# K Nearest Neighbors

# KNN

- KNN (K nearest neighbors) is one of the simplest algorithms we will learn about!
- Section Overview
  - KNN Theory and Intuition
  - KNN Classification Coding Example
  - KNN Exercise Overview
  - KNN Exercise Solution

# KNN

- While KNN can be used for regression tasks, its performance can be quite poor **and** less efficient than other algorithms, so we've decided not to exhibit its use for regression.
- However if you do want to use it for regression it is very easy to swap in the KNNRegressor model with scikit-learn.

# KNN

- You may have also heard of K means algorithm.
- K means is unrelated to KNN, be careful not to confuse the two due to their similar sounding names!

# KNN Classification

Theory and Intuition

# KNN

- K nearest neighbors is one of the simplest machine learning algorithms.
- It simply assigns a label to new data based on the **distance** between the old data and new data.
- Let’s go through the intuition with an example use case…

A 1987 study by psychologist Robert Zajonc proposed that spouses’ facial features become more similar over time.

This convergence was attributed to shared environments, diets, and emotional expressions.

The study also found that couples who grew more alike reported higher marital satisfaction.

## Assortative Mating

Tendency for individuals to select partners who are similar to themselves, may explain the initial resemblance between couples.

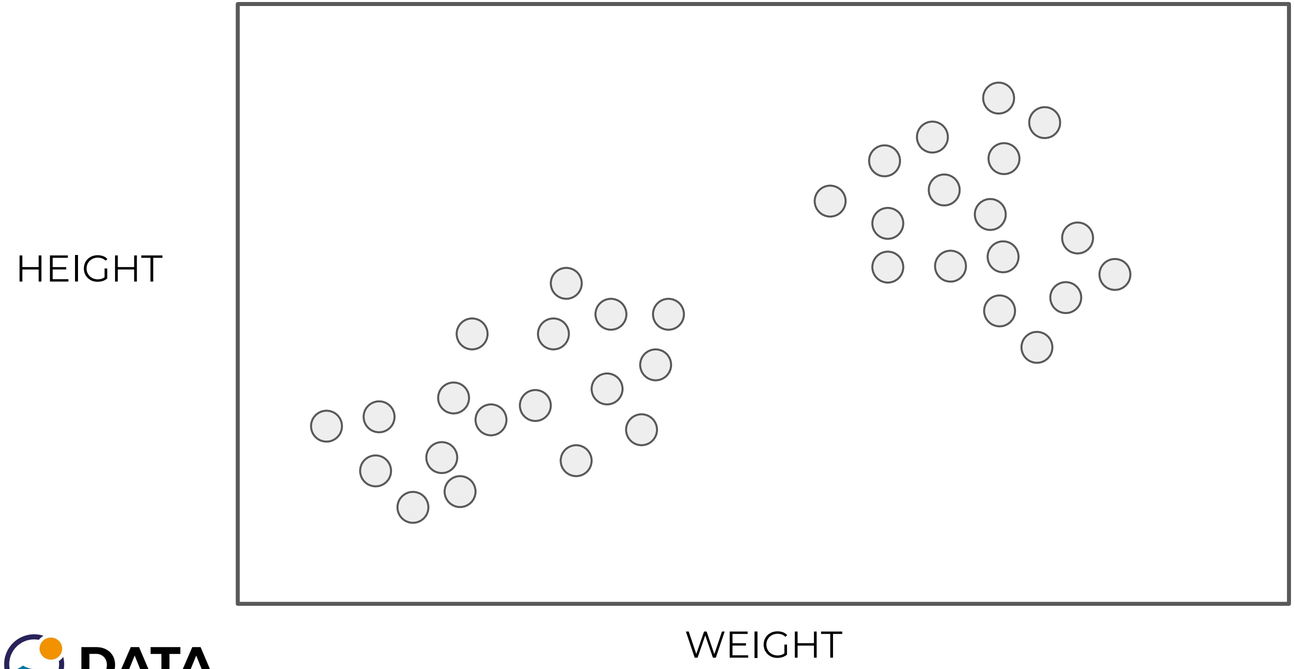
People often choose partners who share similar physical features, backgrounds, and values.

# KNN

- Sexing chicks is still a very manual process:
    - en.wikipedia.org/wiki/Chick_sexing
- Let’s imagine we gathered a dataset of baby chick heights and weights.
- How could we train an algorithm to identify the sex of a new baby chick based on historical features?

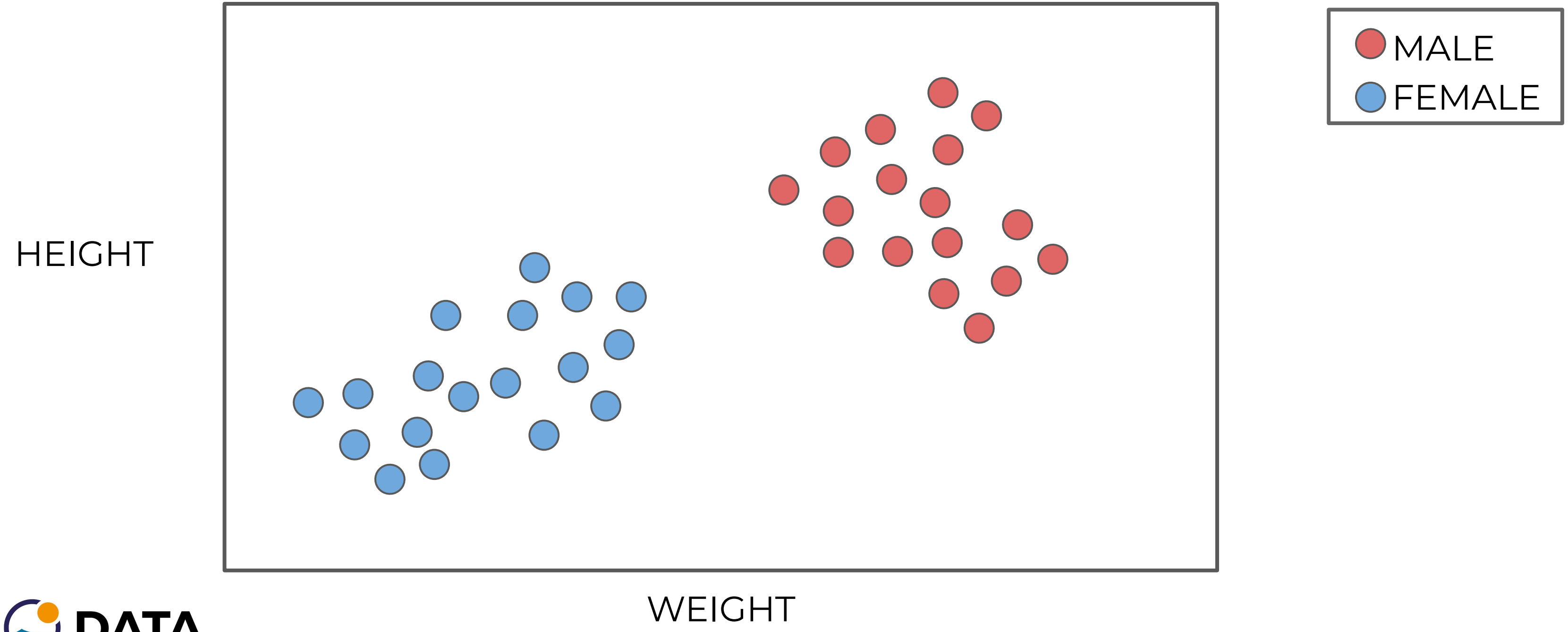
# KNN

- Imagine a height and weight data set



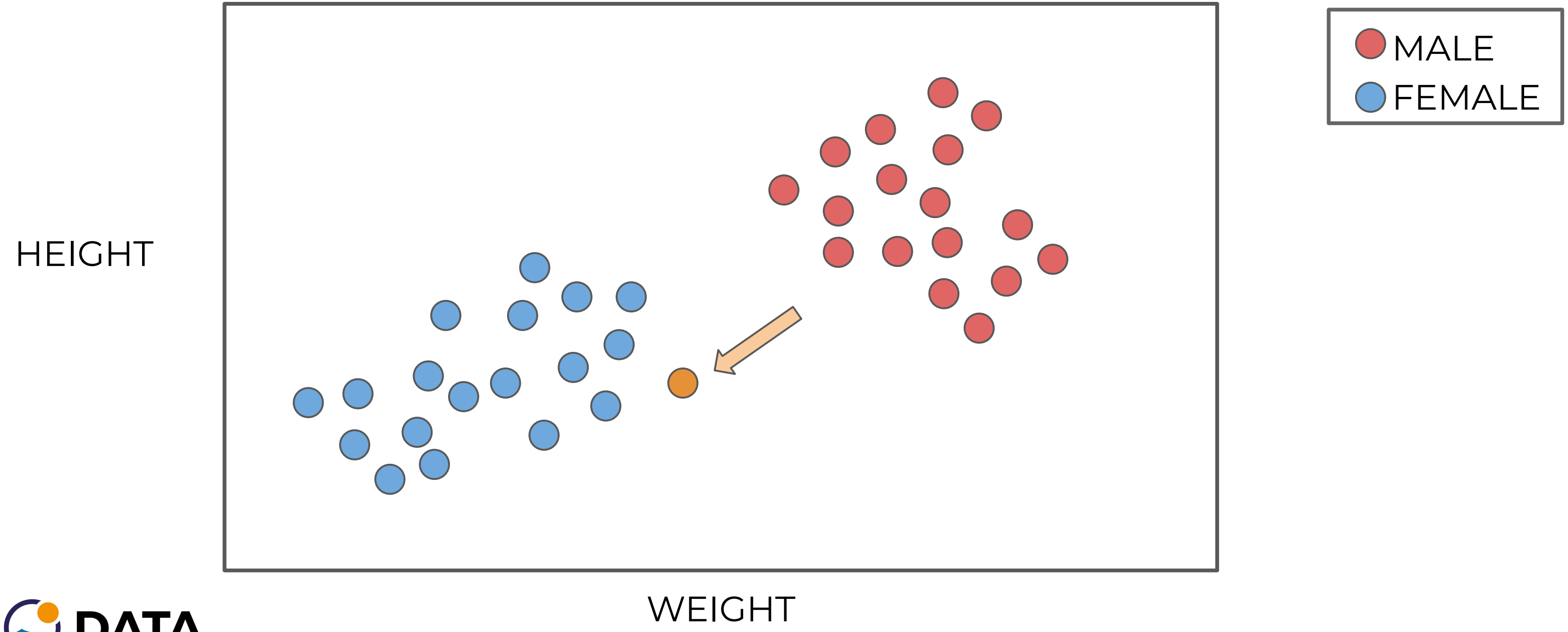
# KNN

- We historically know the sex of the chicks:



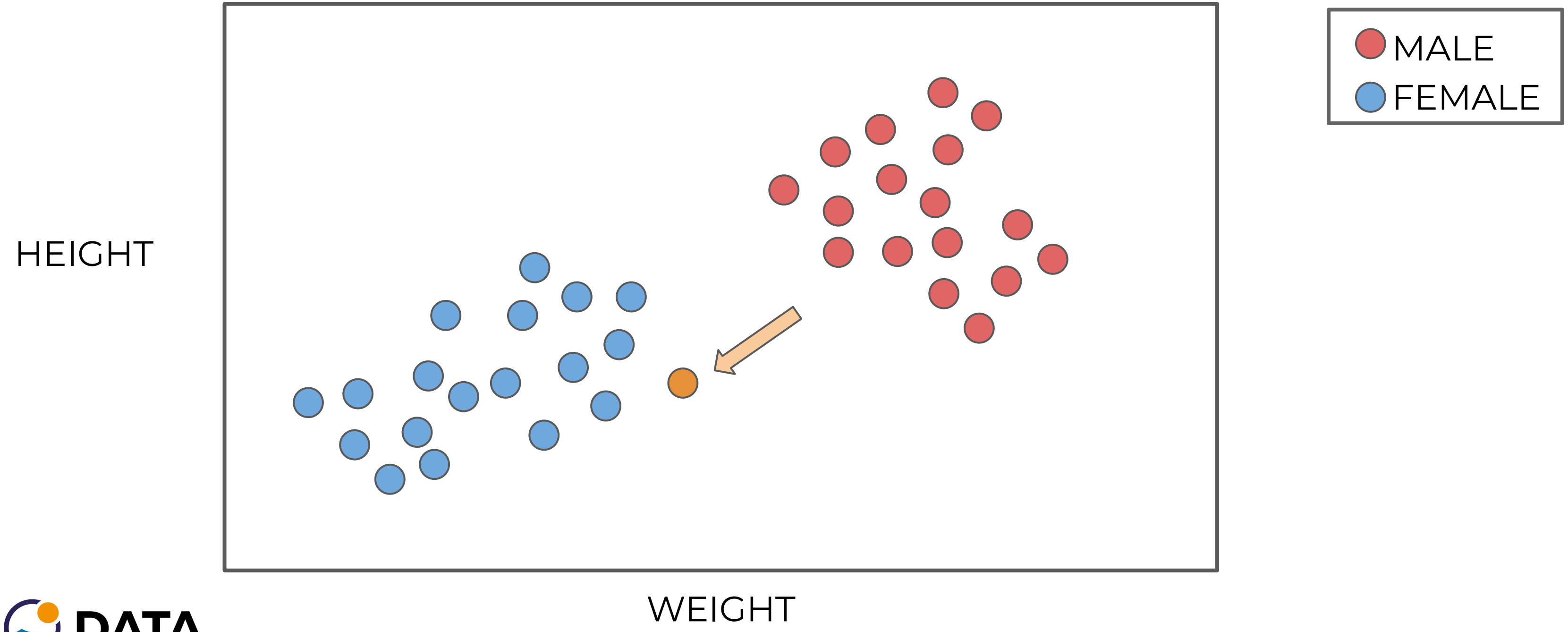
# KNN

- How would we assign sex to a new point?



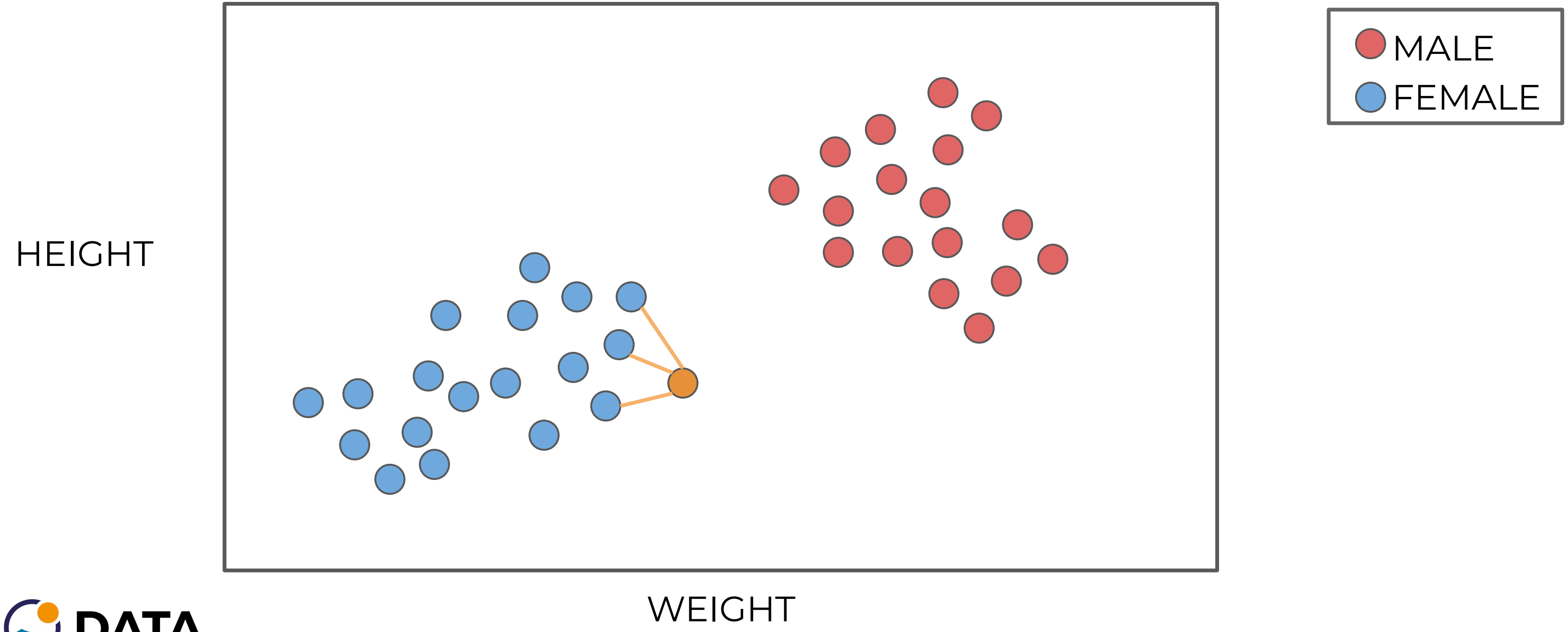
# KNN

- We intuitively “know” this is likely female.



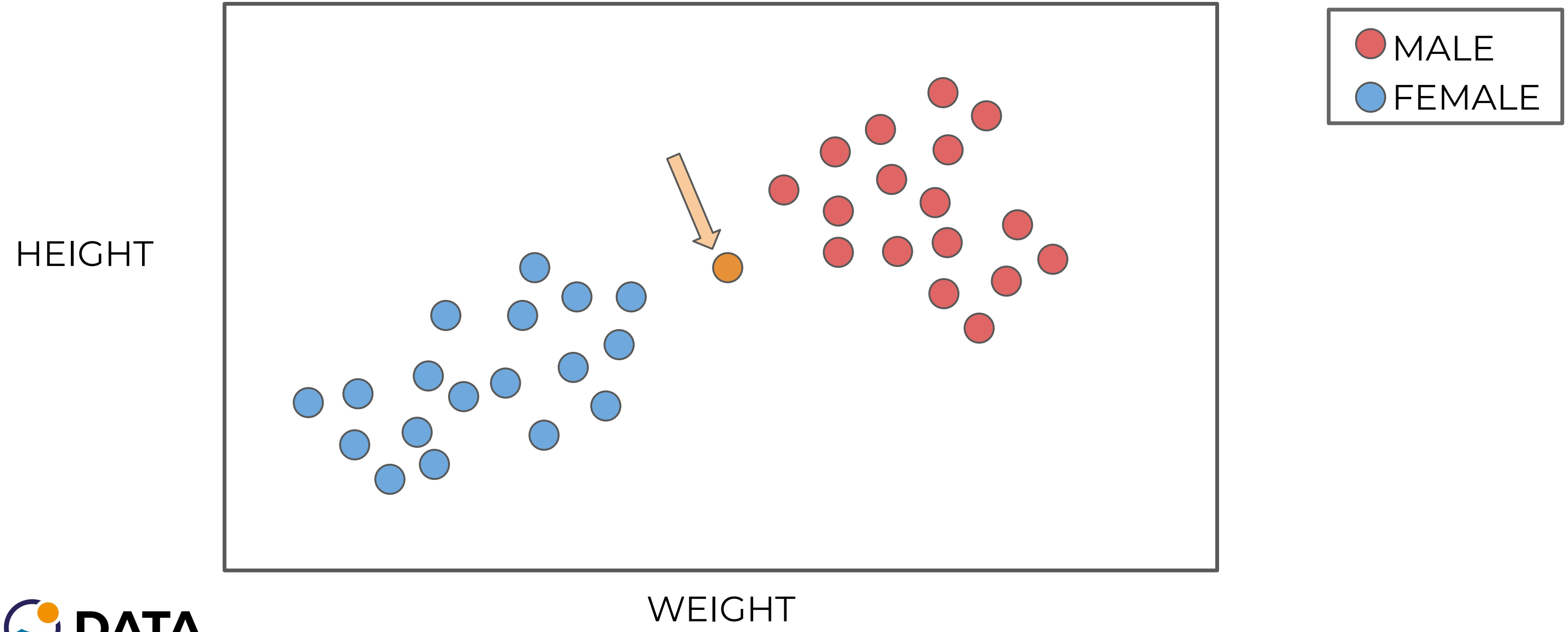
# KNN

- Intuition comes from **distance** to points!



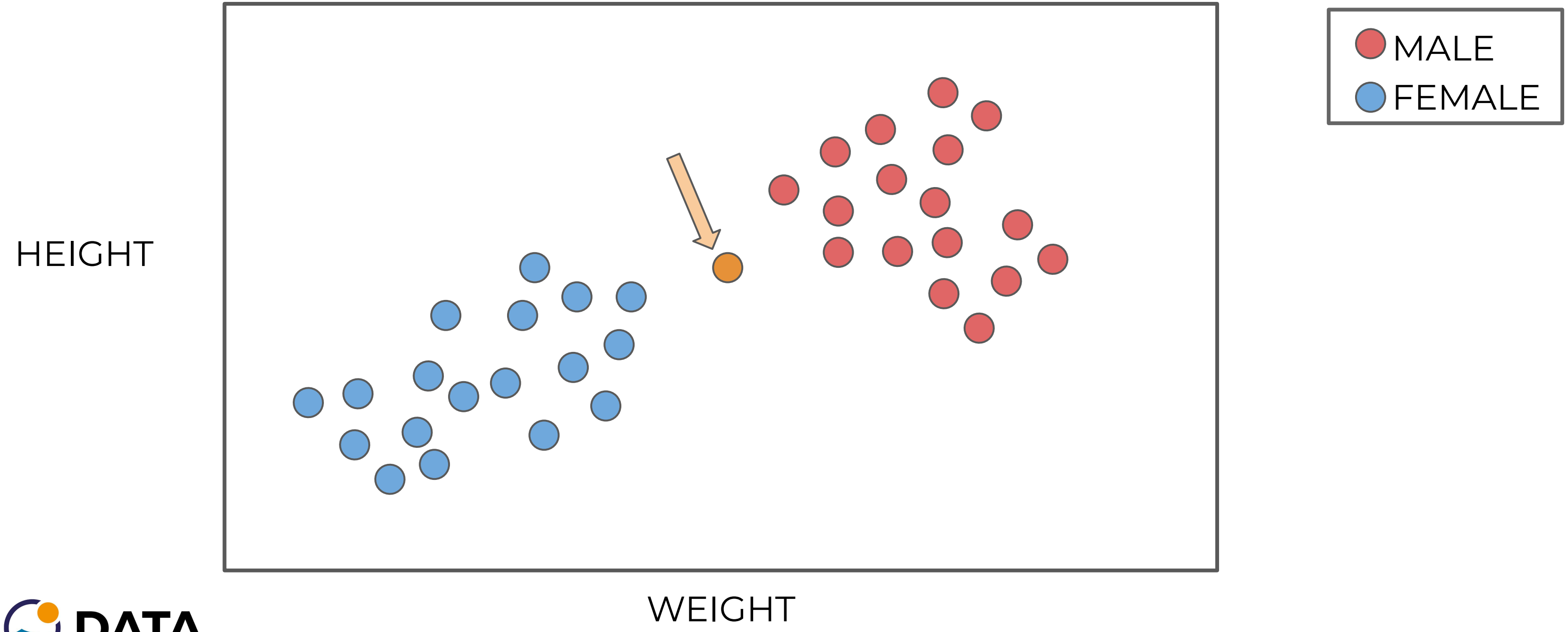
# KNN

- What about a less obvious point?



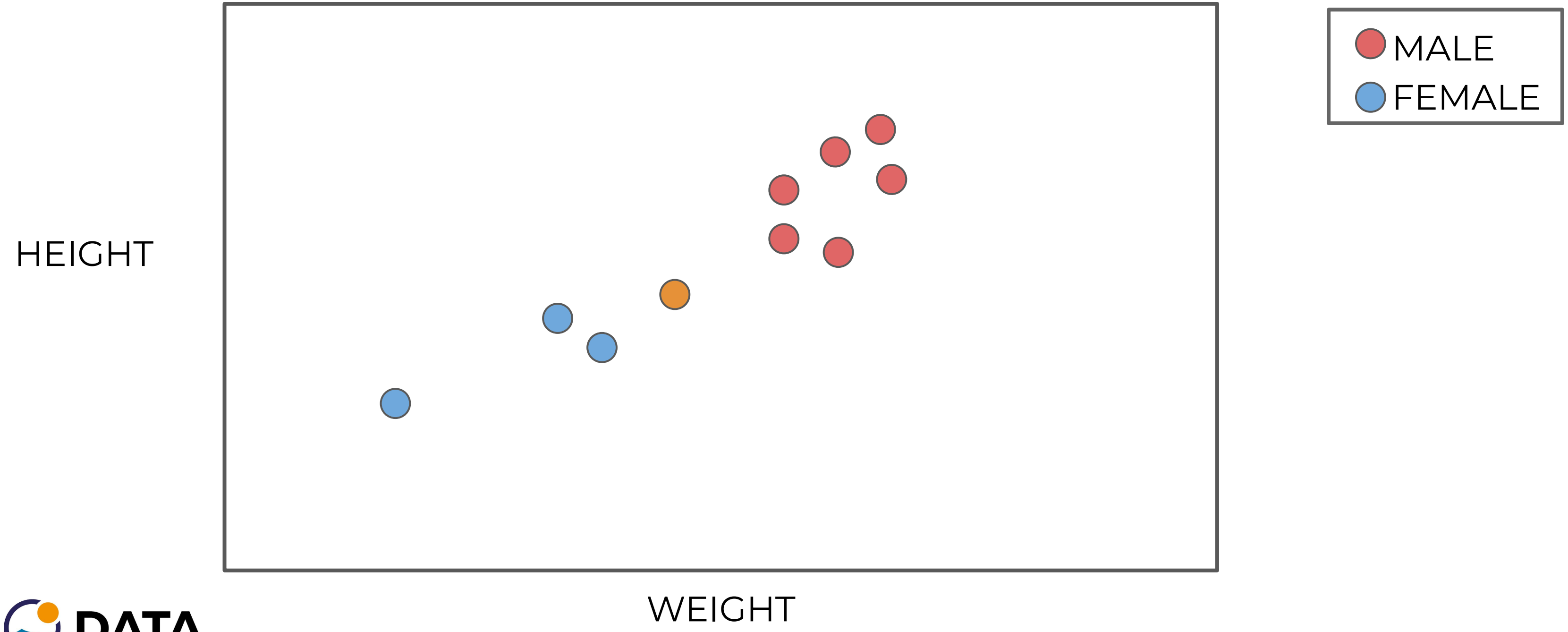
# KNN

- How many points to we consider?



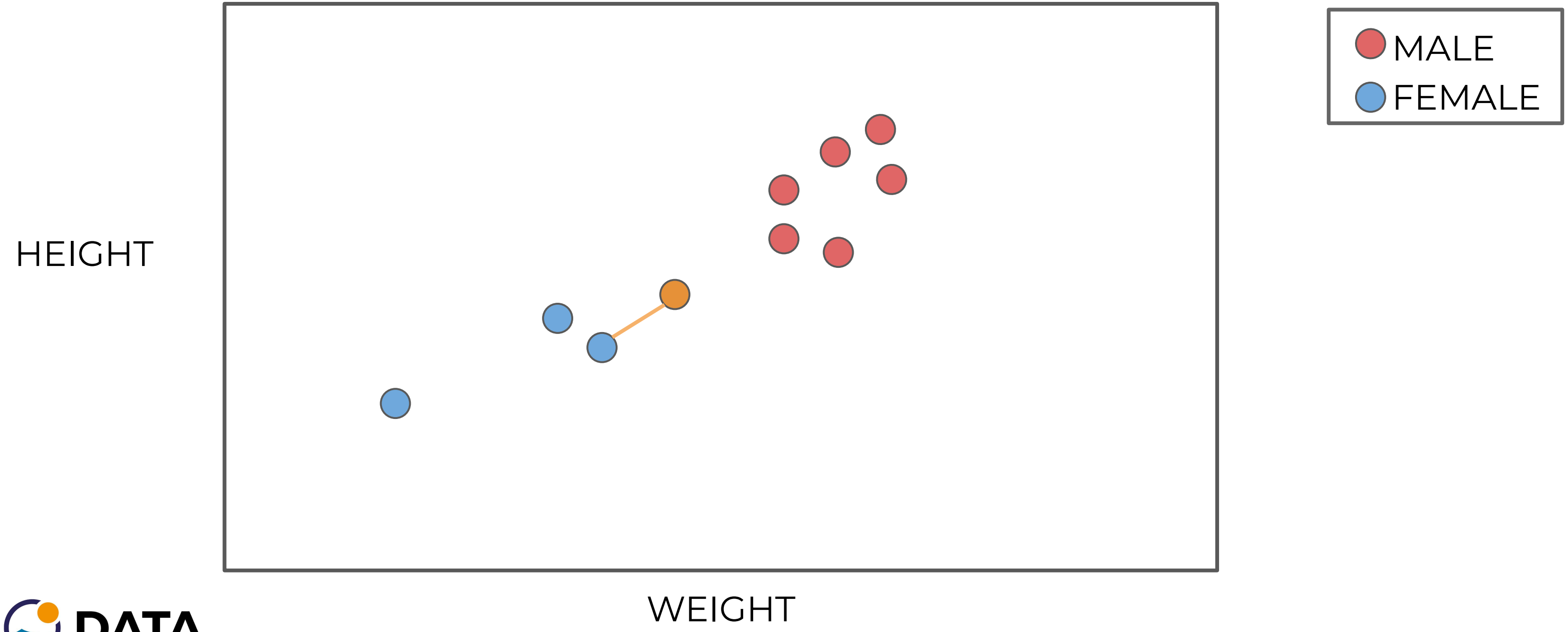
# KNN

- Let’s imagine a situation like this:



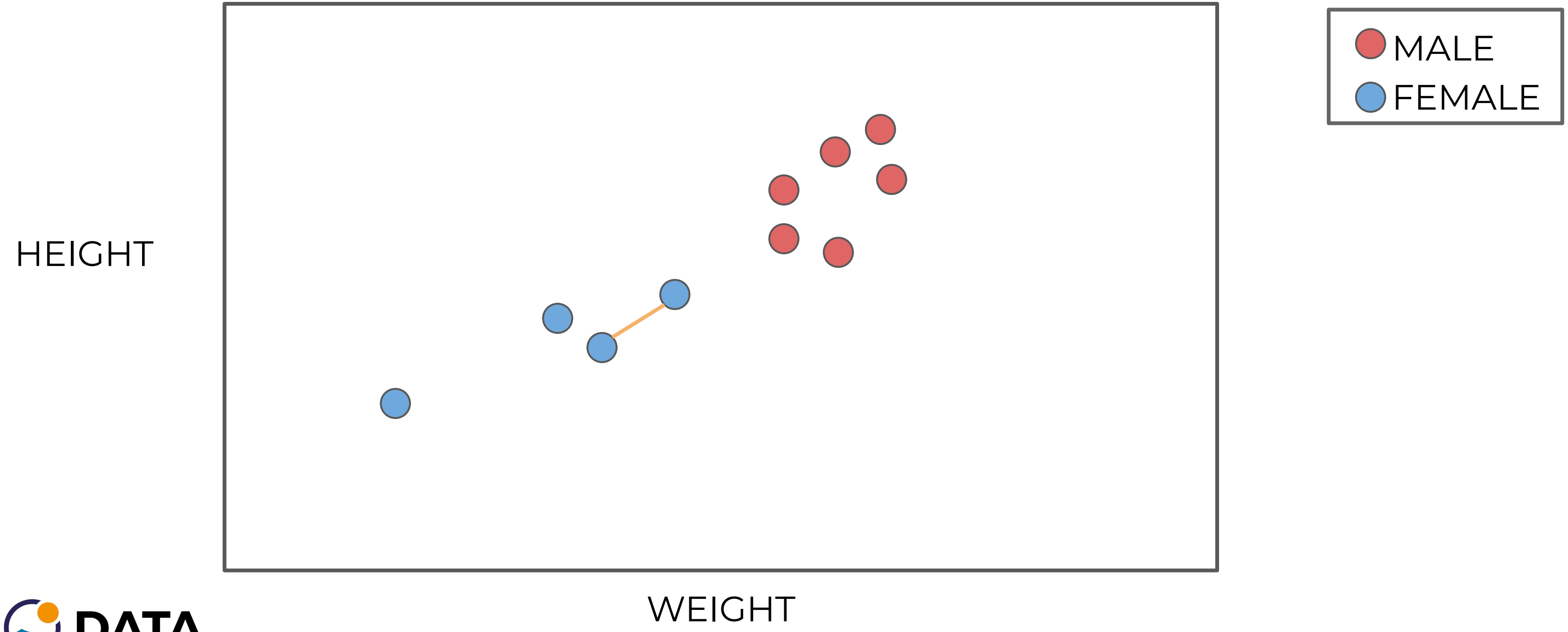
# KNN

- K=1



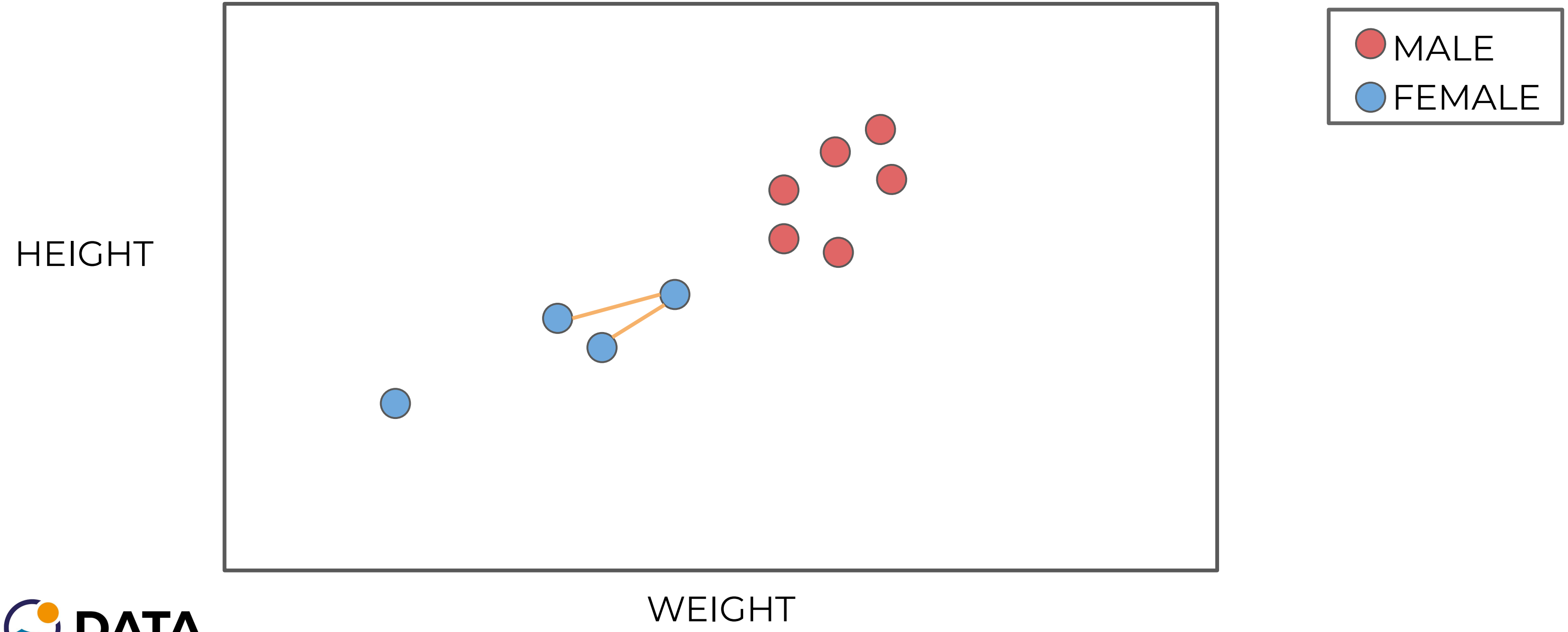
# KNN

- K=1



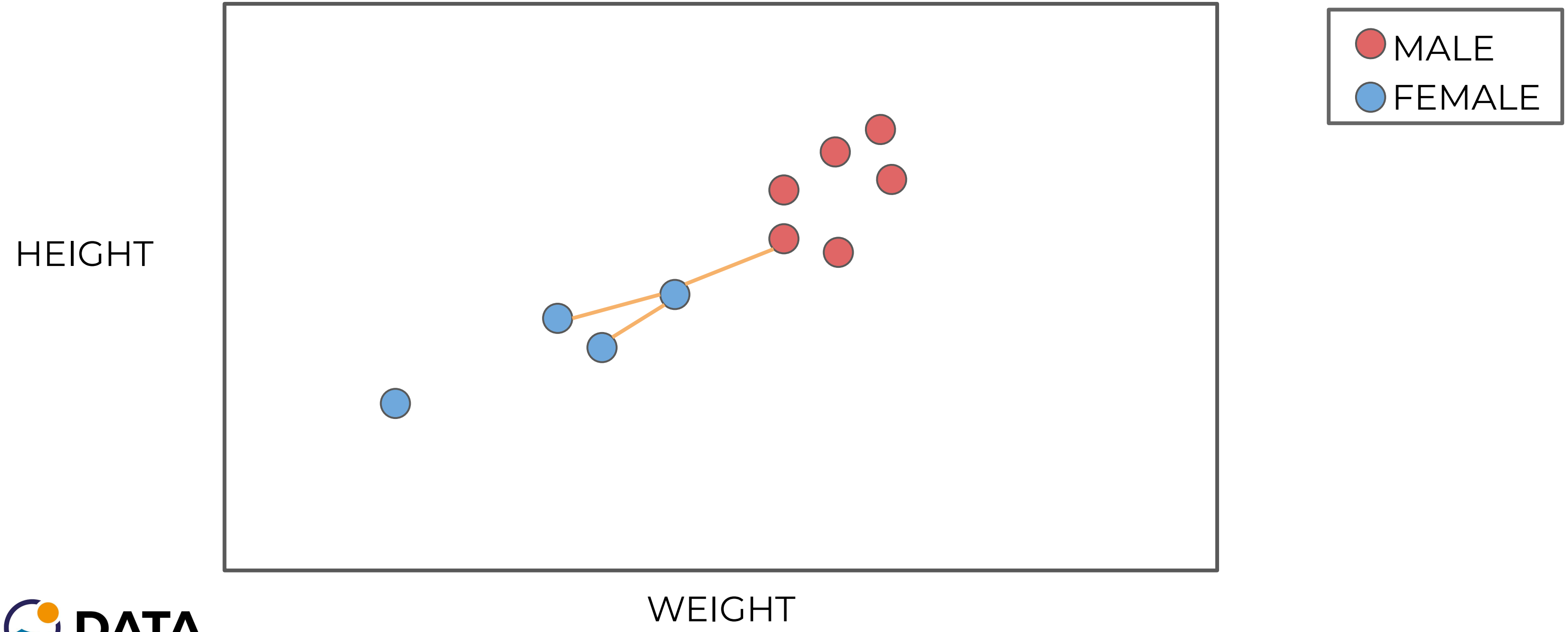
# KNN

- K=2



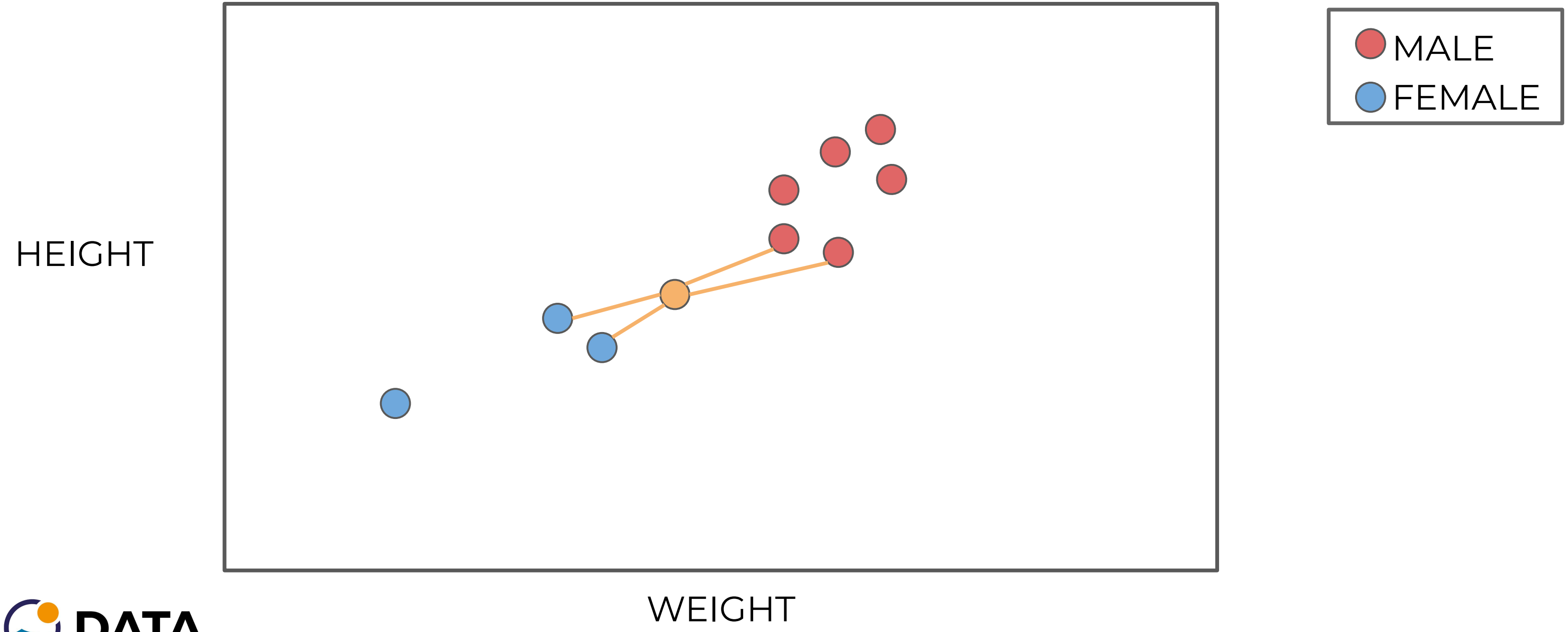
# KNN

- K=3



# KNN

- K=4 leads to a tie!



# KNN

- Tie considerations and options:
  - Always choose an odd K.
  - In case of tie,simply reduce K by 1 until tie is broken.
  - Randomly break tie.
  - Choose nearest class point.

# KNN

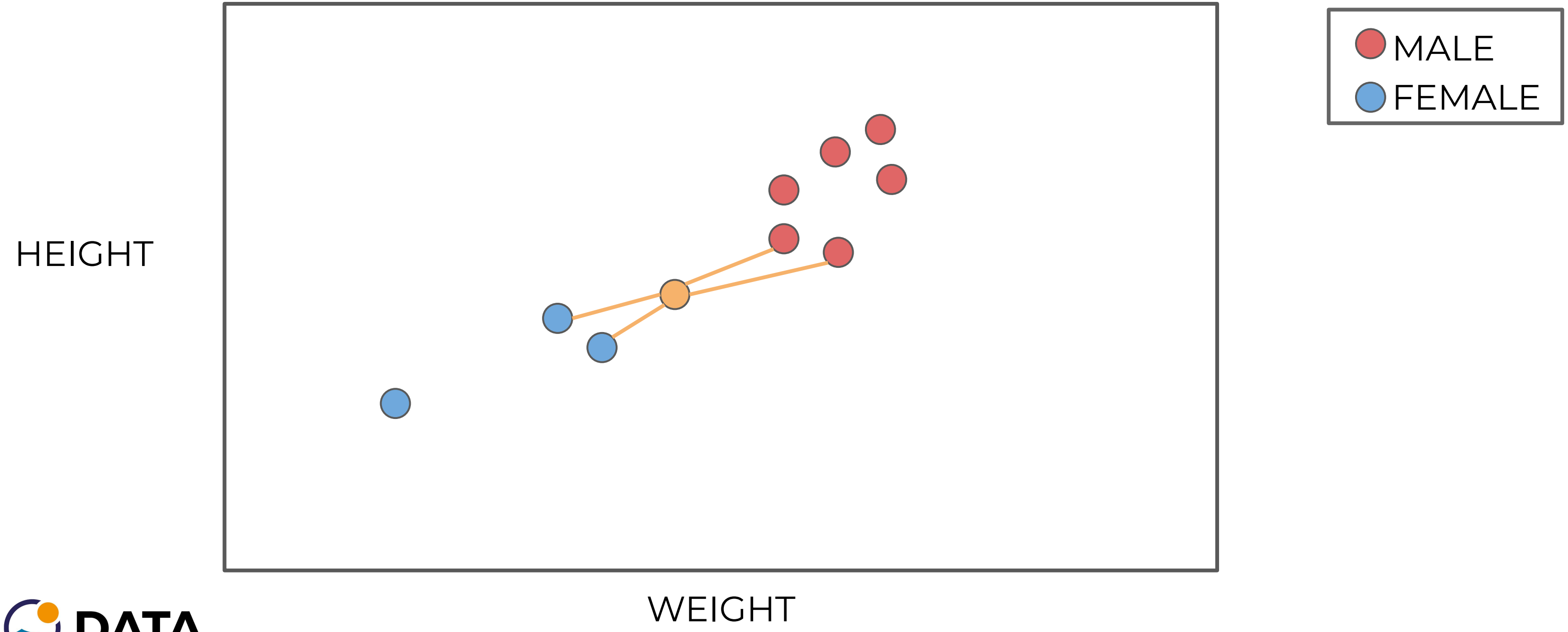
- What does Scikit-Learn do in case of tie?
    - *Warning: Regarding the Nearest Neighbors algorithms, if it is found that two neighbors, neighbor k+1 and k, have identical distances but different labels, the results will depend on the ordering of the training data.*

# KNN

- What does Scikit-Learn do in case of tie?
  - *In the case of ties, the answer will be the class that happens to appear first in the set of neighbors.*
  - *Results are ordered by distance, so it chooses the class of the closest point.*

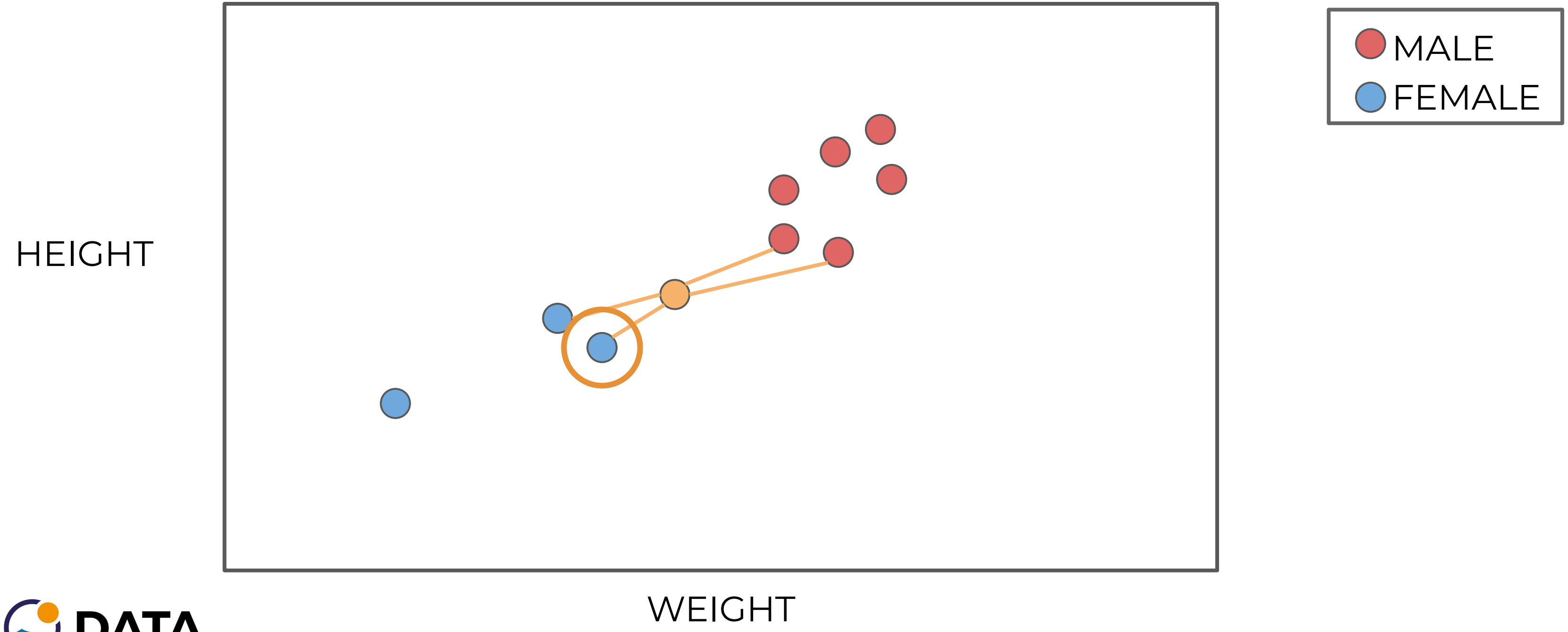
# KNN

- K=4 leads to a tie!



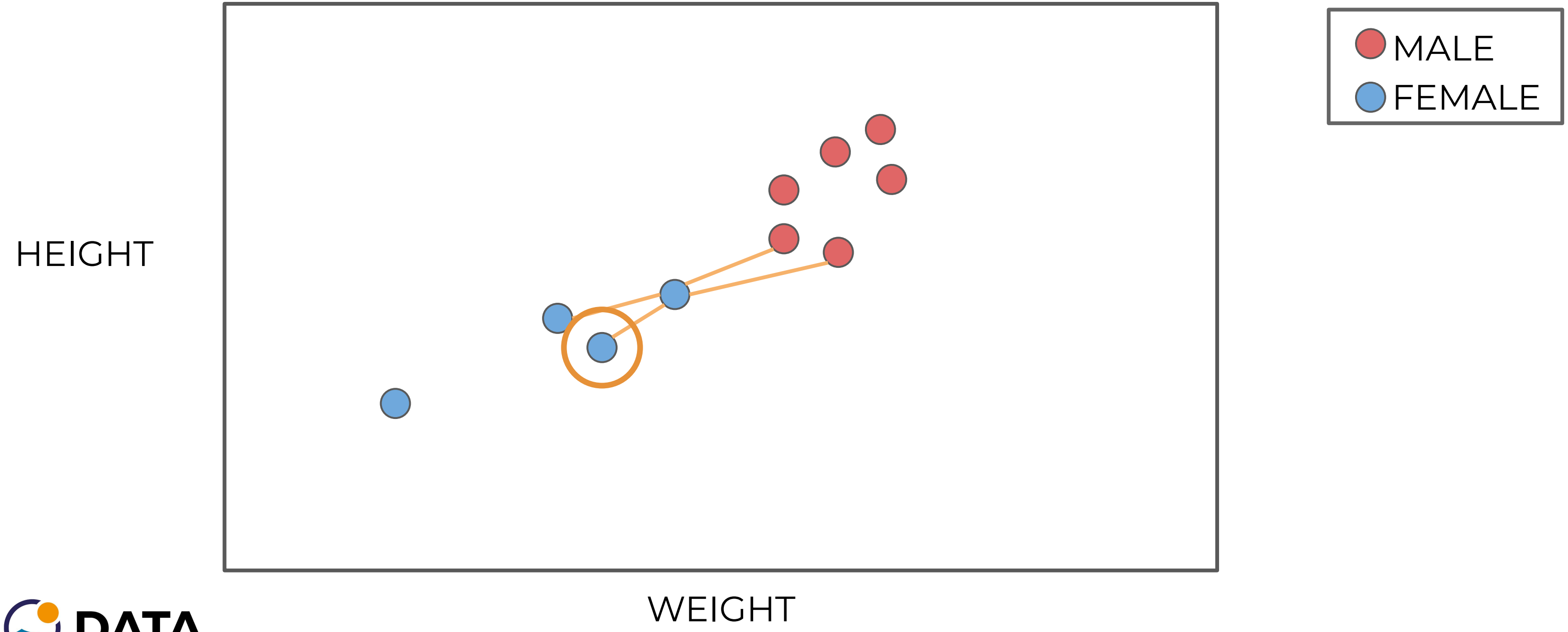
# KNN

- Choose closest K



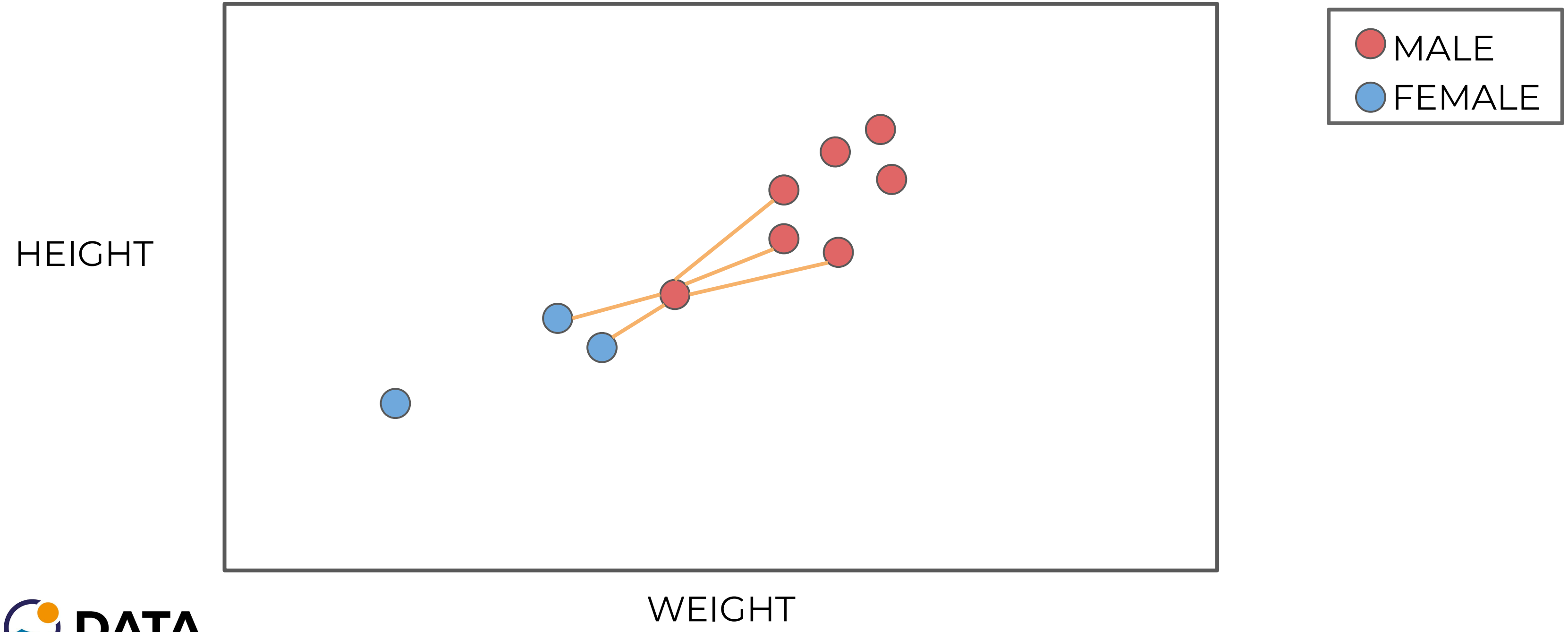
# KNN

- Choose closest K



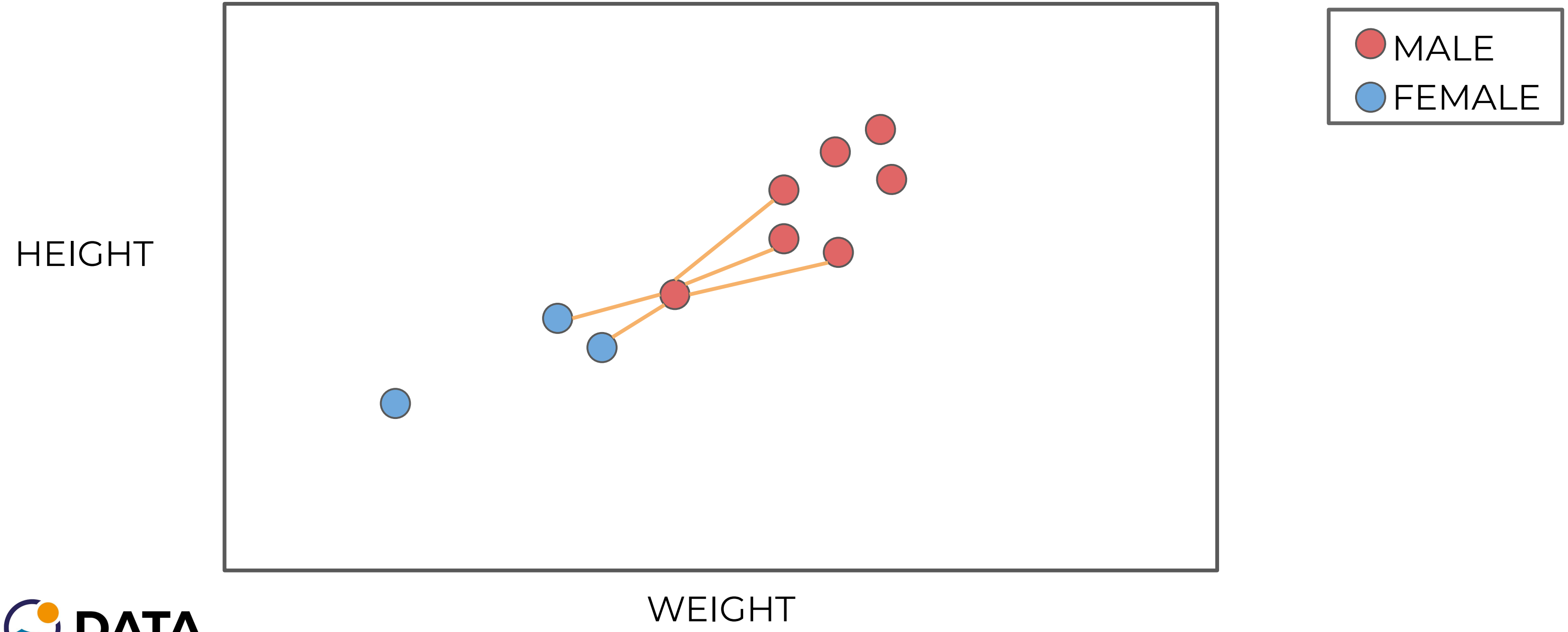
# KNN

- K=5 causes a switch from previous K values.



# KNN

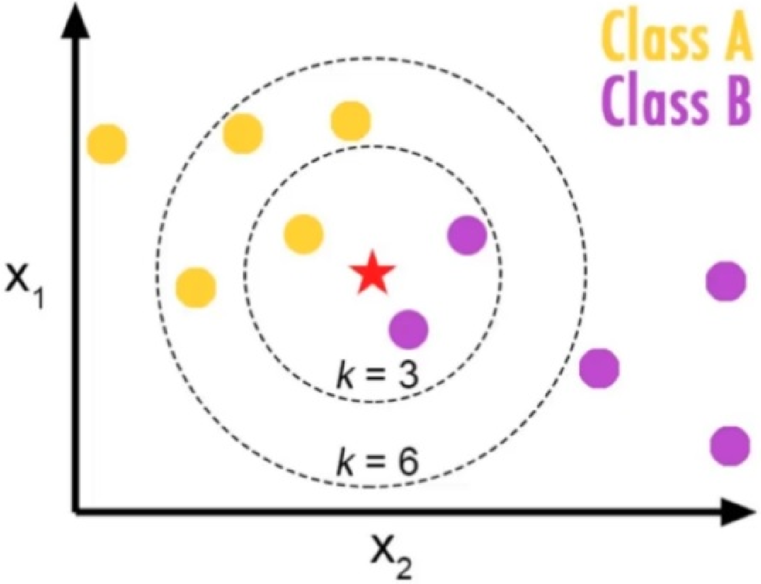
- How to choose best K value?



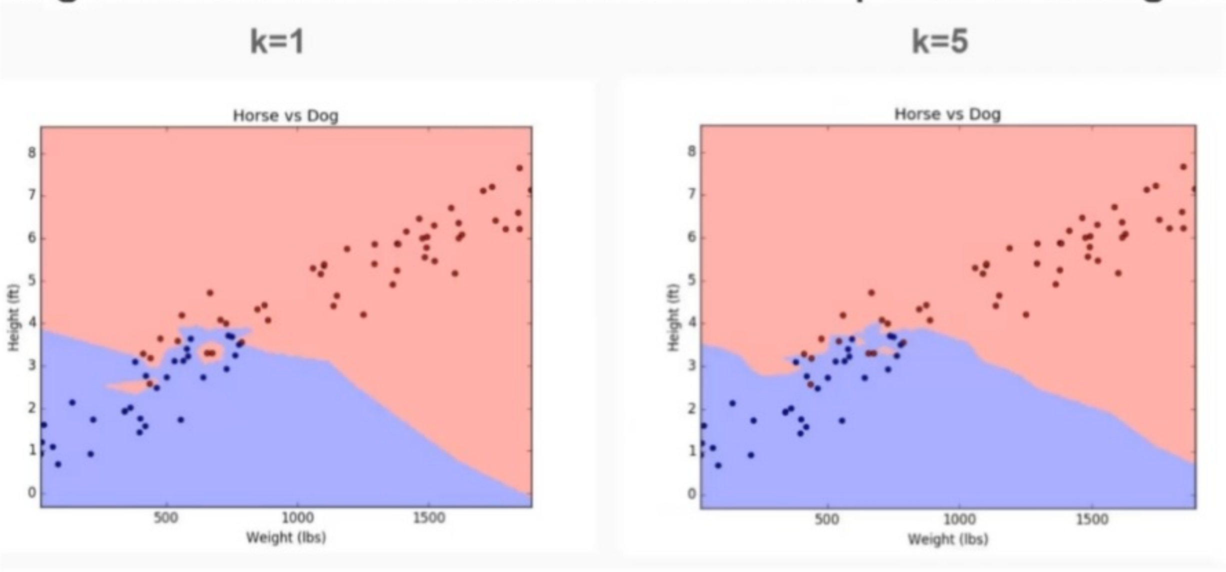
# KNN

- We want a K value that **minimizes** error:
  - Error = 1 - Accuracy
- Two methods:
  - Elbow method.
  - Cross validate a grid search of multiple K values and choose K that results in lowest error or highest accuracy.

Choosing a K will affect what class a new point is assigned to:

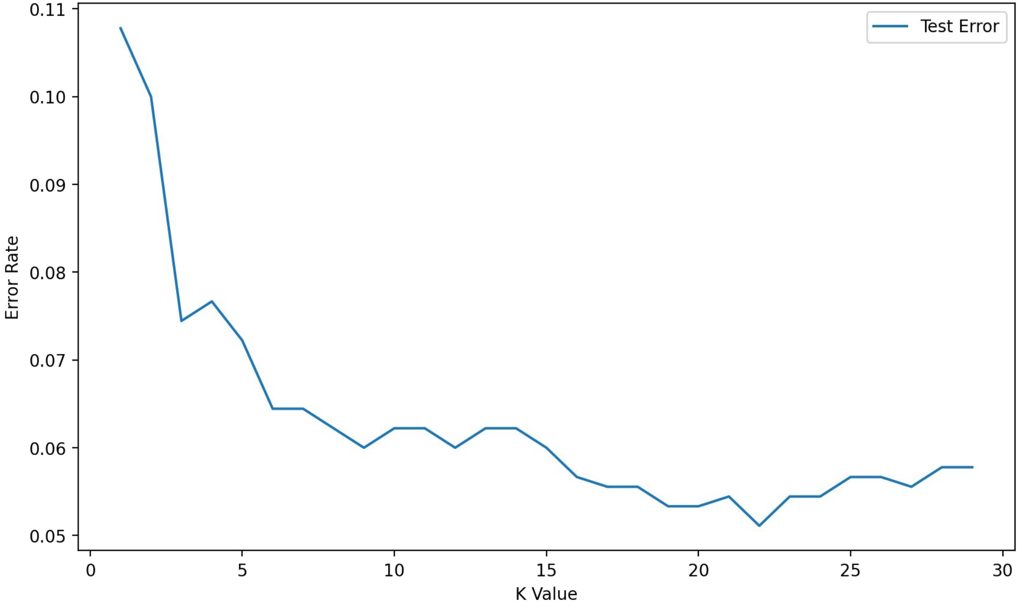


# Choosing a K will affect what class a new point is assigned to:



# KNN

- Elbow method:



# KNN

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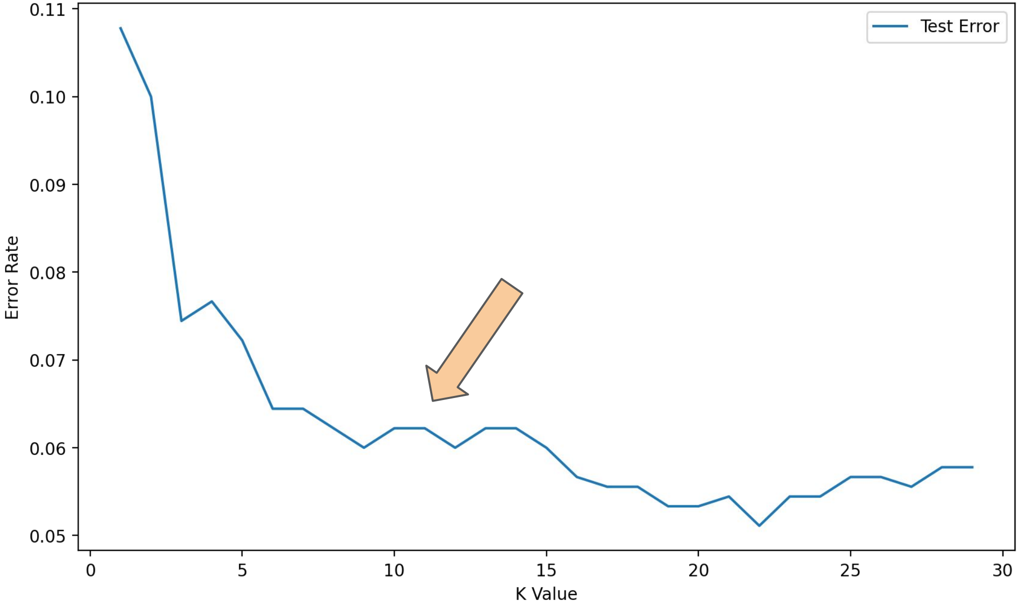

# KNN

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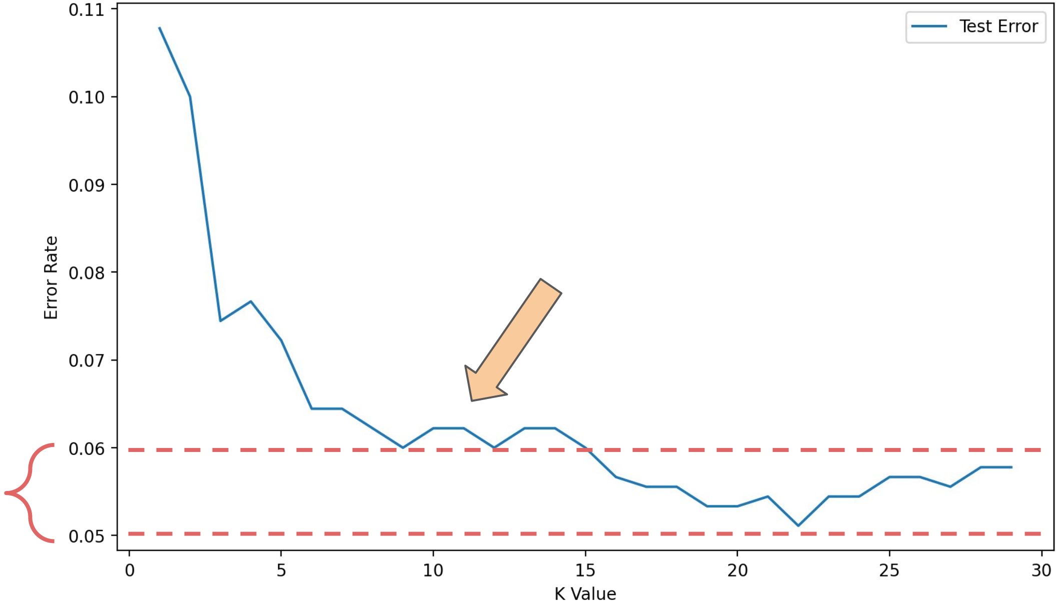


# KNN

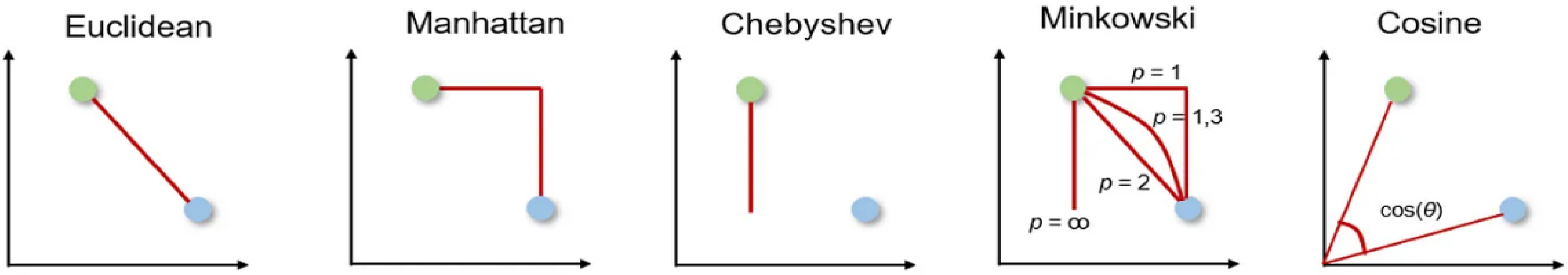
- Cross validation only takes into account the K value with the lowest error rate across multiple folds.
- This could result in a more complex model (higher value of K).
- Consider the context of the problem to decide if larger K values are an issue.

# KNN

- KNN Algorithm
    - Choose K value.
    - Sort feature vectors (N dimensional space) by distance metric.
    - Choose class based on K nearest feature vectors.

# KNN

- KNN Considerations:
  - Distance Metric
    - Many ways to measure distance:
      - Minkowski
      - Euclidean
      - Manhattan
      - Chebyshev



Euclidean

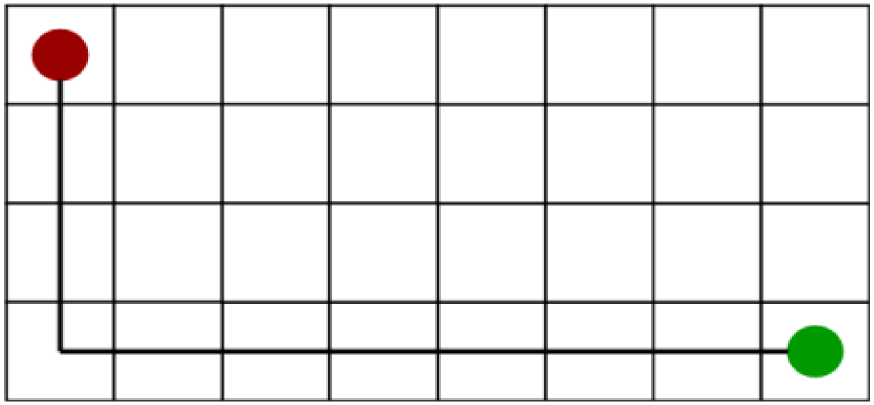
Manhattan

Chebyshev

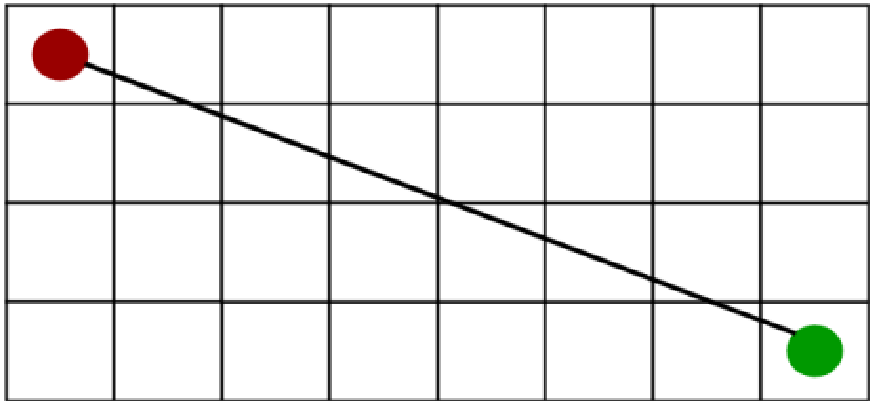
Minkowski

Cosine

**Manhattan Distance**

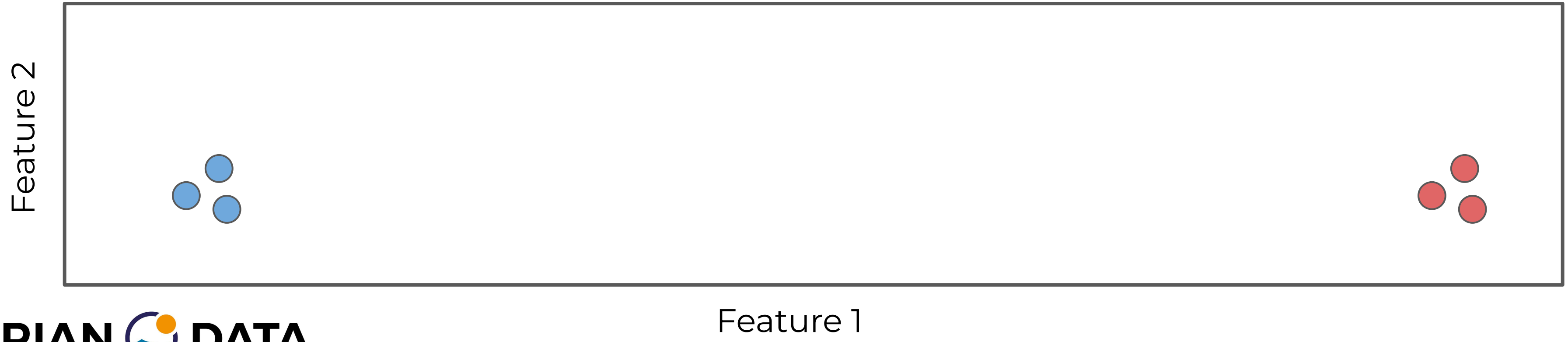


**Euclidean Distance**



# KNN

- KNN Considerations:
  - Scaling for Distance
    - Features could have vastly different value ranges!



# KNN

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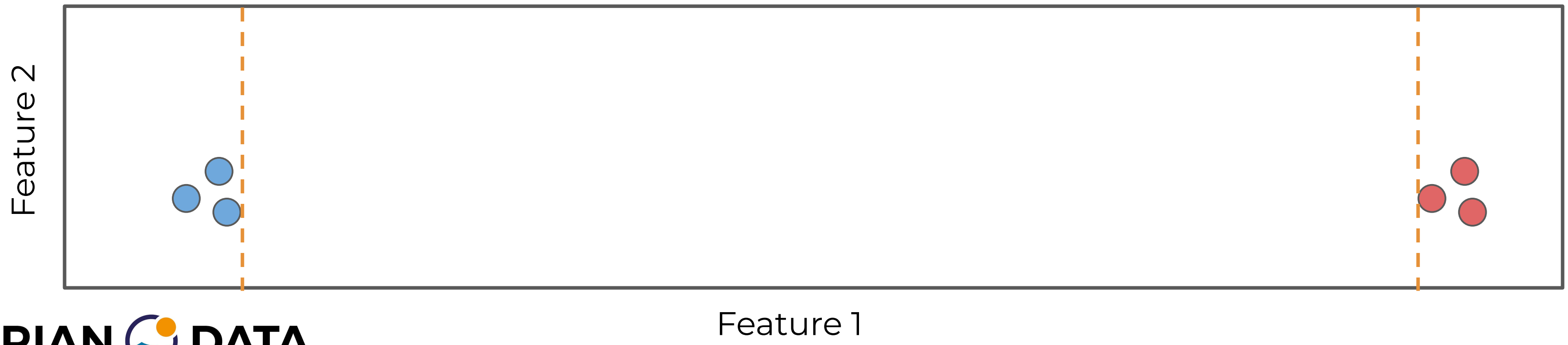

# KNN

- KNN Considerations:
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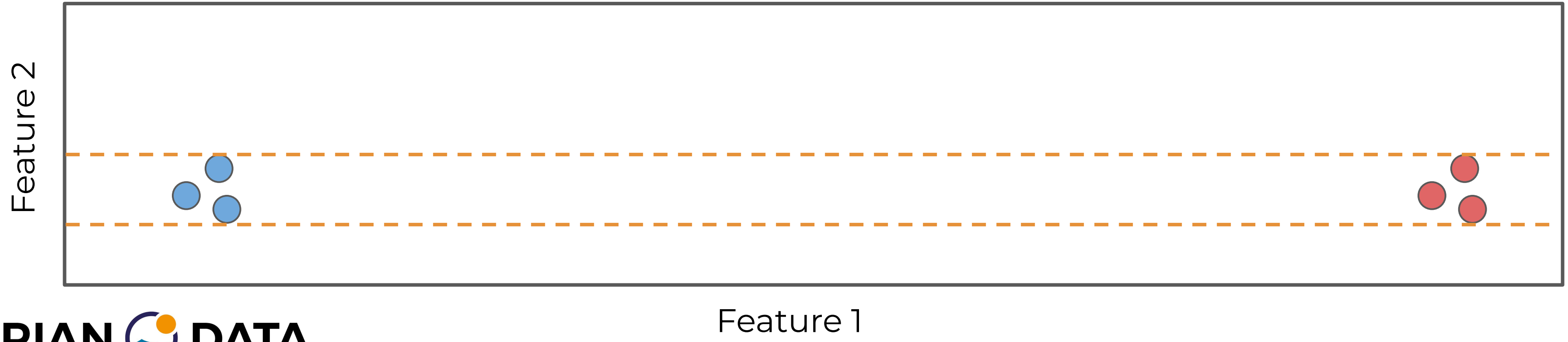
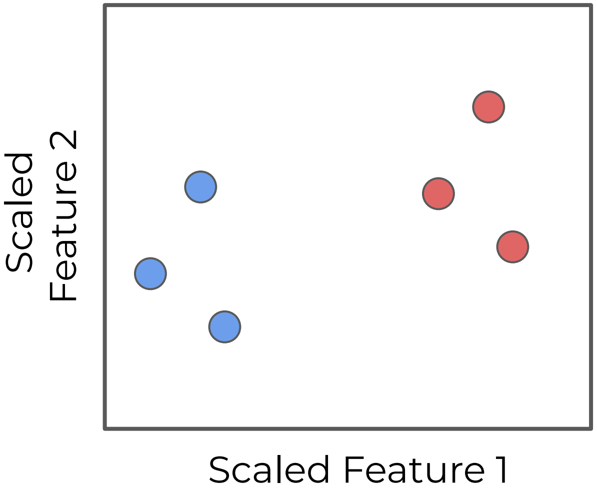


# KNN

- KNN Considerations:
  - Scaling is necessary for KNN.



# KNN

- While the KNN Algorithm is relatively simple, keep in mind the following considerations:
    - Choosing the optimal K value.
    - Scaling features.
- Let’s continue to explore how to perform KNN for classification!

# KNN Classification

Coding Part One: Data and Model

# KNN Classification

Coding Part Two: Choosing K

# KNN

- A Pipeline object in Scikit-Learn can set up a sequence of repeated operations, such as a scaler and a model.
- This way only the pipeline needs to be called, instead of having to repeatedly call a scaler and a model.