Introduction to Machine Learning

Basic Concepts, Supervised Learning, Unsupervised Learning

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2026-I

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Outline

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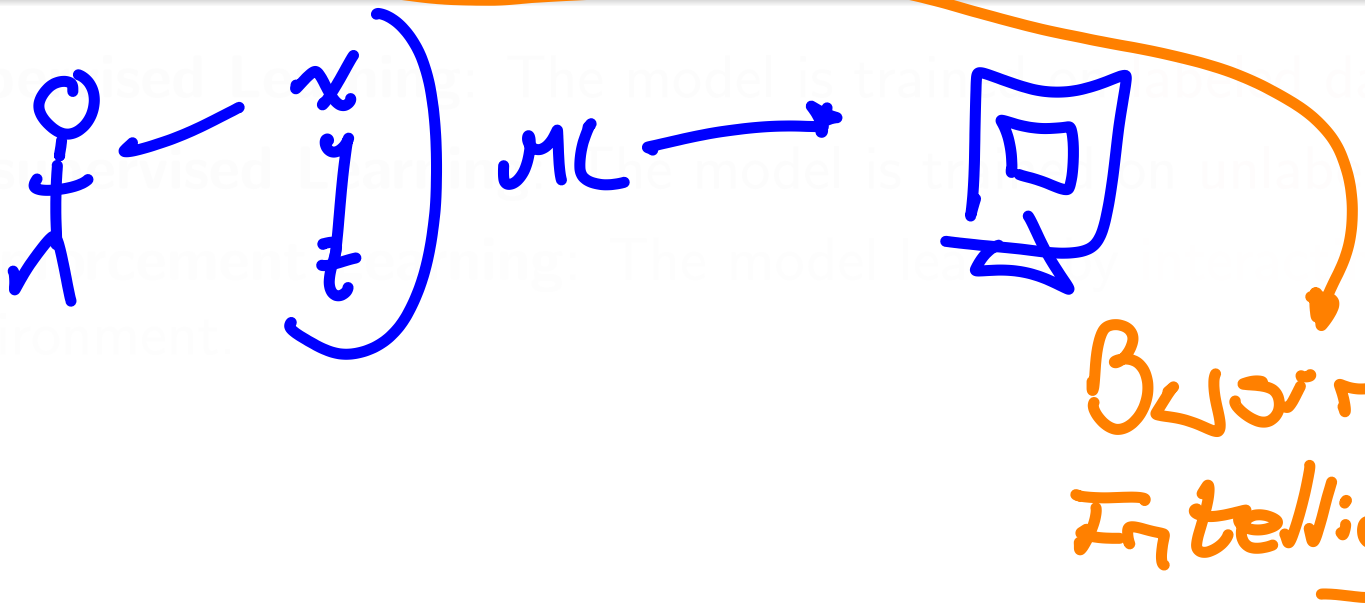
Key Concepts in Machine Learning

Machine Learning

- **Machine learning** is a method of data analysis that automates analytical model building.
- It is a **branch** of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with `minimal human intervention`.



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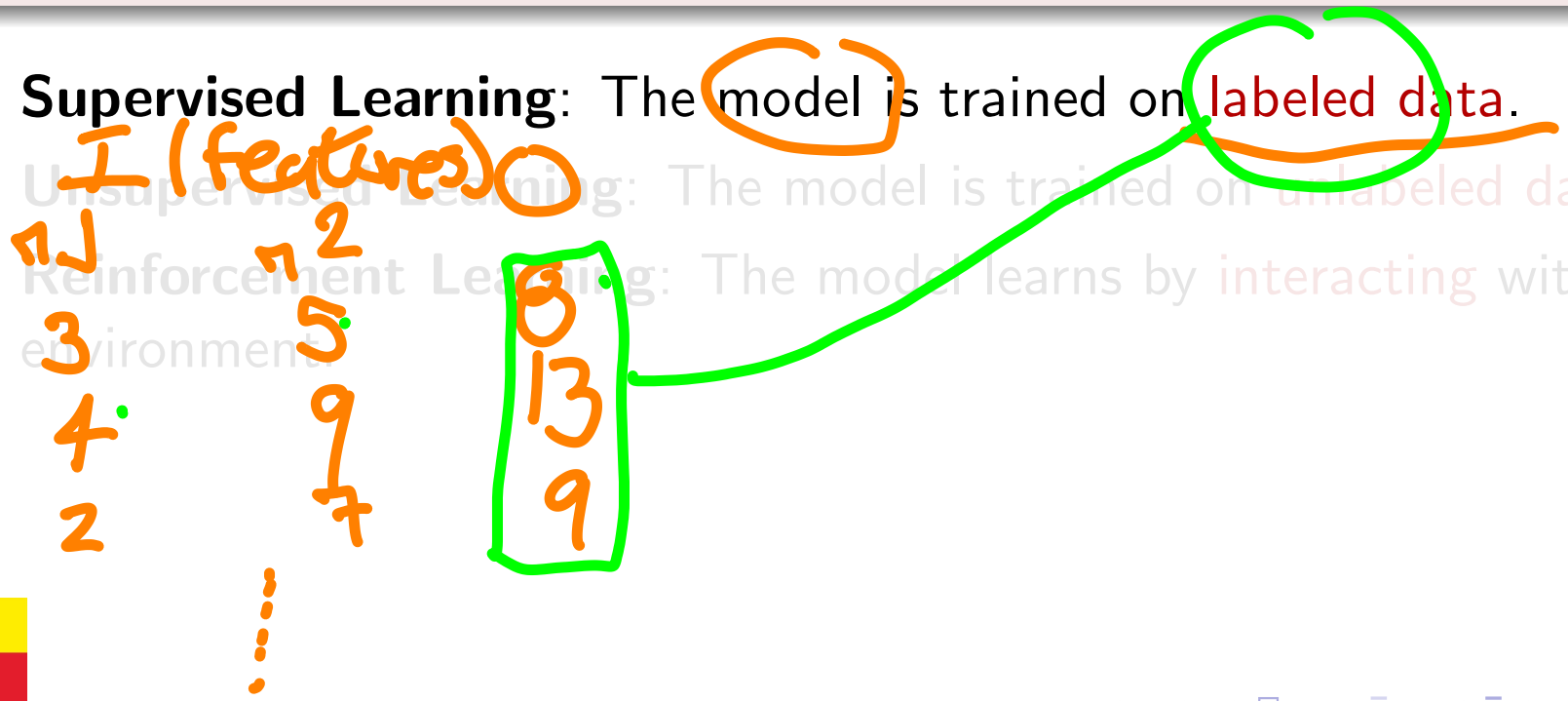
- **Supervised Learning**: The model is trained on labeled data.
- **Unsupervised Learning**: The model is trained on unlabeled data.
- **Reinforcement Learning**: The model learns by interacting with an environment.



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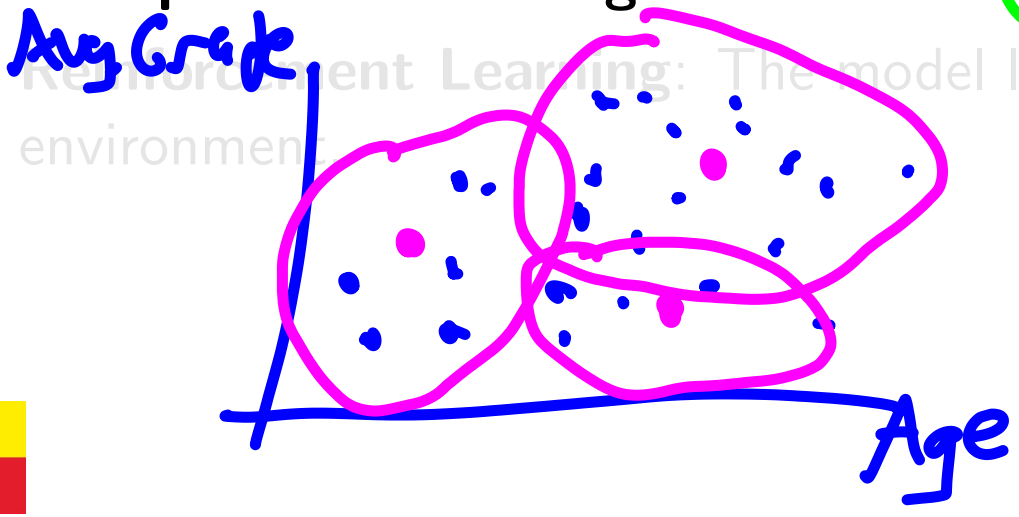

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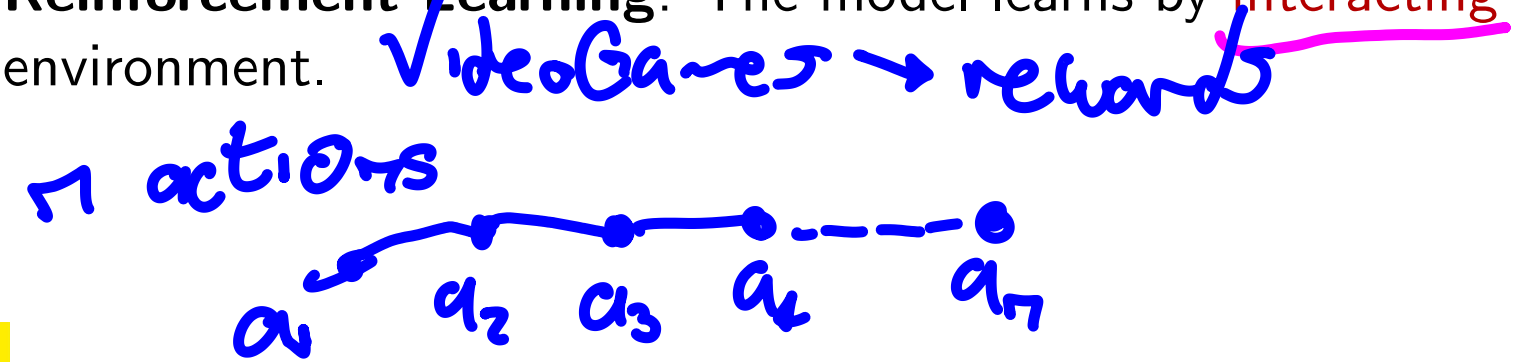

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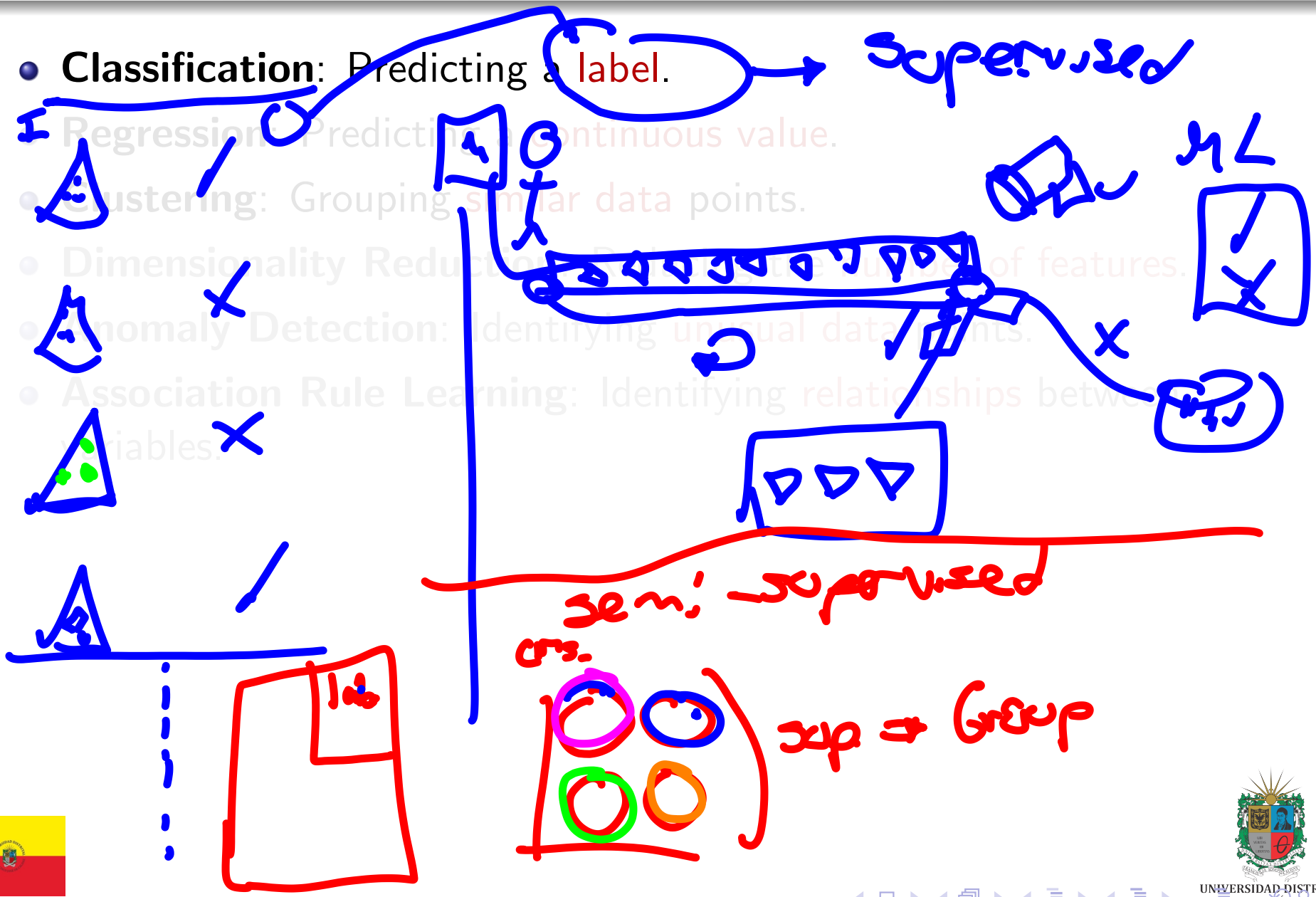
Typical Machine Learning Problems

- **Classification**: Predicting a label.
- **Regression**: Predicting a continuous value.
- **Clustering**: Grouping similar data points.
- **Dimensionality Reduction**: Reducing the number of features.
- **Anomaly Detection**: Identifying unusual data points.
- **Association Rule Learning**: Identifying relationships between variables.



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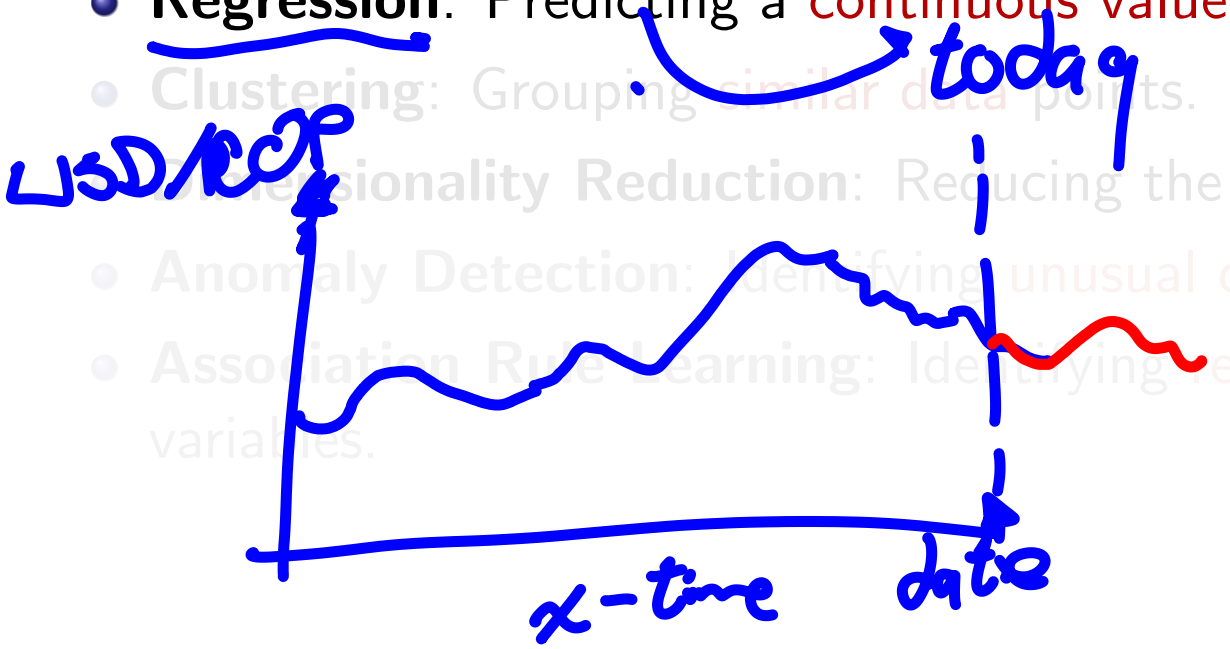

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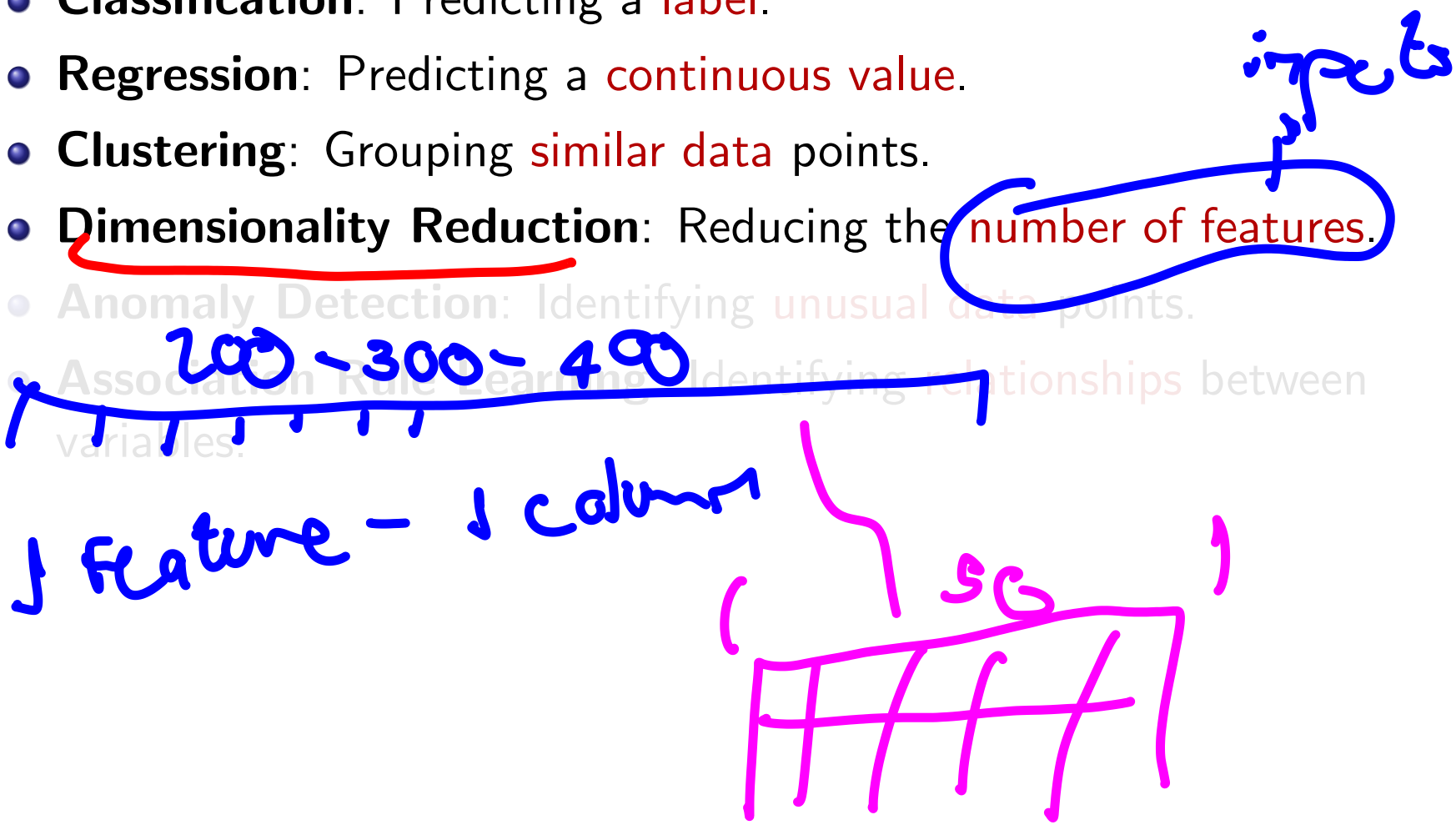

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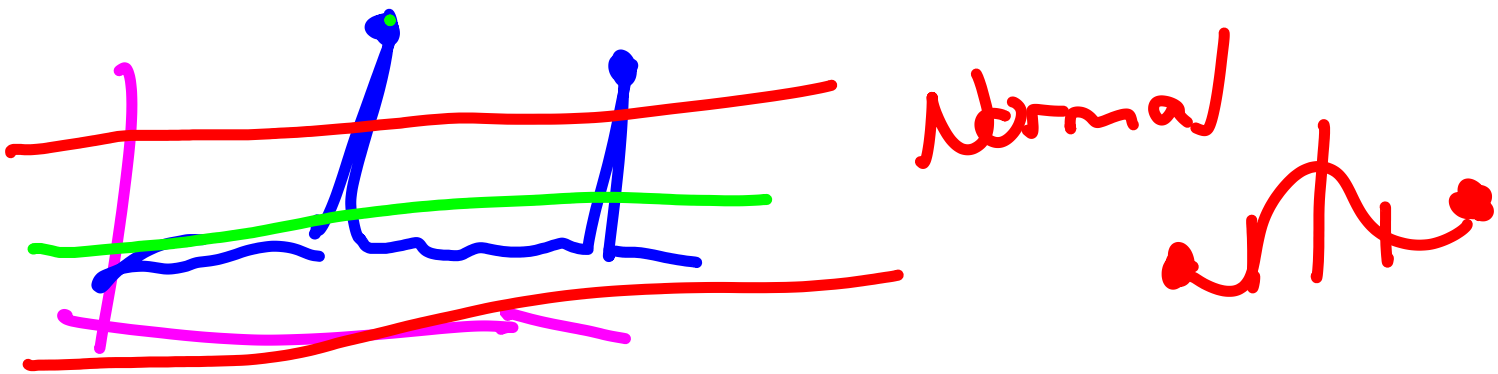

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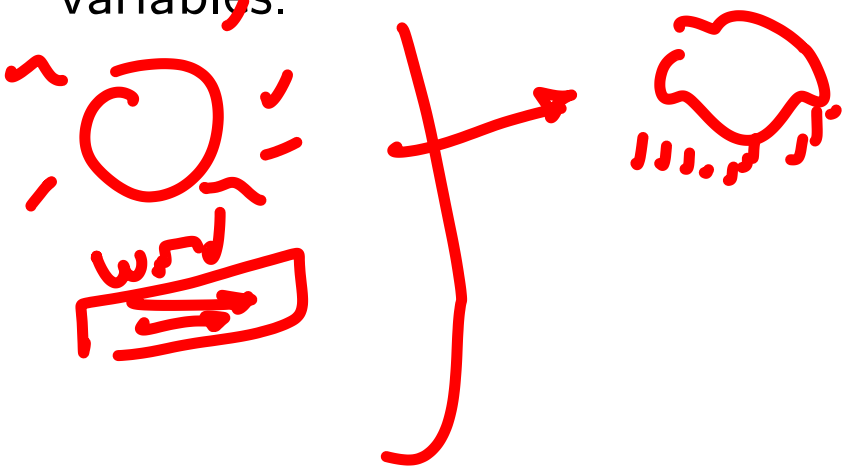

The Machine Learning Workflow

- **Data Collection**: Gathering the data
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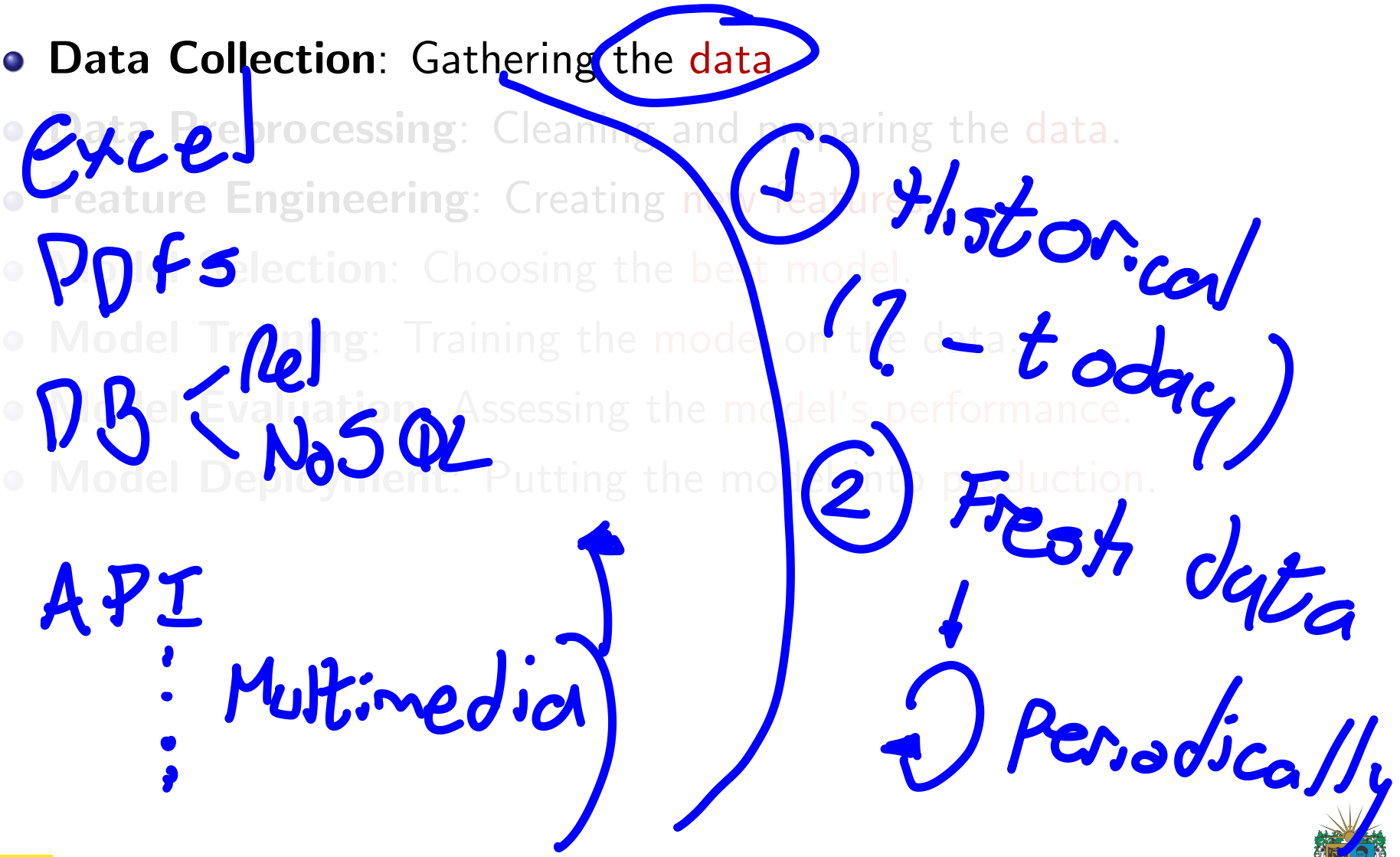

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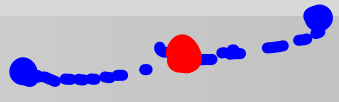

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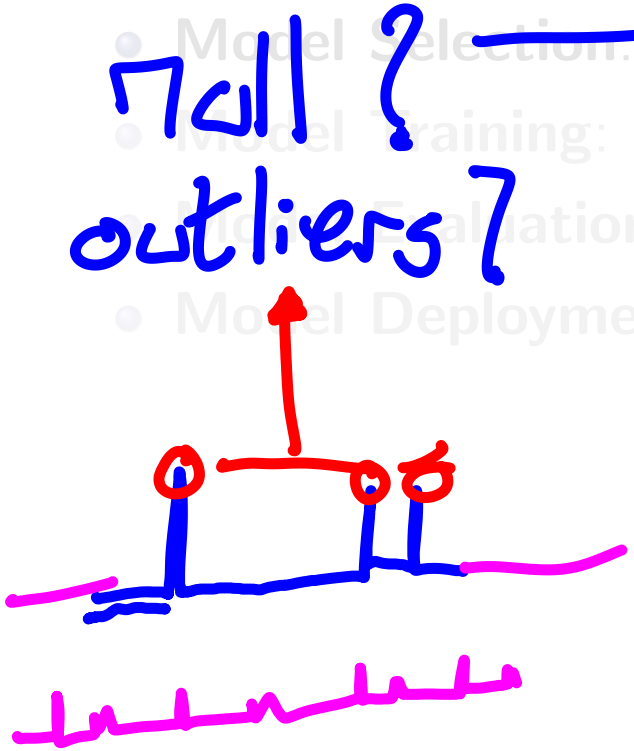

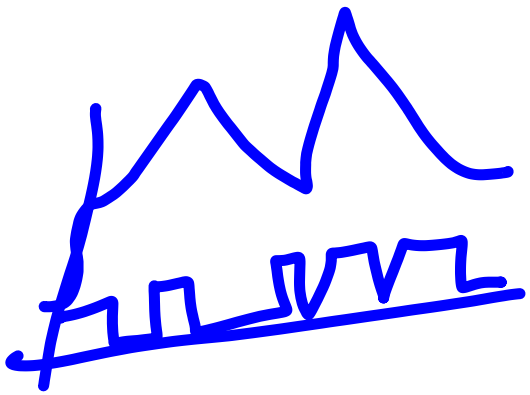

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Semester	Start	Delay
8	2018-2	1
7	2022-1	1
9	2021-2	0
1	2025-1	1
2	2025-1	0

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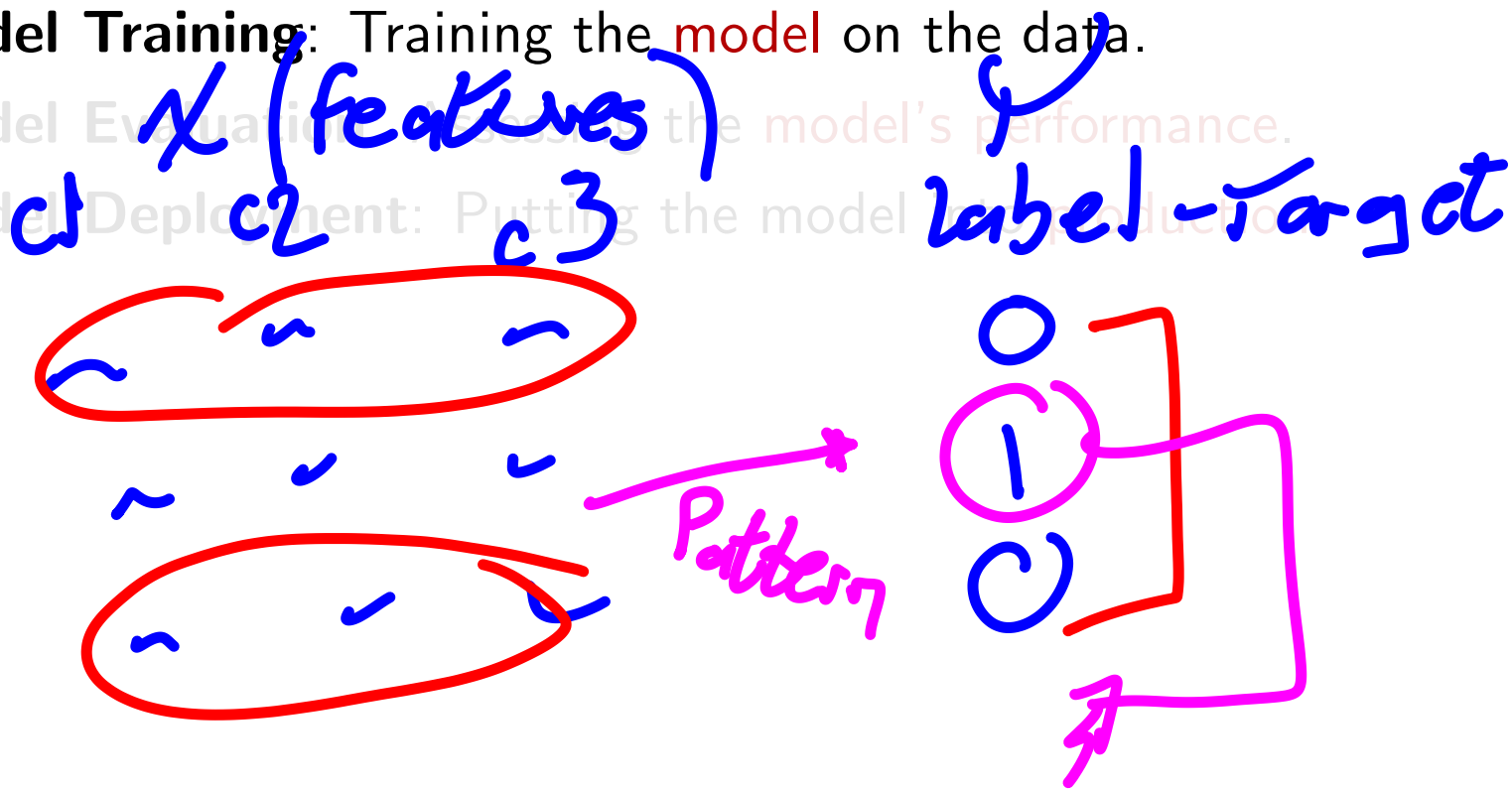

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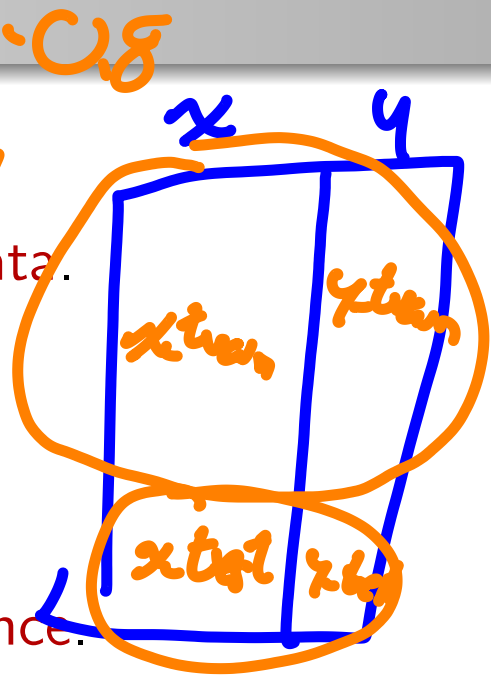

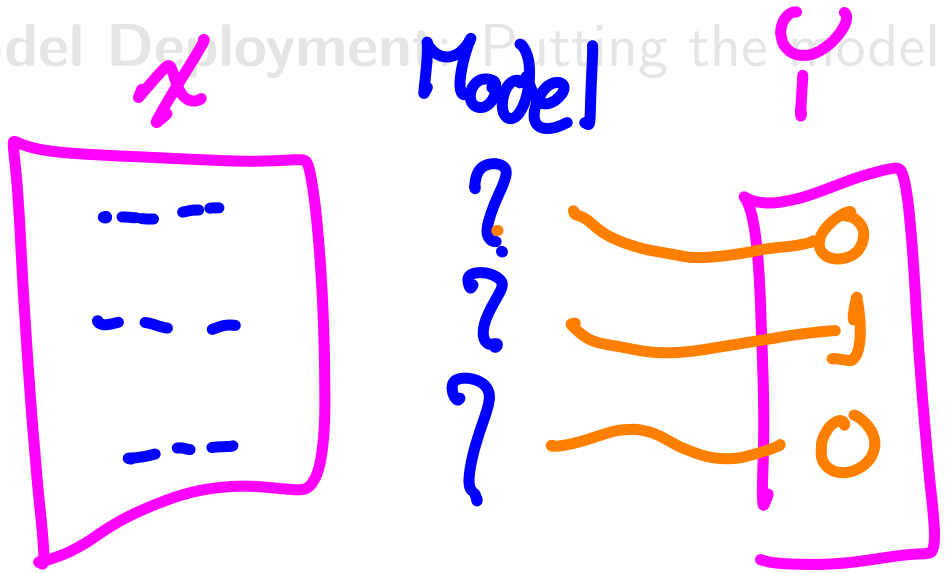

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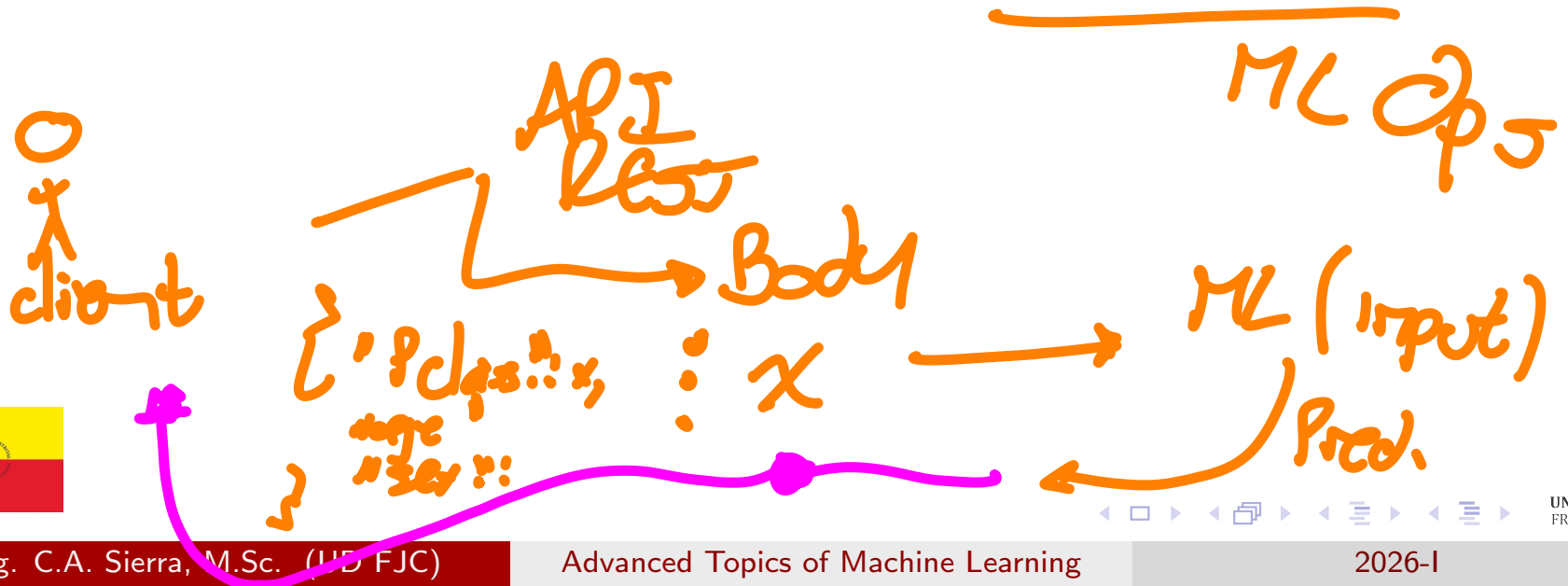
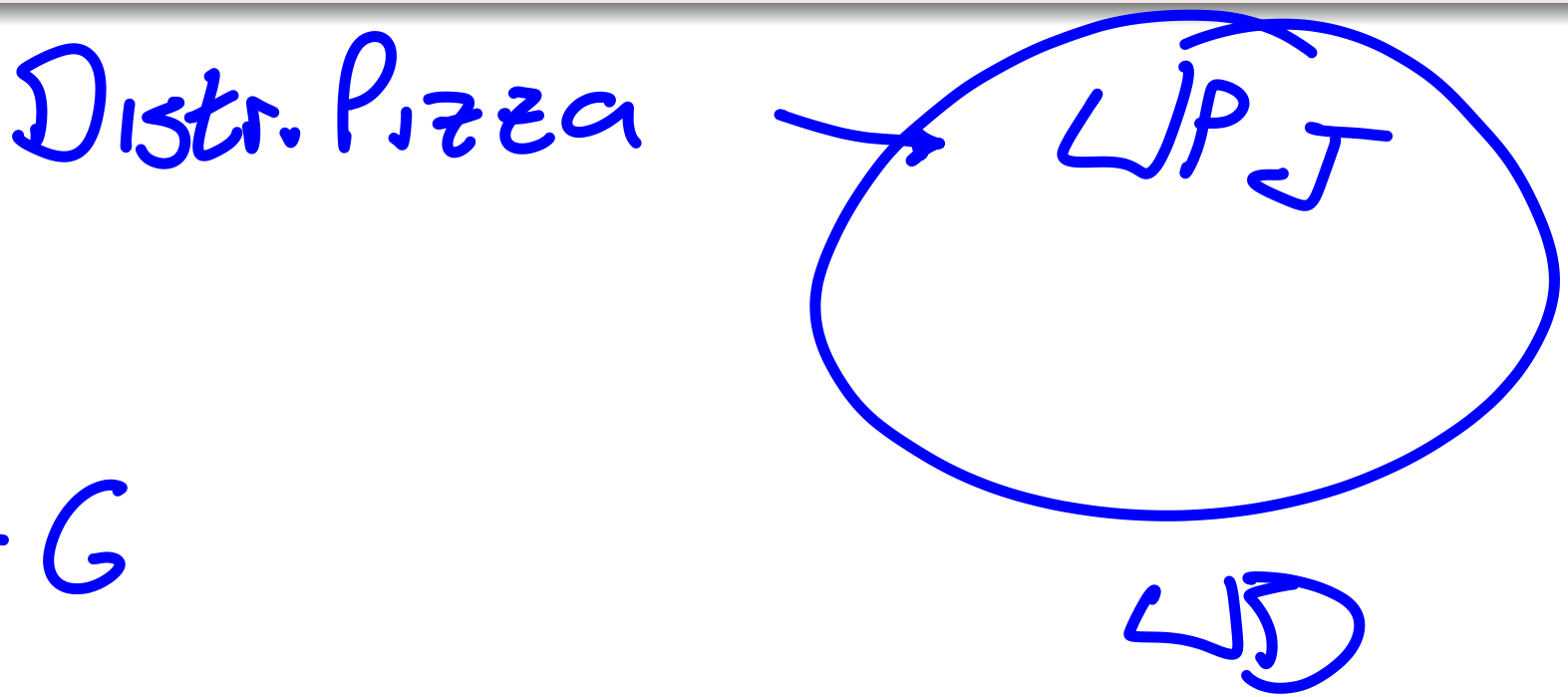


Algorithmic Bias

- **Algorithmic bias** is a systematic error in a model that results in unfair outcomes.
- It can be caused by biased training data, biased algorithms, or biased decision-making.



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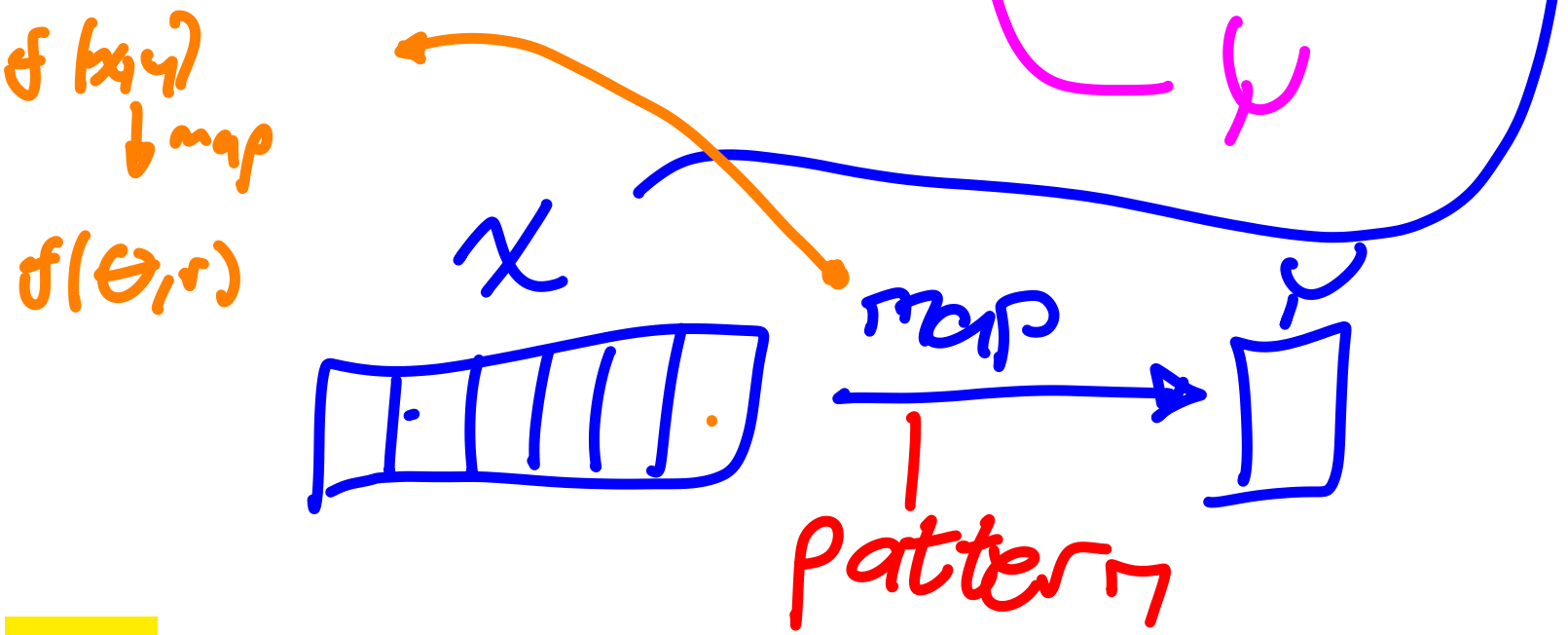
Introduction to Supervised Machine Learning

Definition

- **Supervised learning** is a type of machine learning where the model is trained on labeled data.
- It involves training a model to map input data to output data based on example input-output pairs.



Overfitting and Underfitting

Overfitting

Overfitting occurs when a model learns the training data too well and performs poorly on new data.

Underfitting

Underfitting occurs when a model is too simple to capture the underlying structure of the data.

2+2=4 Train

7+4=11

29992+99532=? Test

Train — 80 20

3 — 2 1 Test

4 — 3 1

9 — 7 2

10 — 8 2

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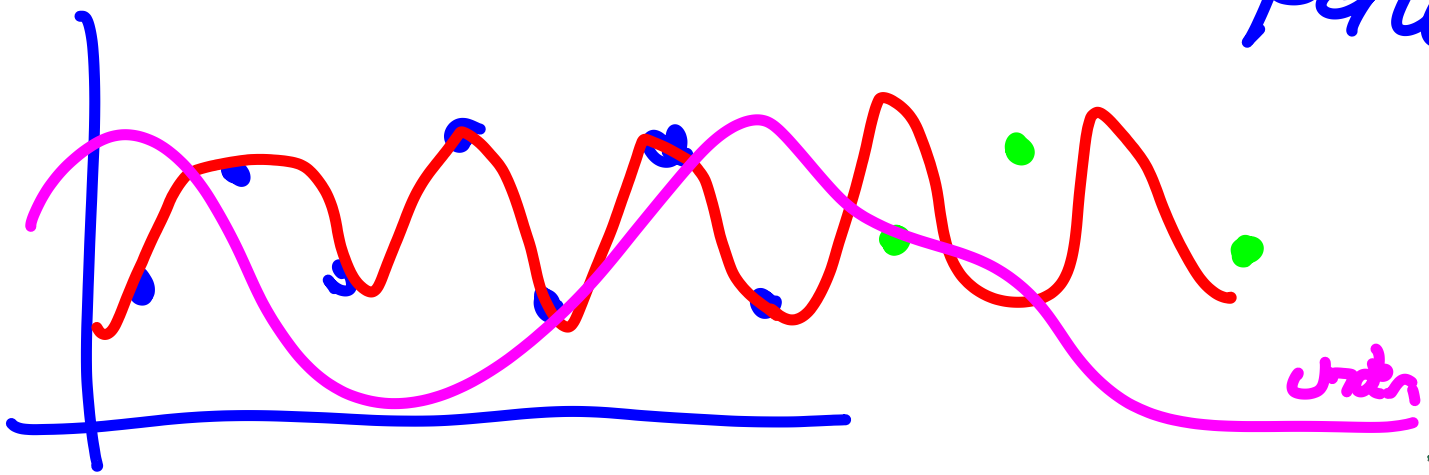
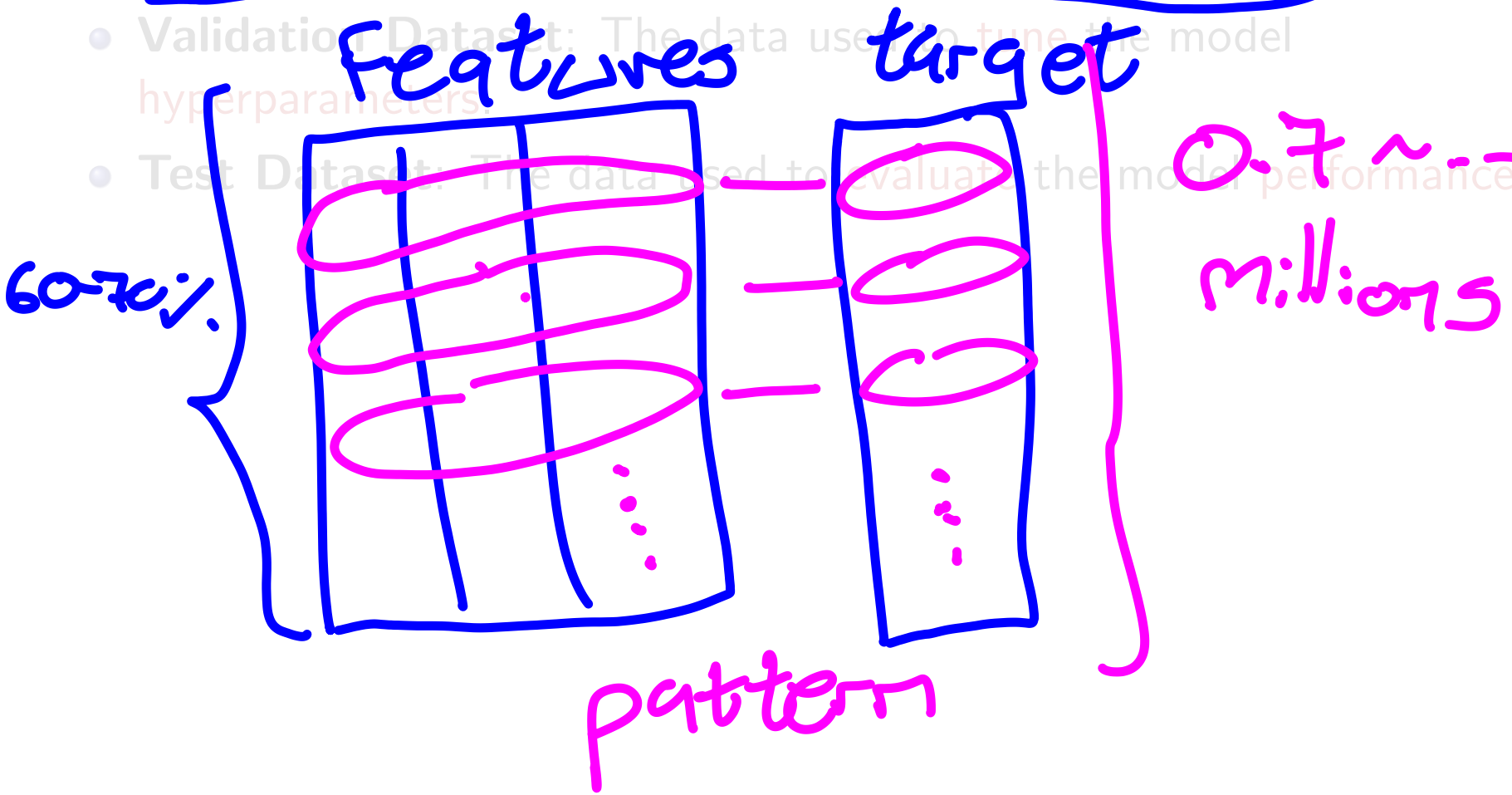


Supervised Learning Datasets

- **Training Dataset**: The data used to train the model.
- **Validation Dataset**: The data used to tune the model hyperparameters.
- **Test Dataset**: The data used to evaluate the model performance.



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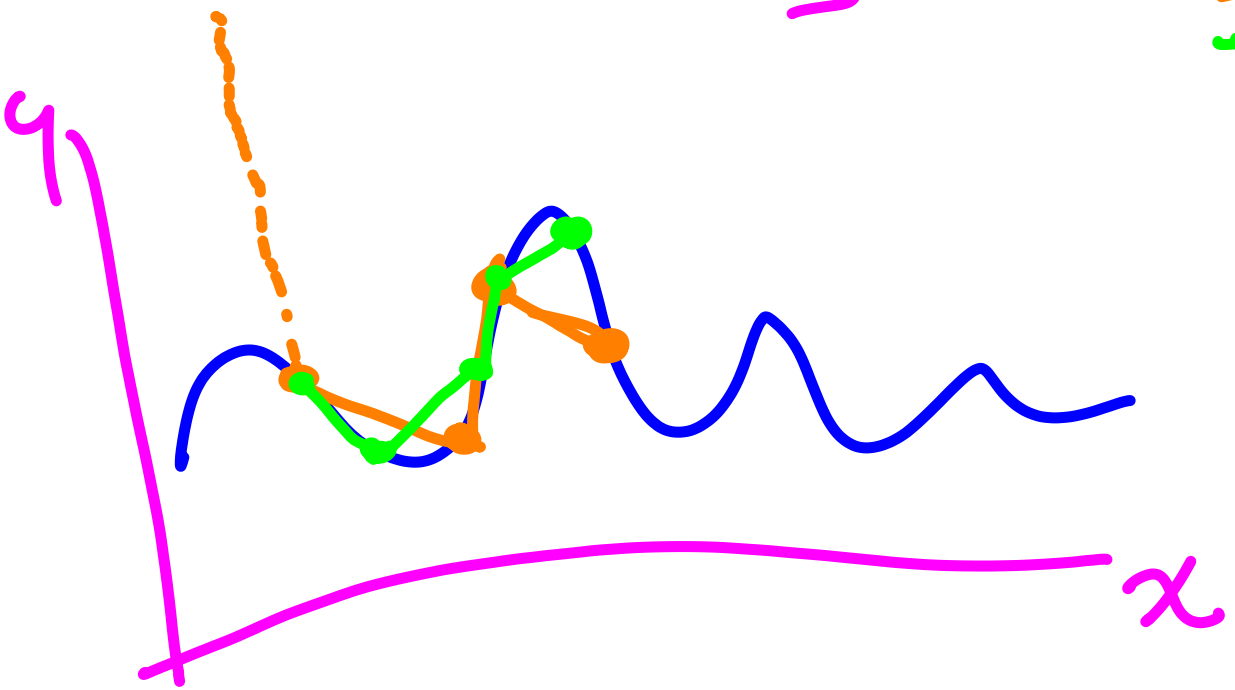

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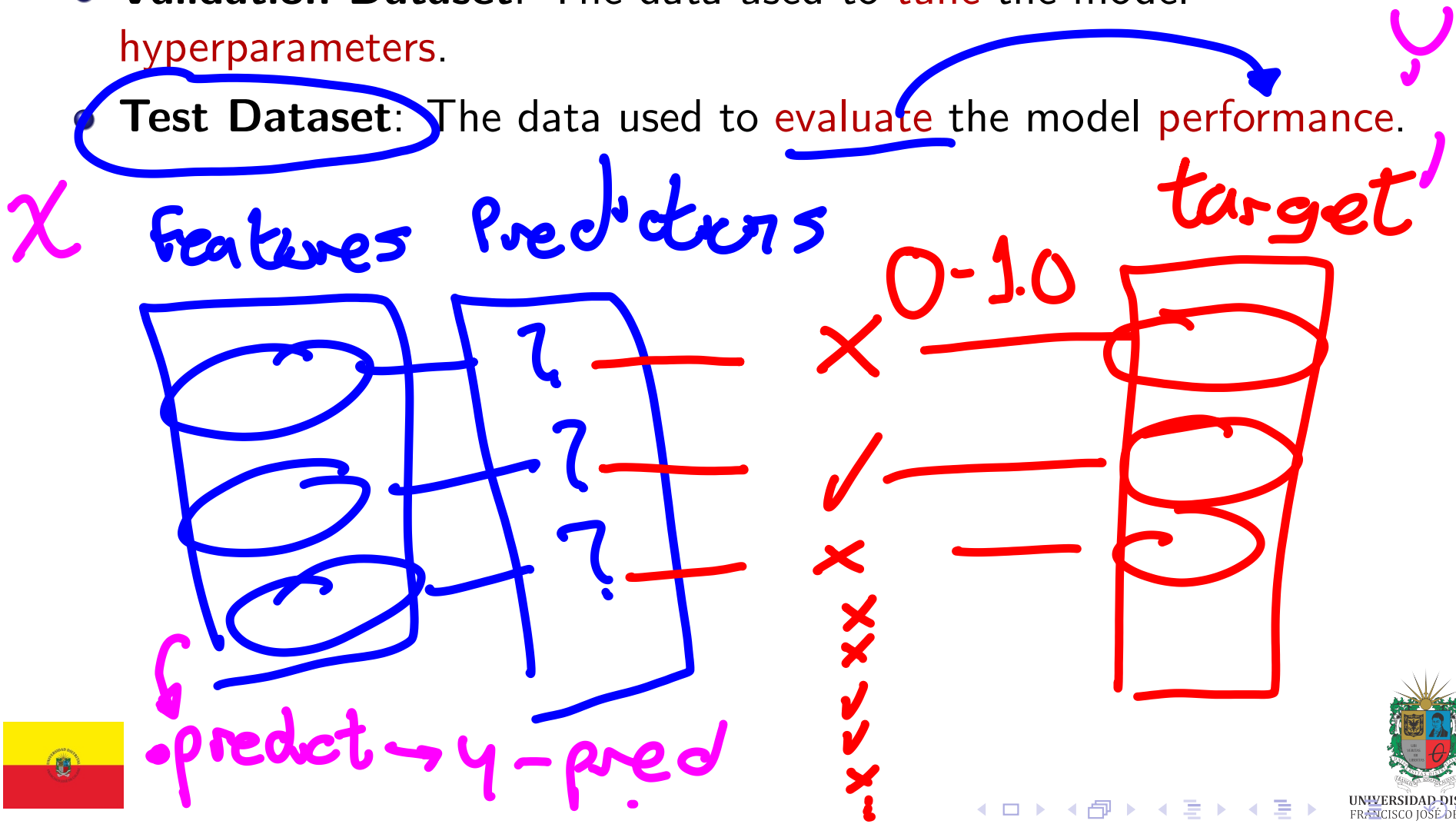
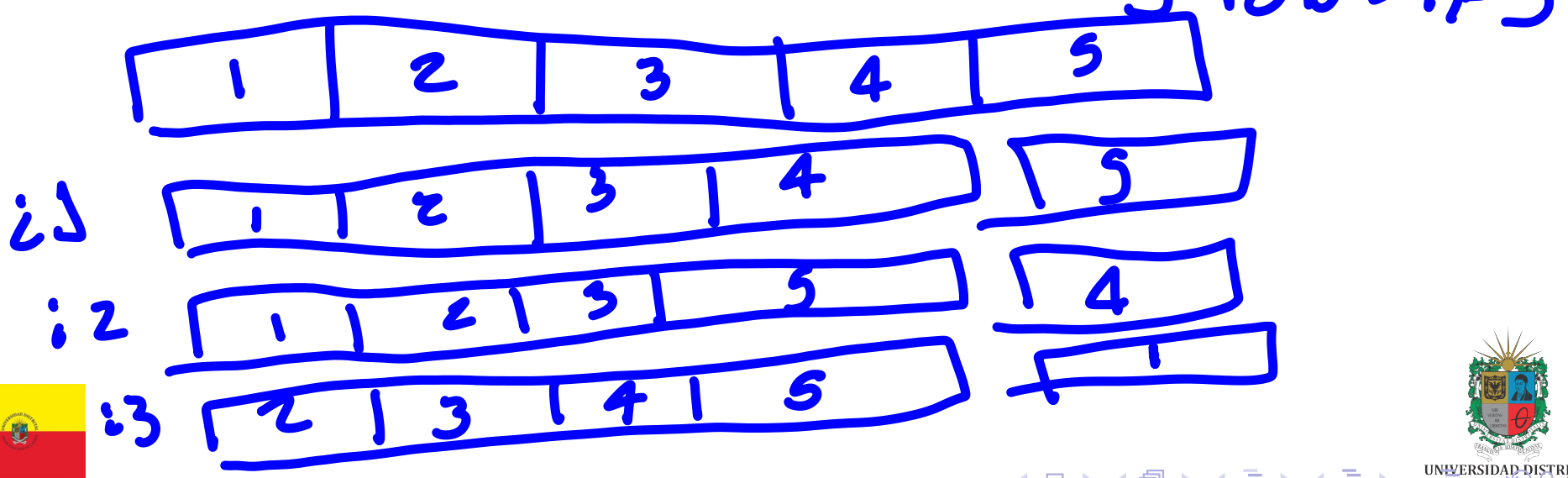


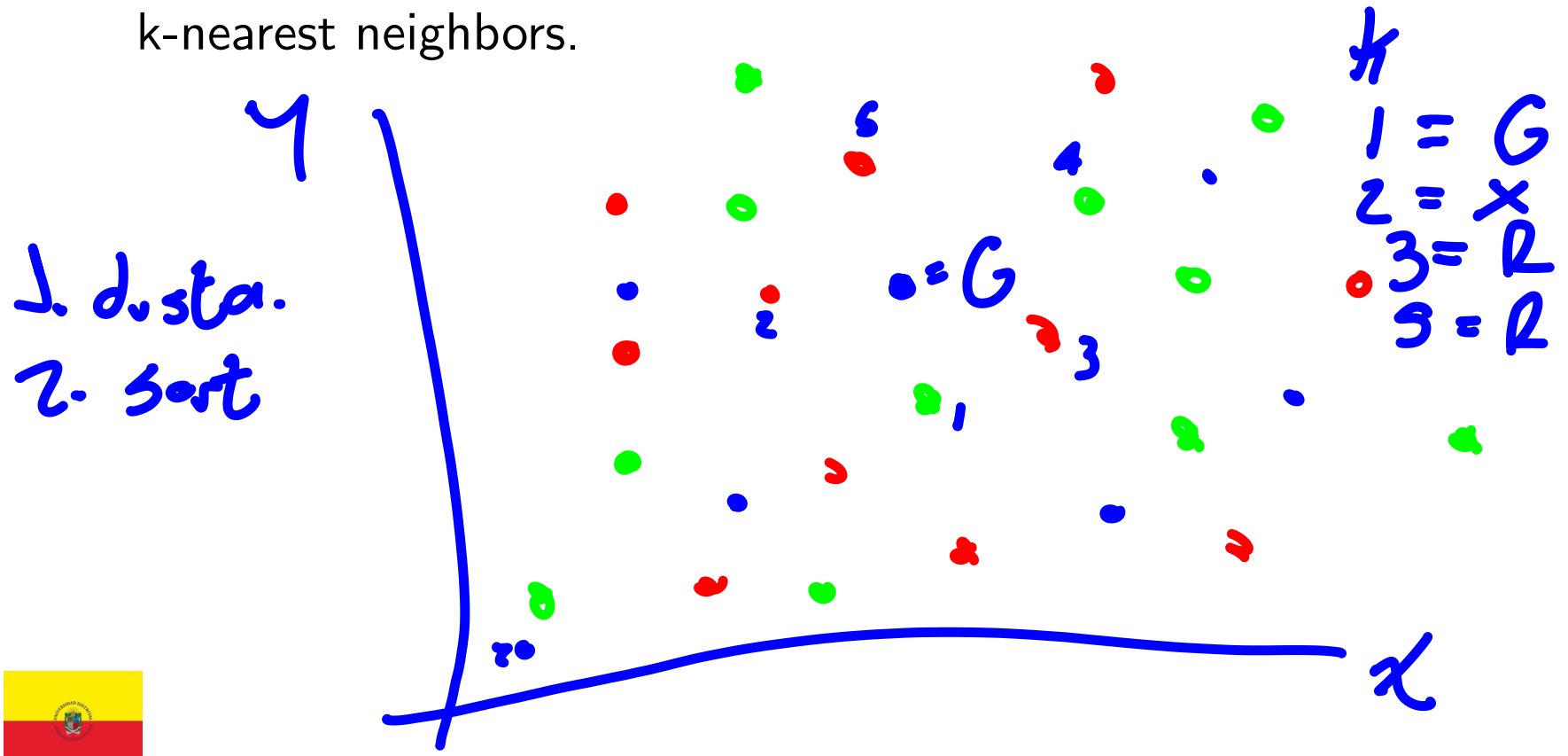
Cross-Validation

- **Cross-validation** is a technique for assessing the performance of a model.
- It involves splitting the data into multiple subsets, training the model on some subsets, and evaluating it on others.
- Common cross-validation **techniques** include k-fold cross-validation and leave-one-out cross-validation.
- Cross-validation helps to reduce overfitting and provides a more accurate estimate of the model's performance.



K-Nearest Neighbors

- **K-Nearest Neighbors (KNN)** is a simple algorithm that stores all available cases and classifies new cases based on a similarity measure.
- It can be used for both classification and regression tasks.
- For classification, the output is the class label of the majority of the k-nearest neighbors.



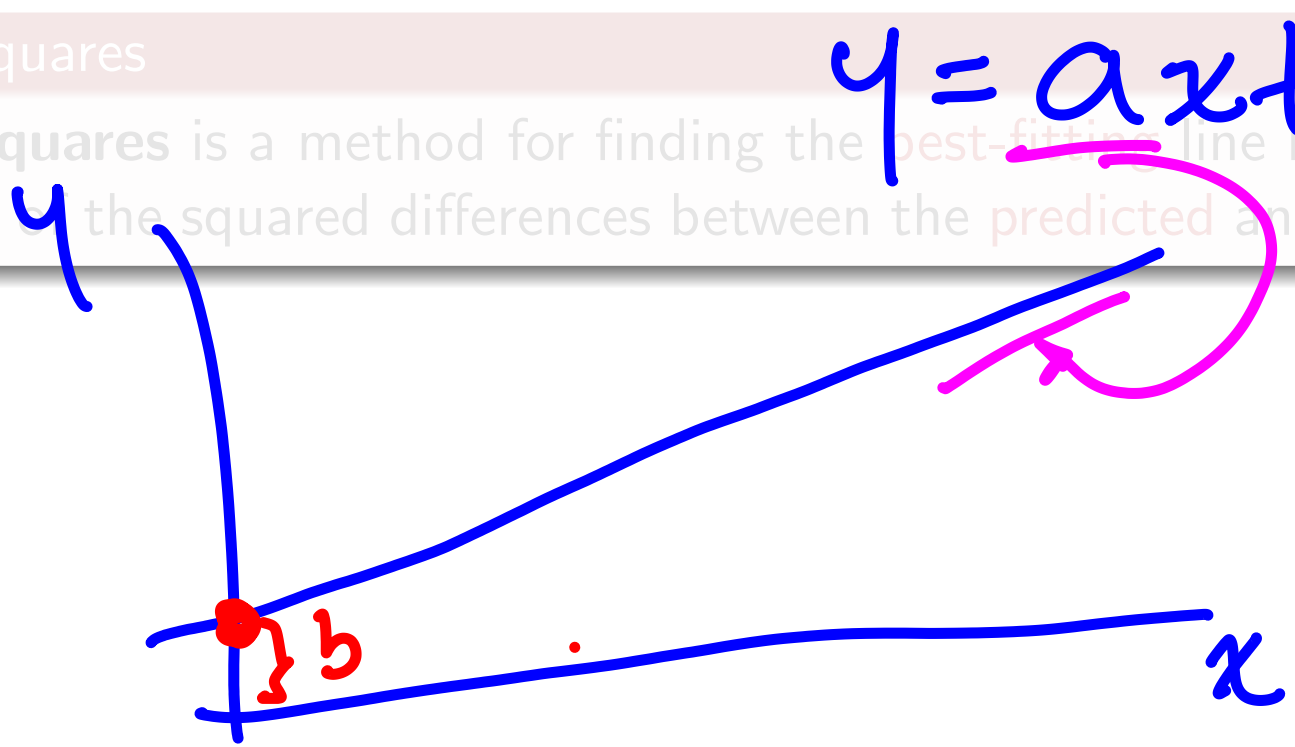
Linear Regression with Least Squares

Linear Regression

- **Linear regression** is a type of regression analysis used for predicting the value of a continuous dependent variable.
- It works by finding the line that best fits the data.

Least Squares

Least squares is a method for finding the best-fitting line by minimizing the sum of the squared differences between the predicted and actual values.



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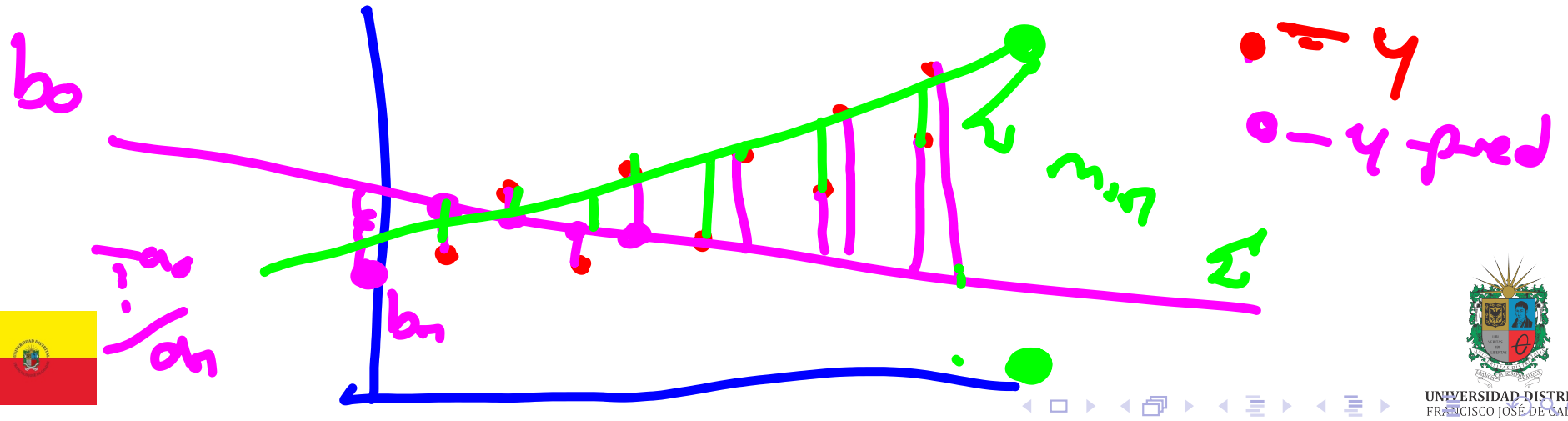
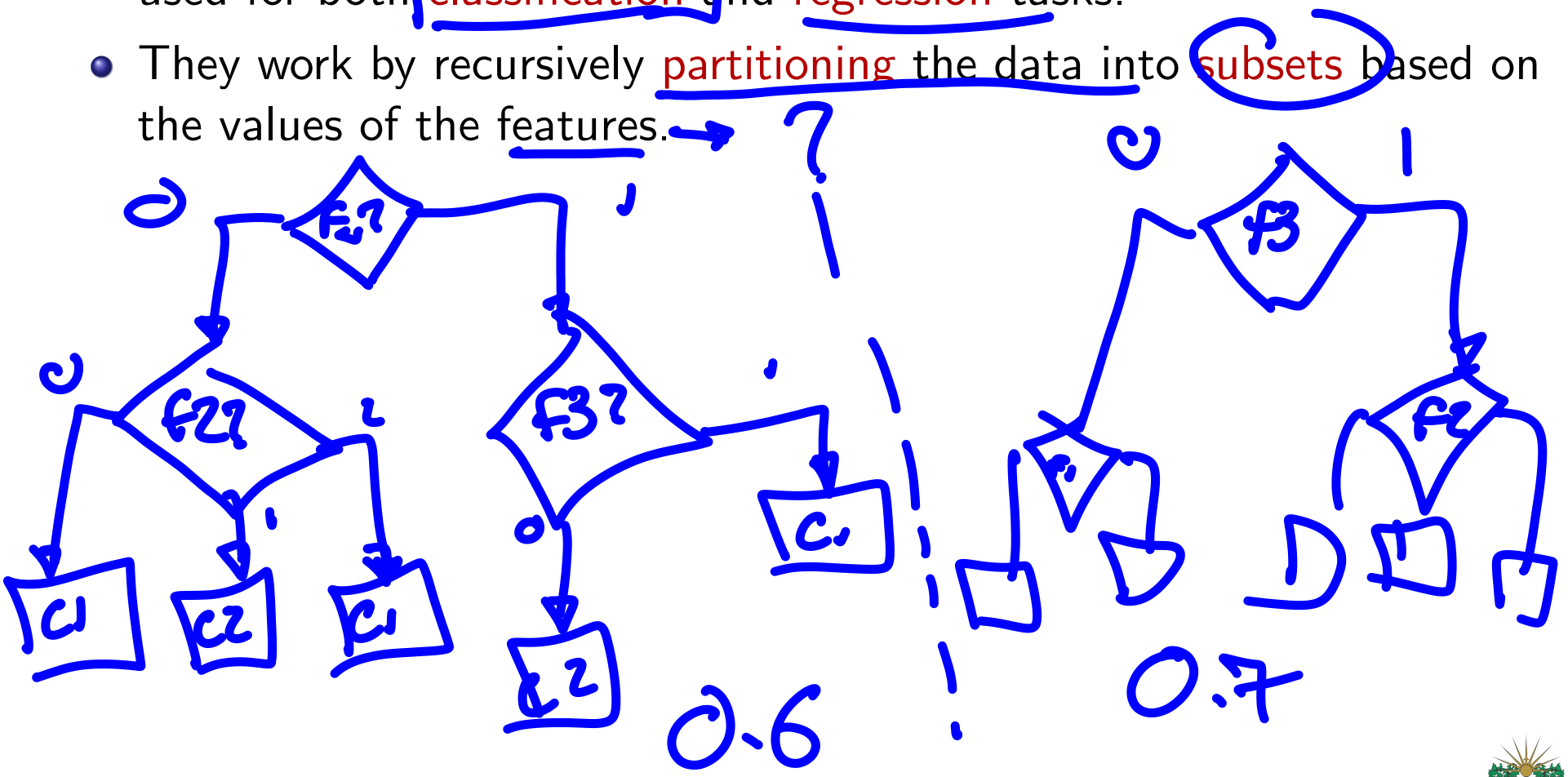


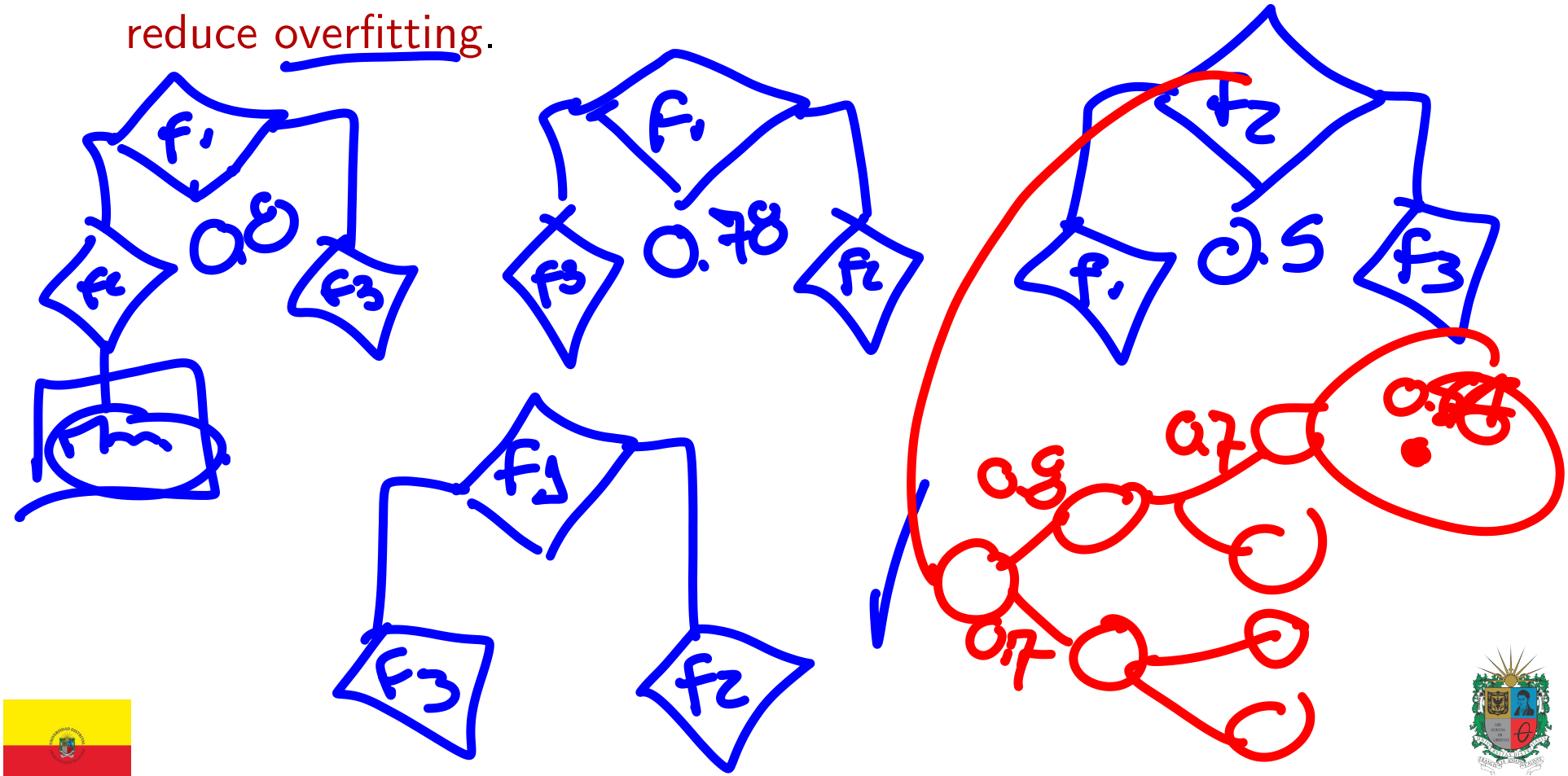
Decision Trees

- **Decision trees** are a type of machine learning model that can be used for both classification and regression tasks.
- They work by recursively partitioning the data into subsets based on the values of the features.



Random Forest

- **Random forest** is an ensemble learning method that combines multiple decision trees to create a strong predictive model
- It works by building multiple trees and averaging their predictions to reduce overfitting.



Neural Networks

- **Neural networks** are a type of machine learning model inspired by the human brain.
- They consist of layers of interconnected nodes that process input data and produce output data.

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Introduction to Unsupervised Machine Learning

Definition

- **Unsupervised learning** is a type of machine learning where the model is trained on unlabeled data.
- It involves finding patterns and relationships in the data without any predefined labels.

Clustering

- **Clustering** is a type of unsupervised learning that involves grouping similar data points together.
- Common clustering algorithms include k-means, hierarchical clustering, and DBSCAN.

K-means

- **K-means** is a popular clustering algorithm that partitions the data into K distinct clusters based on feature similarity.
- It works by iteratively assigning data points to the nearest cluster centroid and updating the centroids based on the assigned points.

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Anomaly Detection

- **Anomaly detection** is a type of unsupervised learning that involves identifying unusual data points in a dataset.
- Common anomaly detection algorithms include Isolation Forest, One-Class SVM, and Autoencoders.

Autoencoders

- **Autoencoders** are a type of neural network used for unsupervised learning.
- They work by encoding the input data into a lower-dimensional representation and then decoding it back to the original data.

Dimensionality Reduction

- **Dimensionality reduction** is a technique for reducing the number of features in a dataset while retaining as much information as possible.
- Common dimensionality reduction techniques include Principal Component Analysis (PCA) and t-Distributed Stochastic Neighbor Embedding (t-SNE).

Principal Component Analysis (PCA)

- **Principal Component Analysis (PCA)** is a statistical technique used for dimensionality reduction.
- It works by transforming the data into a new coordinate system where the greatest variance lies along the first principal component, the second greatest variance along the second principal component, and so on.

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Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/machine-learning*

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