by Google in 2014)
- “Deep Q-Learning” algorithm
 - played seven Atari 2600 games
 - beat previous ML approaches on six
 - beat human expert on three

Mnih et al. (2015)

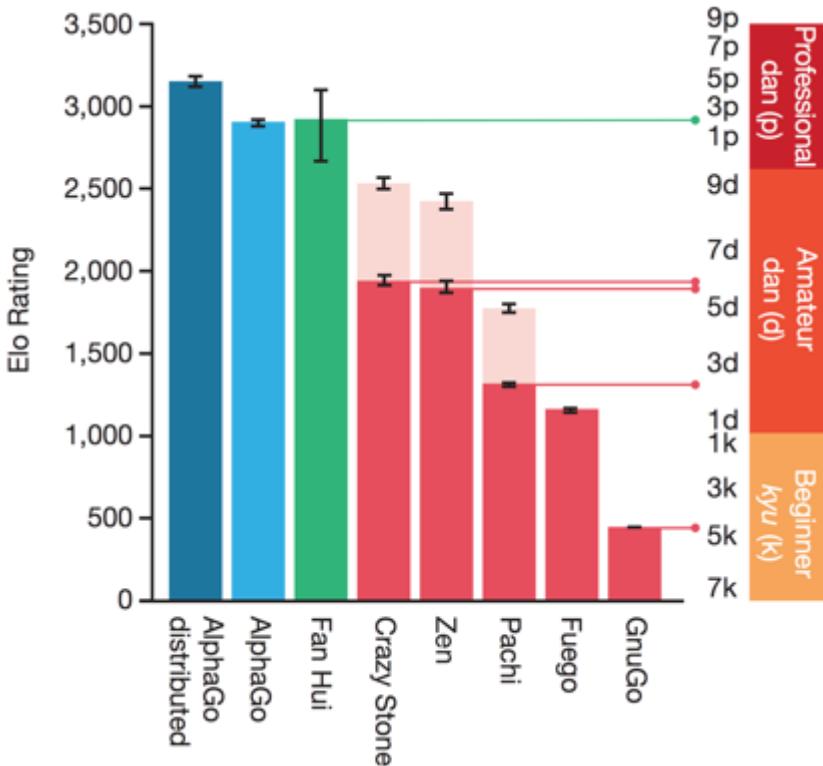


Pearson

Nature 518: 529-33

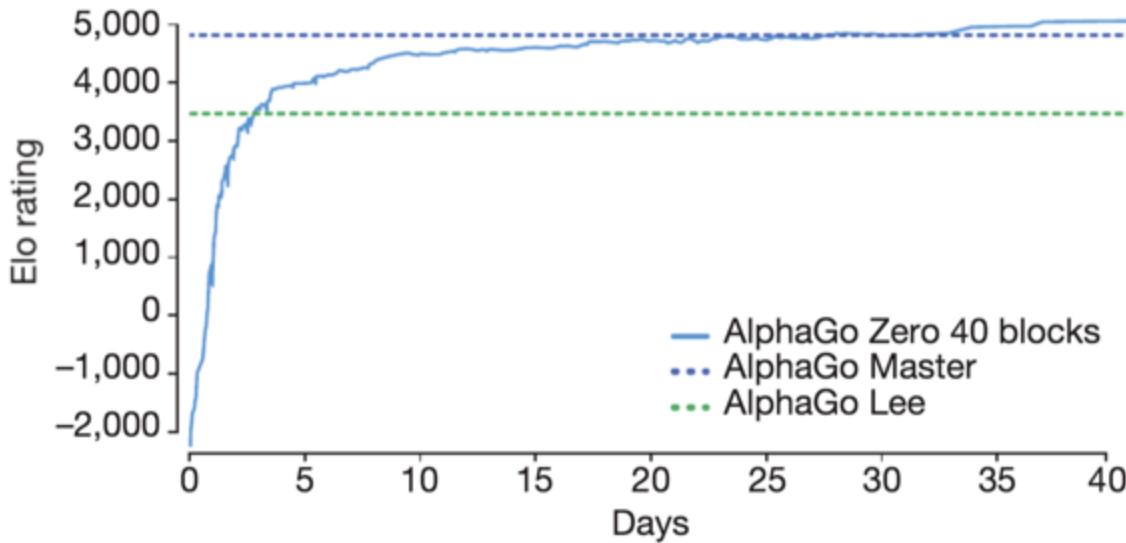
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AlphaGo (Silver et al., 2016)

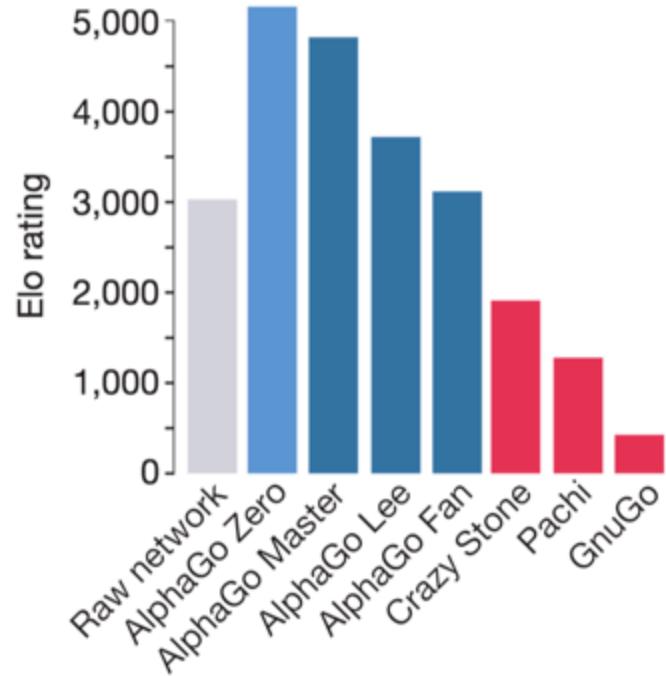


Nature 529: 484-9

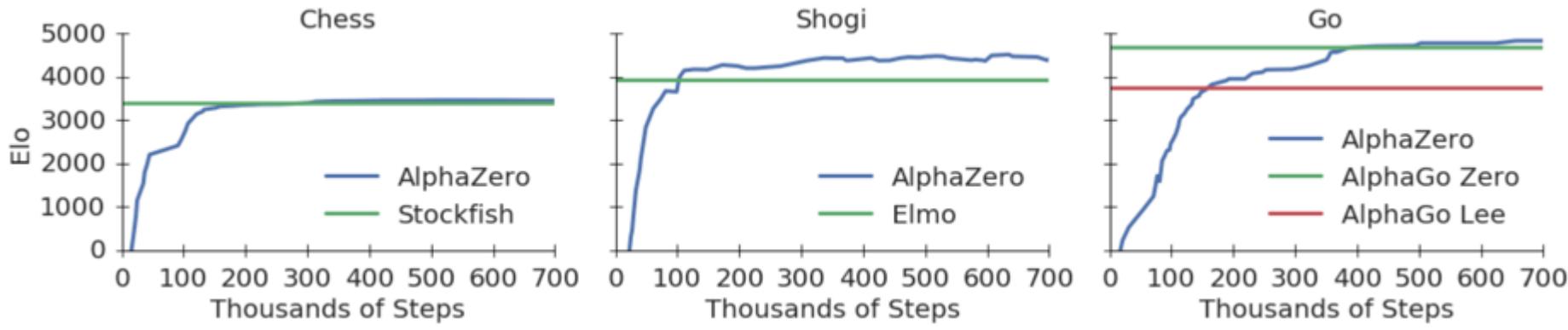
AlphaGo Zero (Silver et al., 2017)



Nature 550: 354-9

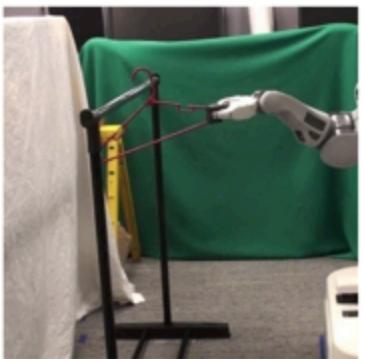
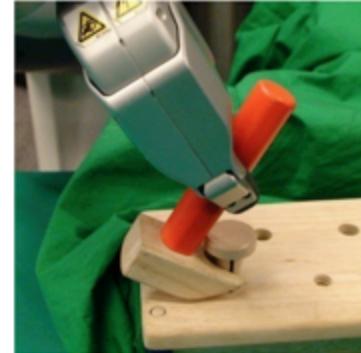
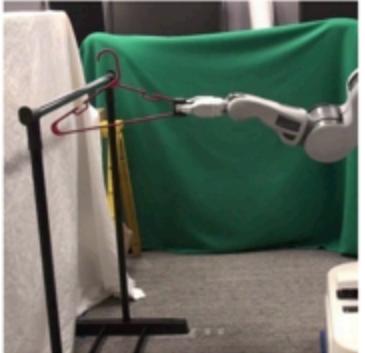


AlphaZero (Silver et al., 2017)



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

Popular Deep RL Environments

1. **OpenAI Gym:** github.com/openai/gym
2. **DeepMind Lab:** github.com/deepmind/lab

Popular Deep RL Environments

1. **OpenAI Gym:** github.com/openai/gym
2. **DeepMind Lab:** github.com/deepmind/lab
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

1.

The Foundations of Artificial Intelligence

- The Contemporary State of A.I.
- Applications of Deep Reinforcement Learning
- **Review of Prerequisite Deep Learning Theory**
(reference “Deep Learning with TensorFlow LiveLessons”)

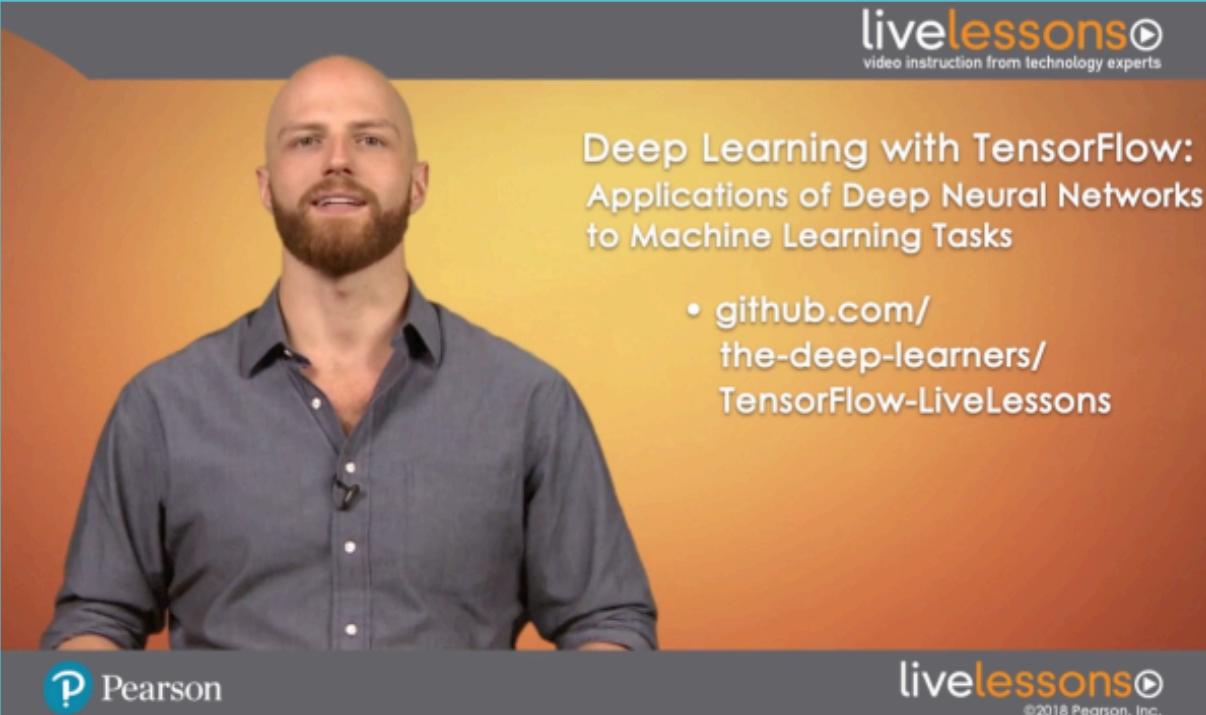
2.

Deep Q-Learning Networks

3.

Advanced Deep Reinforcement Learning Agents

Deep Learning Fundamentals (assumed)



The image shows a screenshot of a video player for a liveLessons video. On the left, there is a video frame showing a man with a beard and short hair, wearing a dark grey button-down shirt, speaking. On the right, there is promotional text and logos. At the top right is the "livelessons" logo with the tagline "video instruction from technology experts". Below the logo is the title "Deep Learning with TensorFlow: Applications of Deep Neural Networks to Machine Learning Tasks". Underneath the title is a bullet point list: • [github.com/
the-deep-learners/
TensorFlow-LiveLessons](https://github.com/the-deep-learners/TensorFlow-LiveLessons). At the bottom left is the Pearson logo, and at the bottom right is the livelessons logo with the copyright notice "©2018 Pearson, Inc."

livelessons
video instruction from technology experts

Deep Learning with TensorFlow:
Applications of Deep Neural Networks
to Machine Learning Tasks

- [github.com/
the-deep-learners/
TensorFlow-LiveLessons](https://github.com/the-deep-learners/TensorFlow-LiveLessons)

P Pearson

livelessons
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Search “*Deep Learning with TensorFlow*” or “*Jon Krohn*” in Safari

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Cost Functions

- quadratic cost

$$\sum_i (y_i - \hat{y}_i)^2$$

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Cost Functions

- quadratic cost
- *cross-entropy*

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Cost Functions

- quadratic cost
- *cross-entropy*

Stochastic Gradient Descent

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

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Cost Functions

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Stochastic Gradient Descent

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Backpropagation

Your Arsenal

Neurons

- sigmoid
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- ReLU

Layers

- dense / fully-connected

Cost Functions

- quadratic cost
- *cross-entropy*

Stochastic Gradient Descent

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

Backpropagation

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Layers

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

Cost Functions

- quadratic cost
- *cross-entropy*

Stochastic Gradient Descent

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

Backpropagation

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
 - Interacting with an OpenAI Gym Environment
3. Advanced Deep Reinforcement Learning Agents

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

Deep Reinforcement Learning

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Defining a DQN Agent

Interactive Jupyter(Hub) Demo:

`cartpole_dqn.ipynb`

Deep Reinforcement Learning

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 - **Interacting with an OpenAI Gym Environment**
(reference RL LiveLessons section 3.5)
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Interacting with OpenAI Gym

Return to Interactive Jupyter(Hub) Demo:

`cartpole_dqn.ipynb`

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

Deep Reinforcement Learning

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OpenAI Lab

Interactive Demo of:

github.com/kengz/openai_lab

Deep Reinforcement Learning

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Popular Deep RL Agents

1. Deep Q-Learning Network (DQN)

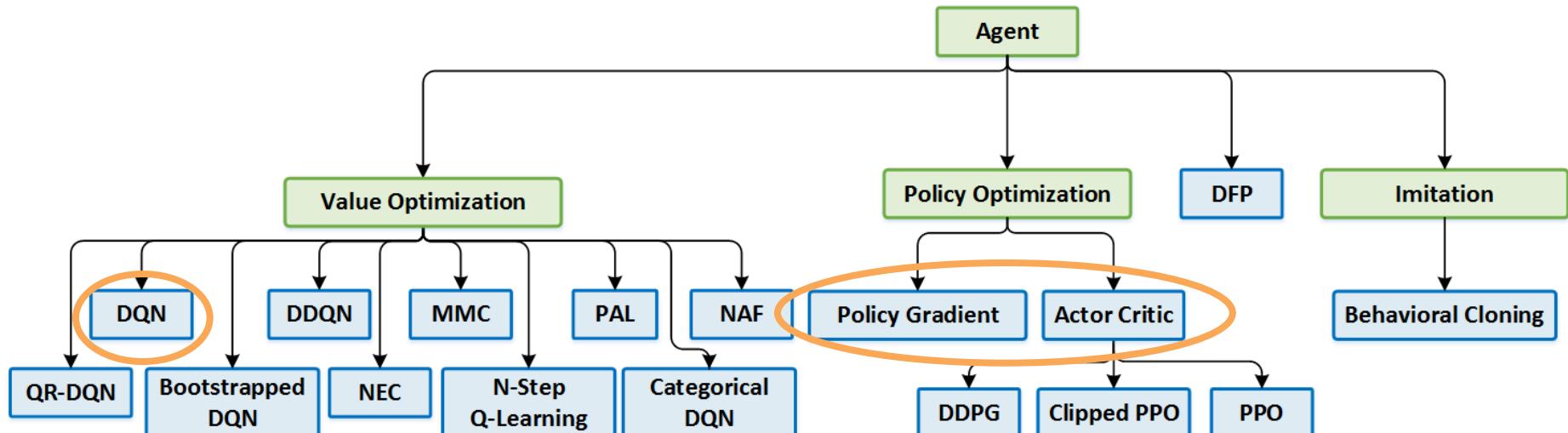
Popular Deep RL Agents

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

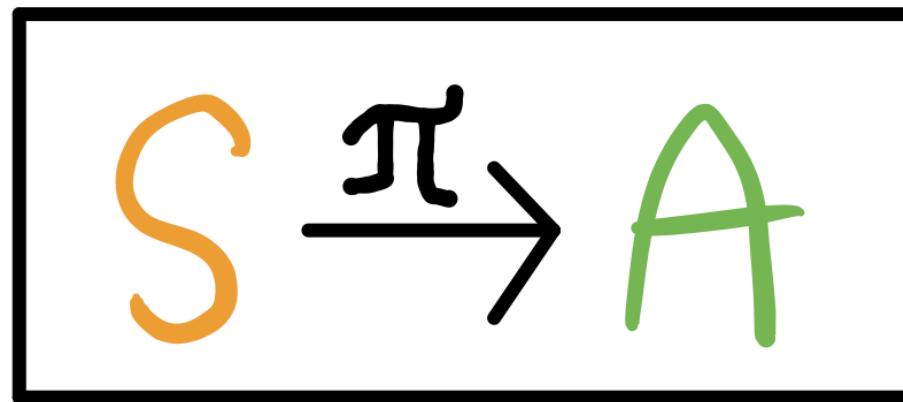


github.com/NervanaSystems/coach

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

Actor - Critic
↑ ↑
PG + Q-Learning

Deep Reinforcement Learning

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 - Policy Gradients: the REINFORCE and Actor-Critic Algorithms
 - **Software 2.0** (*reference RL LiveLessons 5.3*)
 - Approaching Artificial General Intelligence

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

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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/](http://waitbutwhy.com/2015/01/artificial-intelligence-revolution-1.html)

[artificial-intelligence-revolution-1.html](http://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



Deep Learning with TensorFlow:
Applications of Deep Neural Networks
to Machine Learning Tasks

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Deep Reinforcement Learning and GANs LiveLessons

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Deep Learning for Natural Language Processing



Dr. Jon Krohn
Chief Data Scientist, untapt



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Staying in Touch

twitter.com/JonKrohnLearns

medium.com/@jonkrohn

linkedin.com/in/jonkrohn

(with message mentioning today's Live Training)

untapt

PLACEHOLDER
FOR:

5-Minute Timer

PLACEHOLDER
FOR:

10-Minute Timer