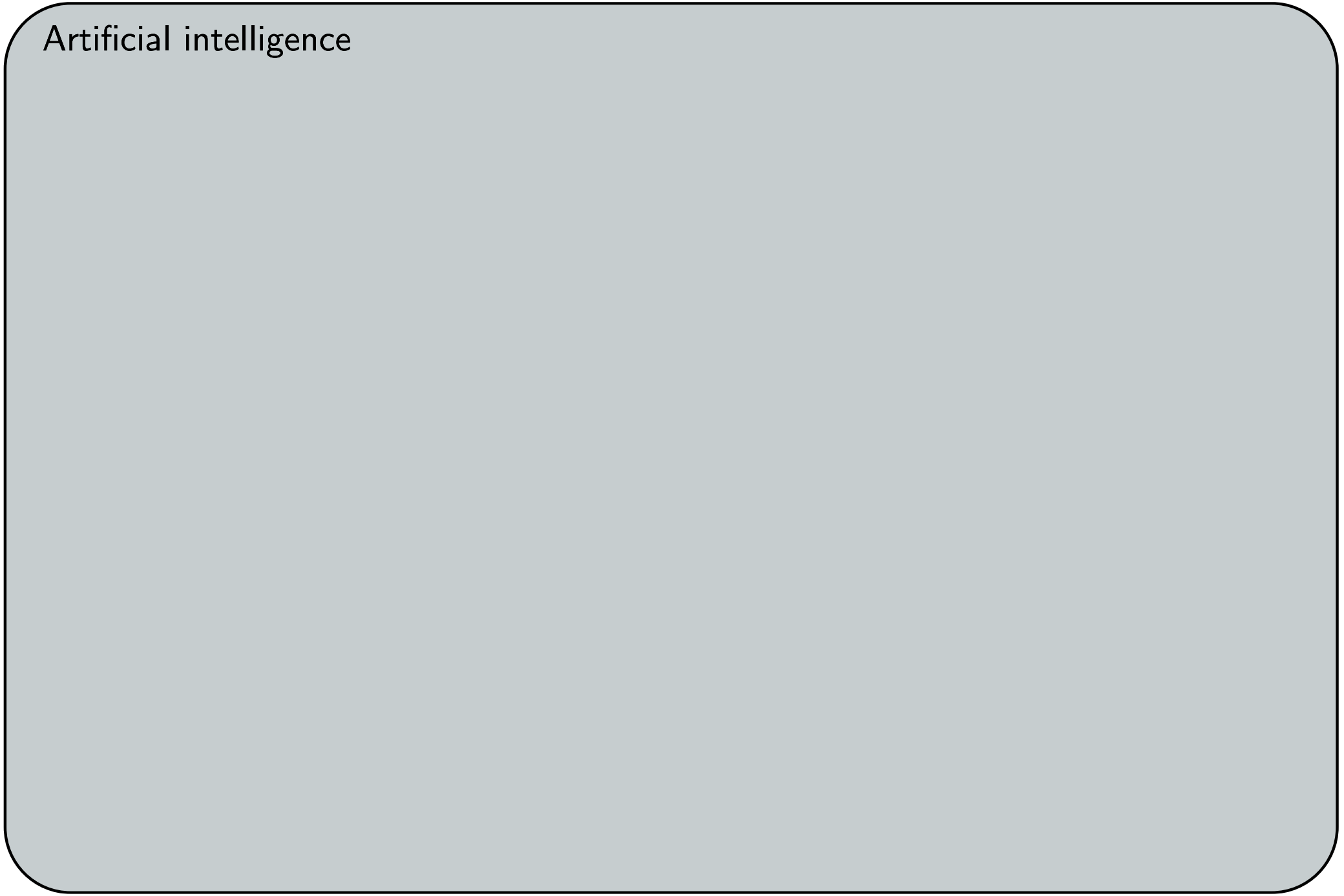
Machine Learning with Python

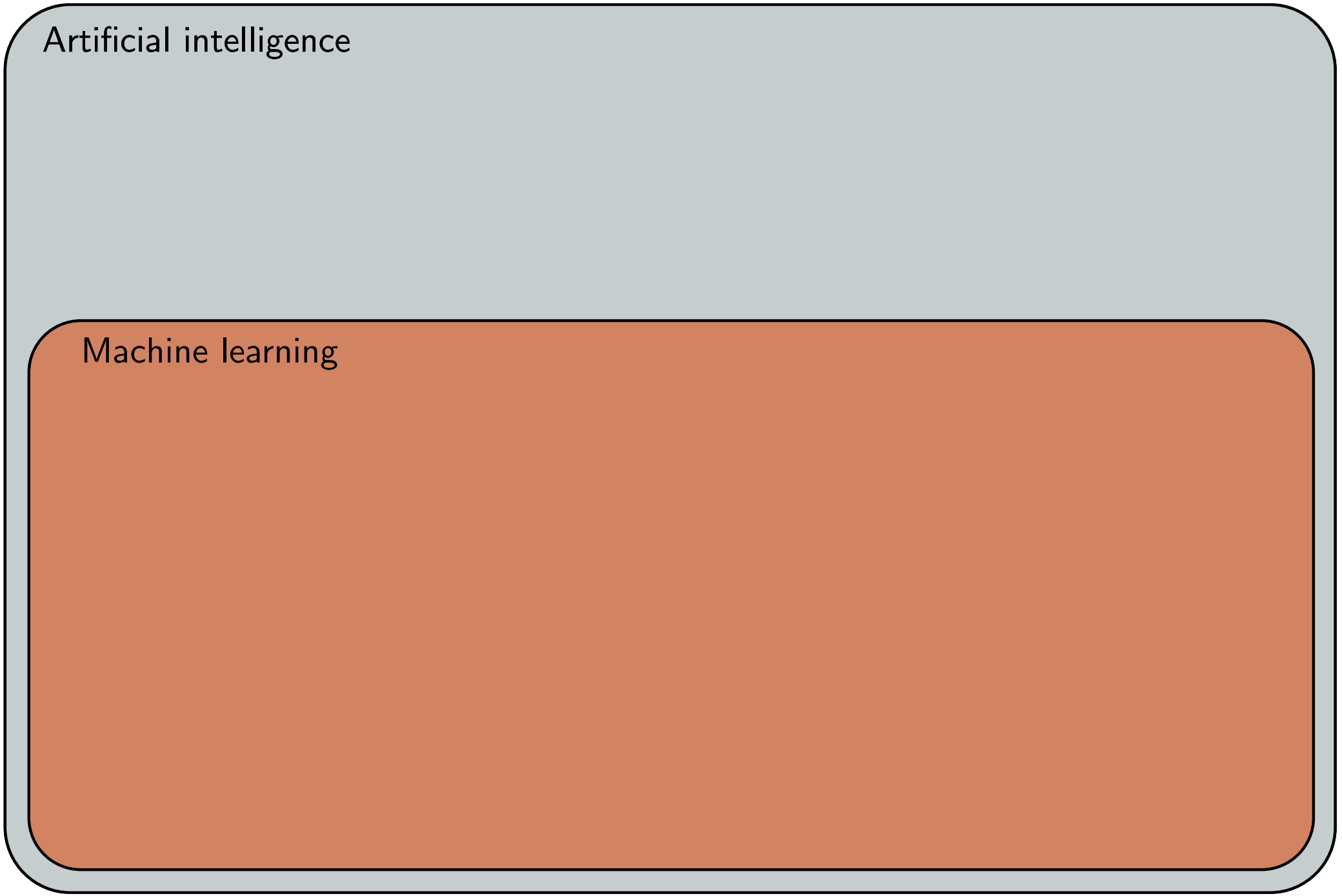
Rina Buoy

AMERICAN UNIVERSITY OF PHNOM PENH

STUDY LOCALLY. LIVE GLOBALLY.

Adopted & (curated) from : http://udlbook.com


Artificial intelligence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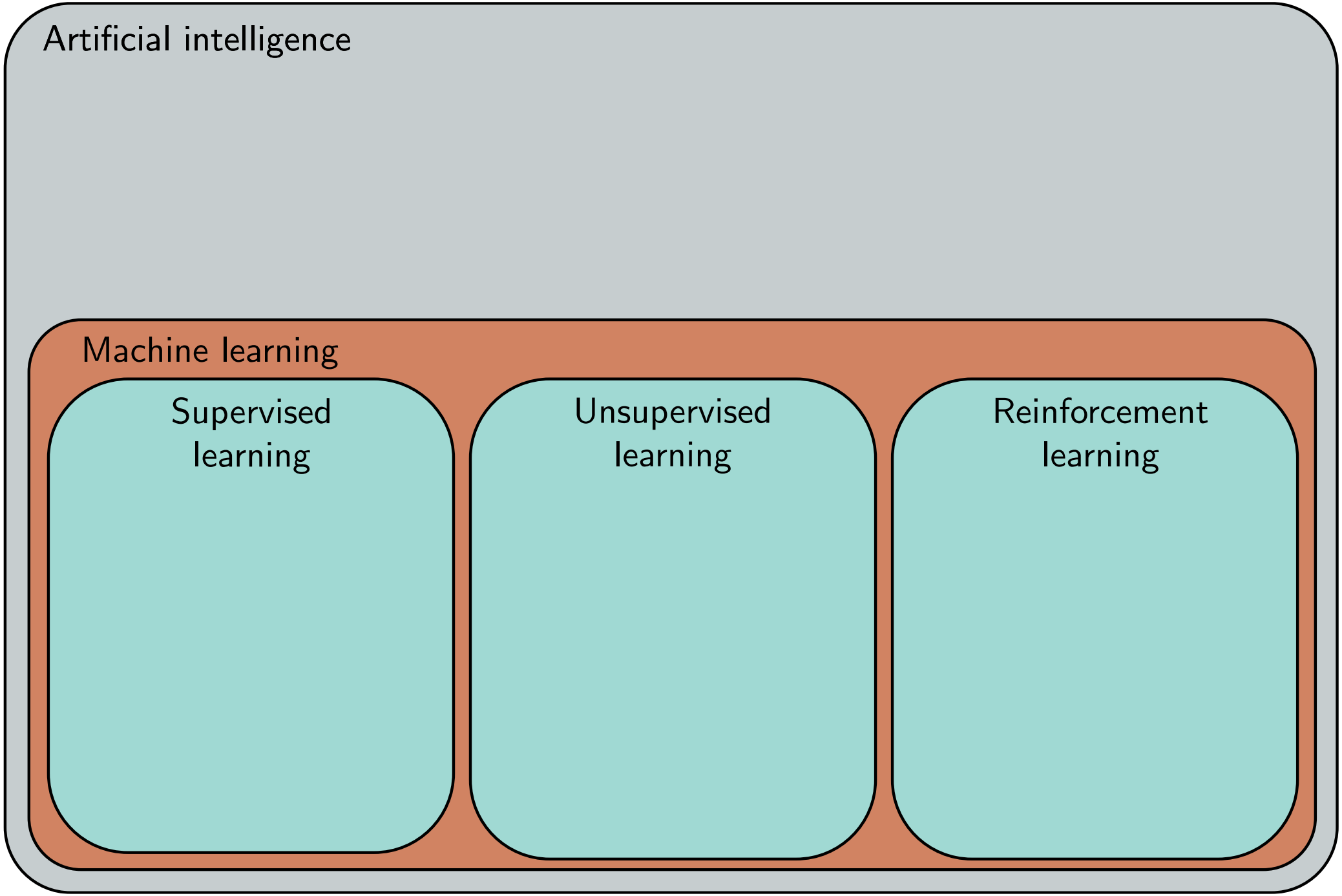
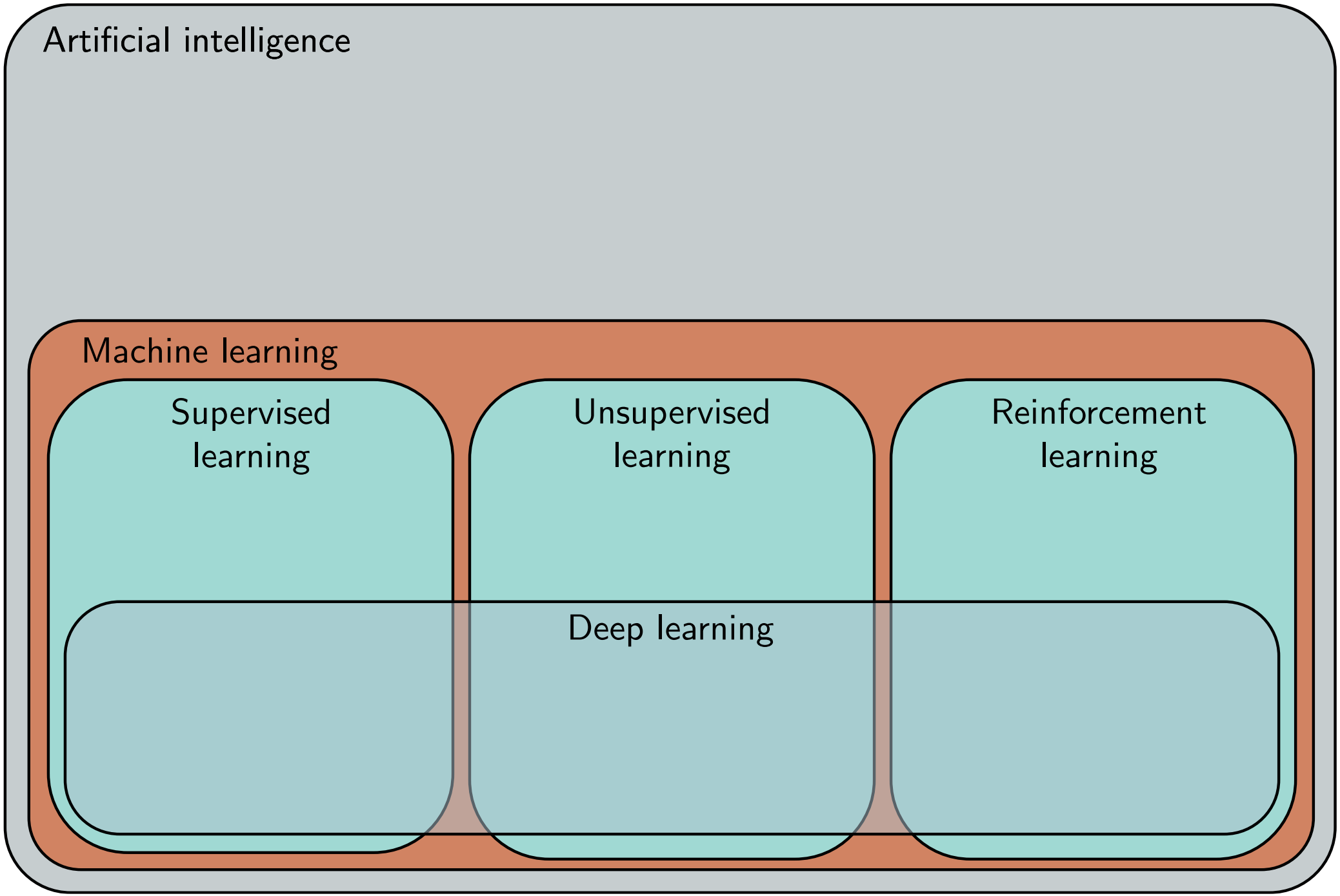
Machine learning


Artificial intelligence
Machine learning
Supervised learning
Unsupervised learning
Reinforcement learning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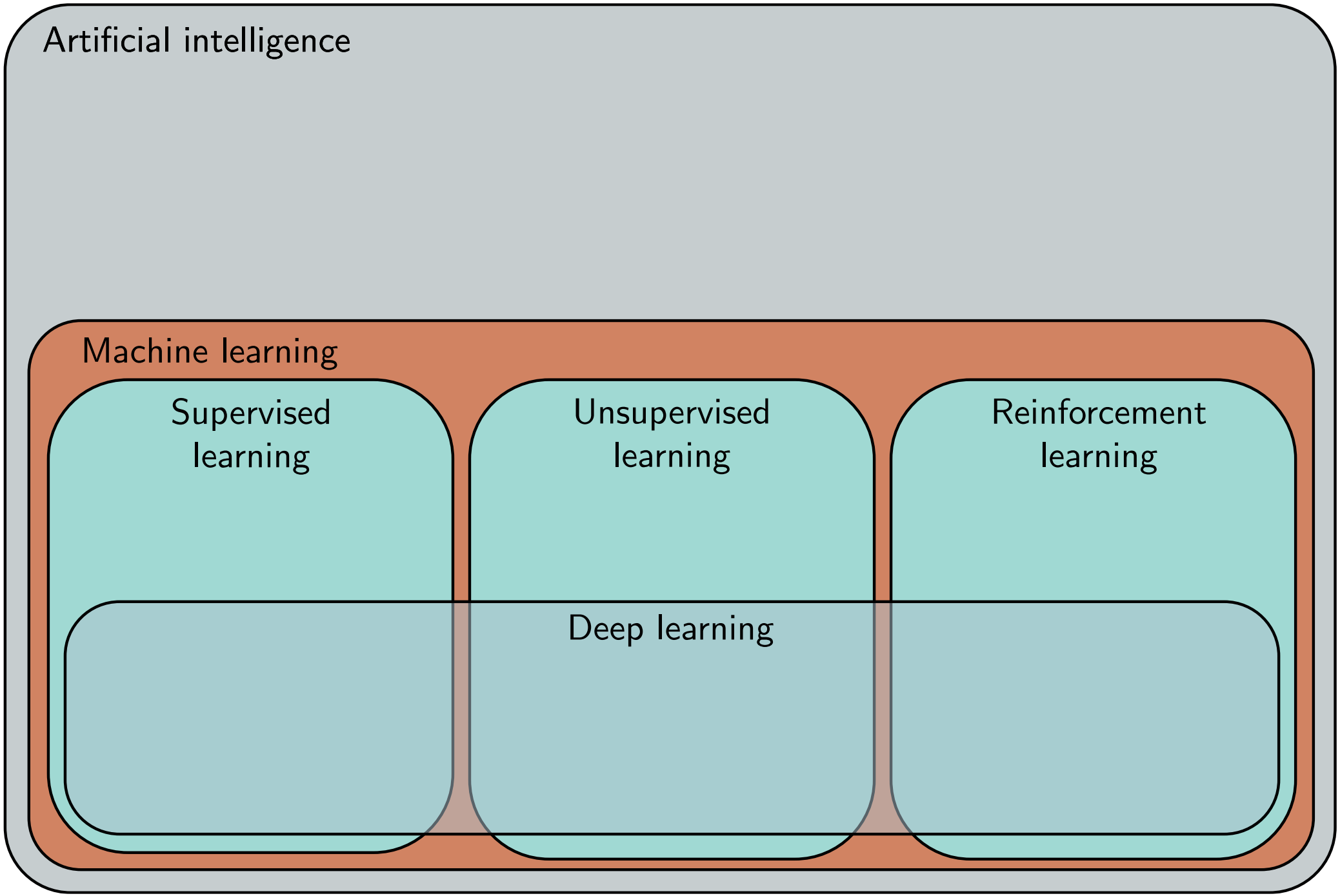
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Book

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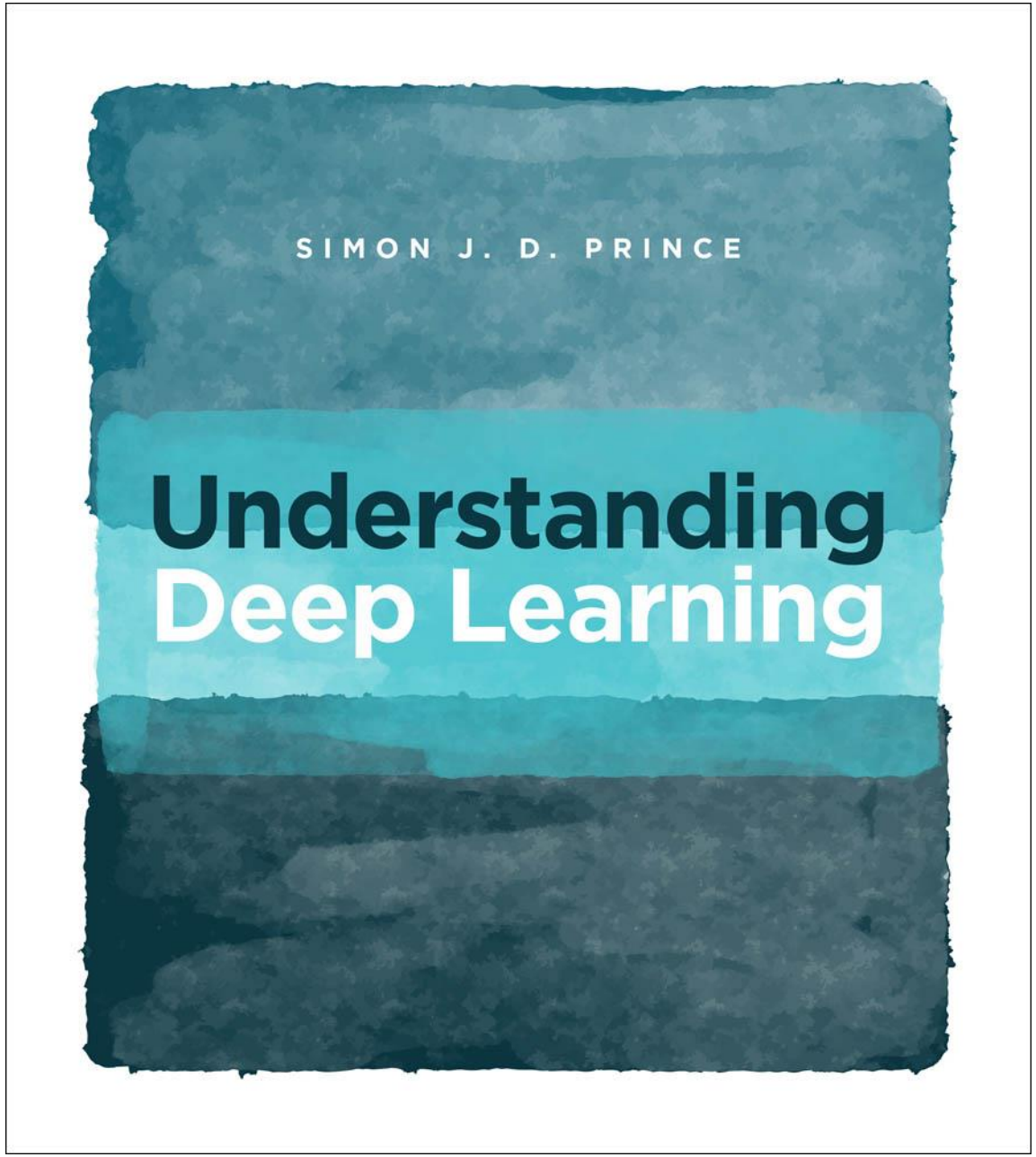

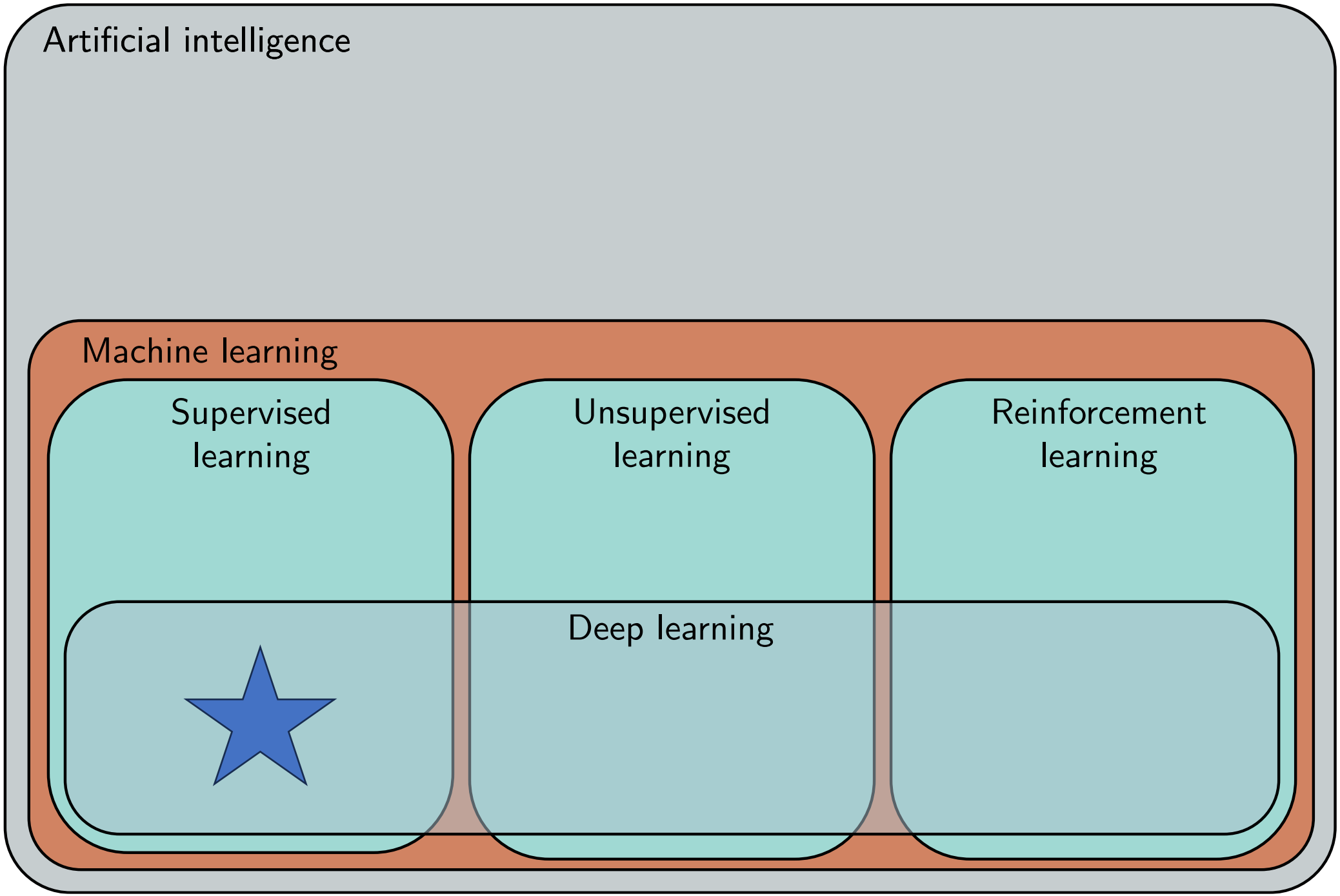
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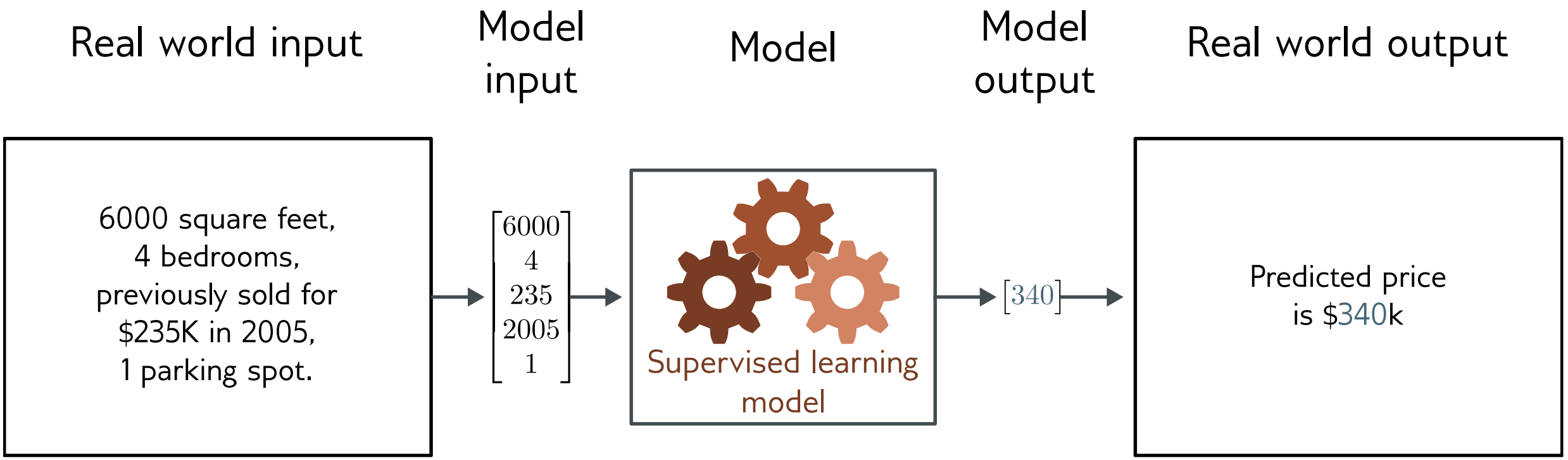
Supervised learning

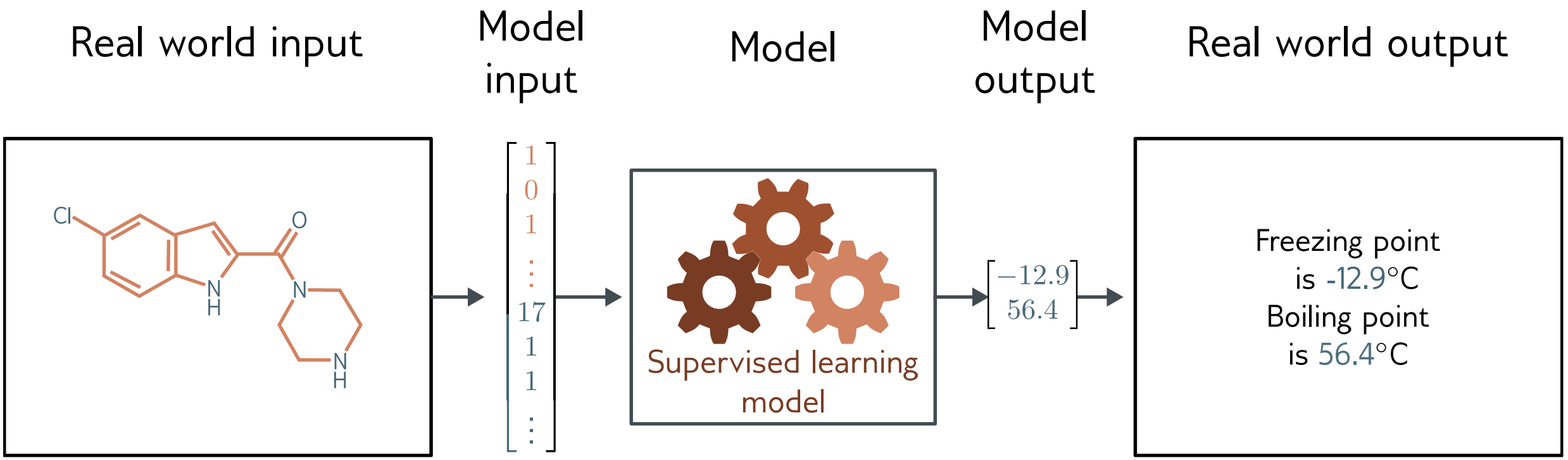
- Define a mapping from input to output
- Learn this mapping from paired input/output data examples

Regression



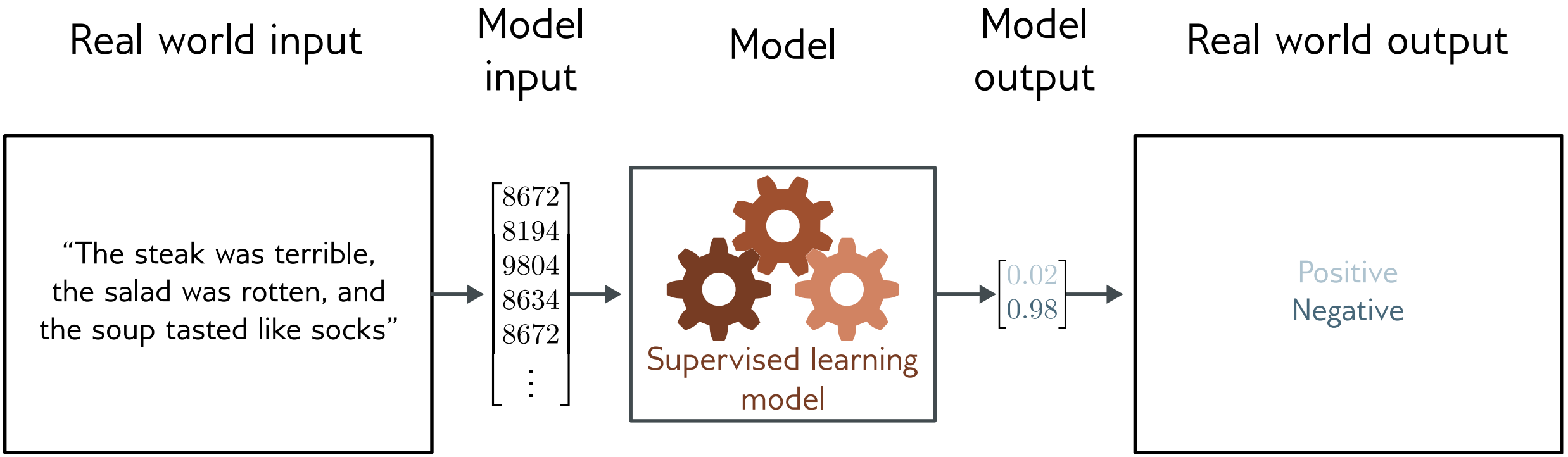
- Univariate regression problem (one output, real value)
- Fully connected network

Graph regression



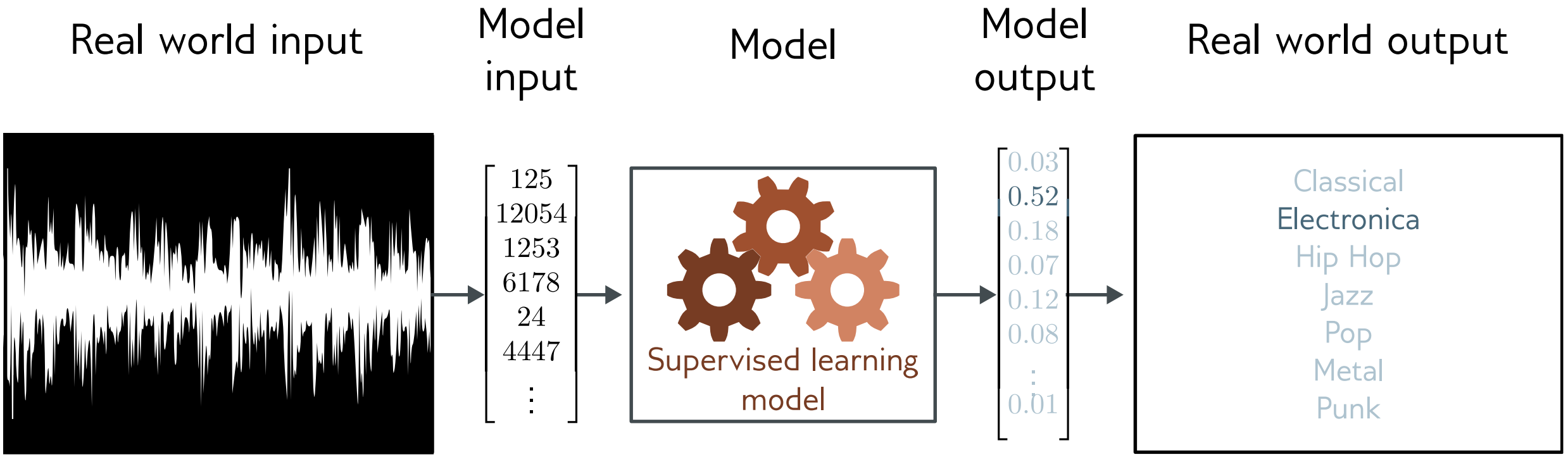
- Multivariate regression problem (>1 output, real value)
- Graph neural network

Text classification



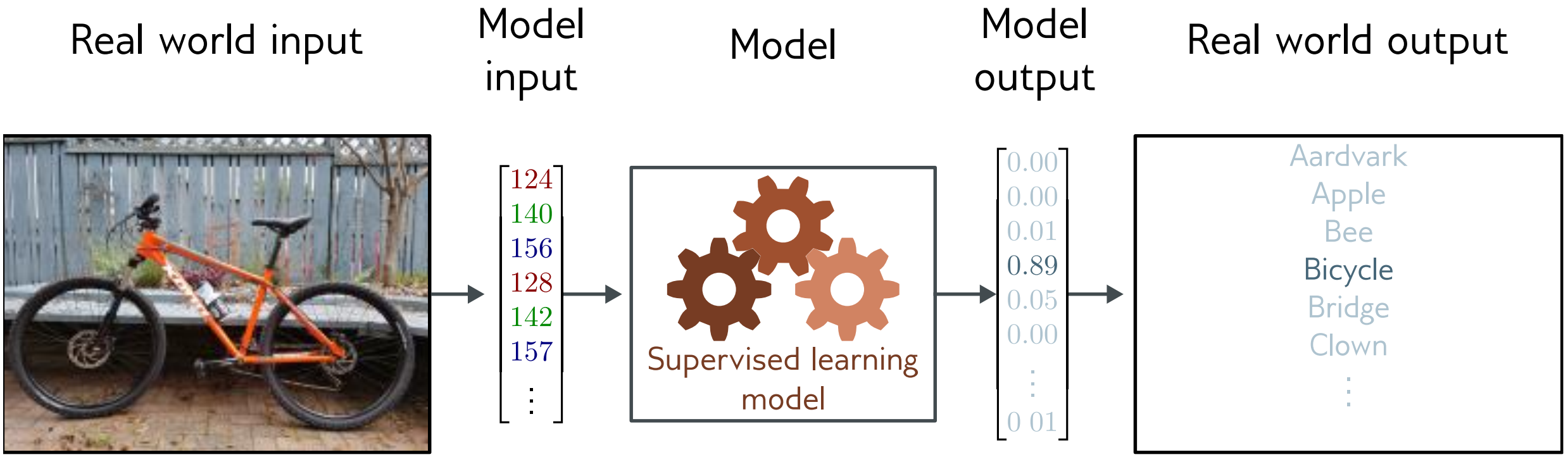
- Binary classification problem (two discrete classes)
- Transformer network

Music genre classification



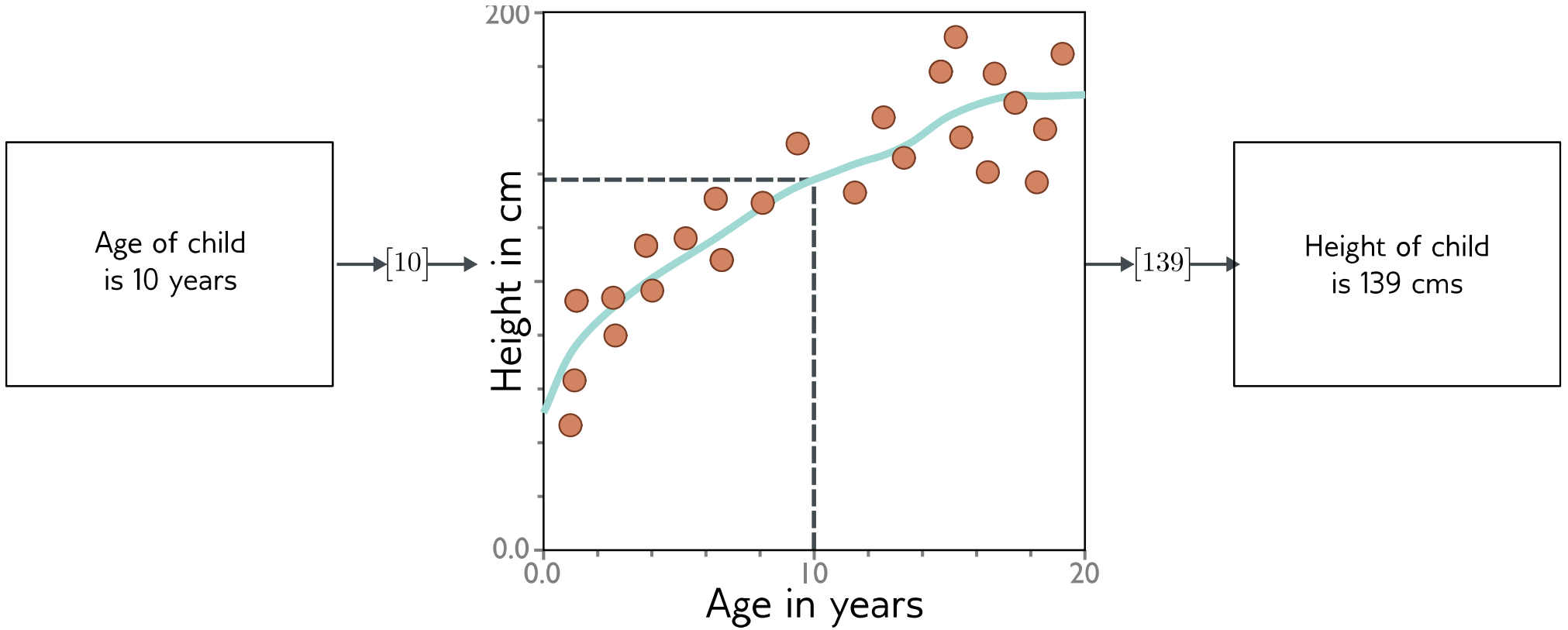
- Multiclass classification problem (discrete classes, >2 possible values)
- Recurrent neural network (RNN)

Image classification



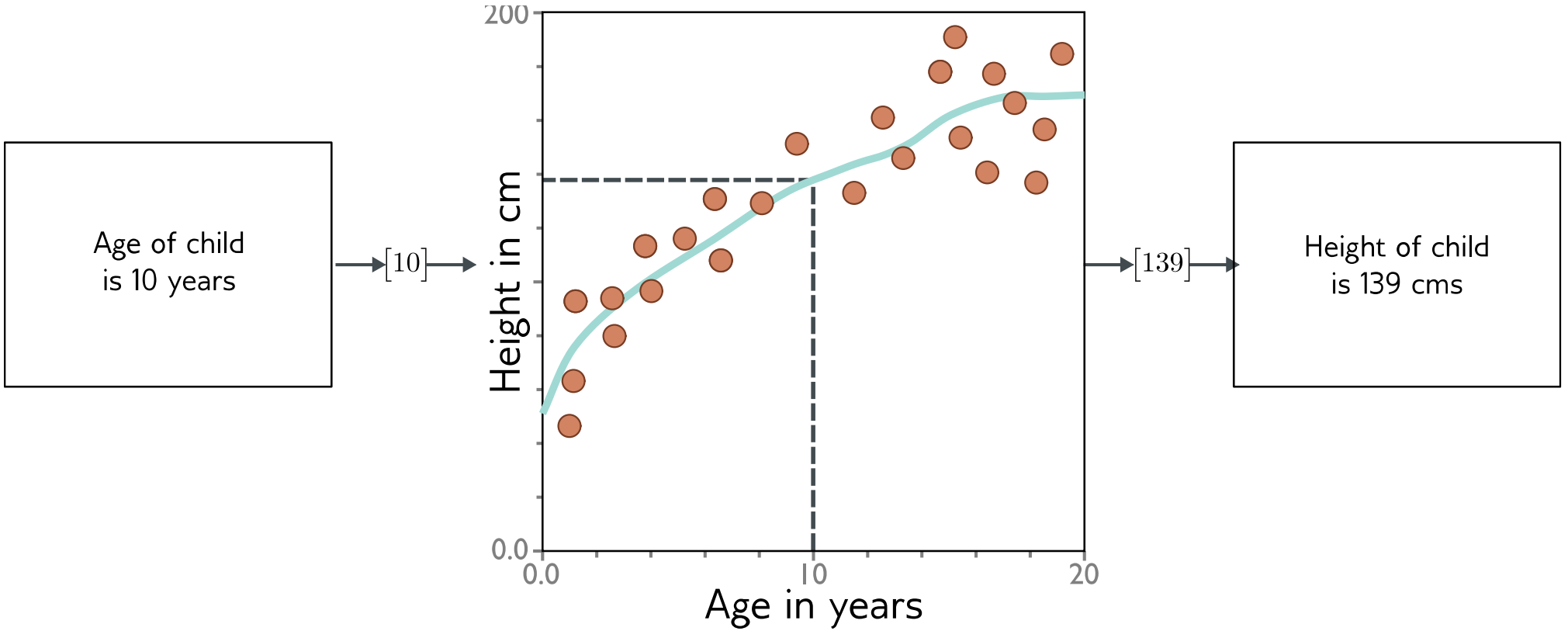
- Multiclass classification problem (discrete classes, >2 possible classes)
- Convolutional network

What is a supervised learning model?



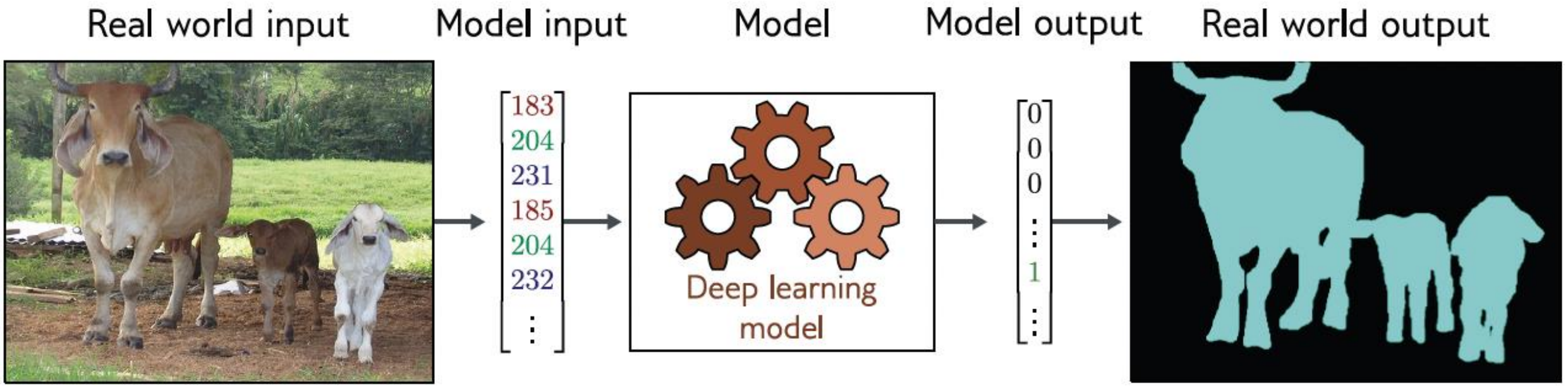
- An equation relating input (age) to output (height)
- Search through family of possible equations to find one that fits training data well

What is a supervised learning model?



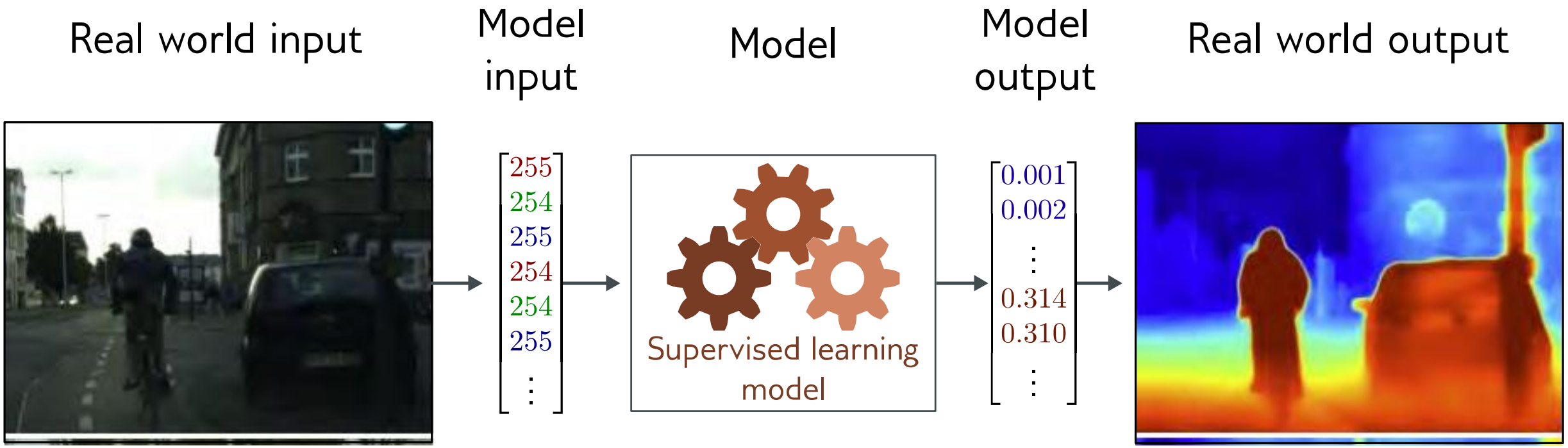
- Deep neural networks are just a very flexible family of equations
- Fitting deep neural networks = “Deep Learning”

Image segmentation



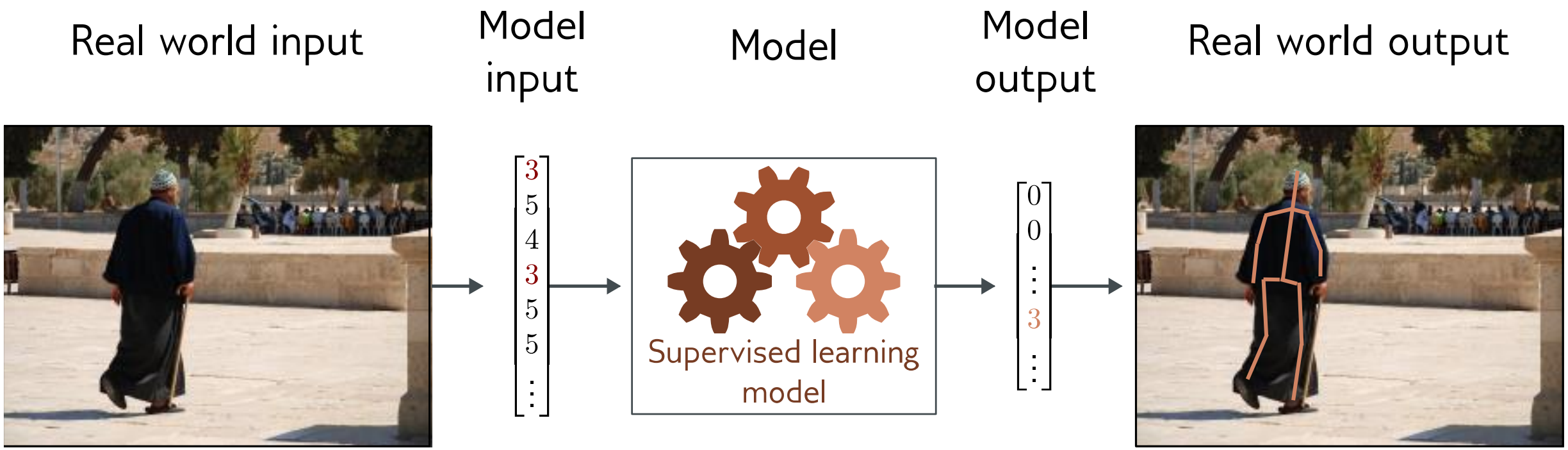
- Multivariate binary classification problem (many outputs, two discrete classes)
- Convolutional encoder-decoder network

Depth estimation



- Multivariate regression problem (many outputs, continuous)
- Convolutional encoder-decoder network

Pose estimation



- Multivariate regression problem (many outputs, continuous)
- Convolutional encoder-decoder network

Terms

- Regression = continuous numbers as output
- Classification = discrete classes as output
- Two class and multiclass classification treated differently
- Univariate = one output
- Multivariate = more than one output

Translation

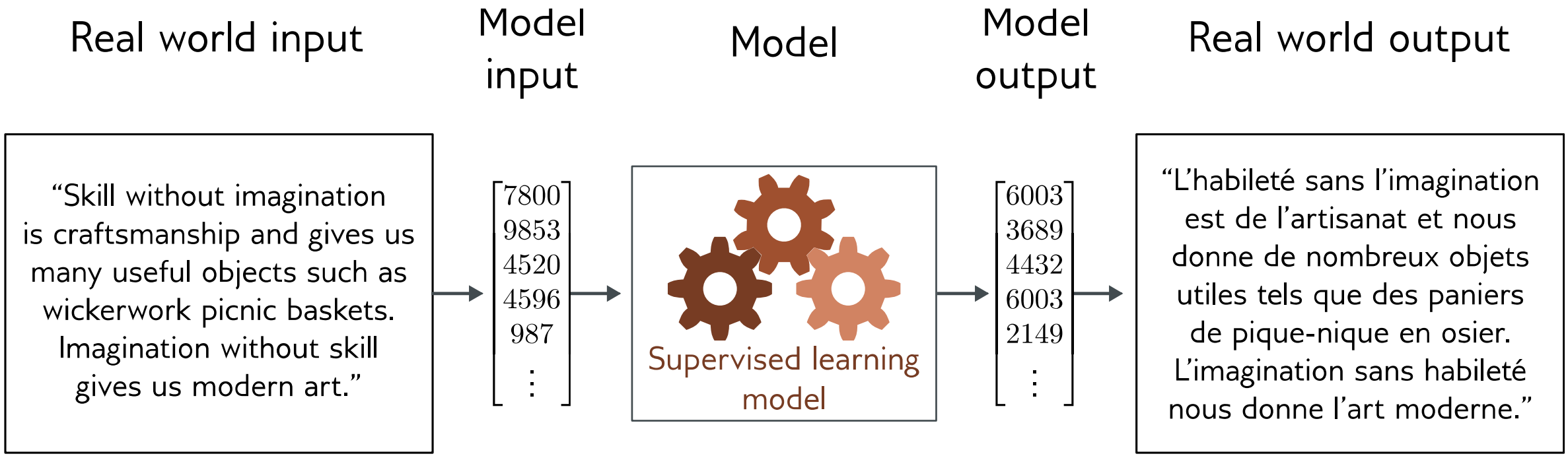


Image captioning

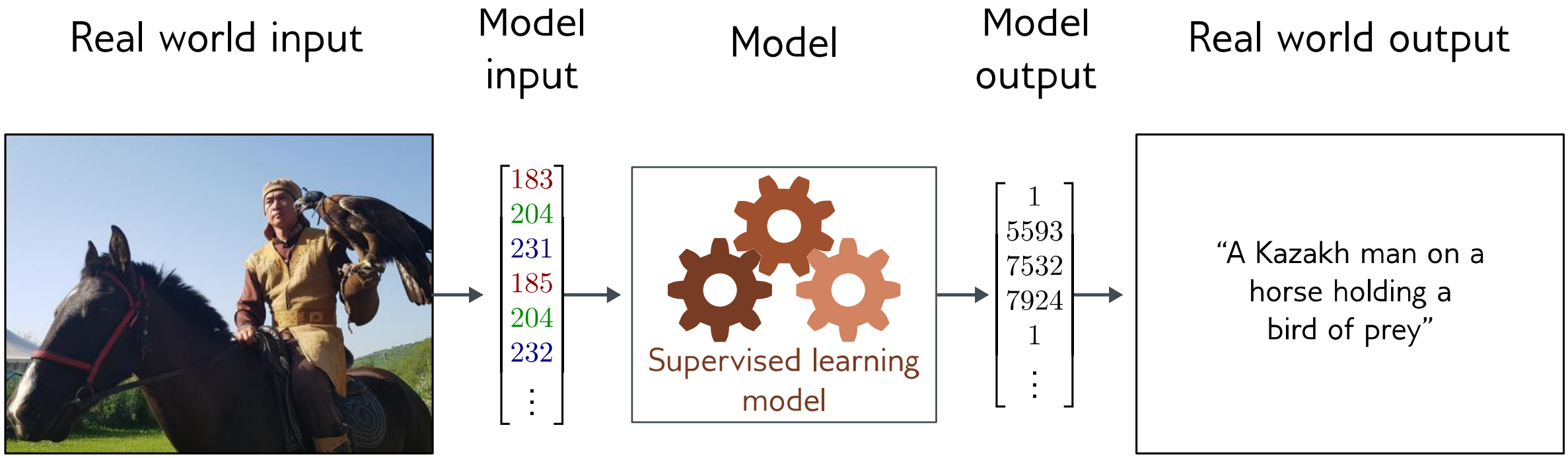
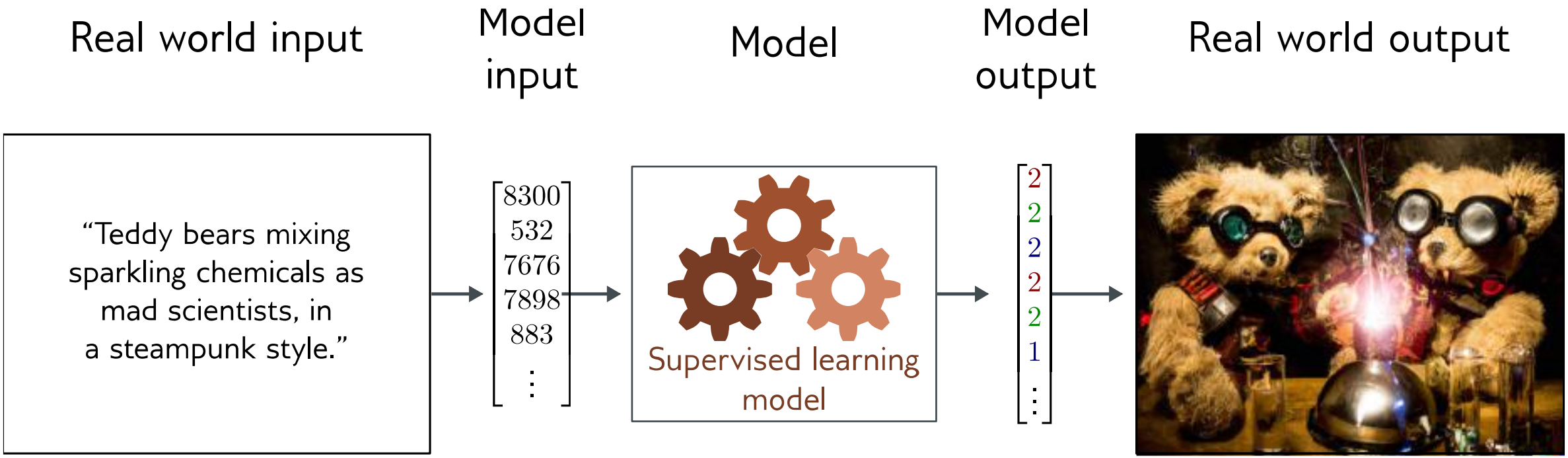


Image generation from text



What do these examples have in common?

- Very complex relationship between input and output
- Sometimes may be many possible valid answers
- But outputs (and sometimes inputs) obey rules

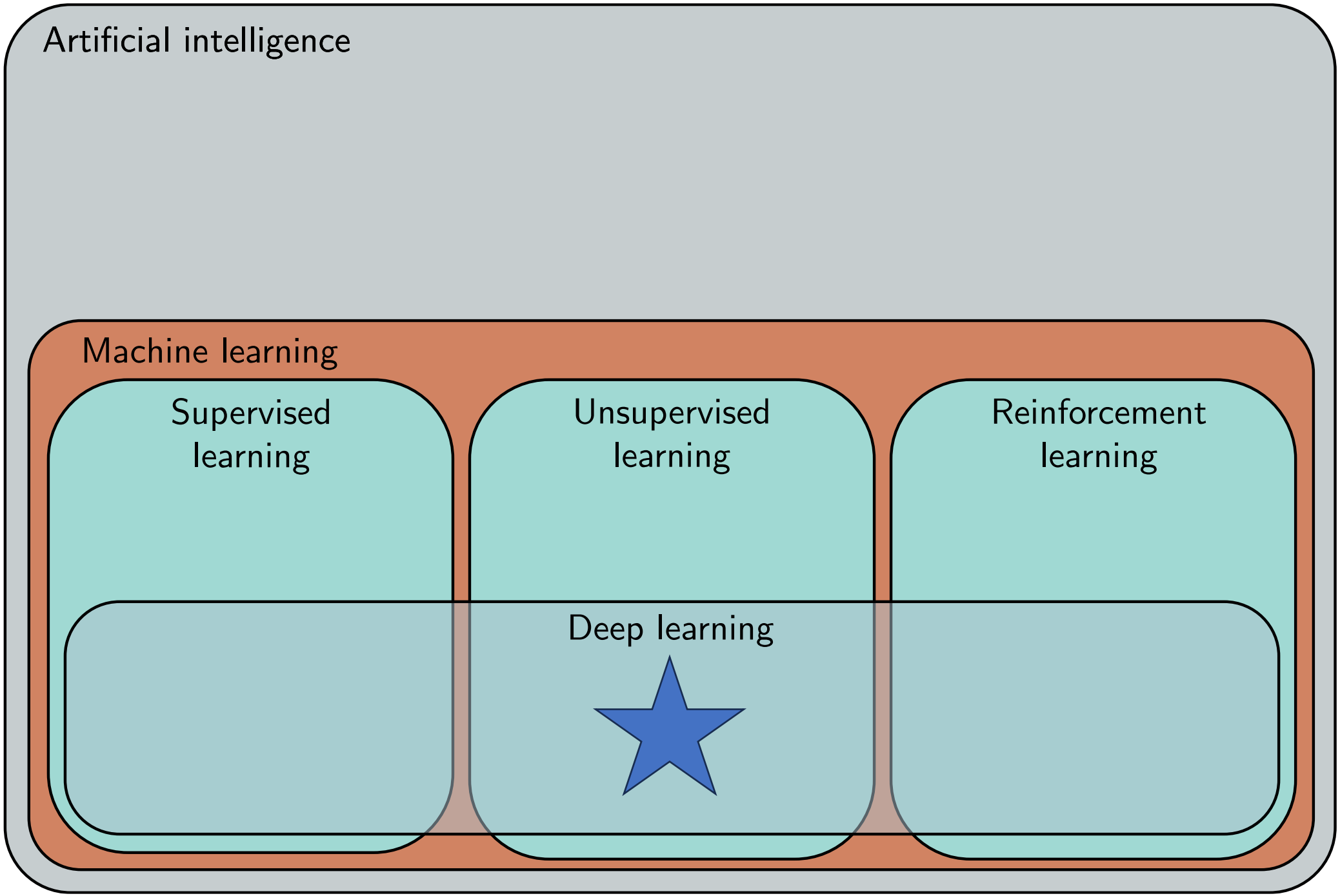
"A Kazakh man on a horse holding a bird of prey"

Language obeys grammatical rules

Natural images also have "rules"

Idea

- Learn the “grammar” of the data from unlabeled examples
- Can use a gargantuan amount of data to do this (as unlabeled)
- Make the supervised learning task earlier by having a lot of knowledge of possible outputs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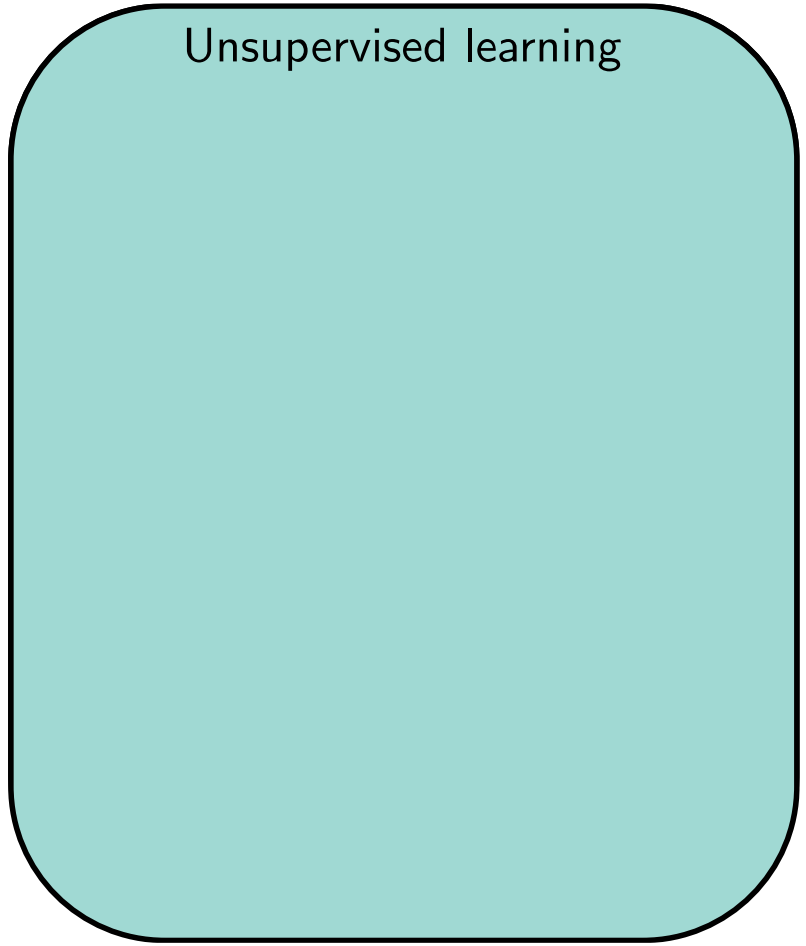
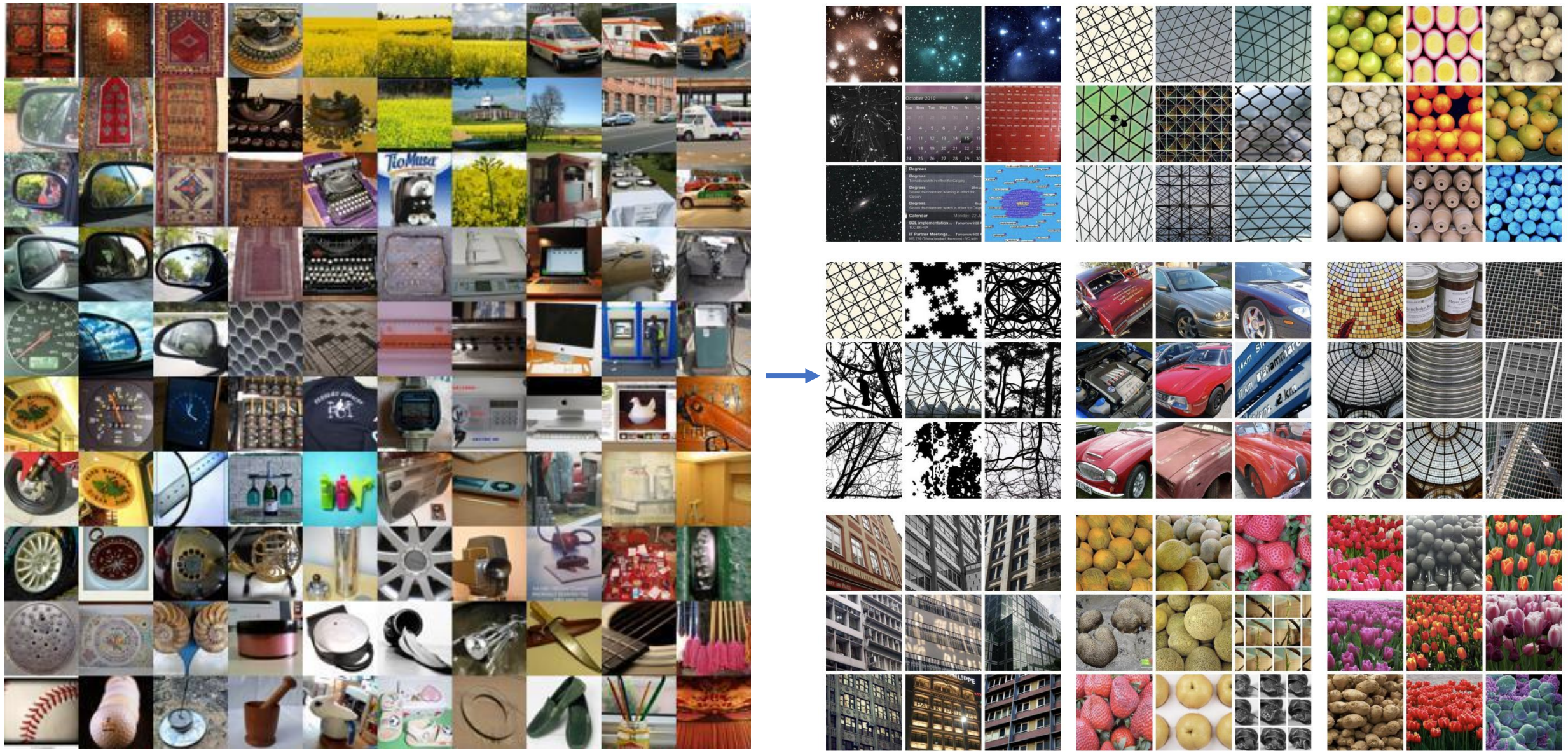
Unsupervised Learning

- Learning about a dataset without labels
  - Clustering
  - Finding outliers
  - Generating new examples
  - Filling in missing data



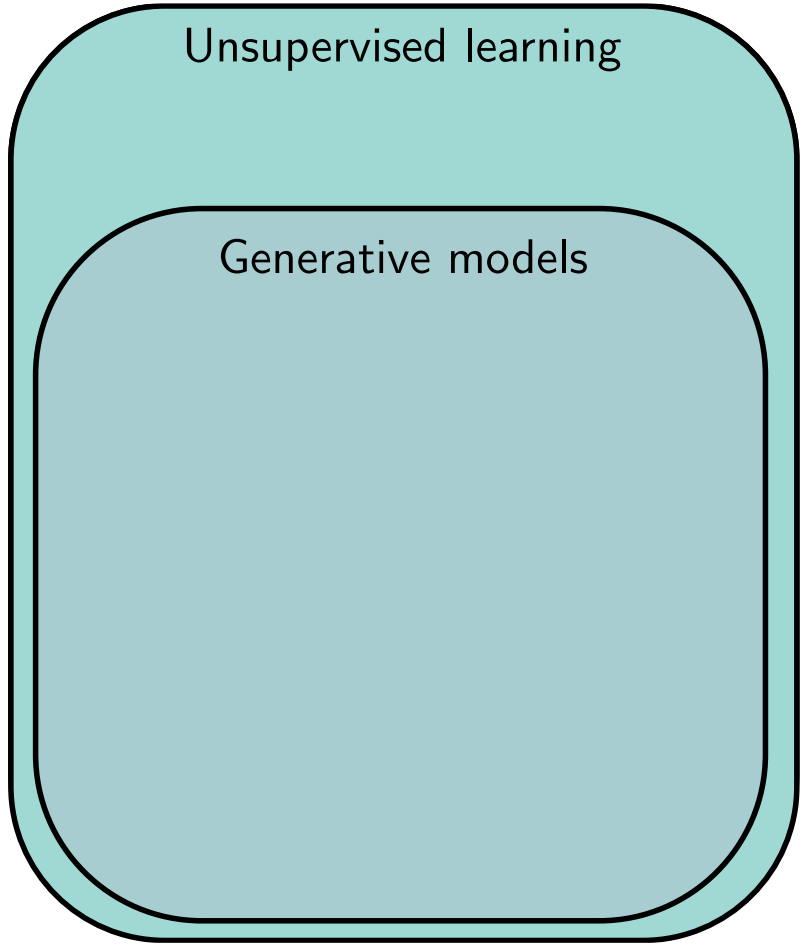
DeepCluster: Deep Clustering for Unsupervised Learning of Visual Features (Caron et al., 2018)



DeepCluster: Deep Clustering for Unsupervised Learning of Visual Features (Caron et al., 2018)

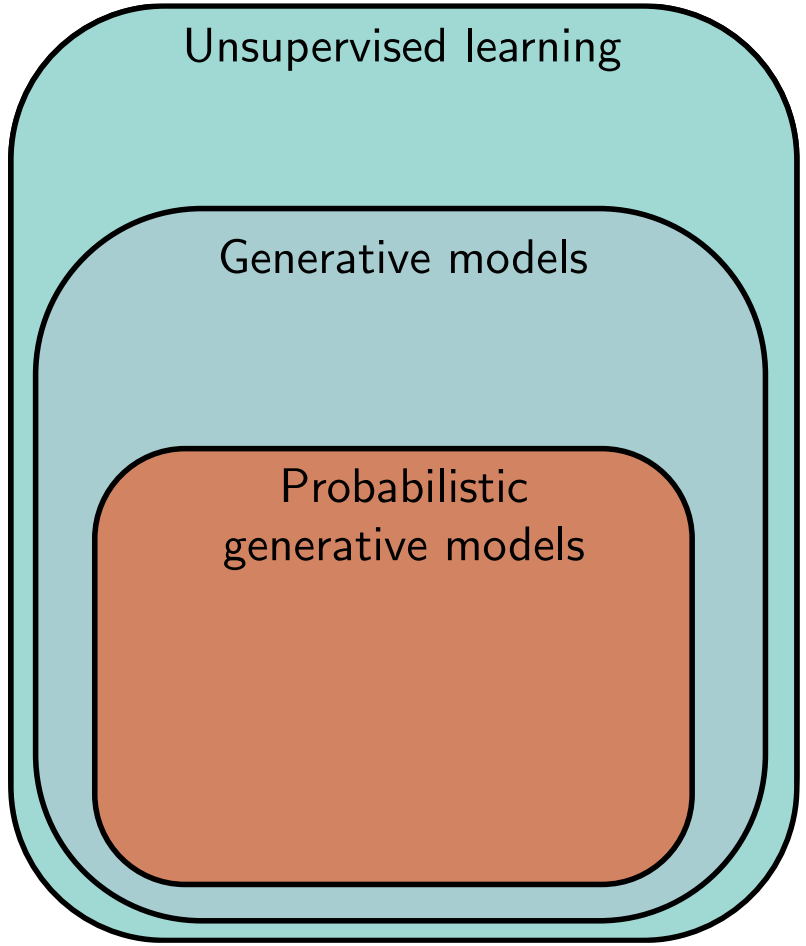
Unsupervised Learning

- Learning about a dataset without labels
  - e.g., clustering
- Generative models can create examples
  - e.g., generative adversarial networks



Unsupervised Learning

- Learning about a dataset without labels
  - e.g., clustering
- Generative models can create examples
  - e.g., generative adversarial networks
- PGMs learn distribution over data
  - e.g., variational autoencoders,
  - e.g., normalizing flows,
  - e.g., diffusion models



Generative models


National Geographic
Domestic cat


Wikipedia
Cat - Wikipedia


The Guardian
pet guru Yuki Hattori explain | ...


Britannica
Cat | Breeds & Facts | Britannica


The Spruce Pets
Tabby Cat: Breed Profile ...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Wikipedia
Cat intelligence - Wikipedia

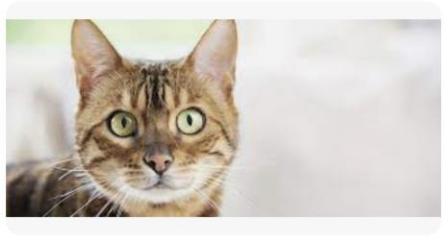

Smithsonian Magazine
Cats React to 'Baby Talk' From Their ...


Alley Cat Allies
The Natural History of Domestic Cats ...


The New York Times
How the Cat Gets Its Stripe...


Country Living Magazine
Friendliest Cat Breeds Tha...


Freepik
Cat Images - Free D...


BBC Science Focus
What's the longest a cat can live for ...


National Geographic
Domestic cat


DK Find Out!
Cat Facts for Kids | What is a Cat | DK ...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A Cat's Personality - FOUR PAWS ...


The Guardian
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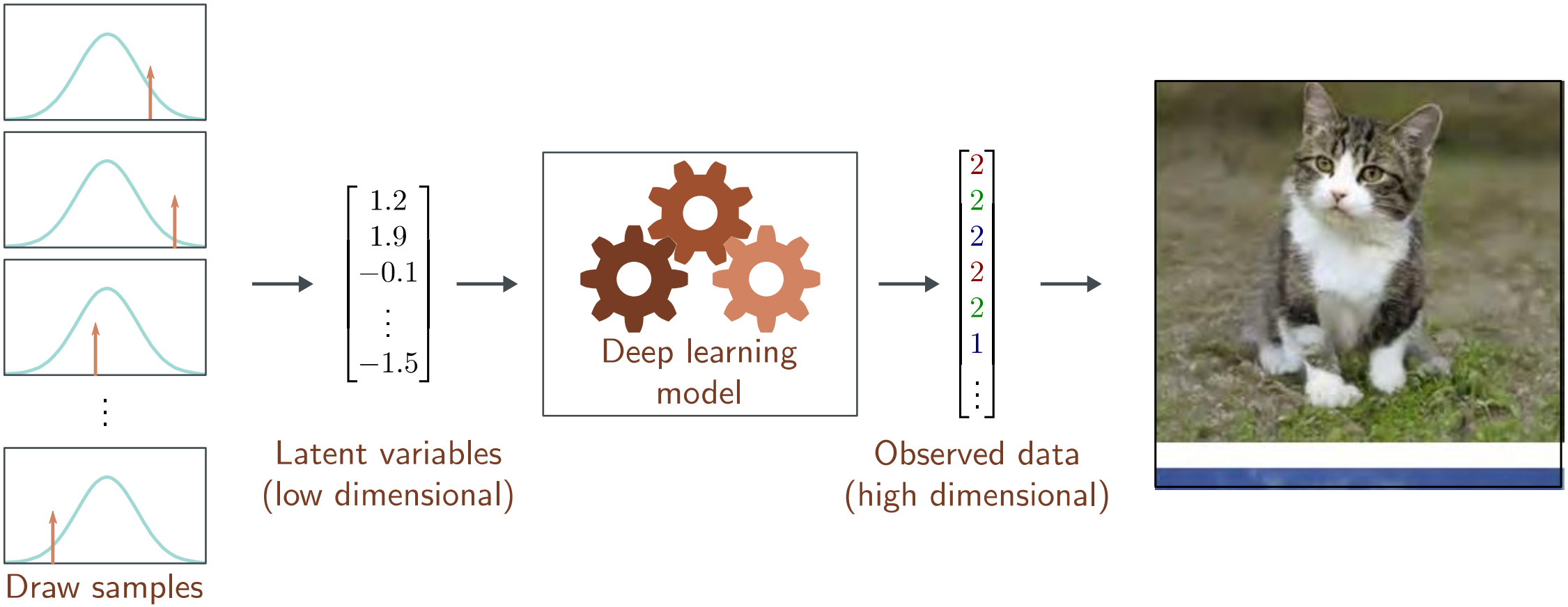
Generative models

Latent variables



Why should this work?

Interpolation

Conditional synthesis

I was a little nervous before my first lecture at the University of Bath. It seemed like there were hundreds of students and they looked intimidating. I stepped up to the lectern and was about to speak, when something bizarre happened.

Suddenly, the room was filled with a deafening noise, like a giant roar. It was so loud that I couldn't hear anything else and I had to cover my ears. I could see the students looking around, confused and frightened. Then, as quickly as it had started, the noise stopped and the room was silent again.

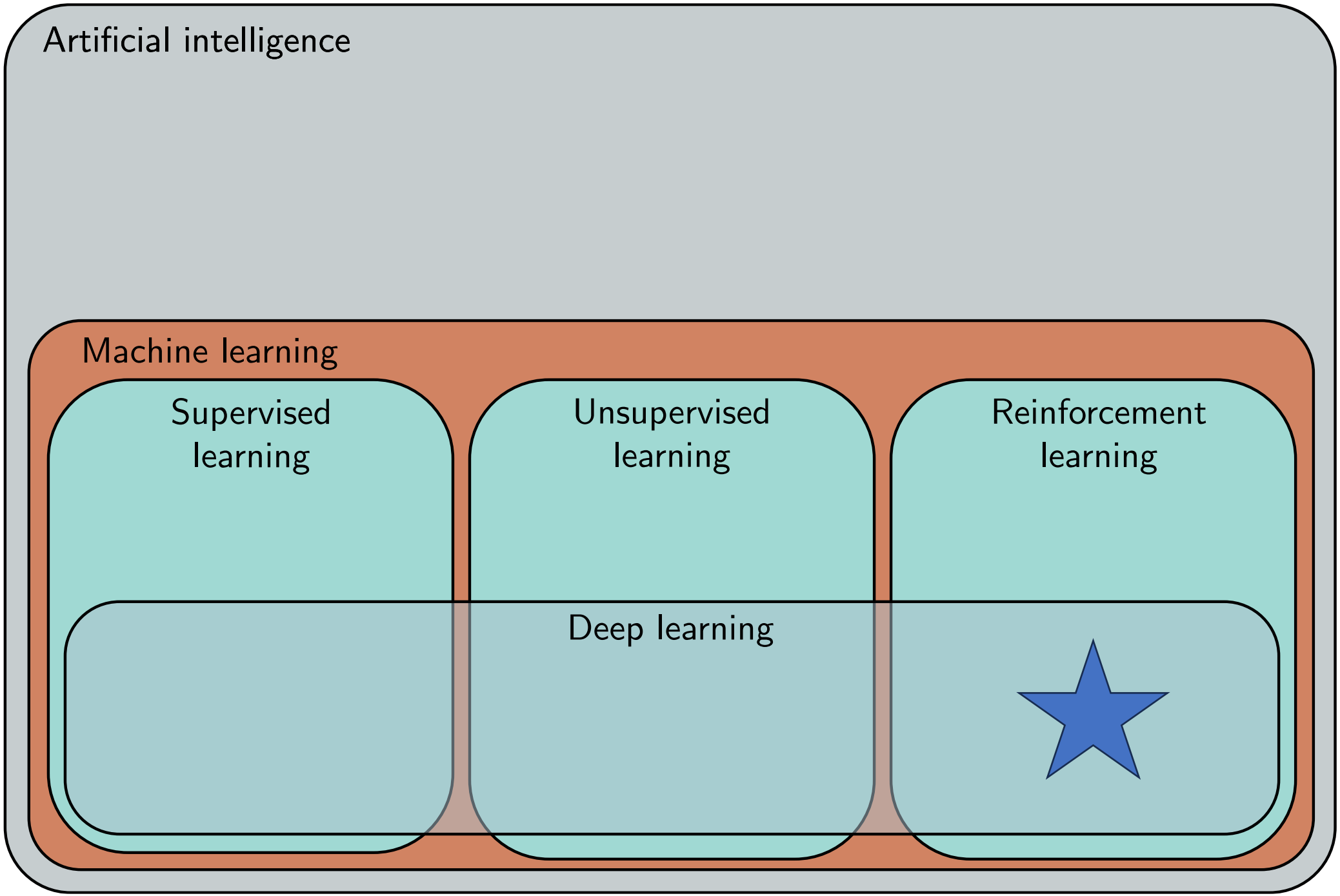
I stood there for a few moments, trying to make sense of what had just happened. Then I realized that the students were all staring at me, waiting for me to say something. I tried to think of something witty or clever to say, but my mind was blank. So I just said, "Well, that was strange," and then I started my lecture.

I was a little nervous before my first lecture at the University of Bath. It seemed like there were hundreds of students and they looked intimidating. I stepped up to the lectern and was about to speak, when something bizarre happened.

Suddenly, a giant rabbit ran into the lecture hall! The students started screaming and running around in panic. I was so shocked that I couldn't move. The rabbit ran up to me and hopped onto the lectern. Then, in a booming voice, it said:

"I am the Easter Bunny! I have come to give you all a special gift!"

The students were so surprised that they stopped screaming and listened to the Easter Bunny. Then, the Easter Bunny started handing out chocolate eggs to everyone in the lecture hall. The students were so happy that they started cheering and clapping. I was so relieved that the Easter Bunny had saved my lecture! After that, I was able to continue and the students paid attention for the rest of the hour. It was a great success!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Reinforcement learning

- A set of states
- A set of actions
- A set of rewards

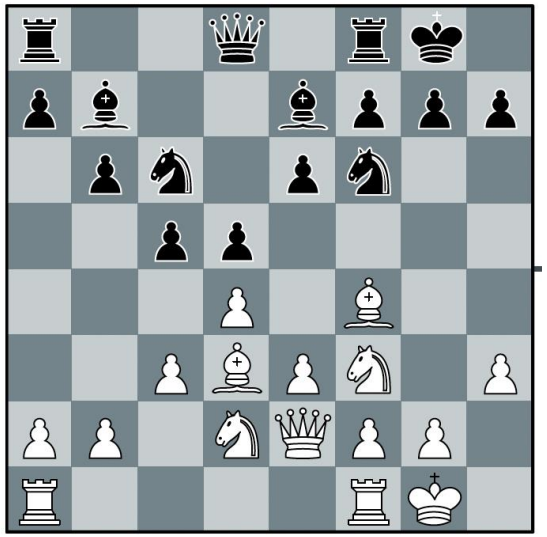
- Goal: take actions to change the state so that you receive rewards

- You don’t receive any data – you have to explore the environment yourself to gather data as you go

Example: chess

- States are valid states of the chess board
- Actions at a given time are valid possible moves
- Positive rewards for taking pieces, negative rewards for losing them

State



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Action

e4
Ne5
dxc5
b3
Kf2
Bc7
⋮
f4

Example: chess

- States are valid states of the chess board
- Actions at a given time are valid possible moves
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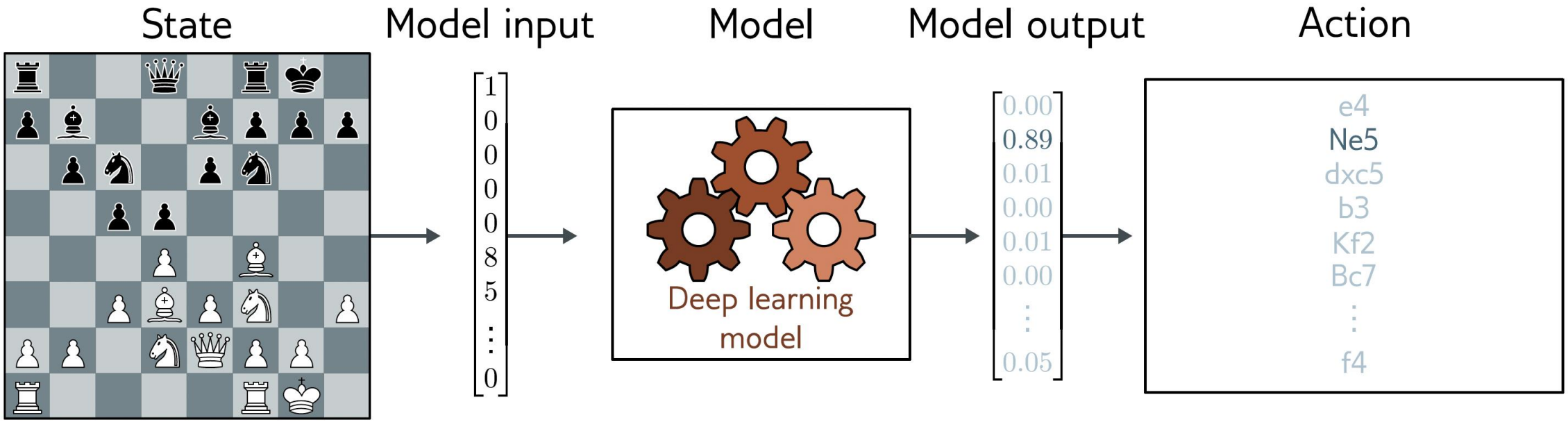

Why is this difficult?

- Stochastic
  - Make the same move twice, the opponent might not do the same thing
  - Rewards also stochastic (opponent does or doesn’t take your piece)
- Temporal credit assignment problem
  - Did we get the reward because of this move? Or because we made good tactical decisions somewhere in the past?
- Exploration-exploitation trade-off
  - If we found a good opening, should we use this?
  - Or should we try other things, hoping for something better?

Landmarks in Deep Learning

- 1958 Perceptron (Simple `neural' model)
- 1986 Backpropagation (Practical Deep Neural networks)
- 1989 Convolutional networks (Supervised learning)
- 2012 AlexNet Image classification (Supervised learning)
- 2014 Generative adversarial networks (Unsupervised learning)
- 2014 Deep Q-Learning -- Atari games (Reinforcement learning)
- 2016 AlphaGo (Reinforcement learning)
- 2017 Machine translation (Supervised learning)
- 2019 Language models ((Un)supervised learning)
- 2022 Dall-E2 Image synthesis from text prompts ((Un)supervised learning)
- 2022 ChatGPT ((Un)supervised learning)
- 2023 GPT4 Multimodal model ((Un)supervised learning)

2018 Turing award winners