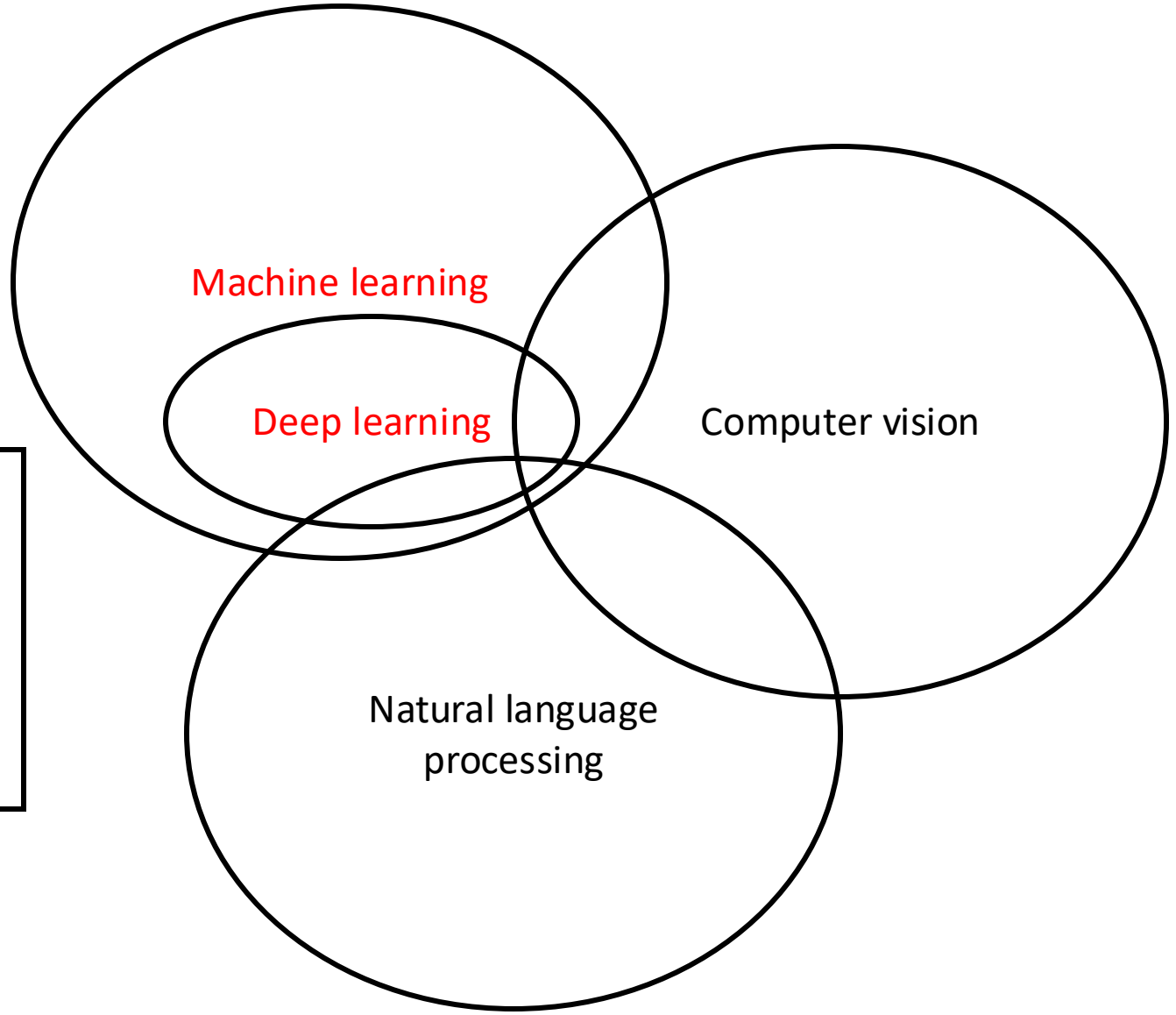
ML Basics

CPT_S 434/534 Neural network design and application

Course overview

Machine learning foundations
Deep learning foundations

Convolutional neural networks
Recurrent neural networks
Graph neural networks
Generative adversarial networks
Neural architecture search
……



Deep learning? What is learning?

What is in this picture?

Deep learning? What is learning?

Past data

Learning system

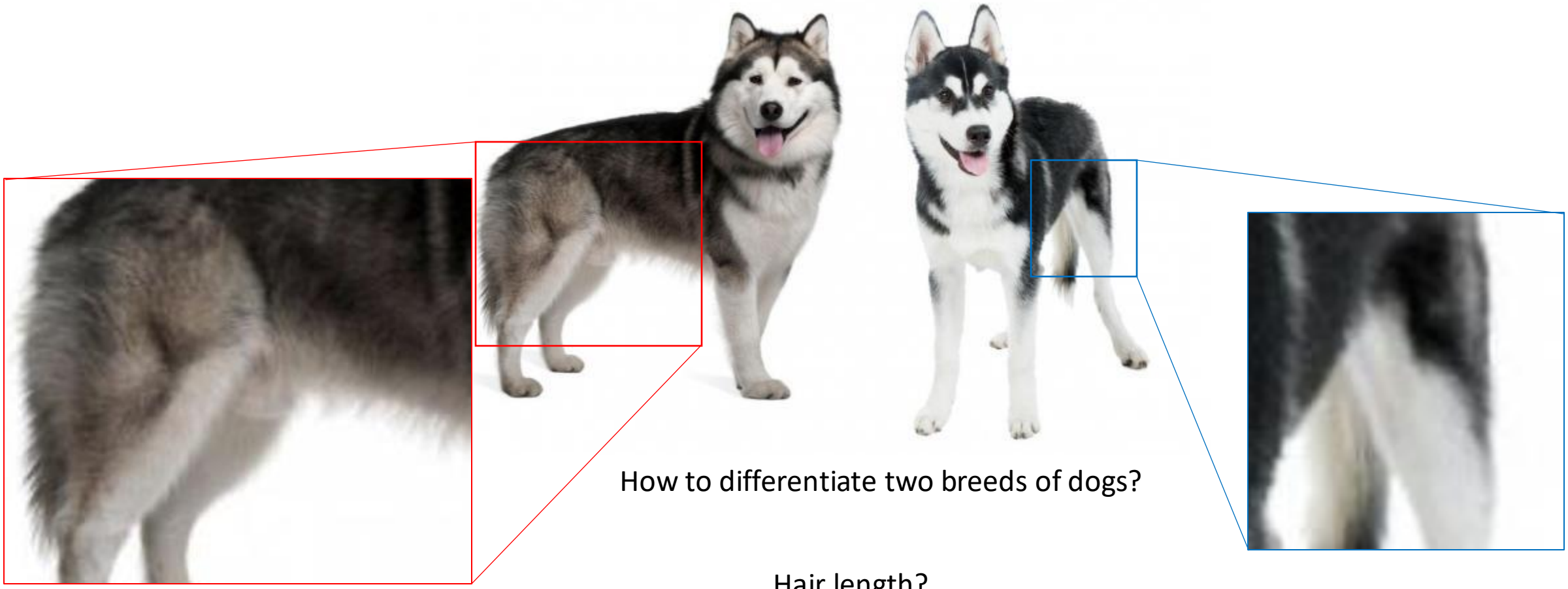
What is it?

Future data

Husky vs Malamute

How to differentiate two breeds of dogs?

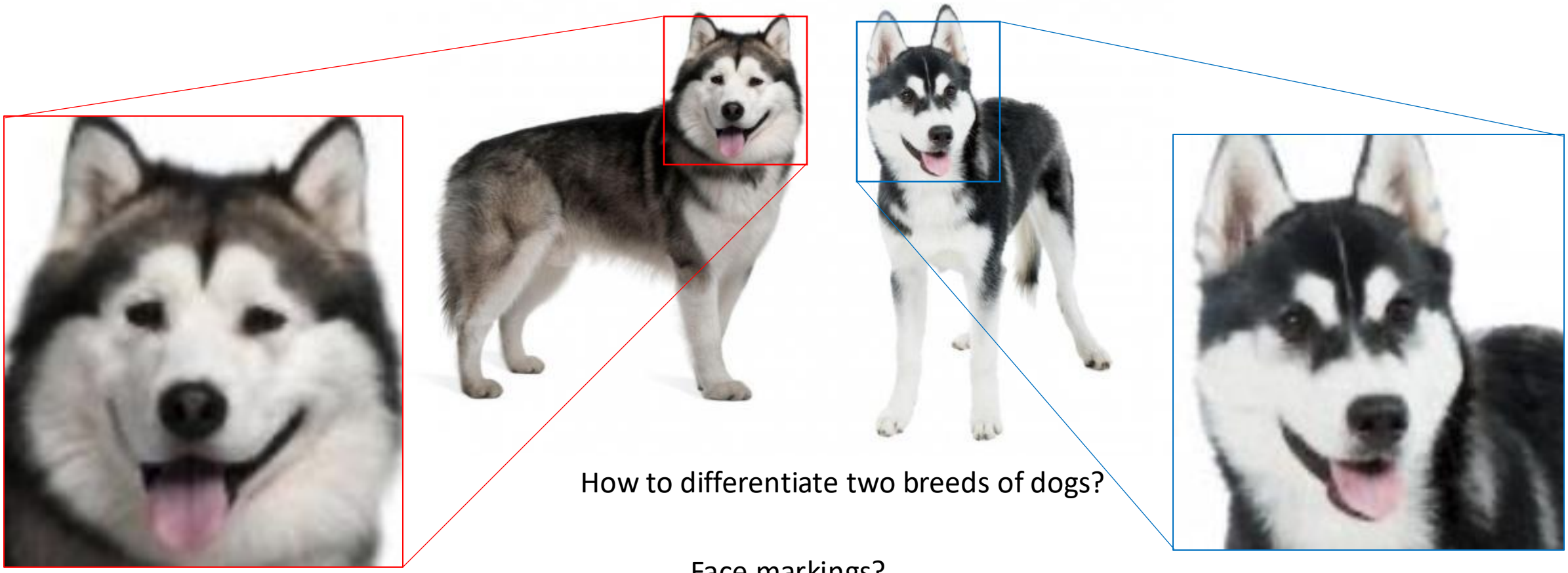
Husky vs Malamute



How to differentiate two breeds of dogs?

Hair length?

Husky vs Malamute



How to differentiate two breeds of dogs?

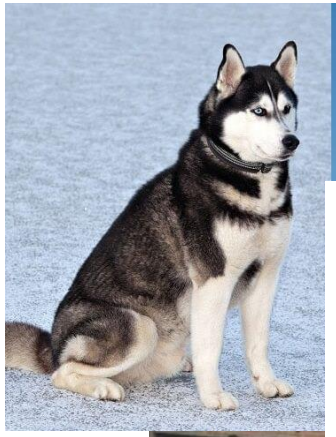
Face markings?

Husky vs Malamute

How to differentiate two breeds of dogs?

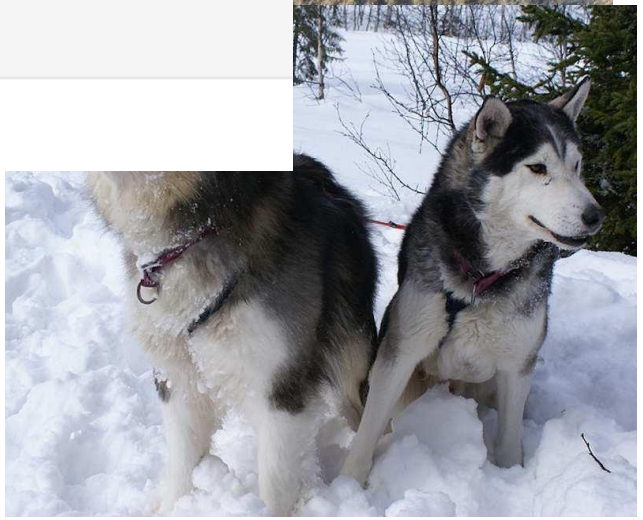
Size?

Husky vs Malamute



Alaskan Malamute vs Siberian Husky Comparison

	Alaskan Malamute	Siberian Husky
Size:	20-25 inches tall	20-22 inches tall
Weight:	85-100lbs	35-60lbs



How to differentiate two breeds of dogs?

Size?

Data from https://www.perfectdogbreeds.com/malamute-vs-husky/

Deep learning? What is learning?

Past data

Q: can we specify those key components?

Learning system

What is it?

Future data

Machine learning paradigm

Past data: features

Learning
model

Prediction on future data

Task: prediction/decision

(pre-defined setting)

Machine learning paradigm

Past data: features

Learning model

Prediction on future data

Task: prediction/decision

(pre-defined setting)

Q: How to choose/generate useful features?

Machine learning paradigm

Past data: features

Q: How to choose/generate useful features?

Learning model

Q: How to determine this model?

Prediction on future data

Task: prediction/decision

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Machine learning paradigm

Past data: features

Q: How to choose/generate useful features?

Learning model

Q: How to determine this model?

Prediction on future data

Task: prediction/decision

(pre-defined setting)

In practice:
We first inspect what TASK it is

Pre-defined problem settings (by task)

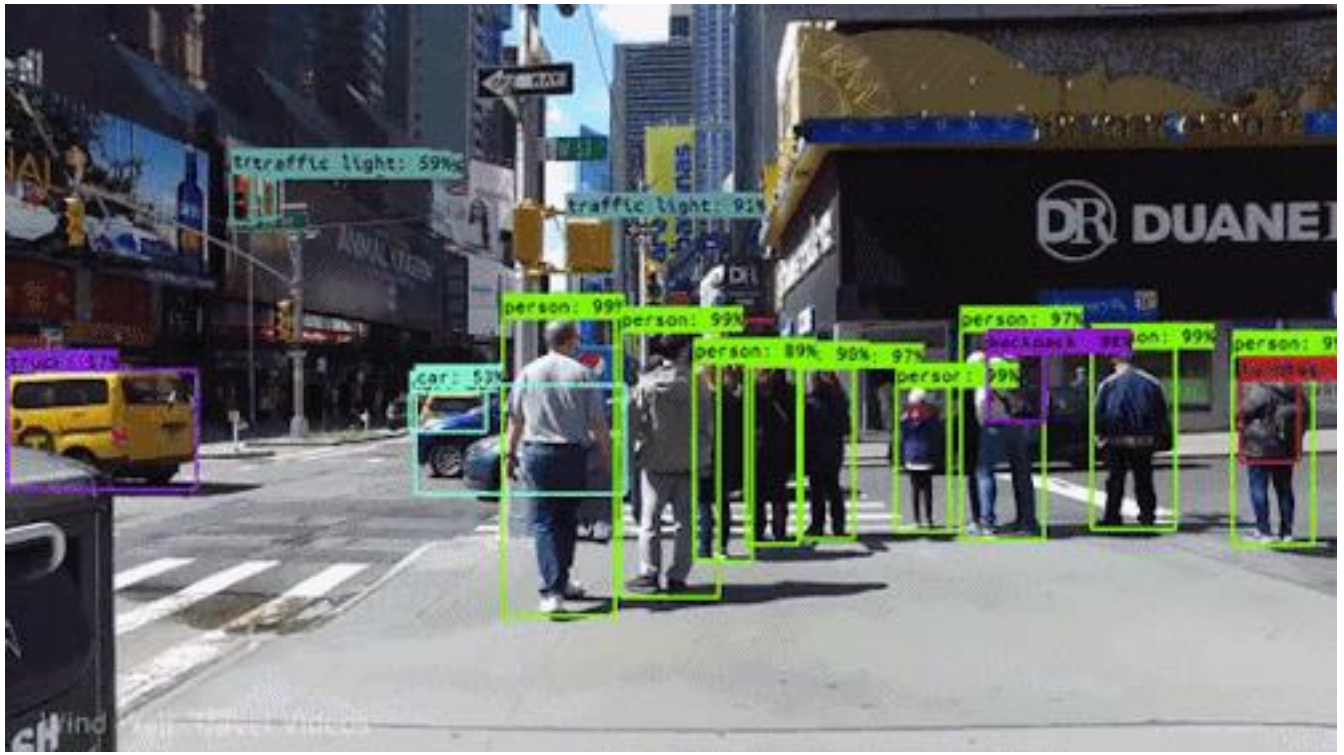
- Classification: traffic sign recognition

Learning model for traffic sign recognition

Q: How we can use recognition in practice?

Pre-defined problem settings (by task)

- Classification: traffic sign recognition



A use example: autonomous driving system

Pre-defined problem settings (by task)

- Classification: camera translate app

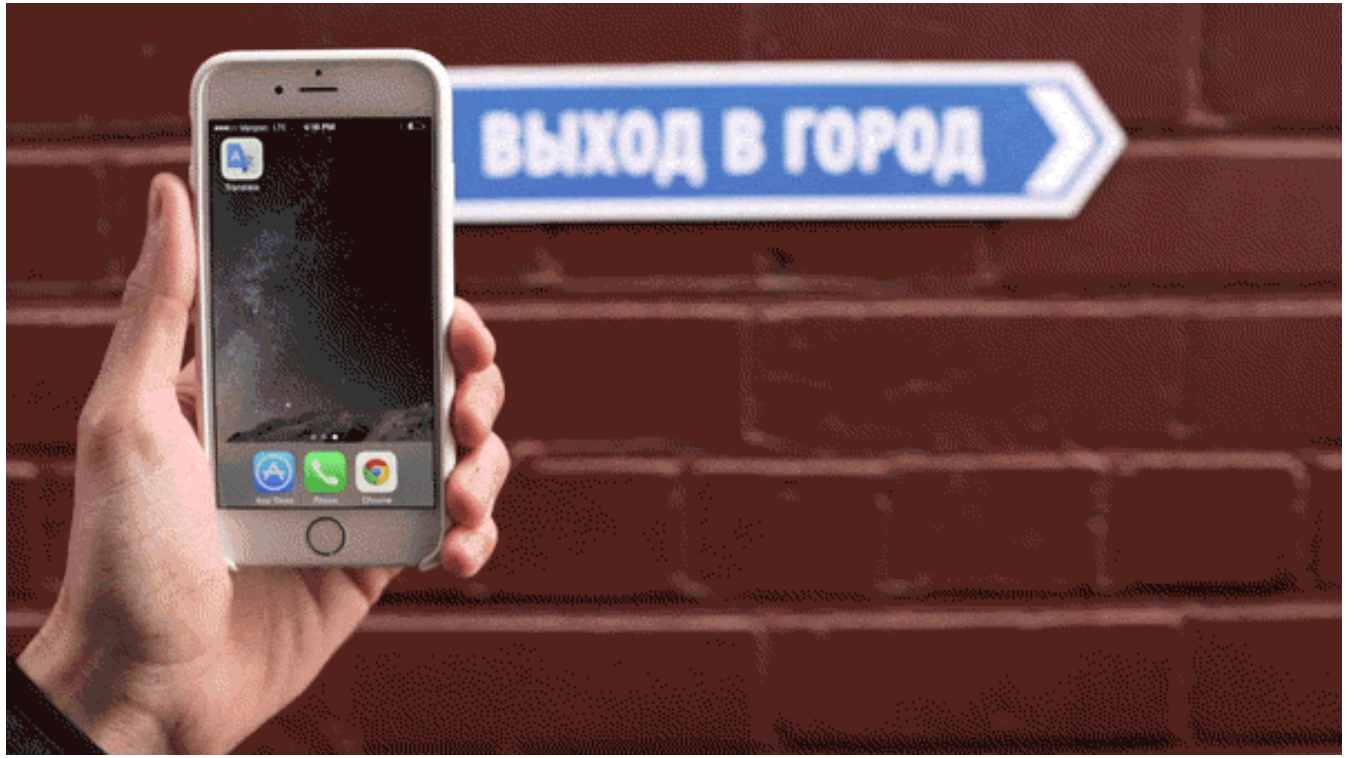
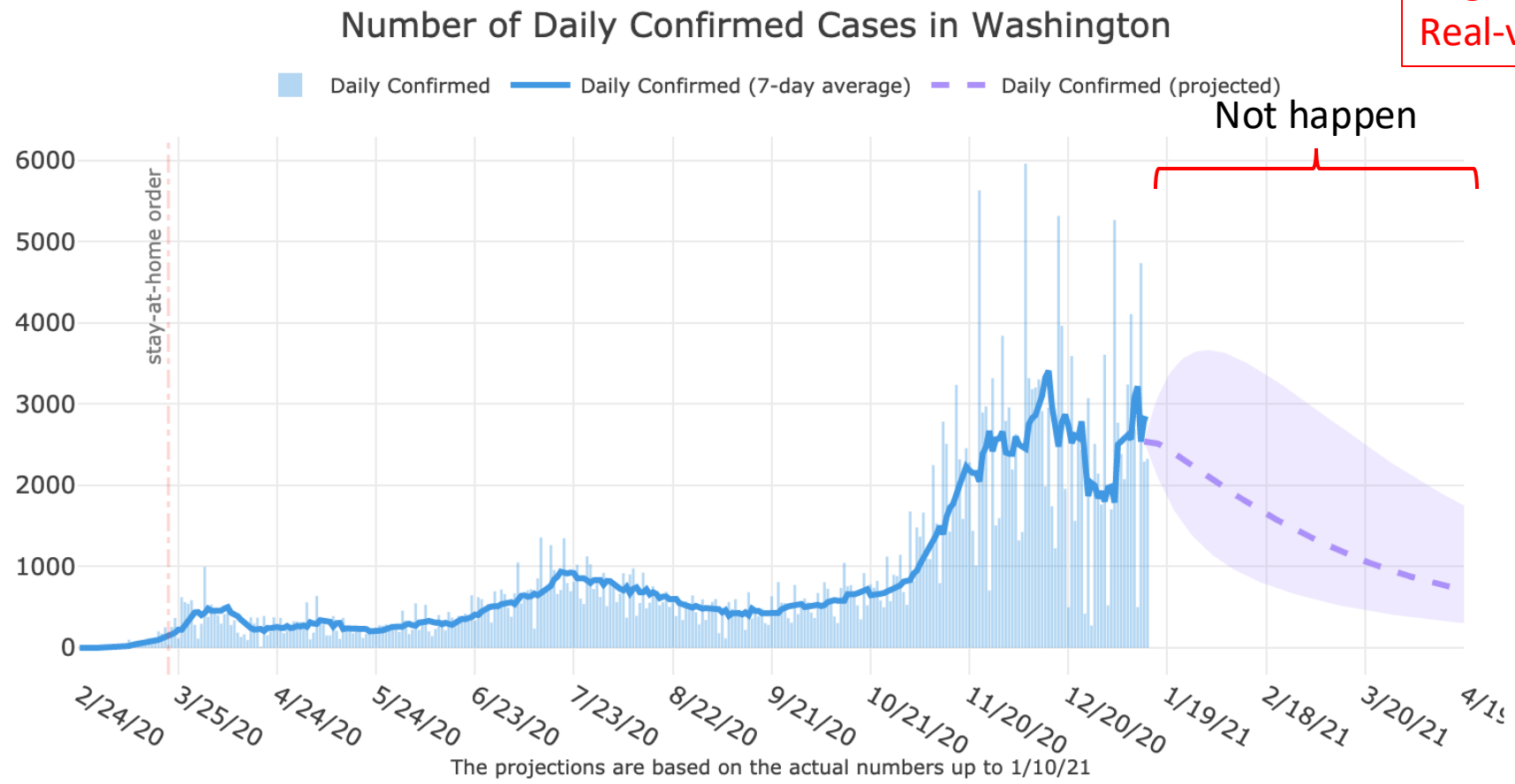


Image from https://petapixel.com/2015/01/14/googles-translate-app-can-now-use-camera-translate-world-real-time/

Pre-defined problem settings (by task)

- Prediction vs decision making

Regression:
Real-valued outputs

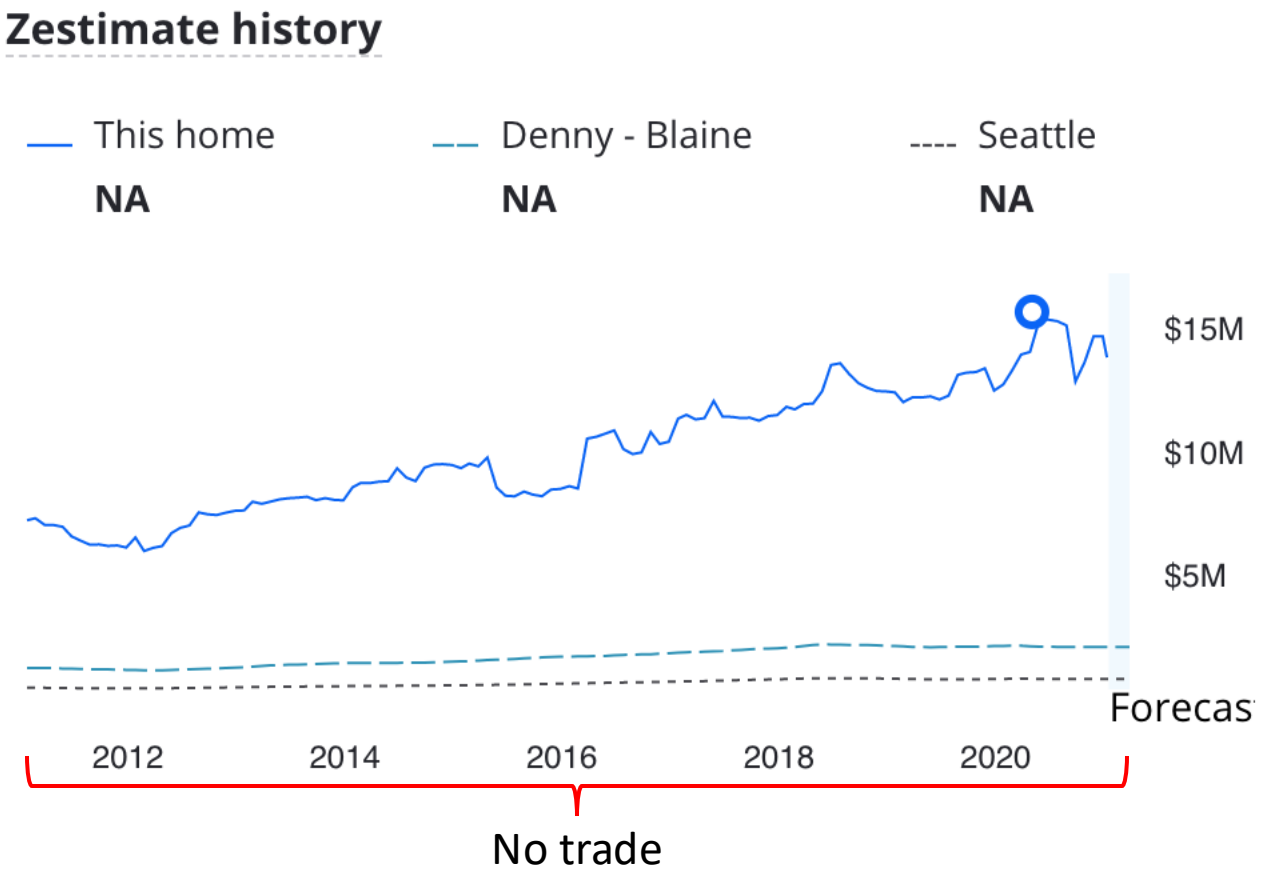


Retrieved from https://covid19.uclaml.org/

Pre-defined problem settings (by task)

- Prediction vs decision making

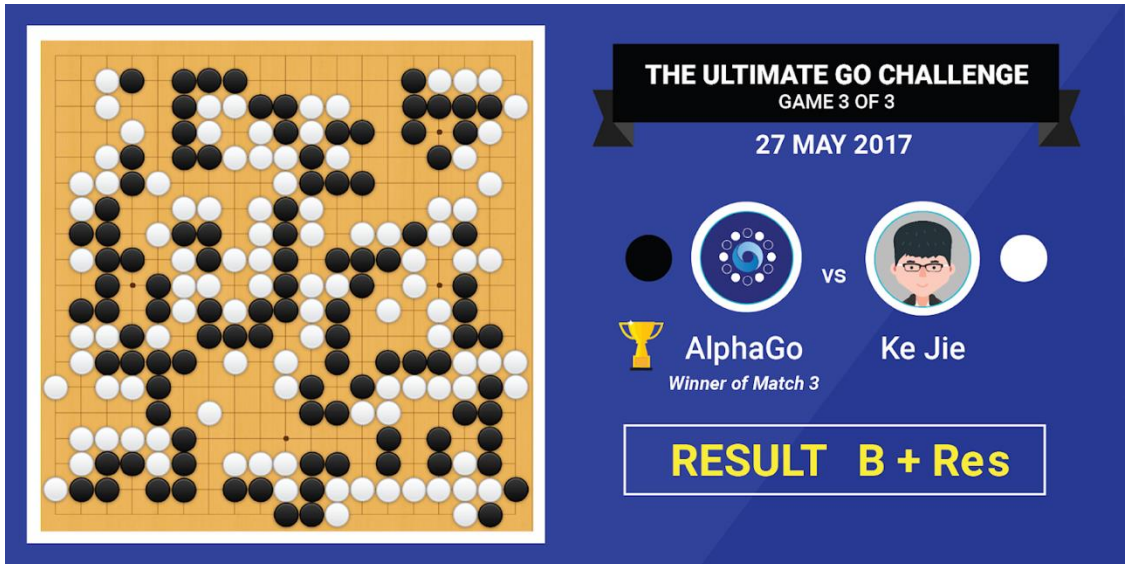
Regression:
Real-valued outputs



Screen-print from zillow.com

Pre-defined problem settings (by task)

- Prediction vs decision making



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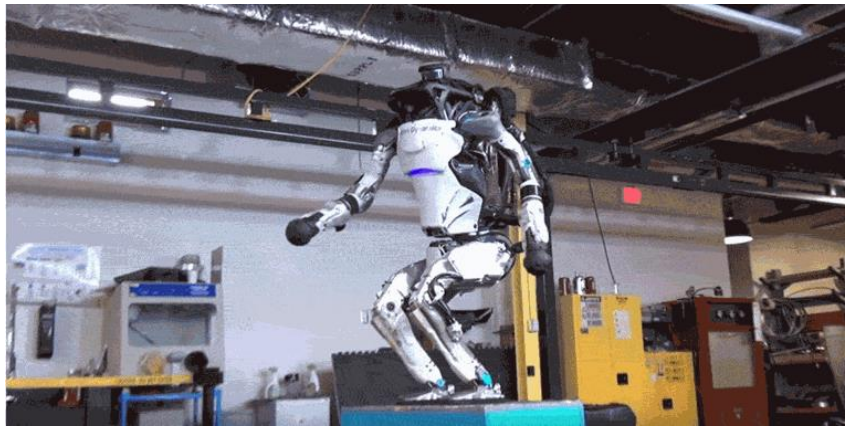
- Prediction vs decision making



Machine learning paradigm

Past data: features

Q: How to choose/generate useful features?

Learning model

Q: How to determine this model?

Prediction on future data

Task: prediction/decision

(pre-defined setting)

In practice:
We first inspect what TASK it is

Pre-defined problem settings (by label info)

- Supervised learning

bus

bus

dog

dog

Complete label information: supervised learning

Pre-defined problem settings (by label info)

- Non-supervised learning?

bus

dog

Labeled and unlabeled data: semi-supervised learning

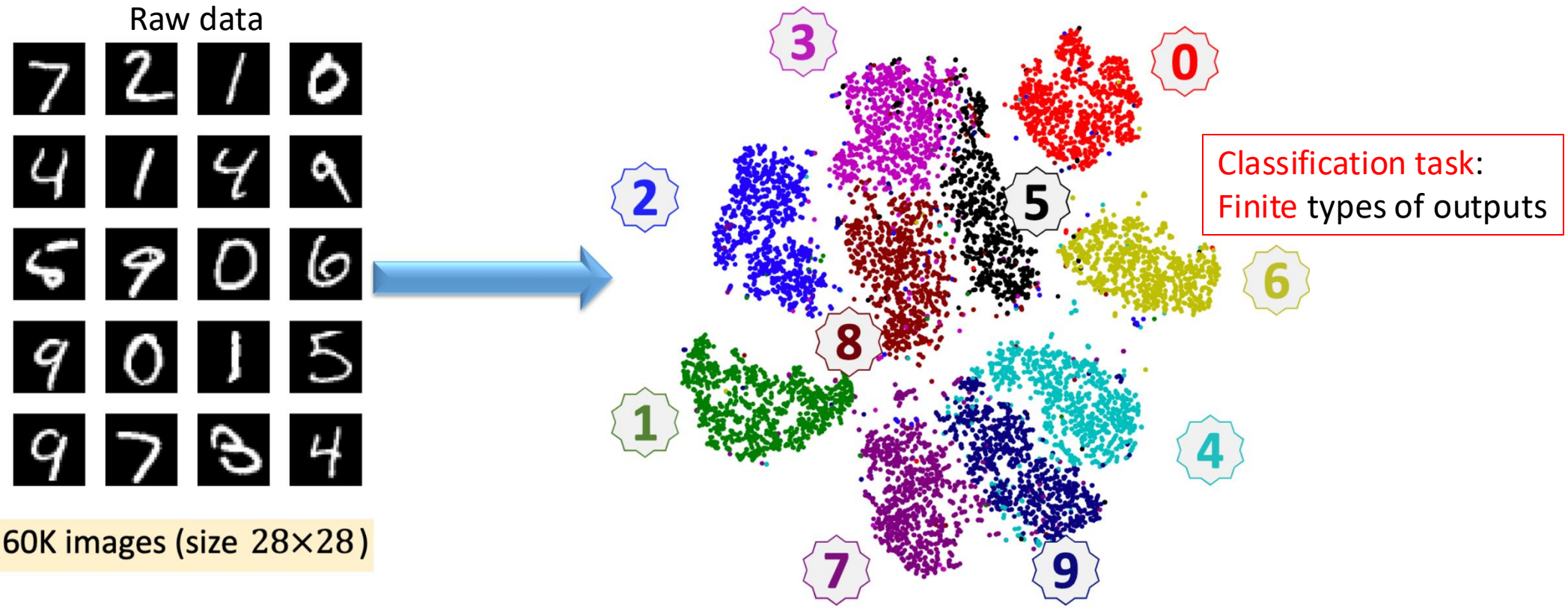
Pre-defined problem settings (by label info)

- Non-supervised learning?

Unlabeled data: unsupervised learning

Pre-defined problem settings (by label info)

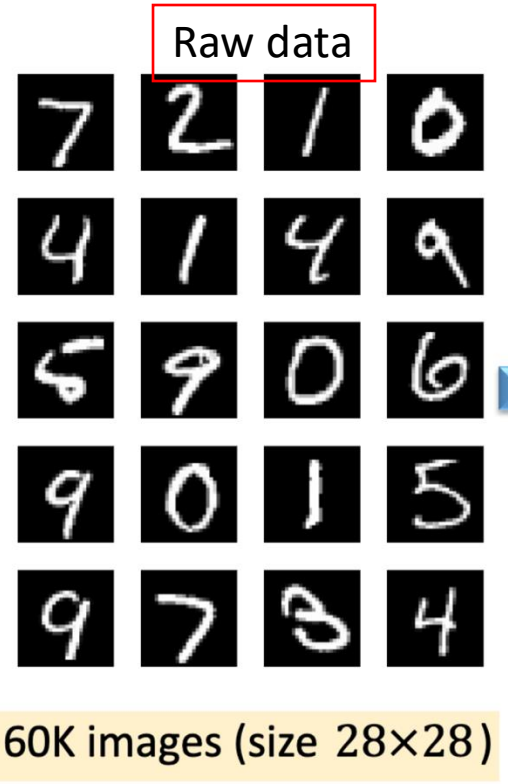
- Unsupervised learning

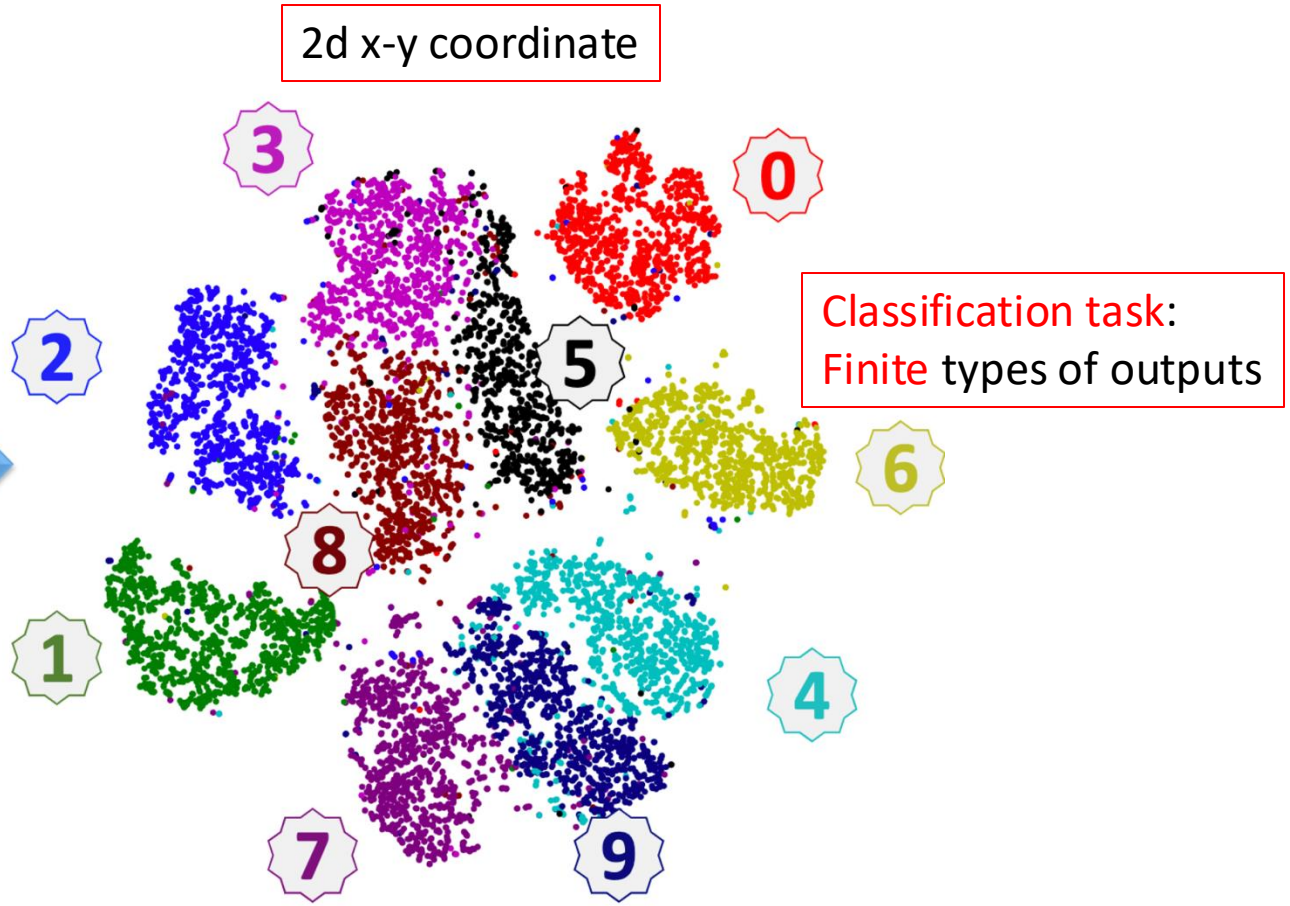


Autoencoder for hand-written digit data, retrieved from Shusen Wang's slides at
https://github.com/wangshusen/DeepLearning/blob/master/Slides/1_ML_Basics.pdf

Pre-defined problem settings (by label info)

- Unsupervised learning





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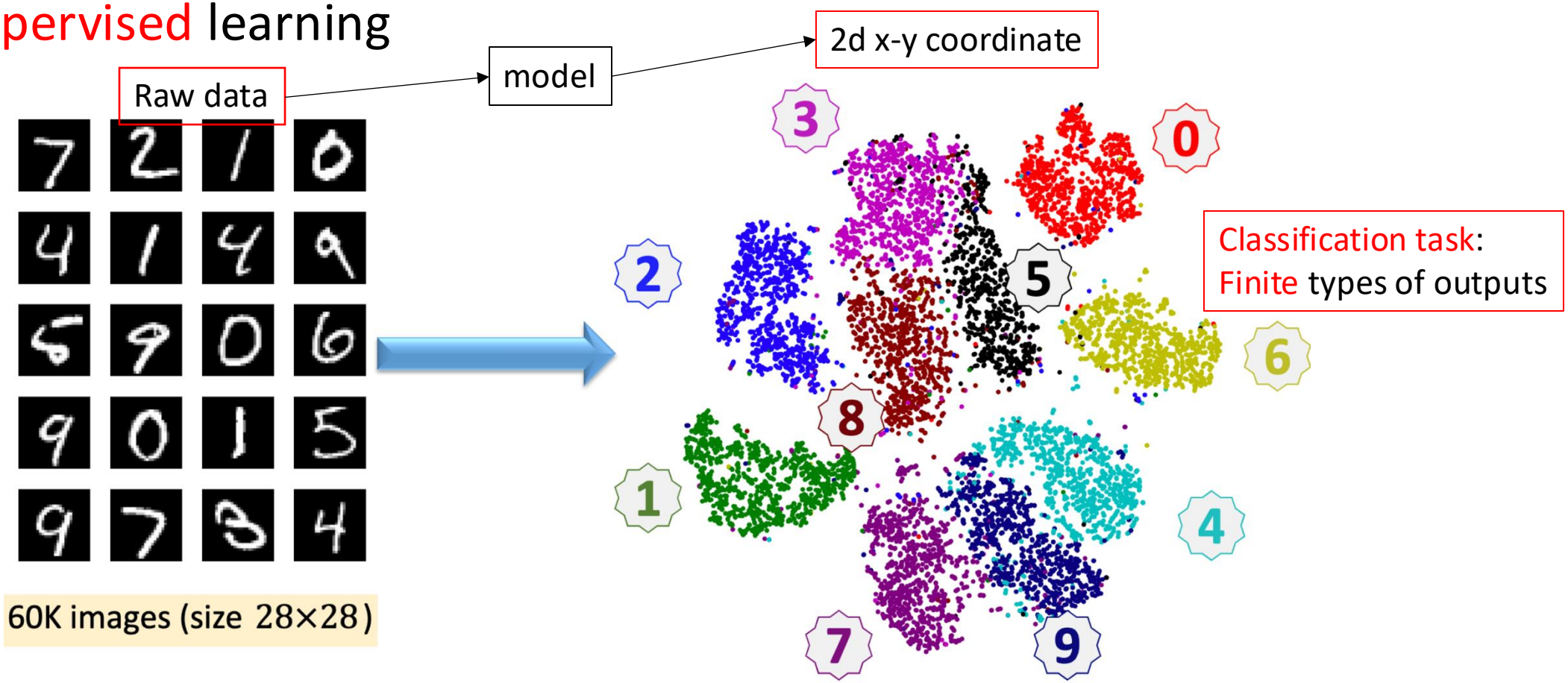

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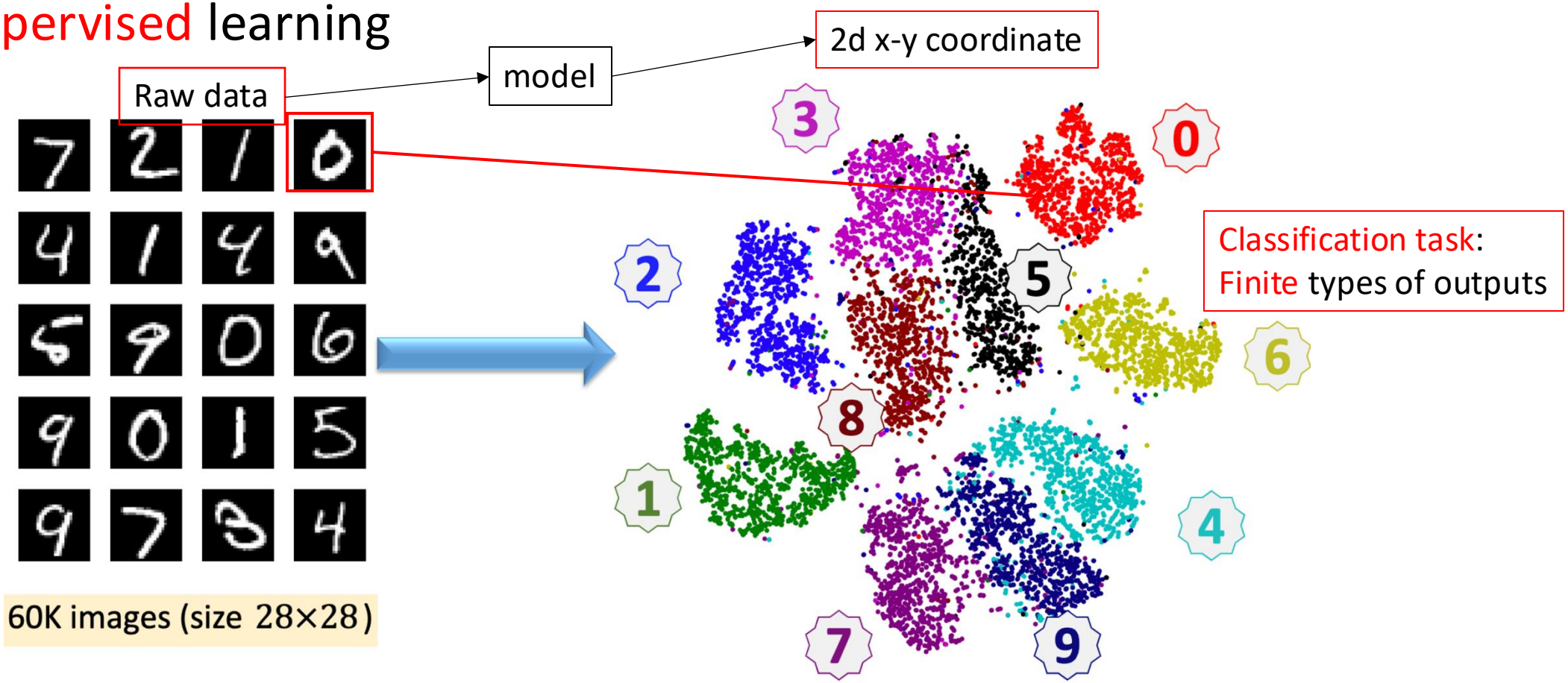

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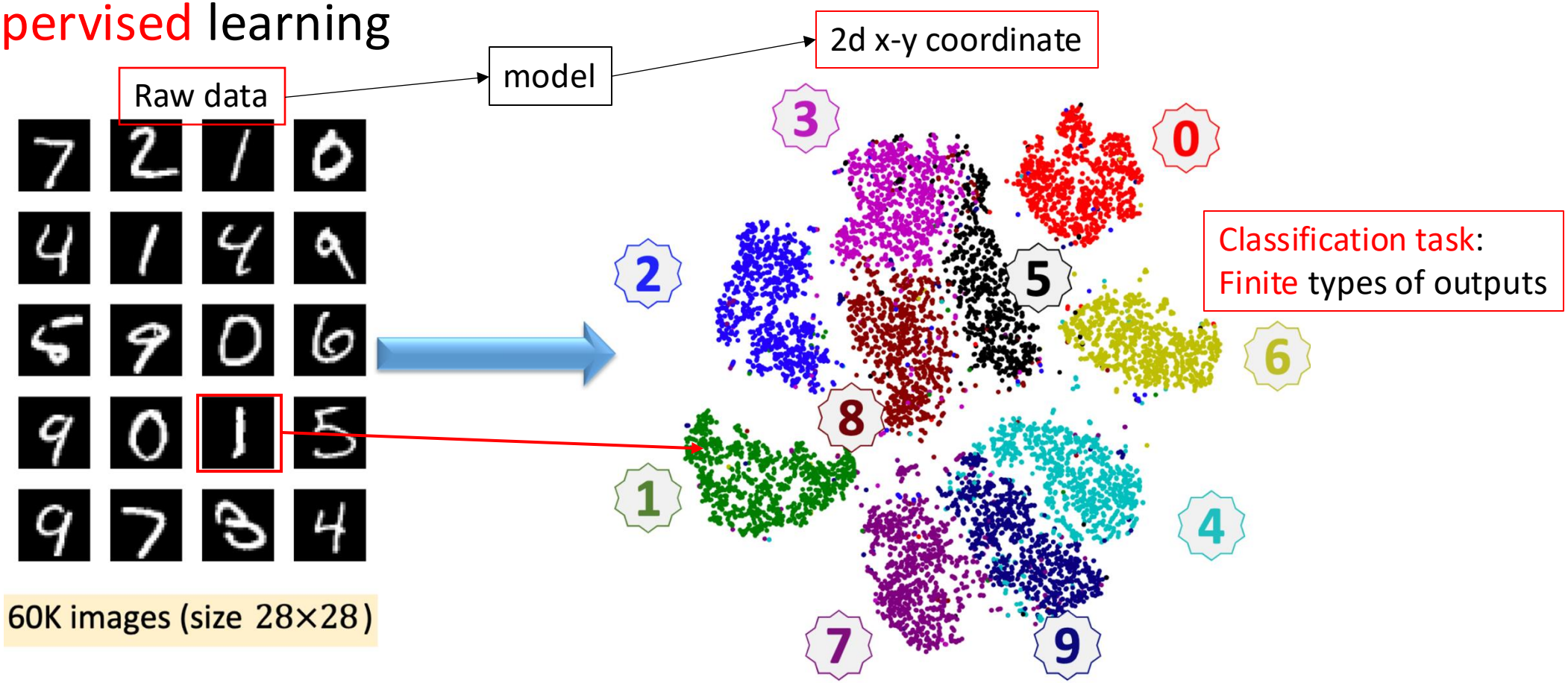
- Unsupervised learning



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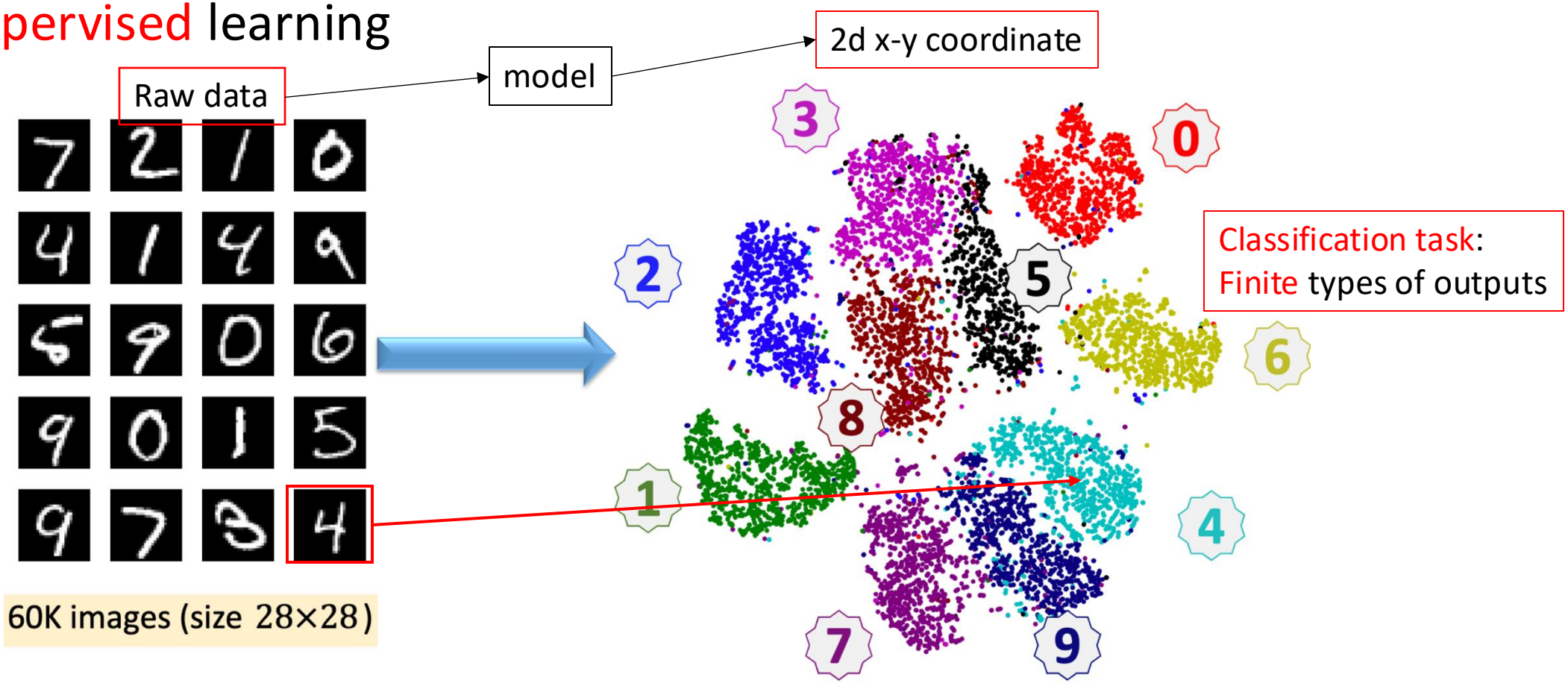

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Machine learning paradigm

Past data: features

Q: How to choose/generate useful features?

Learning model

Q: How to determine this model?

Prediction on future data

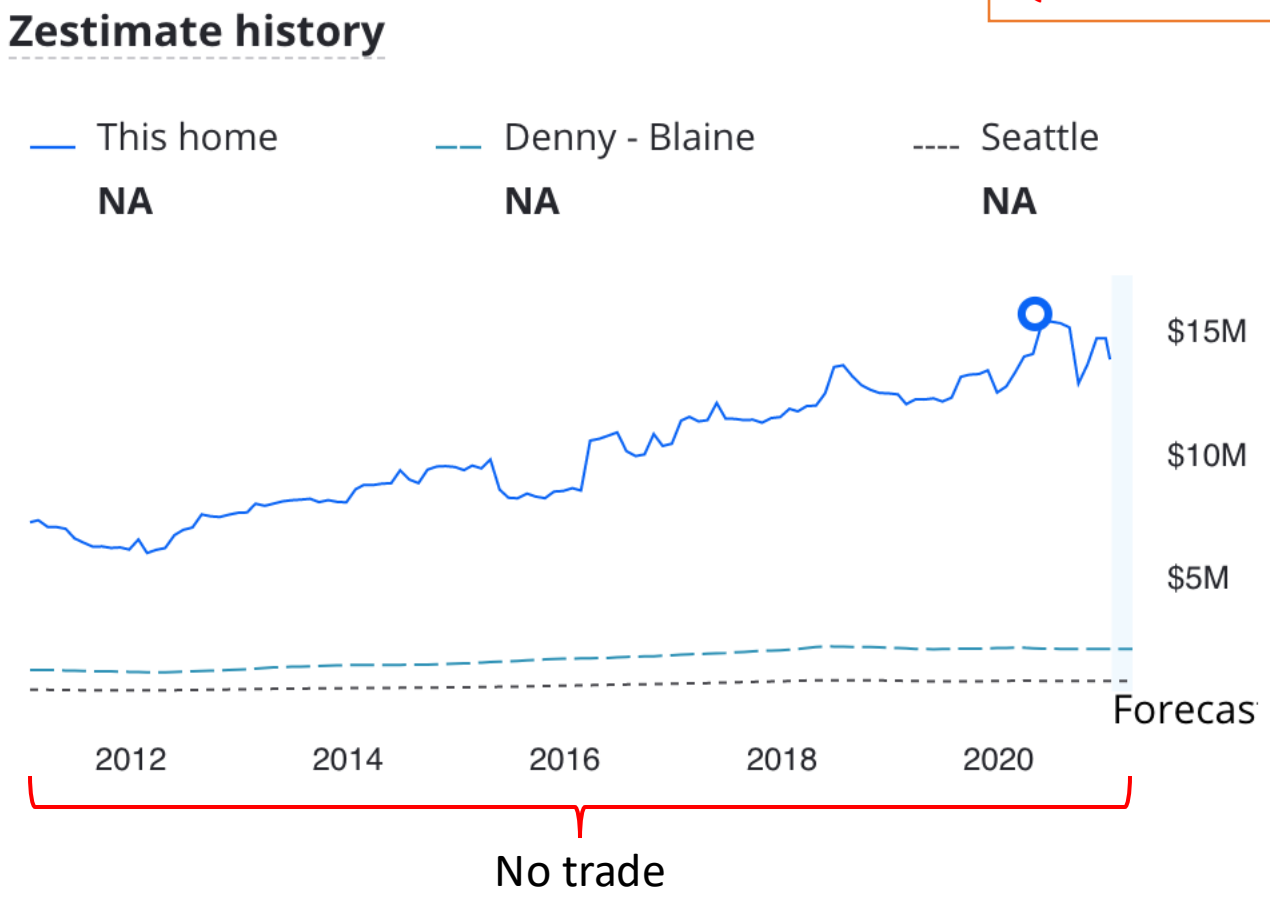
Task: prediction/decision

(pre-defined setting)

In practice:
We first inspect what TASK it is

Features

Q: What features can we use?



Screen-print from zillow.com

Feature in house price prediction

- Home characteristics: lot size, location, #bedrooms
- Unique features: hardwood floors, granite countertops or a landscaped backyard
- On-market data: listing price, description, days on the market
- Off-market data: tax assessments, prior sales

https://www.zillow.com/z/zestimate/

Feature in house price prediction

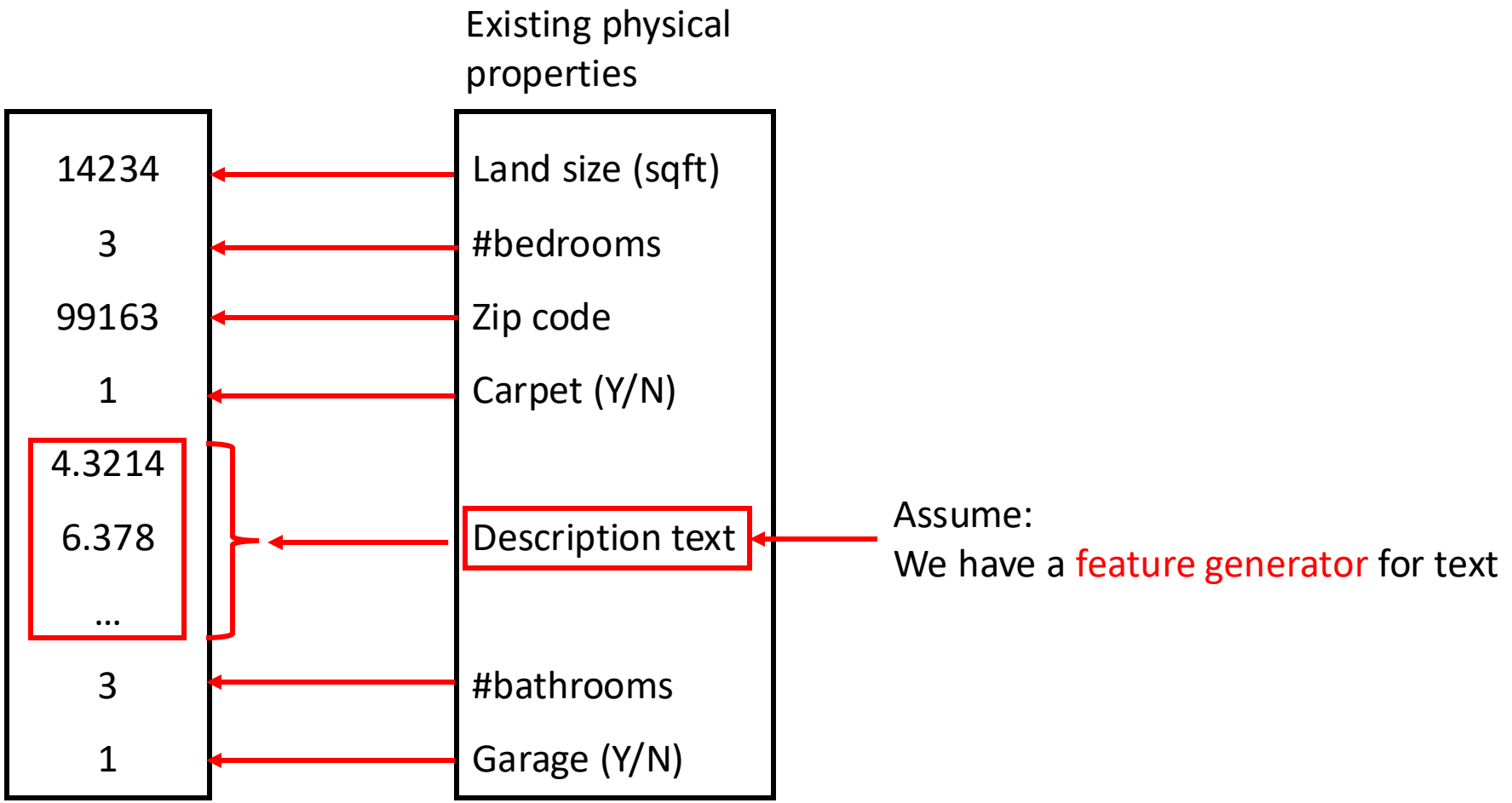
Existing physical properties

- Land size (sqft)
- #bedrooms
- Zip code
- Carpet (Y/N)

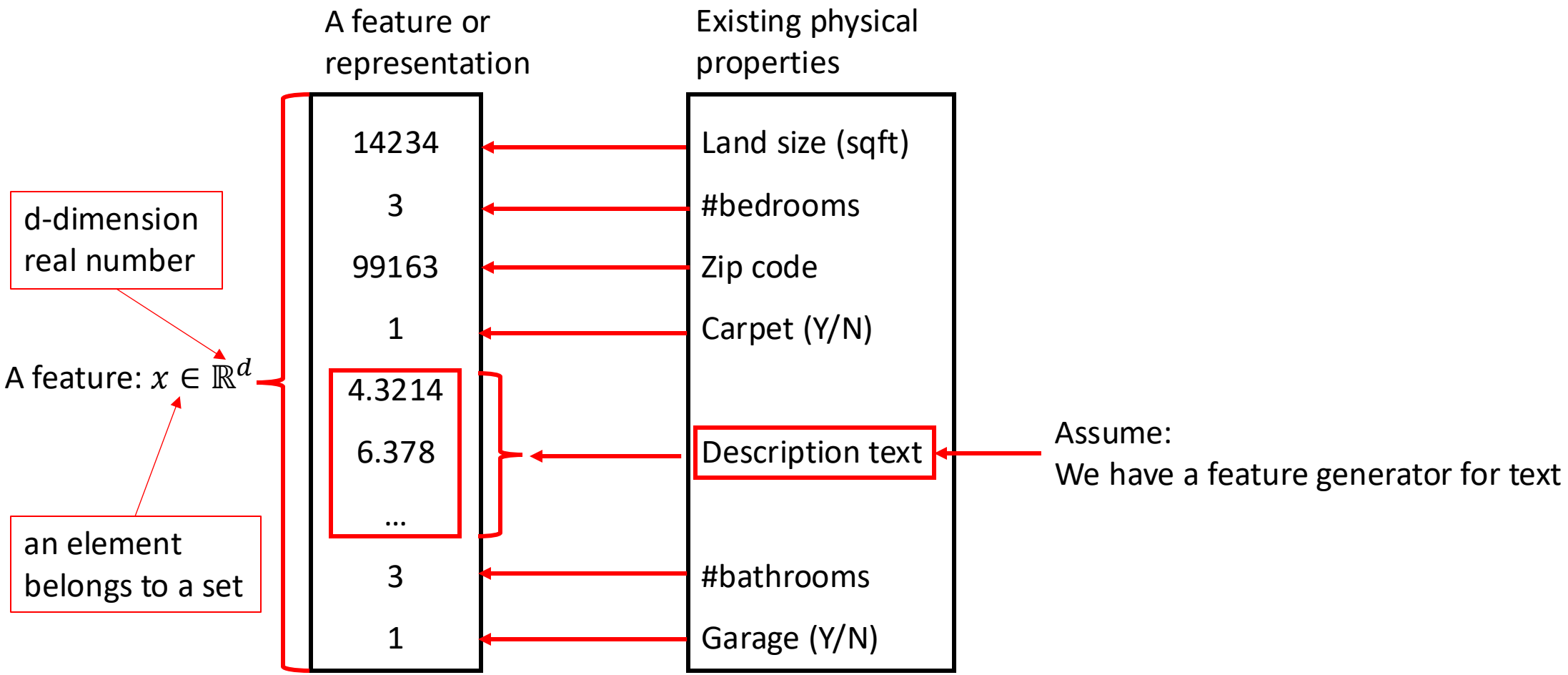
- Description text

- #bathrooms
- Garage (Y/N)

Feature in house price prediction



Feature in house price prediction



Machine learning paradigm

Past data: features

Q: How to choose/generate useful features?

Learning model

Q: How to determine this model?

Choose a type of model
Determine its parameters

Prediction on future data

Task: prediction/decision

(pre-defined setting)

In practice:
We first inspect what TASK it is

Build a model

- What is a model

Try to separate two classes

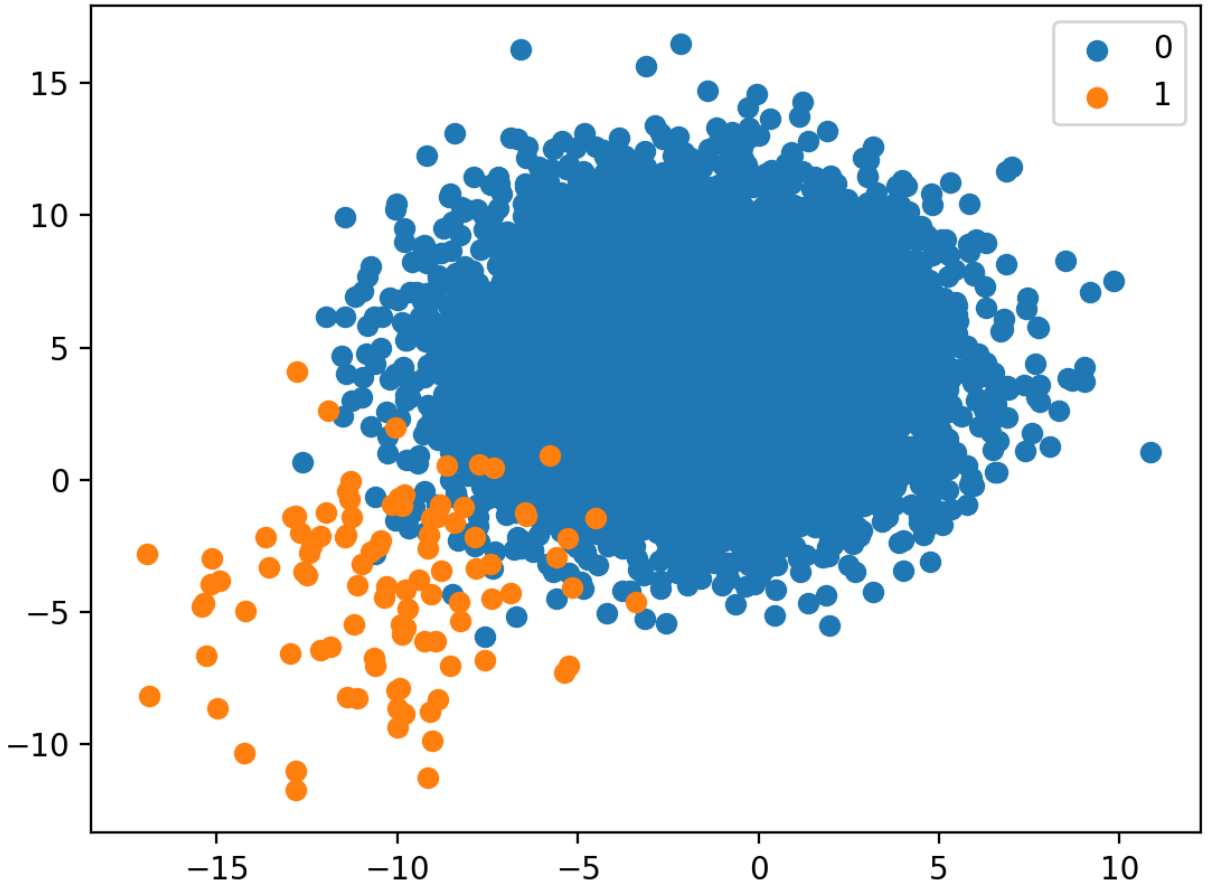


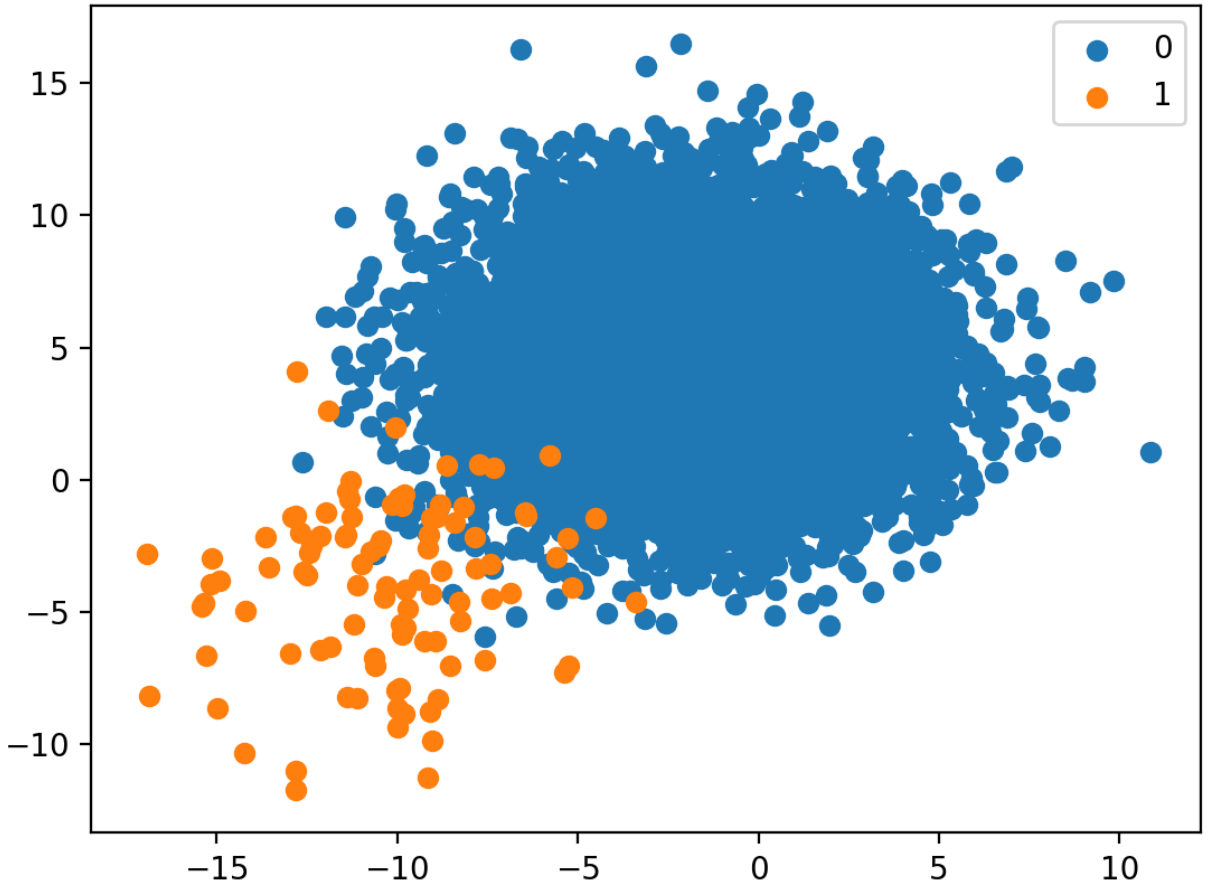
Image retrieved from https://machinelearningmastery.com/how-to-develop-an-intuition-skewed-class-distributions/

Build a model

- What is a model

Try to separate two classes

Q: how to separate them?



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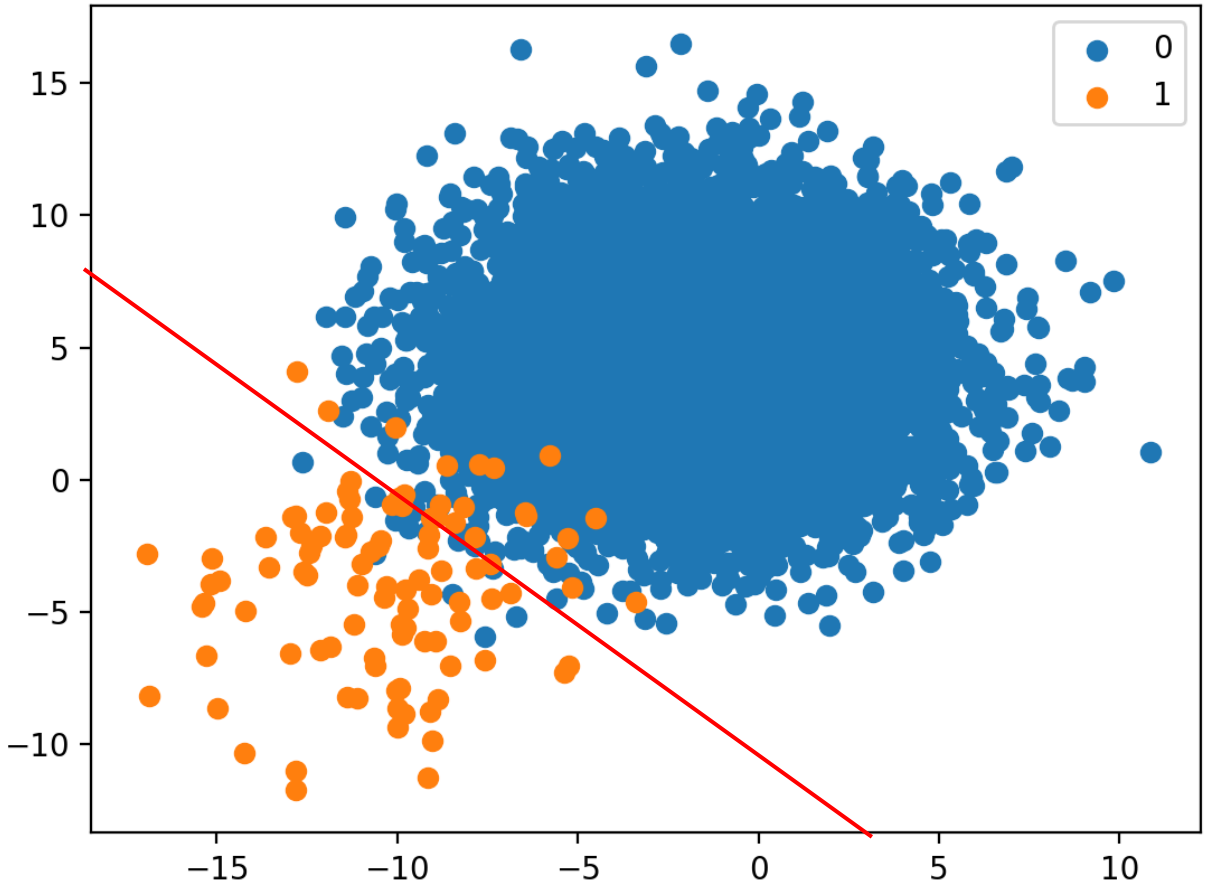
Build a model

- What is a model

A linear function

Try to separate two classes

Q: how to separate them?



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Build a model

- What is a model

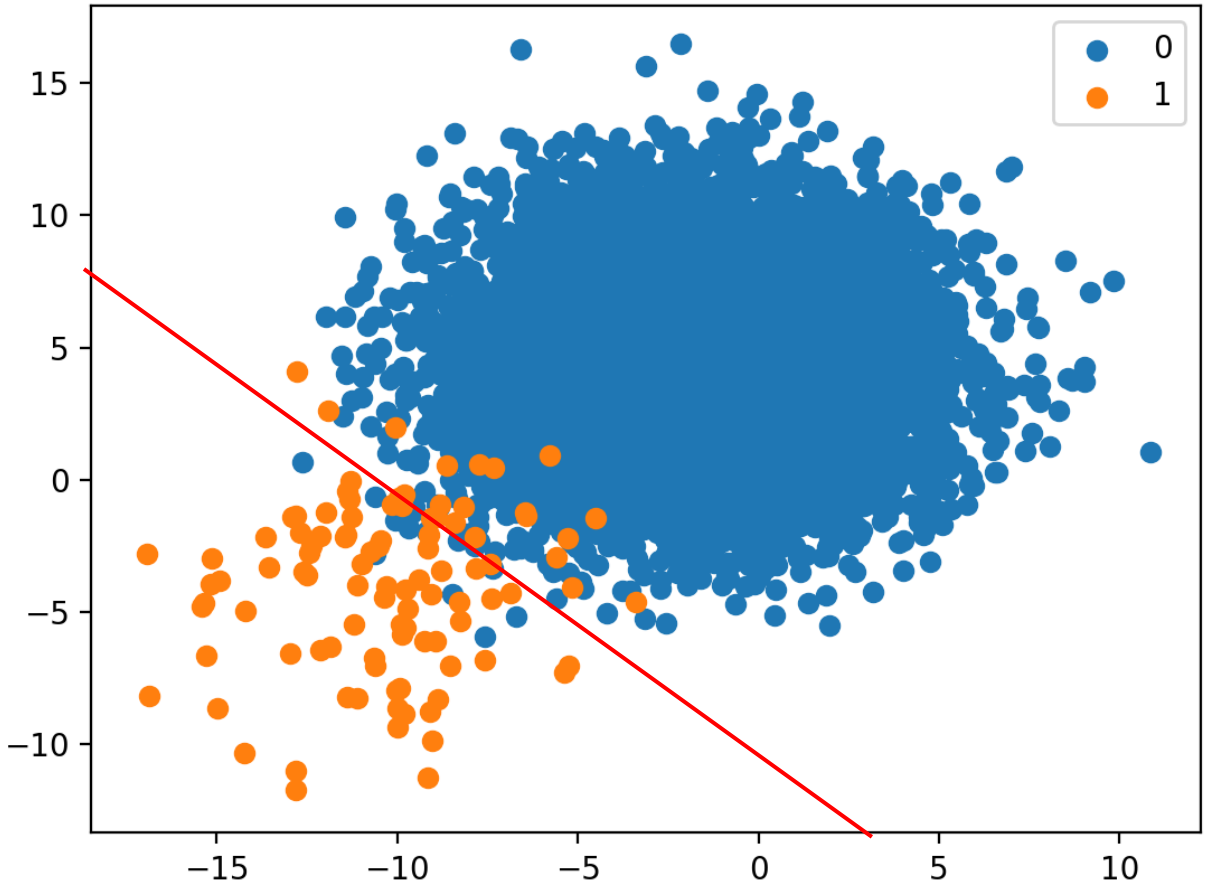
A hypothesis class

A linear function

$$y = ax + b$$

Try to separate two classes

Q: how to separate them?



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Build a model

- What is a model

An ellipse (nonlinear function)

Try to separate two classes

Q: how to separate them?

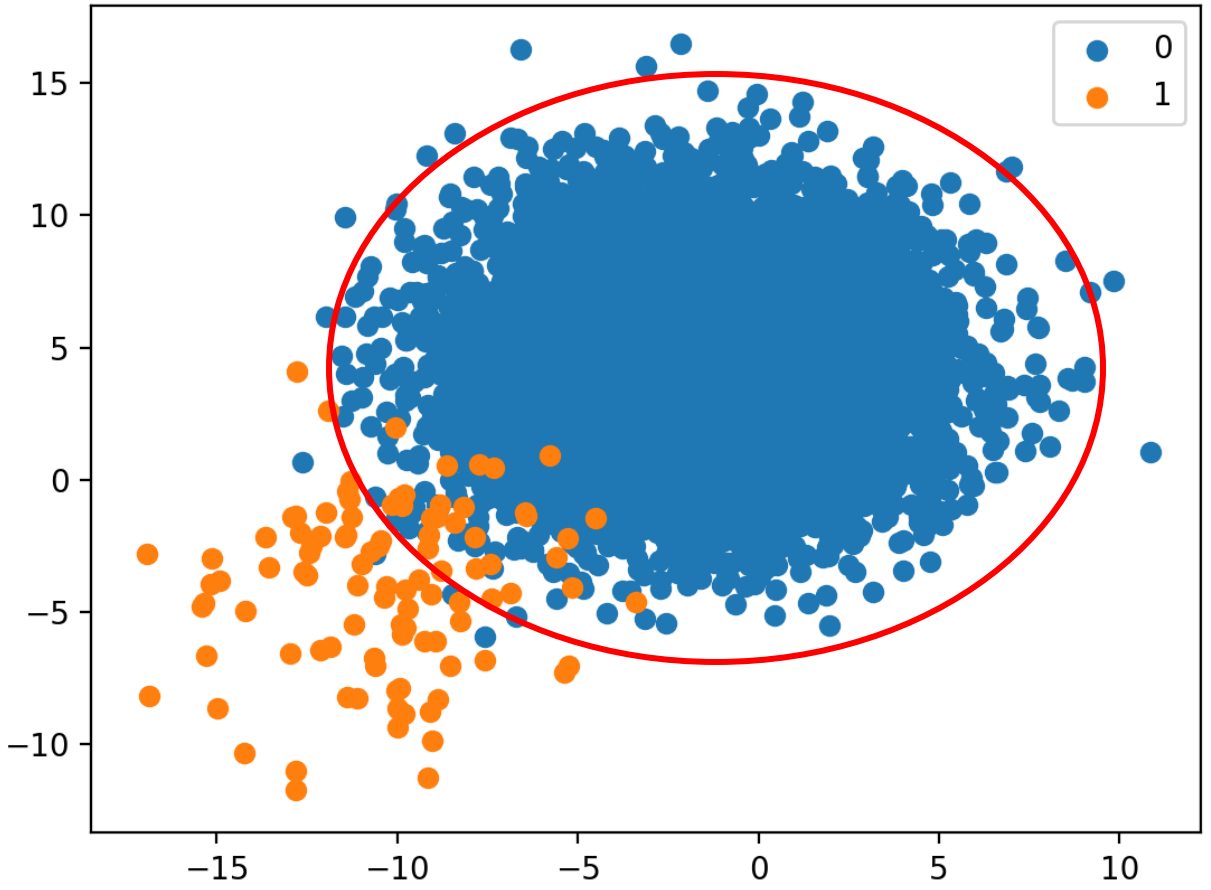


Image retrieved from https://machinelearningmastery.com/how-to-develop-an-intuition-skewed-class-distributions/

Build a model

- What is a model

An ellipse (nonlinear function)

Another hypothesis class

Try to separate two classes

Q: how to separate them?

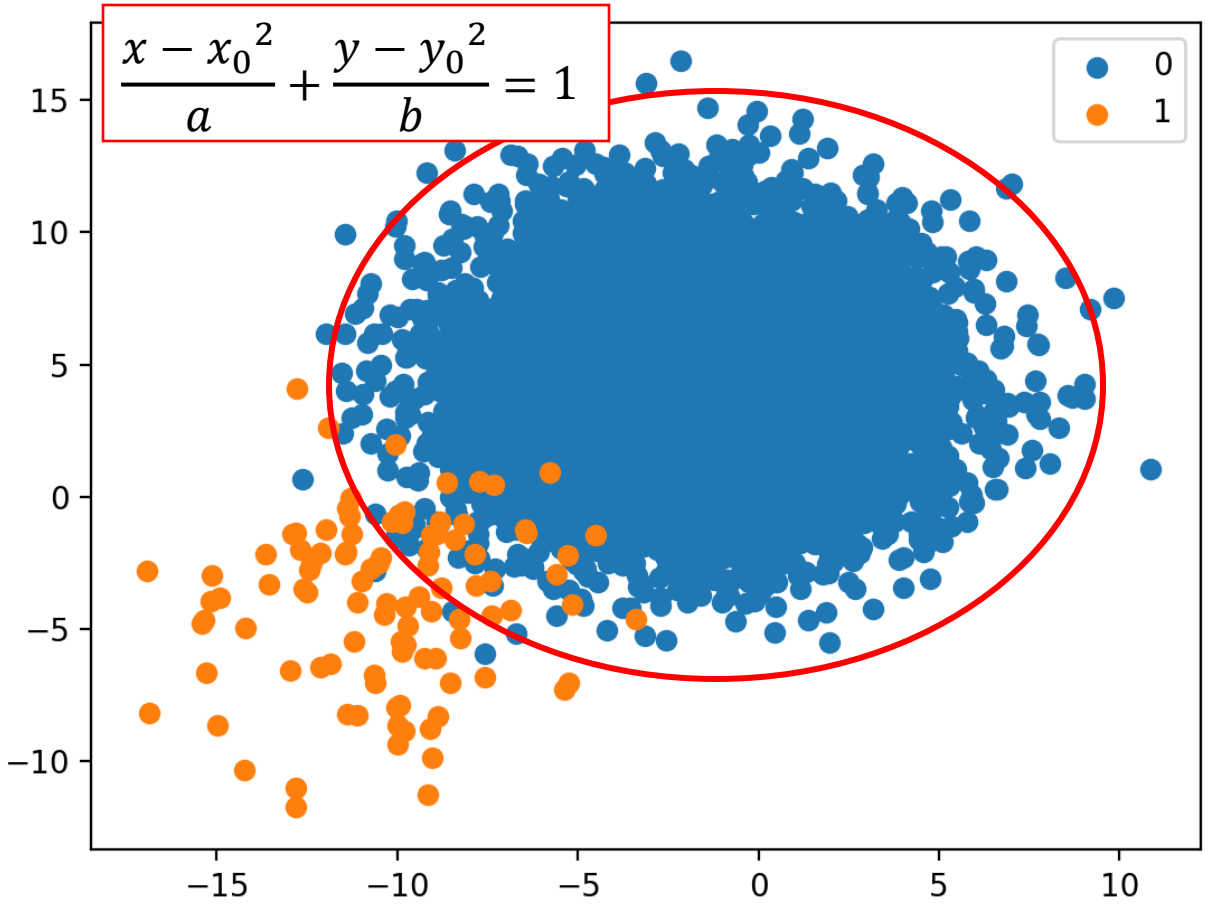


Image retrieved from https://machinelearningmastery.com/how-to-develop-an-intuition-skewed-class-distributions/

Build a model

- What is a model

A hypothesis class

A linear function

or

An ellipse (nonlinear function)

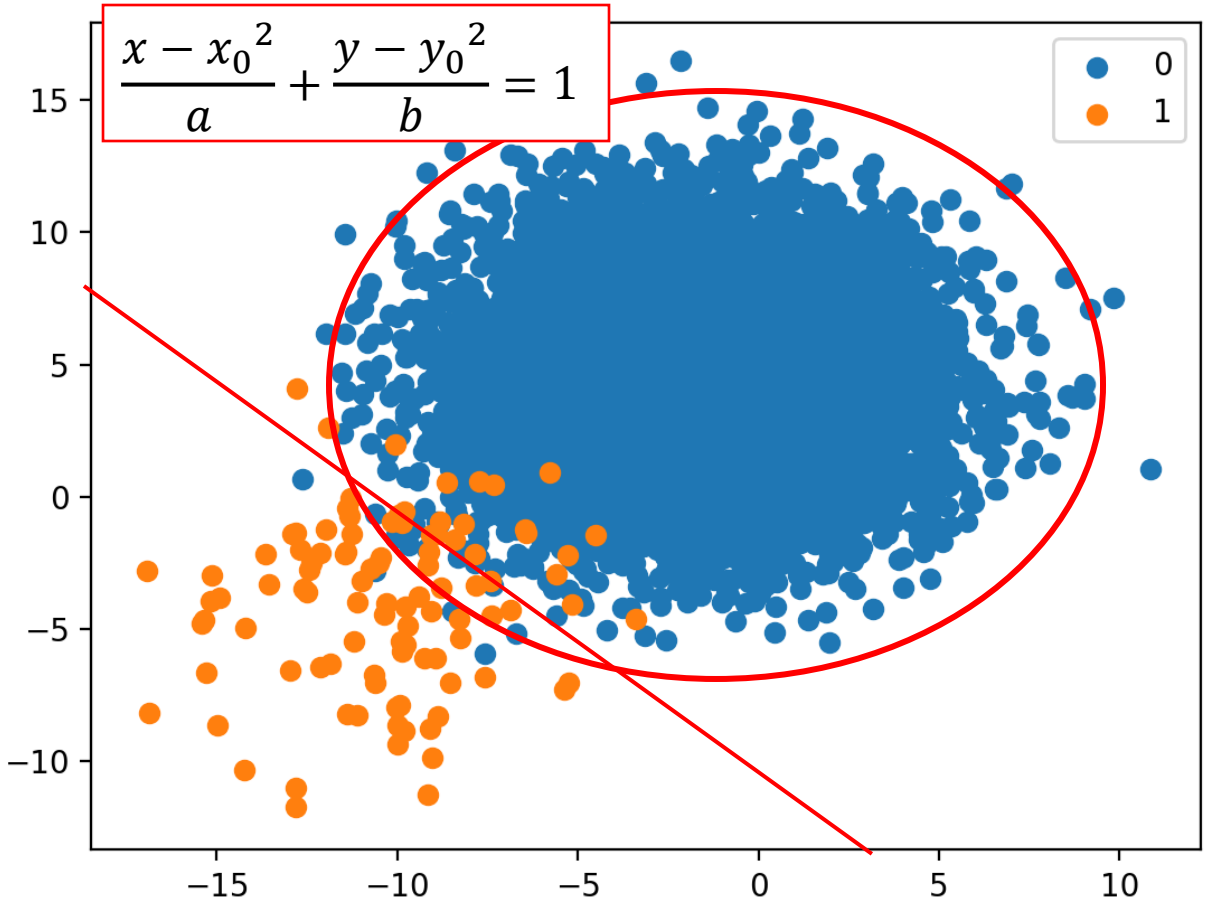
Another hypothesis class

$y = ax + b$

$\frac{x - {x_0}^2}{a} + \frac{y - {y_0}^2}{b} = 1$

Try to separate two classes

Q: how to separate them?



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Build a model

- What is a model

A hypothesis class

A linear function

or

An ellipse (nonlinear function)

Another hypothesis class

Q: what is the feature used here?

$y = ax + b$

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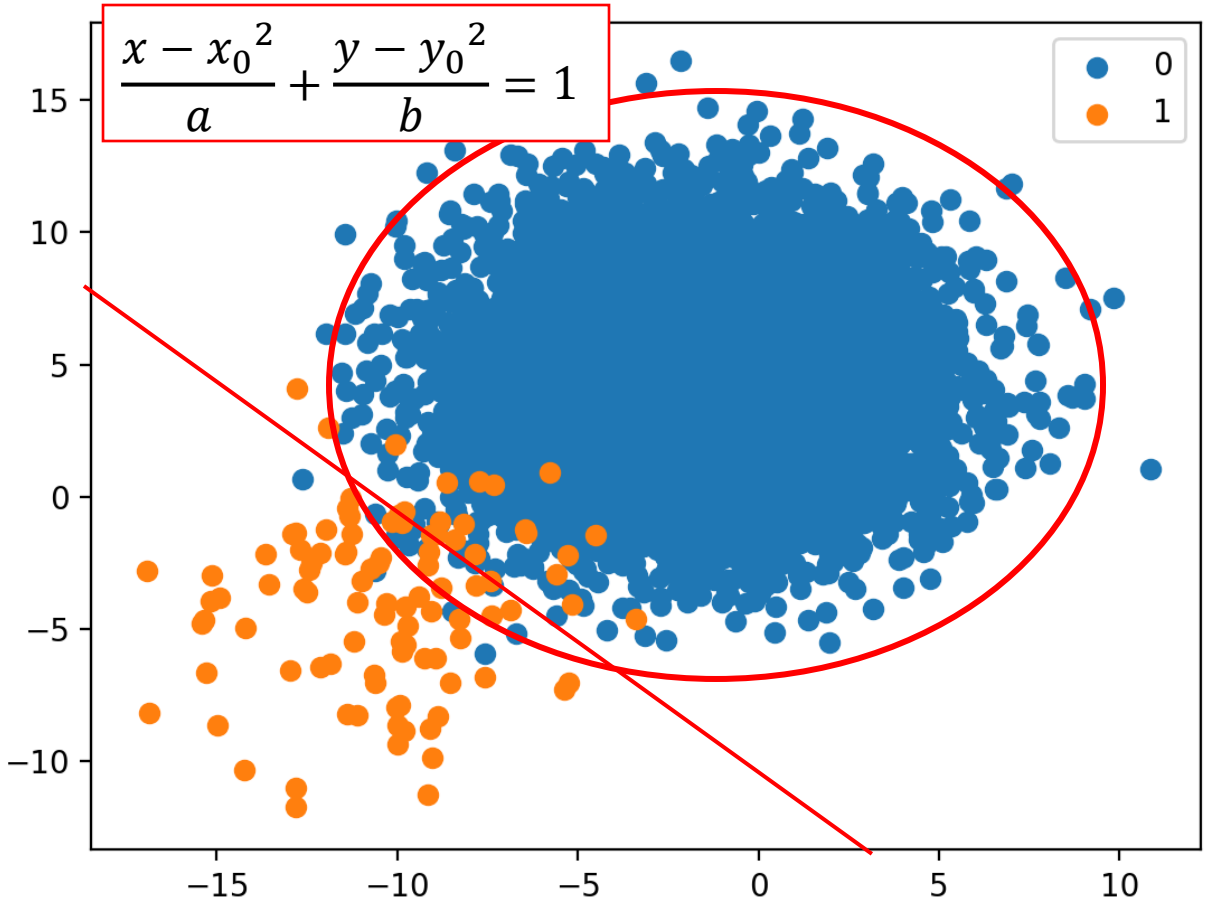

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Build a model

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Another hypothesis class

Q: what is the feature used here?

A: x-y coordinates

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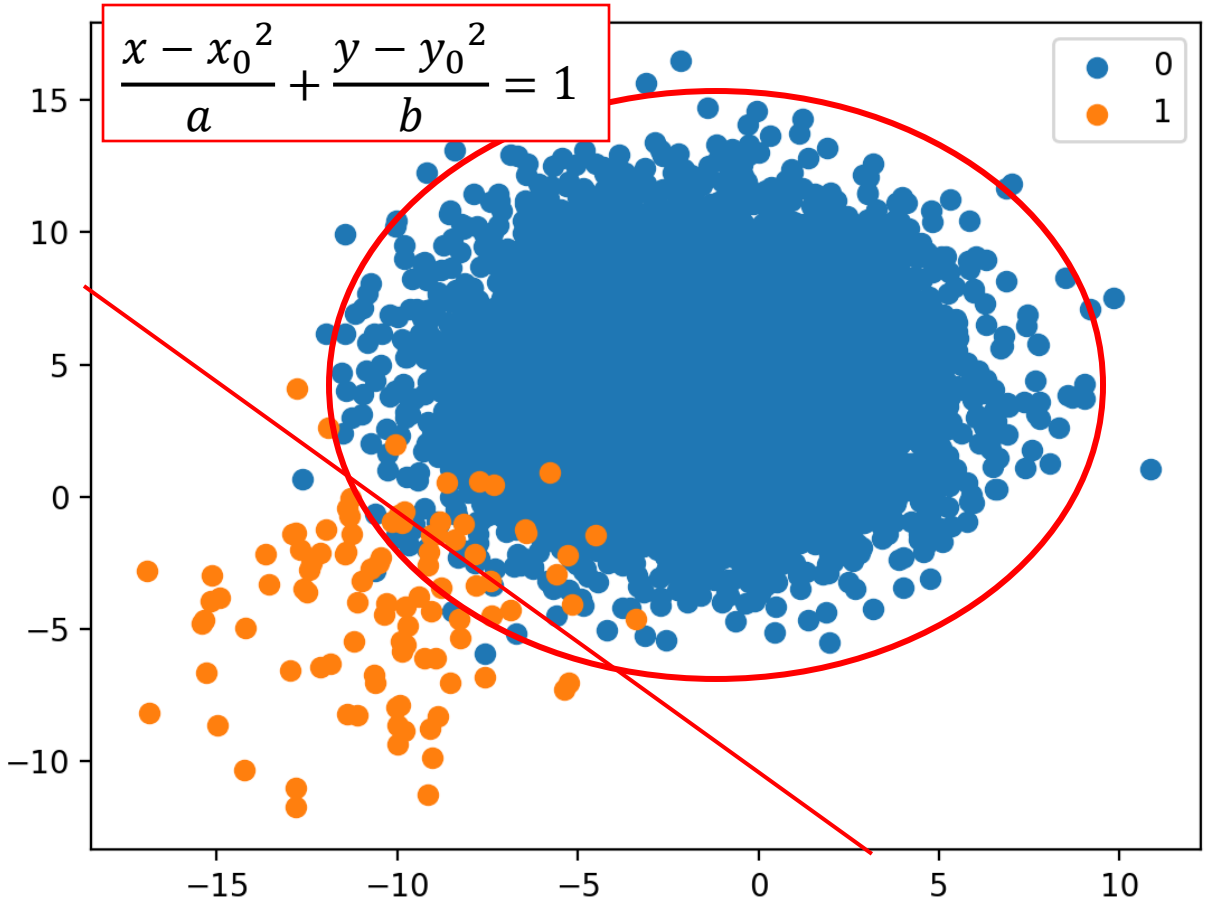
$\frac{x - {x_0}^2}{a} + \frac{y - {y_0}^2}{b} = 1$

Try to separate two classes

Q: how to separate them?



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Build a model

- What is a model

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Another hypothesis class

Q: what are their parameters?

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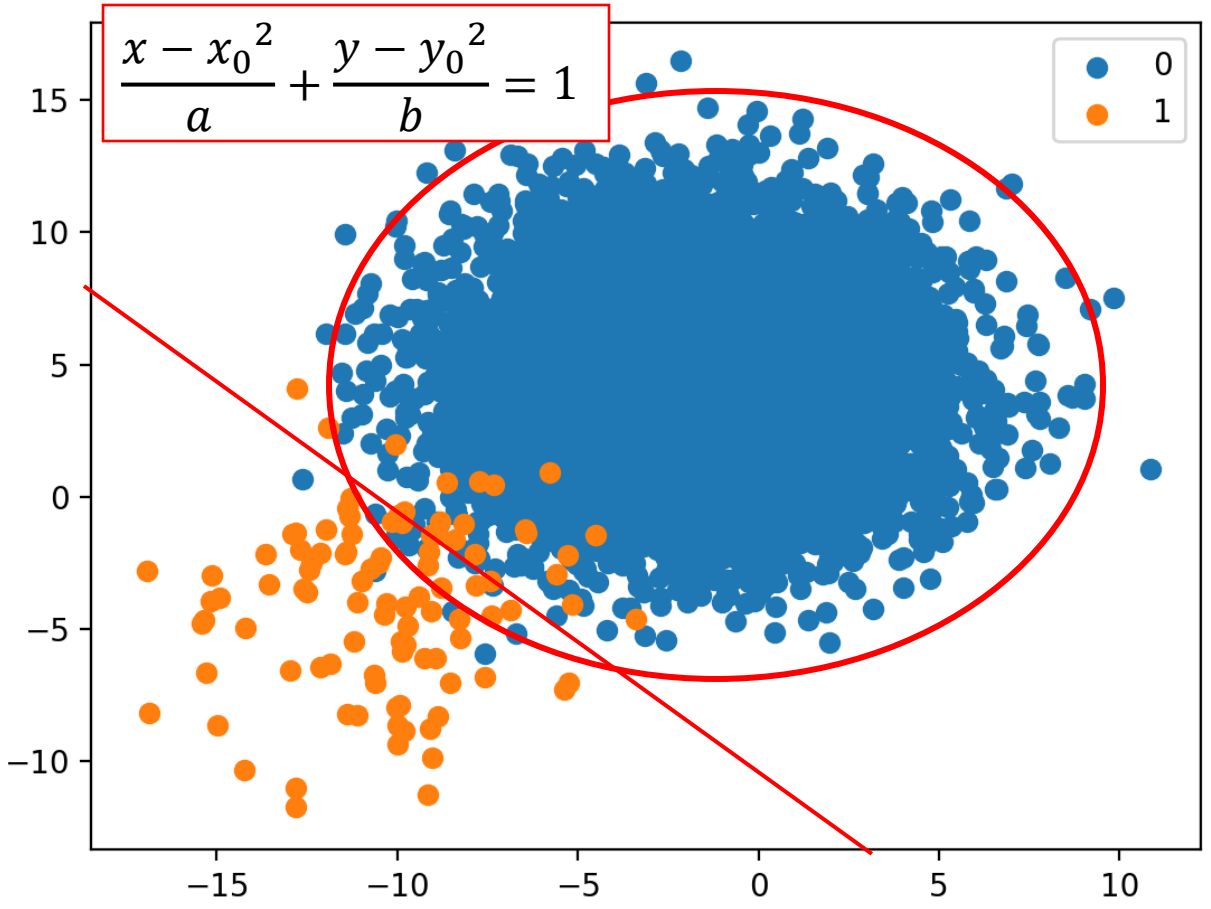
Try to separate two classes

Q: how to separate them?



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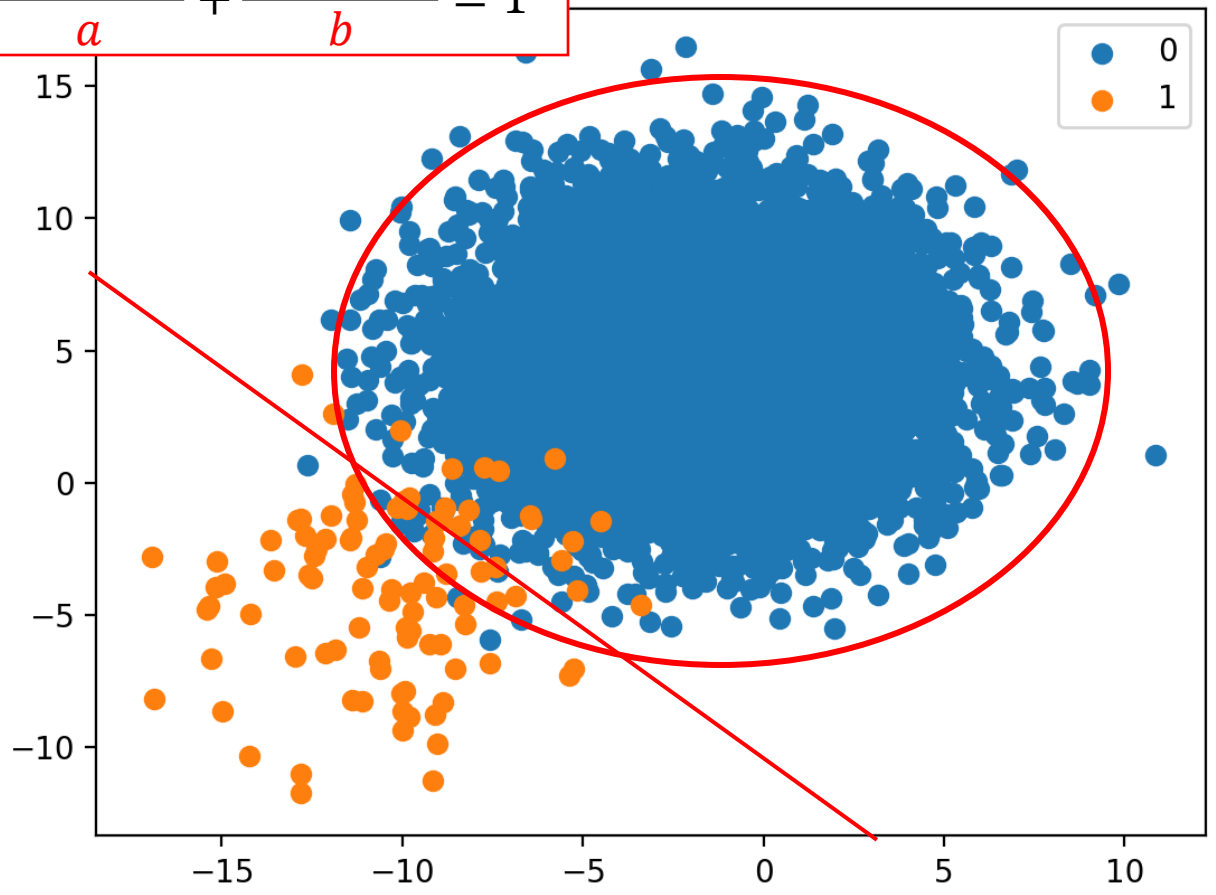
Q: how to separate them?



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Analogous to Thermometers

- Types of thermometers
  - Liquid thermometers
  - Dial thermometers
  - Electronic thermometers

Analogous to Thermometers

- Types of thermometers
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Image from www.explainthatstuff.com

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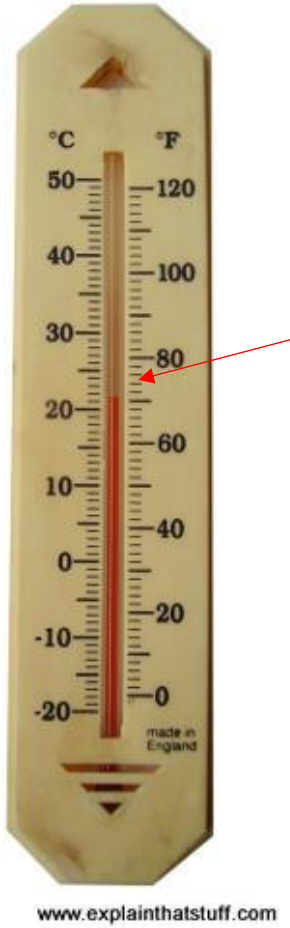

Mercury or alcohol

Image from www.explainthatstuff.com

Analogous to Thermometers

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  - Liquid thermometers
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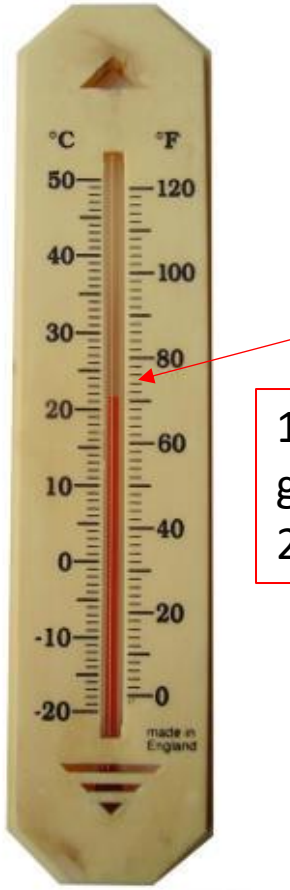

Mercury or alcohol

1. Expands when temperature goes higher
2. Thermal expansion coefficients

Image from www.explainthatstuff.com

Analogous to Thermometers

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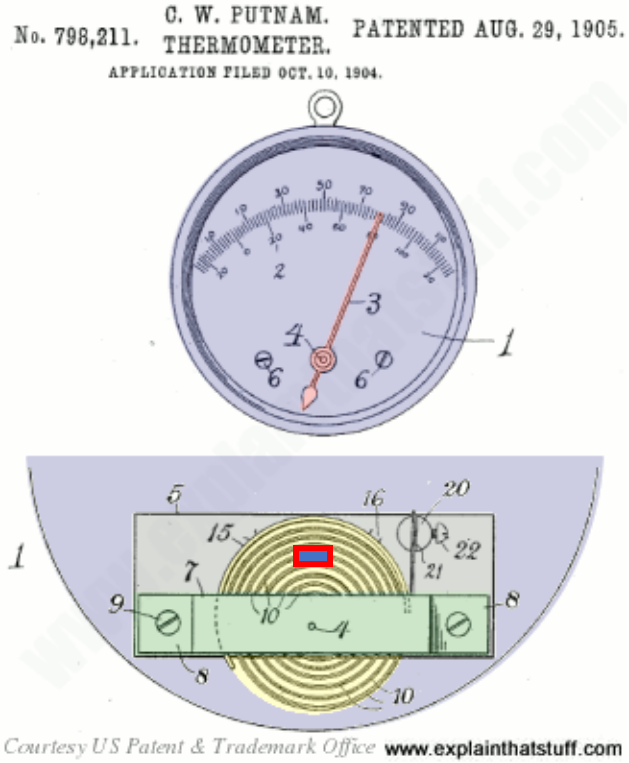

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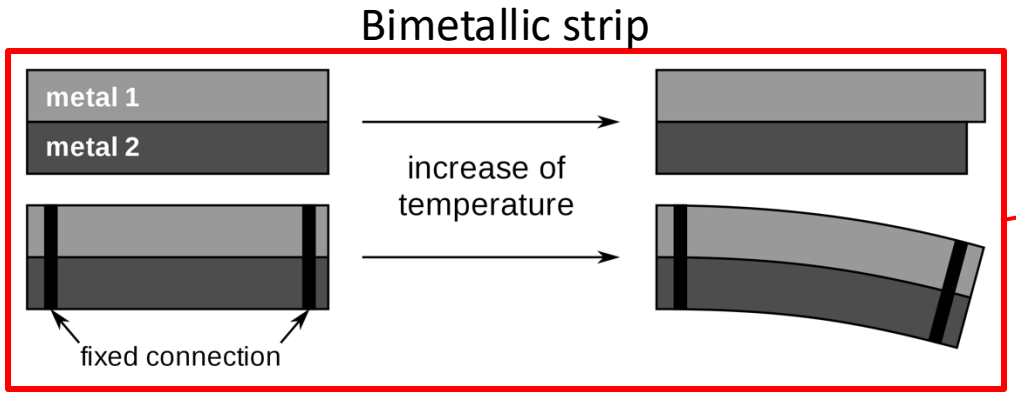

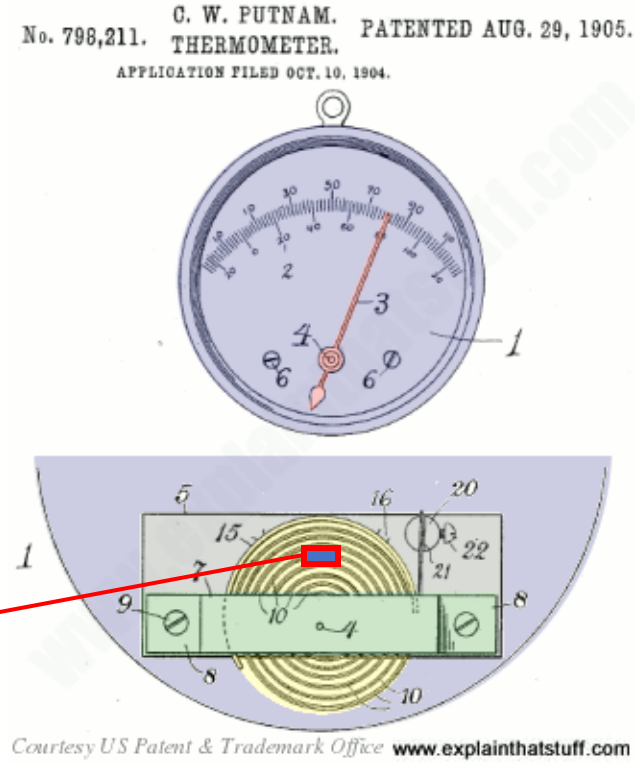

Left image from https://en.wikipedia.org/wiki/Bimetallic_strip

Right image from www.explainthatstuff.com

Analogous to Thermometers

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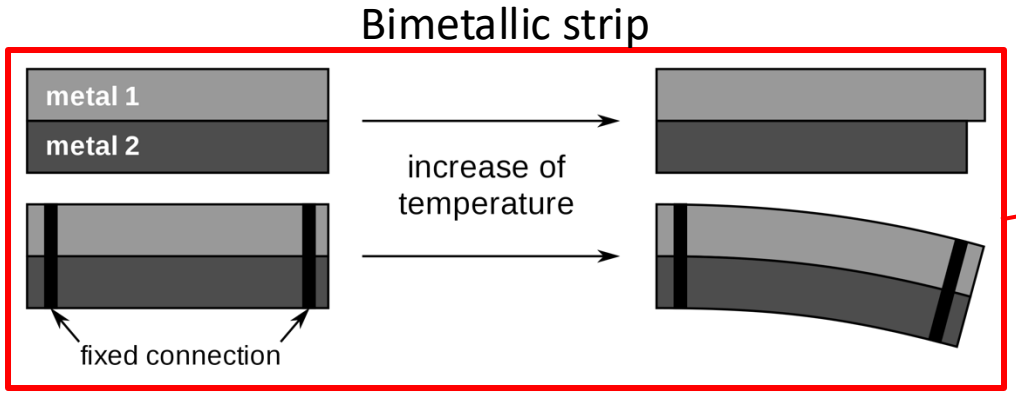
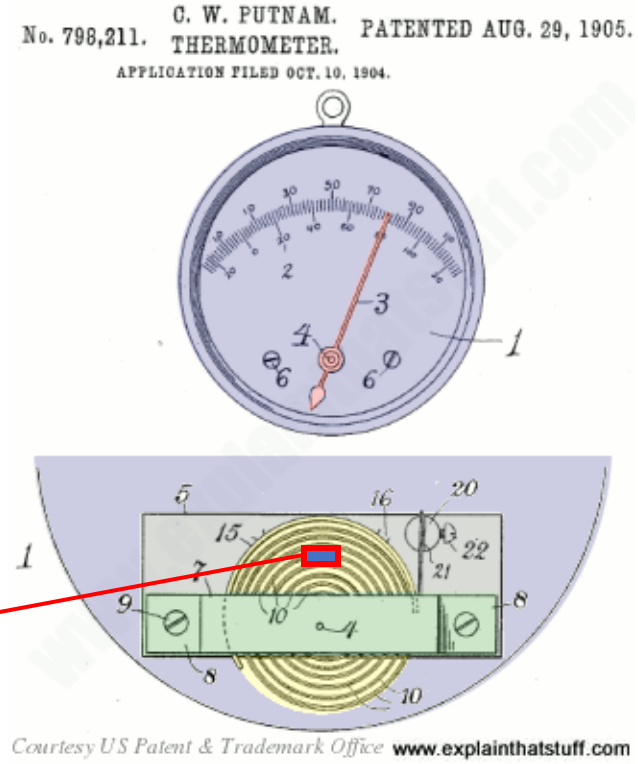
  - Electronic thermometers





1. Metal 1 expands faster than metal 2 when heating
2. Convert to temperature difference
   by thermal expansion coefficients

Left image from https://en.wikipedia.org/wiki/Bimetallic_strip

Right image from
www.explainthatstuff.com

Analogous to Thermometers

- Types of thermometers
  - Liquid thermometers
  - Dial thermometers
  - Electronic thermometers

Image from www.explainthatstuff.com

Analogous to Thermometers

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1. Read voltage across its metal probe
2. Measure how much current flow through it and the resistance
3. Convert resistance into a measurement of temperature

Image from www.explainthatstuff.com

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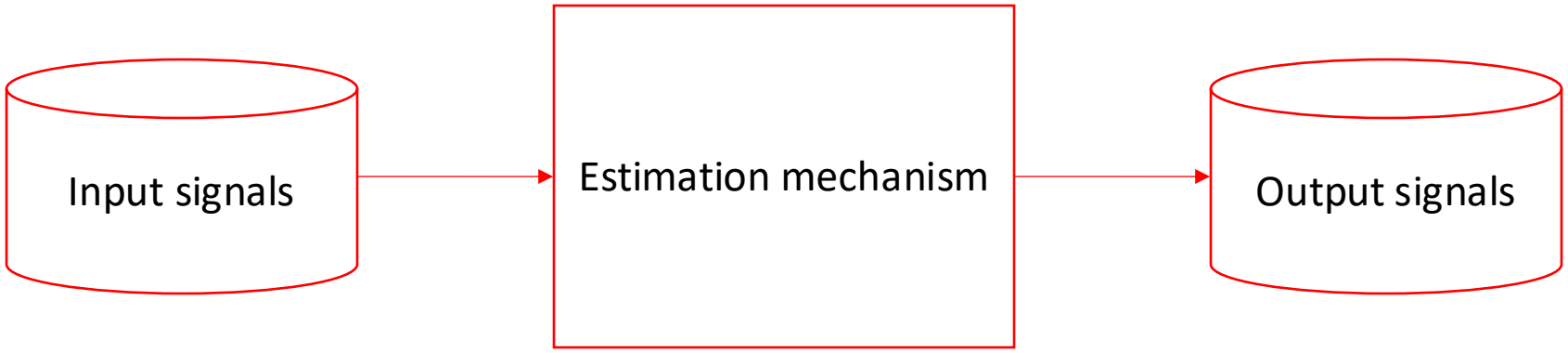

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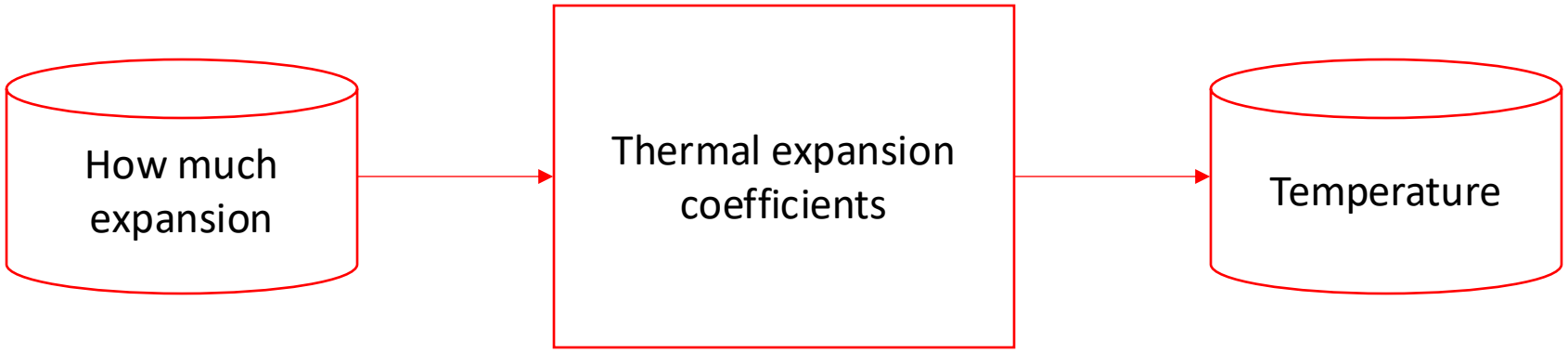

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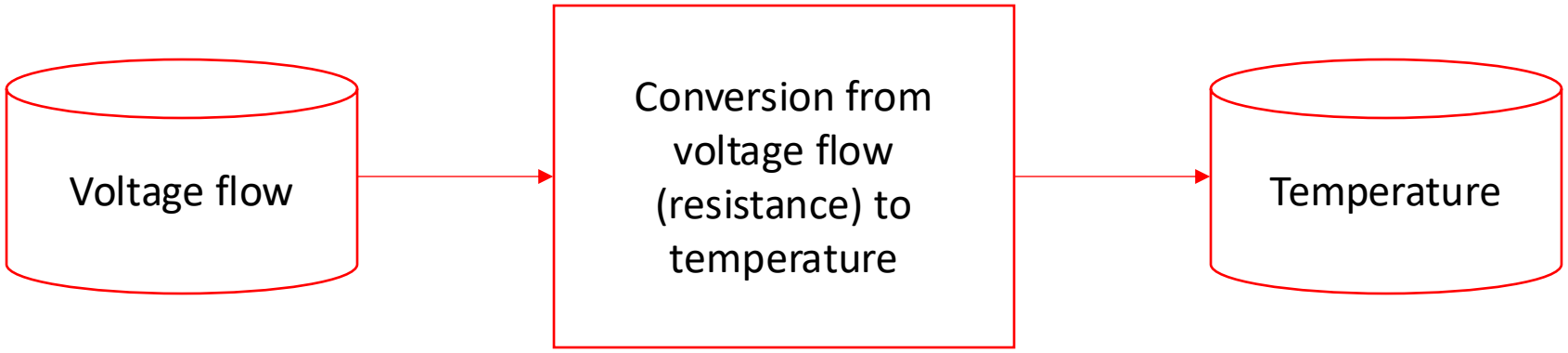

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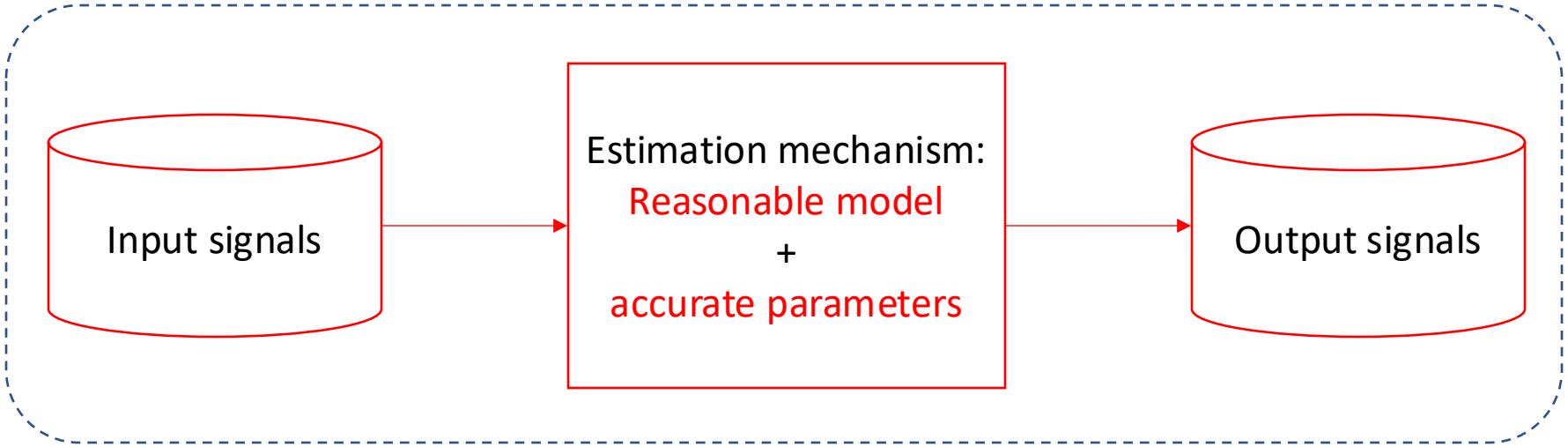

Analogous to machine learning paradigm

Analogous to Thermometers

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