CPSC 330 Lecture 11: Midterm review

Announcements

- Midterm next week! Important information about Midterm 1
  - Piazza Post
  - **Good news for you: You will have access to our course notes in the midterm!**

What is machine learning

- ML uses data to build models that identify patterns, make predictions, or generate content.
- It enables computers to learn from data.
- No single model is suitable for all situations.

When is ML suitable?

- ML excels when the problem involve identifying complex patterns or relationships in large datasets that are difficult for humans to discern manually.
- Rule-based systems are suitable where clear and deterministic rules can be defined. Good for structured decision making.
- Human experts are good with problems which require deep contextual understanding, ethical judgment, creative input, or emotional intelligence.

Terminology

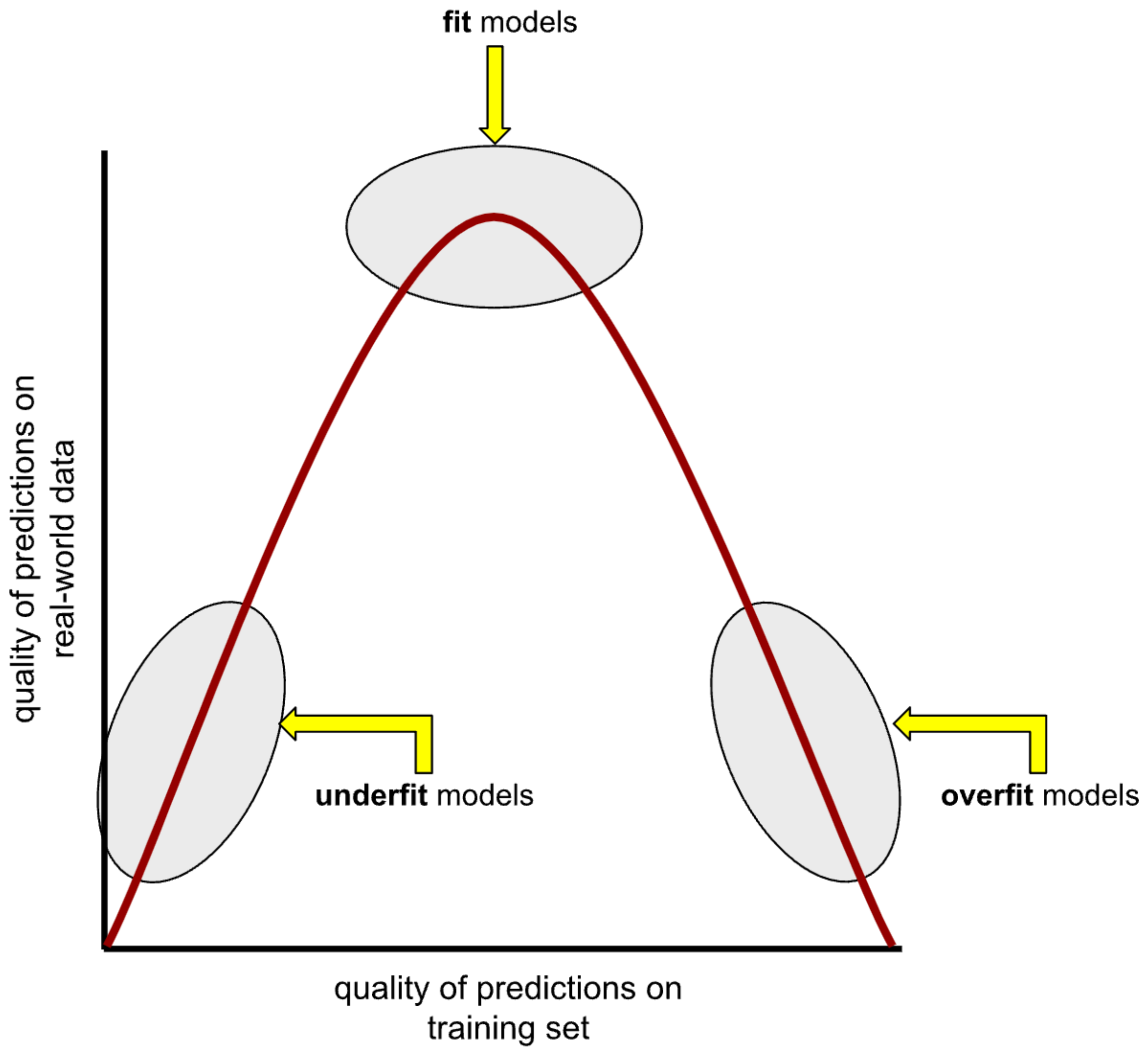
- Features (X) and target (y)
- Examples
- Predictions
- Accuracy, error
- Parameters and hyperparameters
- Decision boundaries

ML fundamentals

Important concepts

- Why do we split the data? What are train/valid/test splits?
- What are the benefits of cross-validation?
- What is underfitting and overfitting?
- What’s the fundamental trade-off in supervised machine learning?
- What is the golden rule of machine learning?

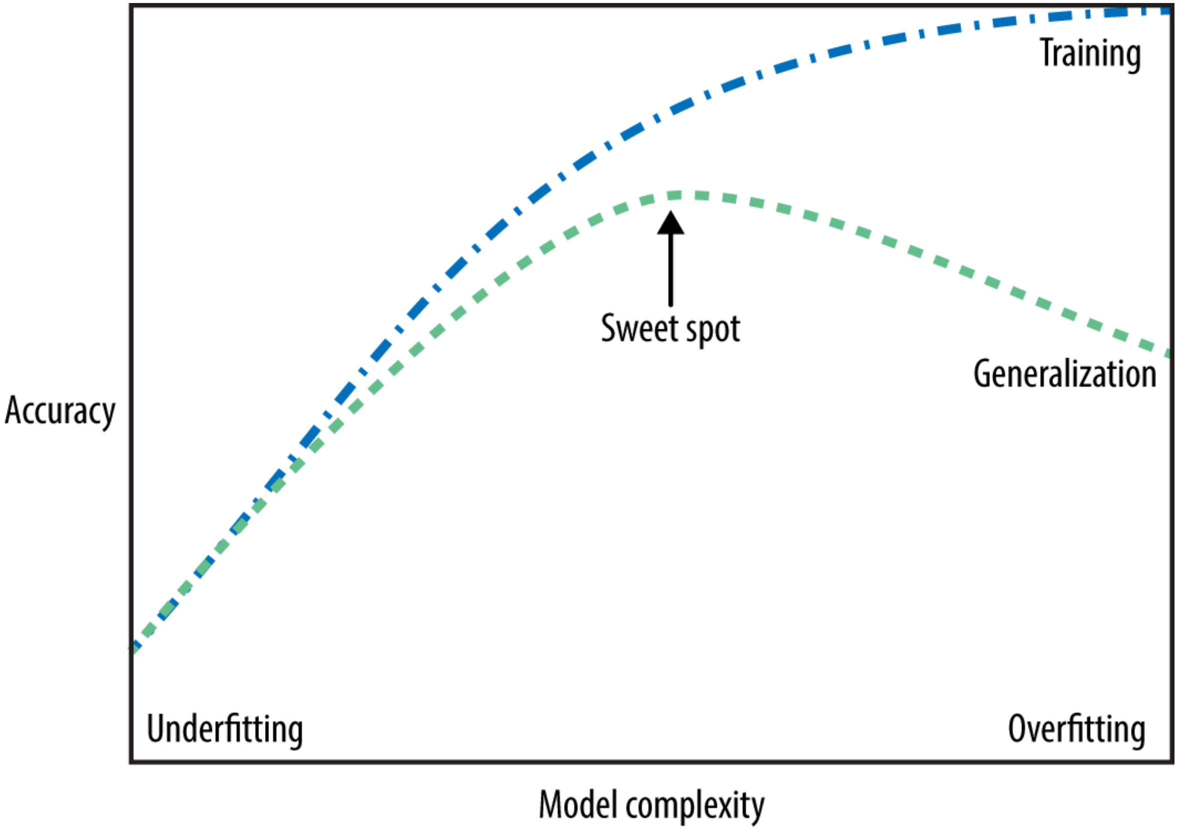
Overfitting and underfitting


fit models
underfit models
overfit models
quality of predictions on real-world data
quality of predictions on training set

Source

- An **overfit model** matches the training set so closely that it fails to make correct predictions on new unseen data.
- An **underfit model** is too simple and does not even make good predictions on the training data

The fundamental tradeoff



- As you increase the model complexity, training score tends to go up and the gap between train and validation scores tends to go up.
- How to pick a model?

Models

Supervised models we have seen

- Decision trees: Split data into subsets based on feature values to create decision rules
- k-NNs: Classify based on the majority vote from k nearest neighbors
- SVM RBFs: Create a boundary using an RBF kernel to separate classes
- Linear models: Assumption that the relationship between X and y is linear

Comparison of models

Model	Parameters	Hyperparameters	Strengths
Decision Trees			
KNNs			
SVM RBF			
Linear models			

Transformers

sklearn Transformers

Transformer	Hyperparameters	When to use?
SimpleImputer		
StandardScaler		
OneHotEncoder		
OrdinalEncoder		
CountVectorizer		
TransformedTargetRegressor		

Data leakage

Features

- Using features that are directly related to the target can cause data leakage.
  - Example: If you’re building a model to predict the churn rate of customers in a subscription service (churned or not churned) and you are using a feature like “account deactivation date”.
- If a feature essentially gives away the answer, the model might perform exceptionally well during training but fail to generalize to new, unseen data.

Preprocessing

- Incorporating information from the validation or test data during the preprocessing phase (e.g., scaling based on the distribution of the entire dataset instead of just the training set) can also lead to leakage. This can happen if the transformations applied to the training data are influenced by the whole dataset, thus indirectly feeding information about the test set into the model during training.

Preprocessing to avoid data leakage

Pipelines

- Pipeline is a way to chain multiple steps (e.g., preprocessing + model fitting) into a single workflow.
- Simplify the code and improves readability.
- Reduce the risk of data leakage by ensuring proper transformation of the training and test sets.
- Automatically apply transformations in sequence.

Column Transformers

- In what scenarios do we use column transformers?
  - Different transformations for different types of columns (e.g., scaling numerical data, encoding categorical data).
- Handle datasets with heterogeneous data types effectively.

Hyperparameter Optimization

Method	Strengths/Weaknesses	When to use?
Nested for loops		
Grid search		
Random search		

Classification Metrics

Metric	How to generate/calculate?	When to use?
Accuracy		
Precision		
Recall		
F1-score		
AP score		
AUC		

Regression Metrics

Metric	How to generate/calculate?	When to use?
MSE		
RMSE		
r2 score		
MAPE		

Group Work: Class Demo & Live Coding (if time permits)

This is mostly on regression metrics though it may serve as a good review of everything.

For this demo, each student should click this link to create a new repo in their accounts, then clone that repo locally to follow along with the demo from today.

If you really don't want to create a repo,

- Navigate to the `cpsc330-2024W1` repo
- run `git pull` to pull the latest files in the course repo
- Look for the demo file here