K-NEAREST NEIGHBORS

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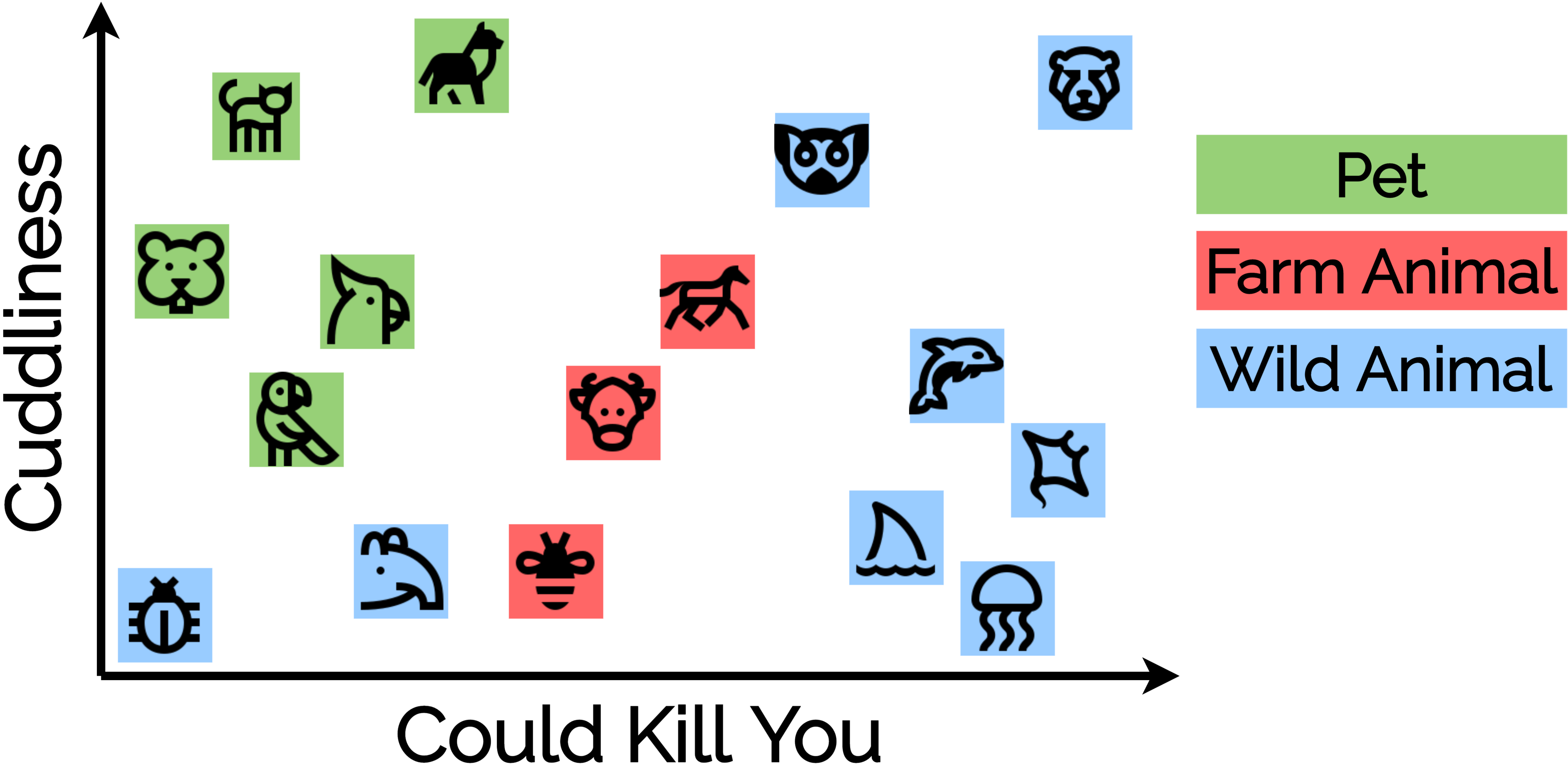
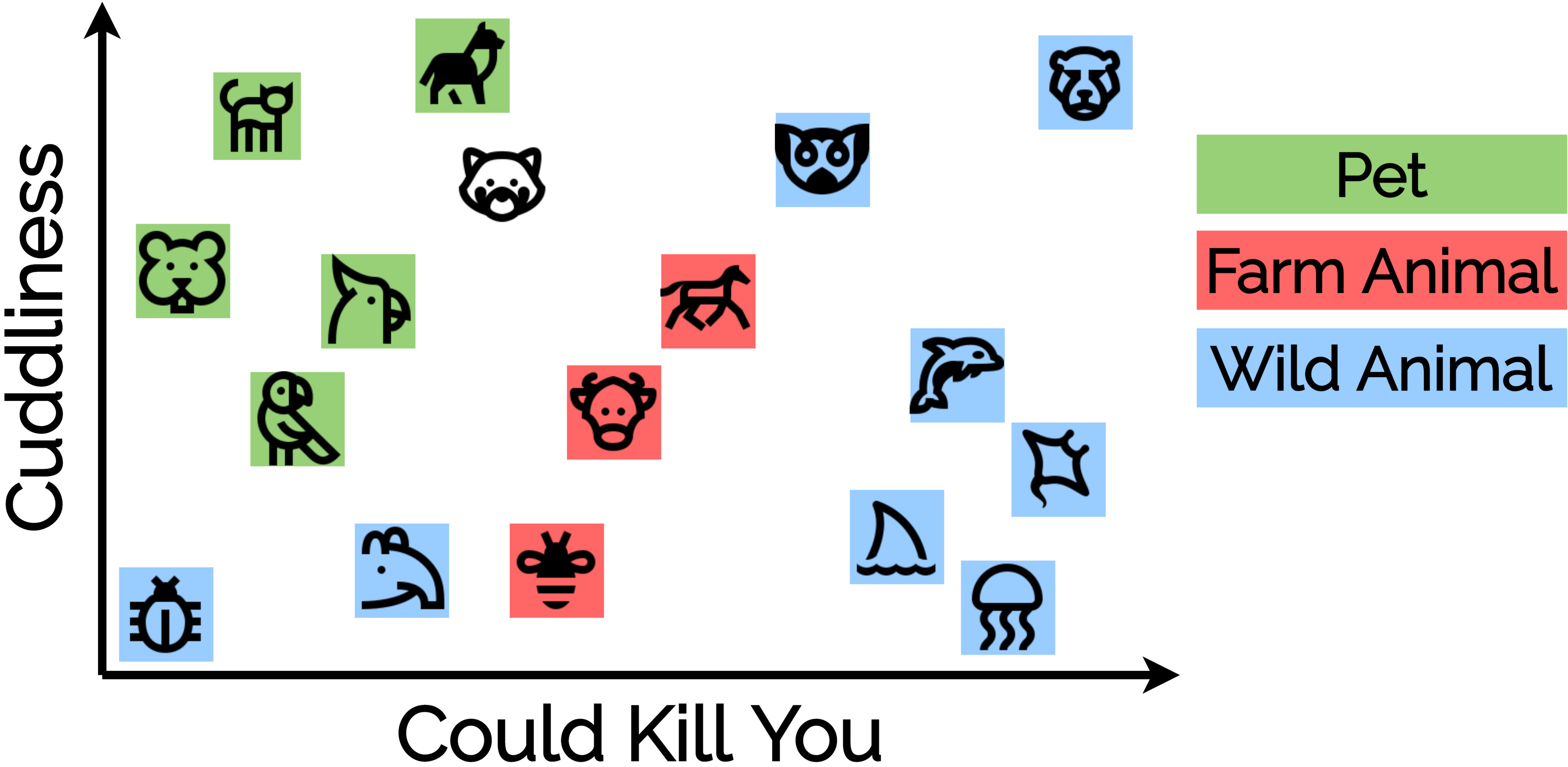
K-NEAREST NEIGHBORS (K-NN)

- **Supervised learning**
- Can be used for **regression** and **classification** algorithms
- **Instance-based learning** (lazy learning)
- Based on the assumption that **like instances** are the **closest distance** to one another
- Uses **voting** mechanism: **k-nearest instances** vote to classify an unknown instance


Cuddliness
Could Kill You
Pet
Farm Animal
Wild Animal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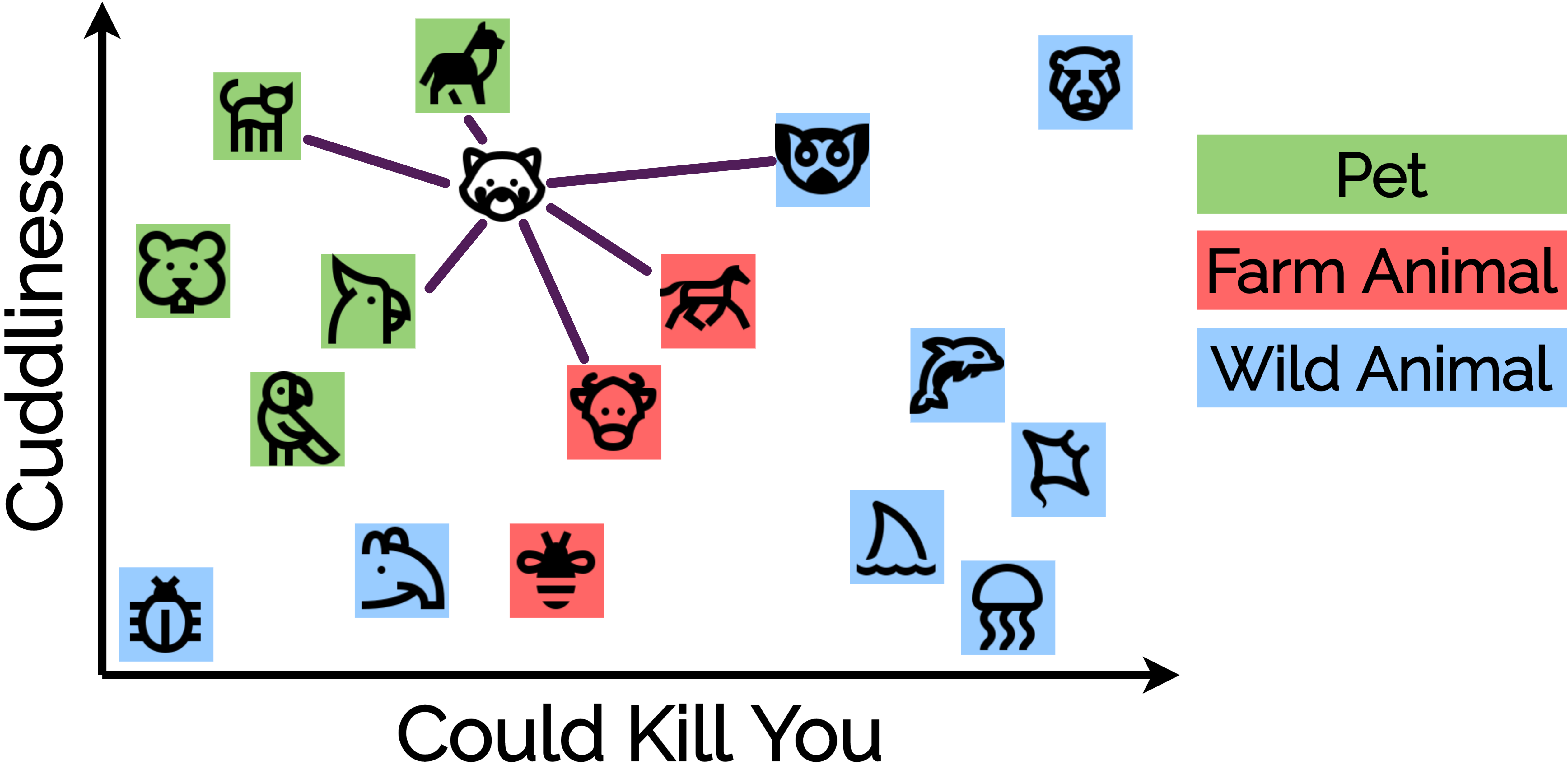
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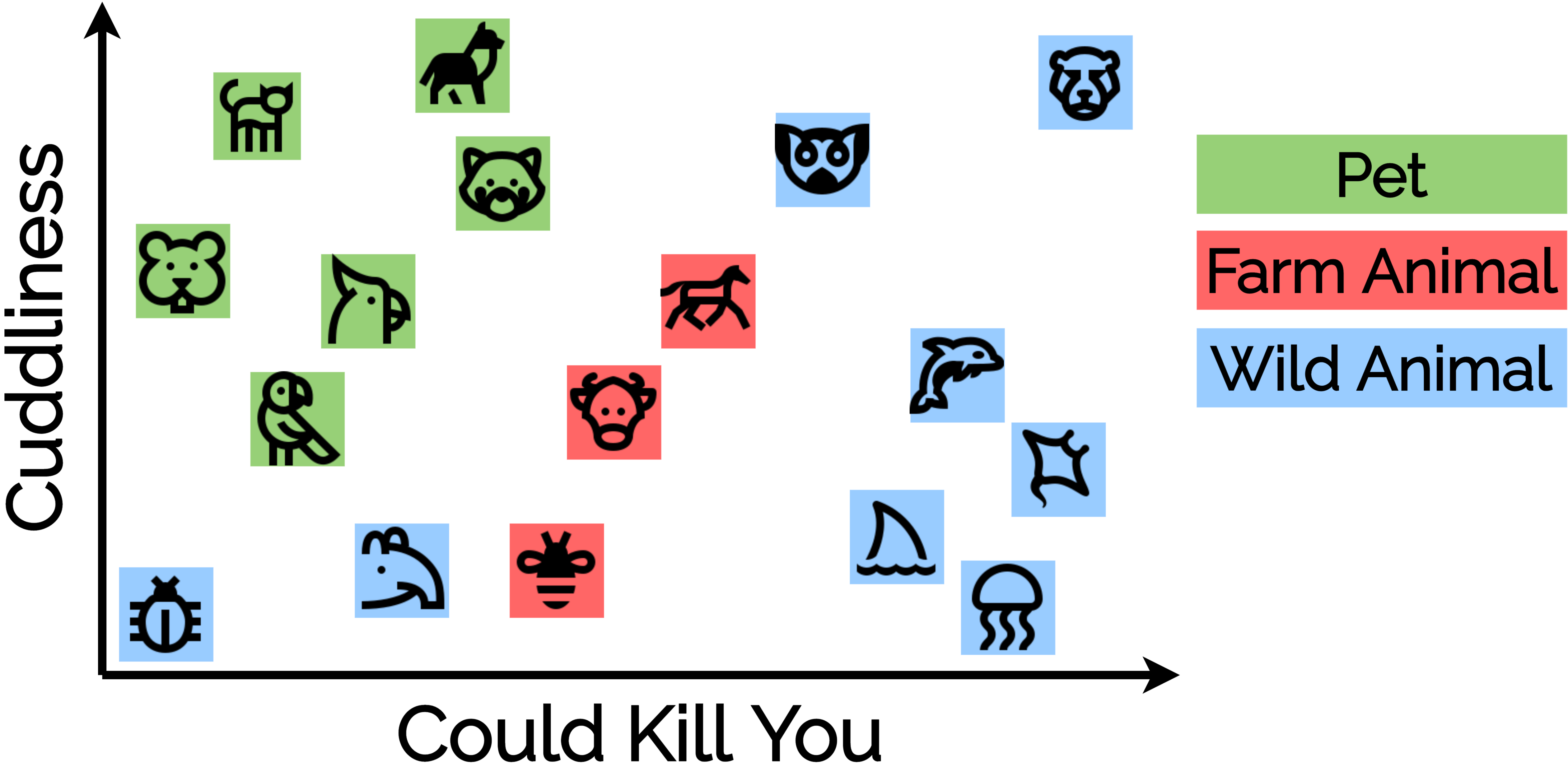
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PREPROCESSING: INTERPOLATION AND NAN HANDLING

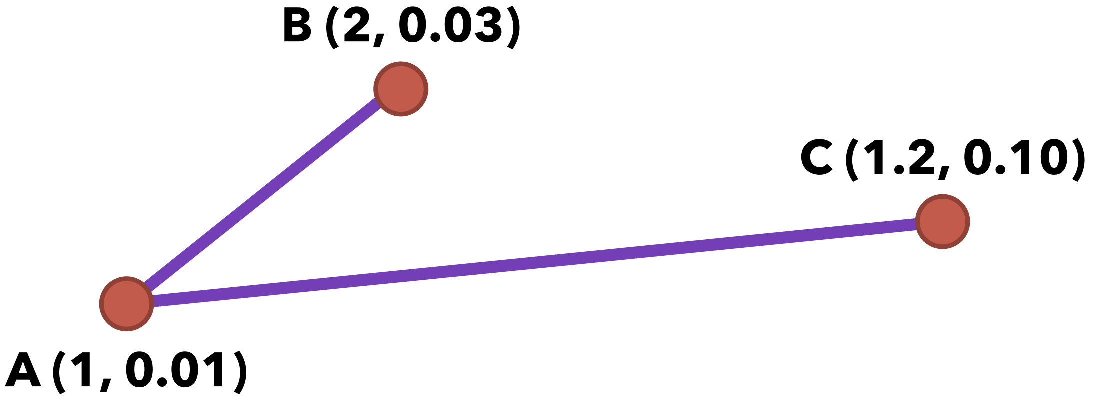
- **Mean interpolate** any unknown numeric values *(optional)*
- **Mode interpolate** any unknown categorical values *(optional)*
- **Remove** any completely unique columns (e.g., names, IDs…)
- **Convert** all categories to numeric values
  - Make need to consider the **values** of being part of **category**
  - E.g.: **extremely rare category** could be given a **weight stronger than 1**

PREPROCESSING: NORMALIZATION

Normalization of data is REQUIRED

Why?

- Distance is evaluated by the **relative difference between points**
- Points with **greater unit values** will be **more heavily weighted**

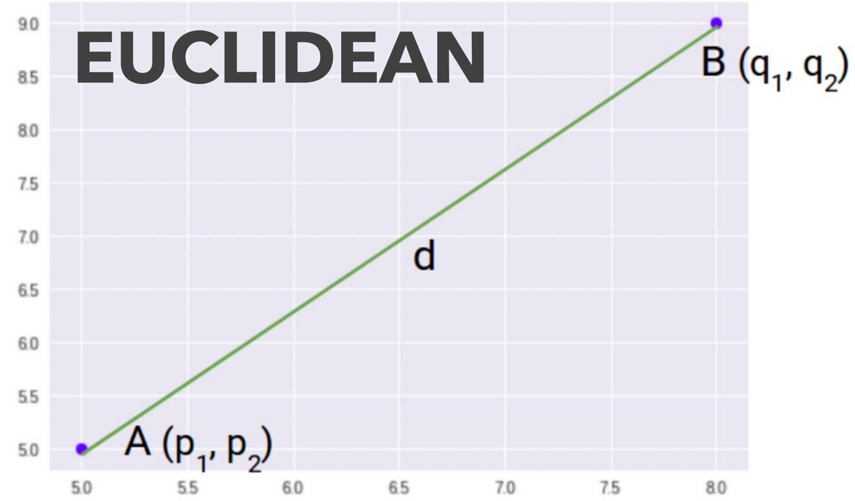


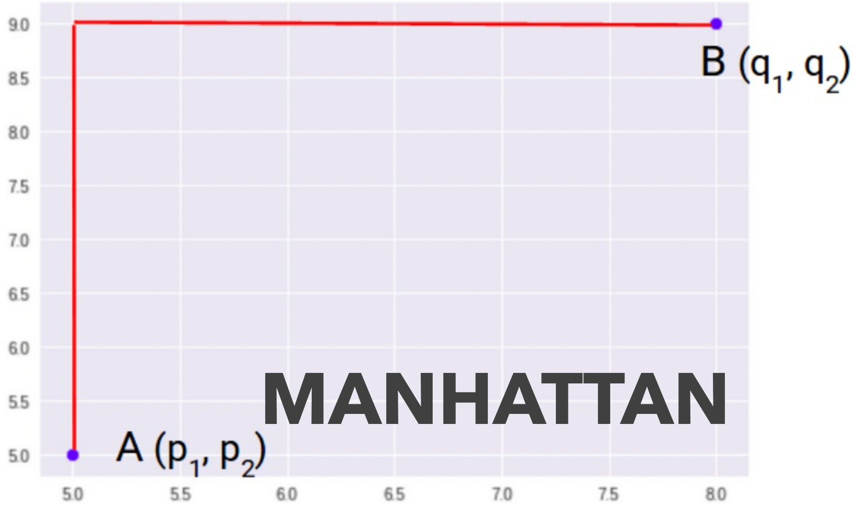
$$\overline{AB} = \sqrt{(2-1)^2 + (0.03-0.01)^2} = \mathbf{1.0002}$$

$$\overline{AC} = \sqrt{(1.2-1)^2 + (0.10-0.01)^2} = \mathbf{0.2193}$$

HYPERPARAMETERS: DISTANCE

Type	Description	Dim.	Equation
Manhattan	City block distance	1	$d(A,B) = \sum_{i=1}^{n} \lvert p_i - q_i \rvert$
Euclidean	Pythagorean shortest distance	2	$d(A,B) = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}$
Minkowski	General form of Manhattan and Euclidean	L	$d(A,B) = \sqrt[L]{\sum_{i=1}^{n} (\lvert p_i - q_i \rvert)^L}$

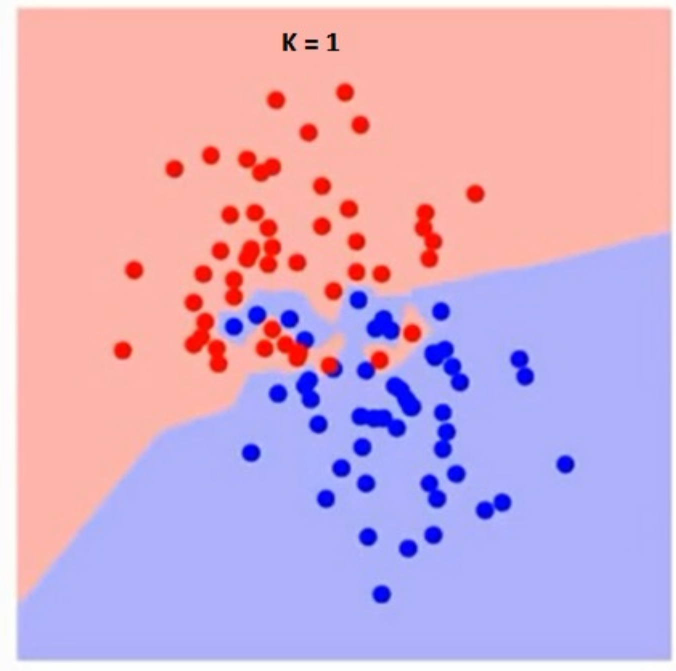




HYPERPARAMETERS: K

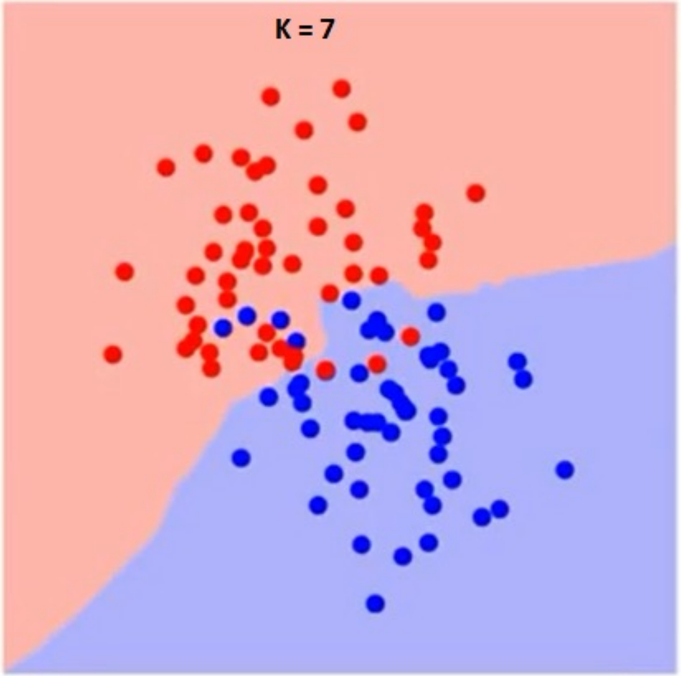
K: number of nearest neighbors involved in classification

- **Overfitted**: too **small** K
- **Underfitted**: too **large** K



OVERFIT

UNDERFIT



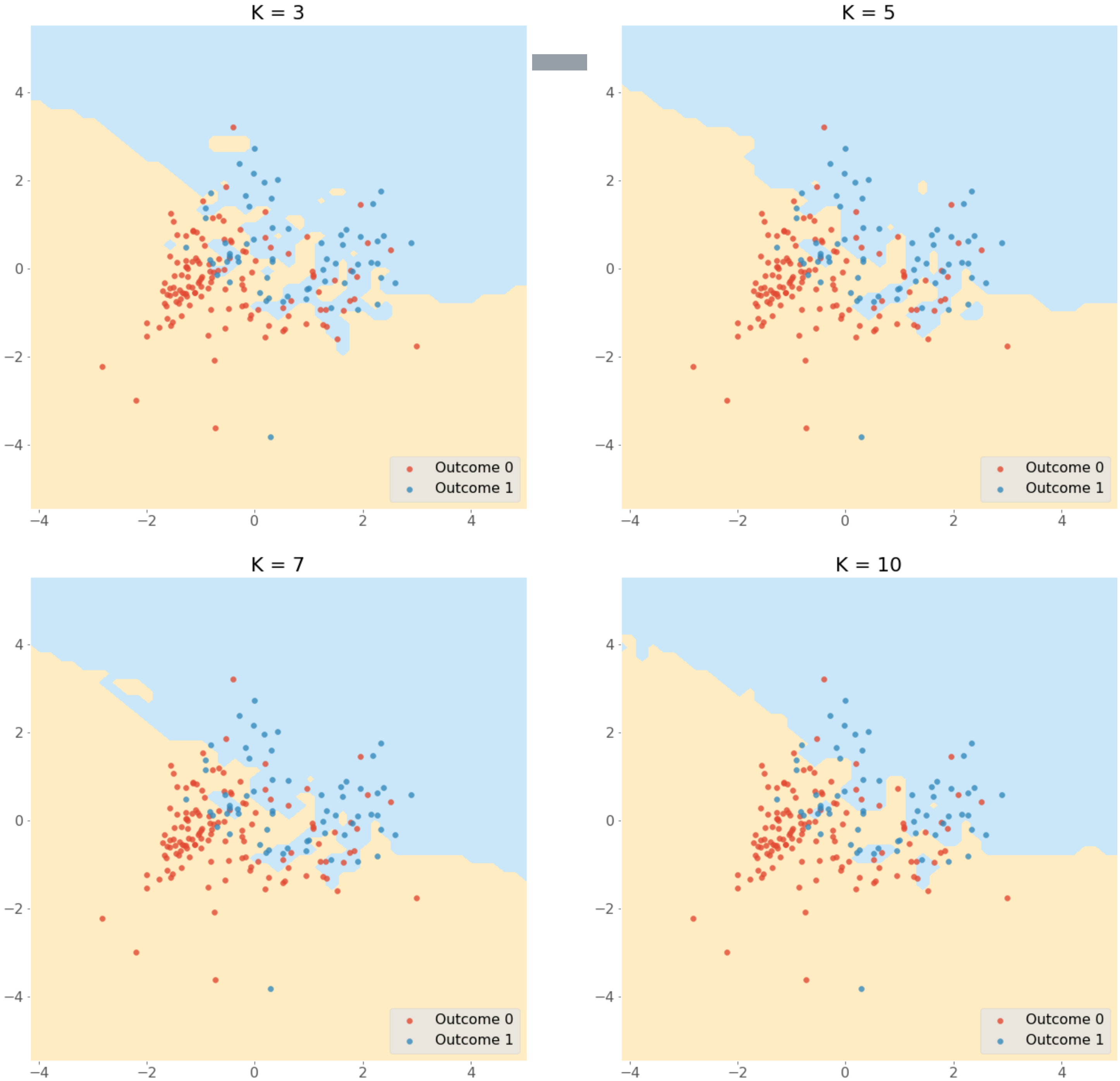
HYPERPARAMETERS: ALGORITHMS

- Change the **how distance is calculated** (to save time)
- Also tuned with **'leaf_size'**

Name	Description	Time Complexity	Dataset Size	Dataset Sparsity	Accuracy
'brute'	Compute all distances	$O(DN^2)$ - *cubic*	Small	Sparse	Highest Accuracy
'kd_tree'	Approximate distances with KD tree	$O(DN)$ – *quadratic*	Large	Dense	High Accuracy
'ball_tree'	Approximate distances with ball tree	$O(D\log N)$ - *nlog(n)*	Very Large	Dense	Decent Accuracy

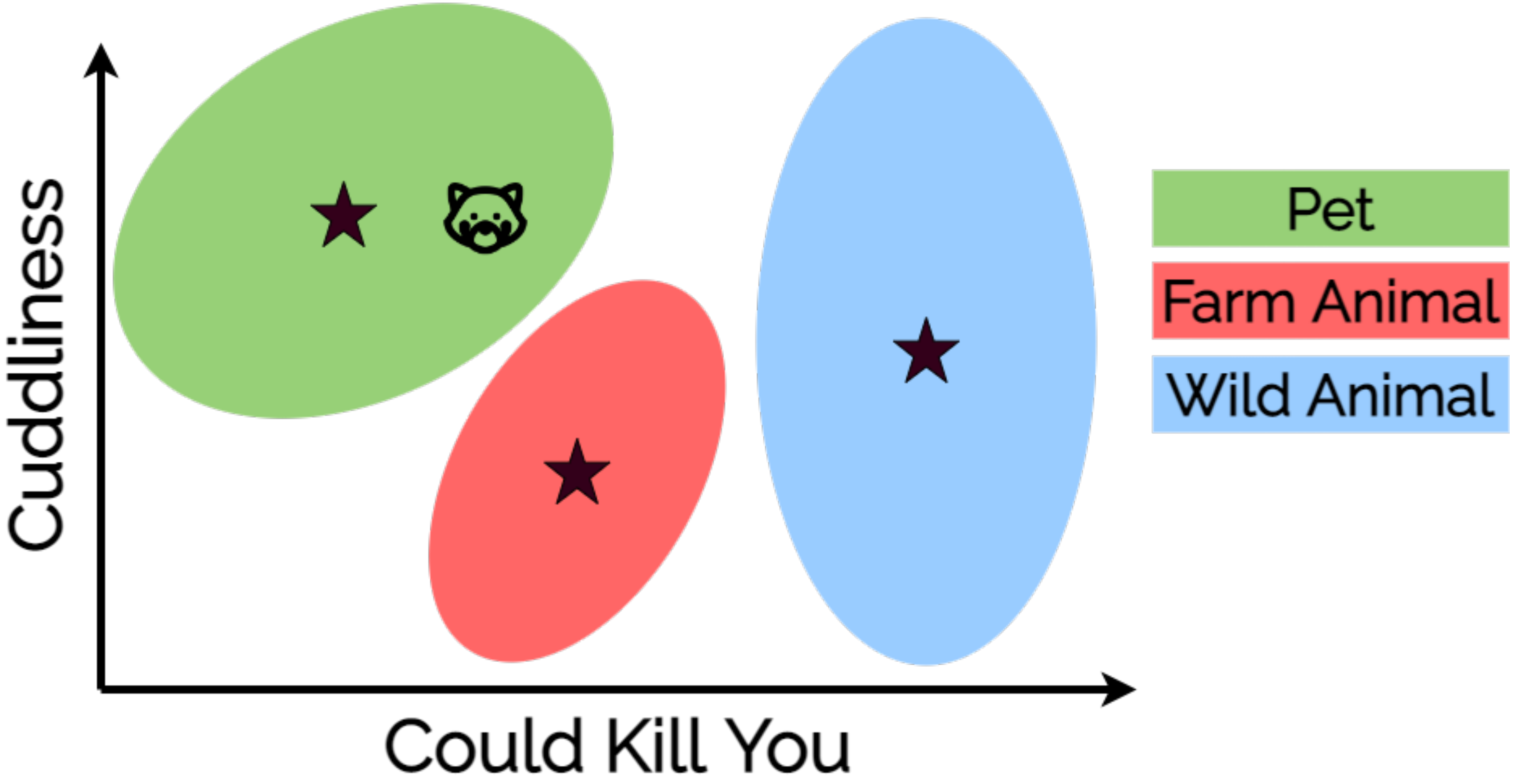
BENEFITS

- **Intuitive** and human friendly
- Allows user to **chose** the **hyperparameters**
- Memory-based
- Both **classification** and **regression**
- Ease after establishing hyperparameters
- **Non-parametric**



TRADE-OFFS AND LIMITATIONS

- **Non-parametric**
- **Slow** to implement
- **Dimensionality**
- Requires **homogenous** features
- **Sensitive to outliers**



QUESTIONS?