

Effective Programming Practices for Economists

Data Analysis in Python

Introduction to Machine Learning

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The Fundamental difference

Econometrics

- Estimate **fundamentally unobservable** parameters and test hypotheses about them
- Cannot test how well it worked
- Focus on justifying assumptions

(Supervised) Machine learning

- Predict observable things
- Can check how well it works
- Focus on experimentation, evaluation and finding out what works

Some implications

- Even though it is tempting, you cannot interpret parameters
- Can be creative in combining simple models into complex ones
- Rapid progress and development of new models
- Programming skills matter more

Terminology

Machine Learning	Econometrics
feature, attribute	x-variable, independent variable
target	y-variable, dependent variable
model, algorithm	model
training procedure	estimation method
fitting	running an estimation
classification	regression with discrete dependent variable
logistic regression	binary or multivariate logit
instance	observation
classes	possible values of a discrete dependent variables

Supervised vs unsupervised learning

- **Supervised learning**

- Training data contains labeled examples of the task to solve
- Model generalizes this to unseen data
- Example: Regression, classification

- **Unsupervised learning**

- Training with label free data
- Model finds patterns in data
- Example: Clustering, dimensionality reduction

Overfitting

- Estimating large models on small datasets can lead to overfitting
- Overfitting means:
 - Model can explain the concrete dataset well
 - Model would not work on any other dataset
 - Same reason why we need adjusted R^2 in econometrics
 - Need to make sure our model evaluation accounts for overfitting!
- Example: Estimate person fixed effects in short panel

The bias-variance trade-off

- Econometrics: Model is correctly specified, want consistency and unbiasedness
- Very simple models, e.g. just an intercept and a couple of regressors
 - Large bias, low variance, no overfitting
- Very large models, e.g. including squares, interactions, ...
 - Small bias, high variance, danger of overfitting
- ML: Model is a simplification and some amount of bias is ok
- Most ML models have one or more parameters that govern the bias variance trade-off

Holdout samples

- Split data into training and test dataset
- Fitting and experimentation is only done on training data
- Evaluation is only done on test data
 - Overfitting on training data cannot influence the evaluation
 - Need to avoid leaking any information from test data into model training!
- Typical sizes:
 - 70 to 80 percent for training
 - Rest for validation

Hyperparameters

- No parameters of the model itself
- Instead: Control behavior of the model algorithm
- E.g., balance bias and variance