Machine Learning

B. N. M. Institute of Technology

Department: Artificial Intelligence and Machine Learning (AI)

Course: Machine Learning (18AI61) effective from the academic year 2018–2019 under VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

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Machine Learning Landscape

What is Machine Learning?

Few Examples

Spam Email Filter	*Recommender*	*Optical Character Recognition*	*Chatbots*	*Voice Recognition*
Facial Recognition	*Forecasting*	*Autonomous Vehicle*	*Medical Diagnostics*	*Fraud Detection*

and many more...

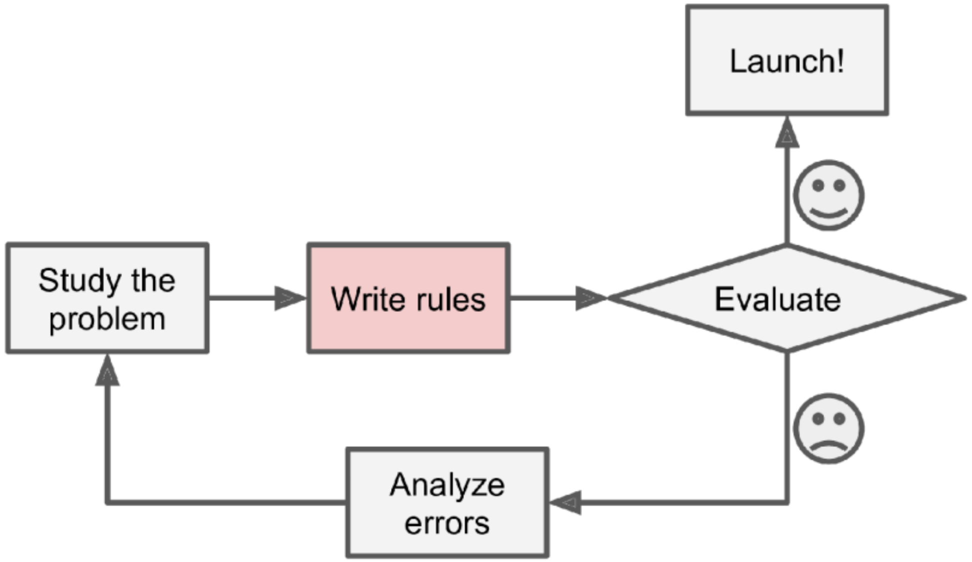
Some Definitions

"Science of programming computer to learn from data

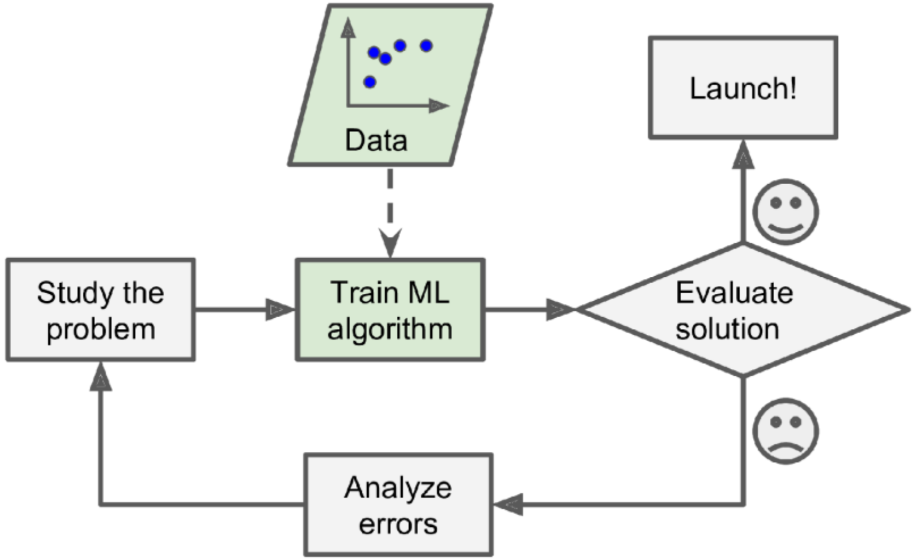
"field of study that gives computers the ability
to learn without being explicitly programmed

*"A computer program is said to learn from experience **E** with respect to some task **T** and some performance measure **P**, if its performance on **T**, as measured by **P**, improves with experience **E***

Why is Machine Learning Required?

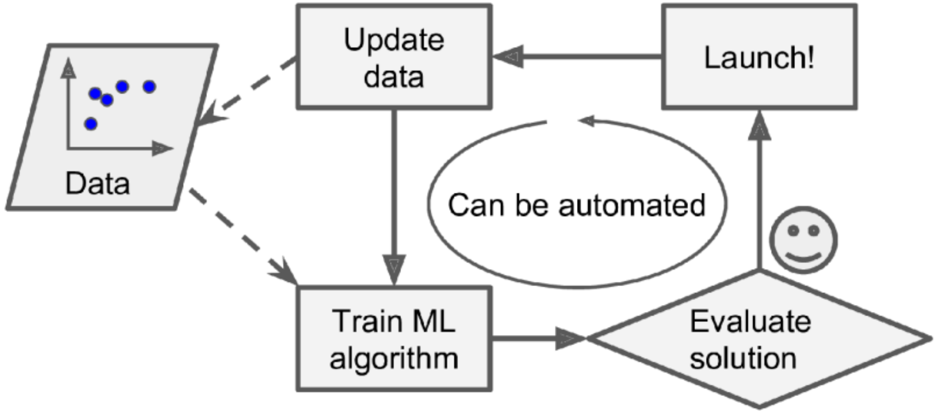


Traditional program writing approach

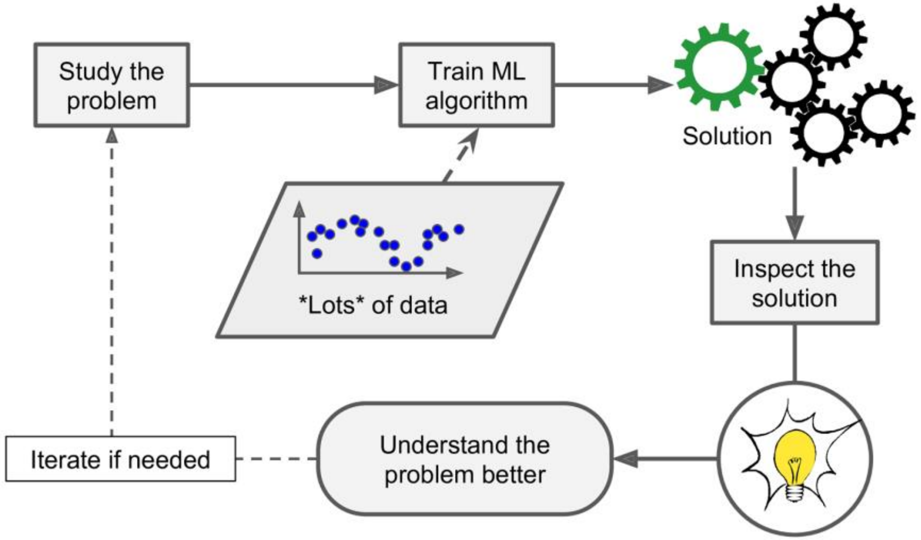


The Machine Learning approach

Why is Machine Learning Required? (Cont.)



Automatically adapting change



Discovering patterns for human learning

Machine Learning is a Good Option for

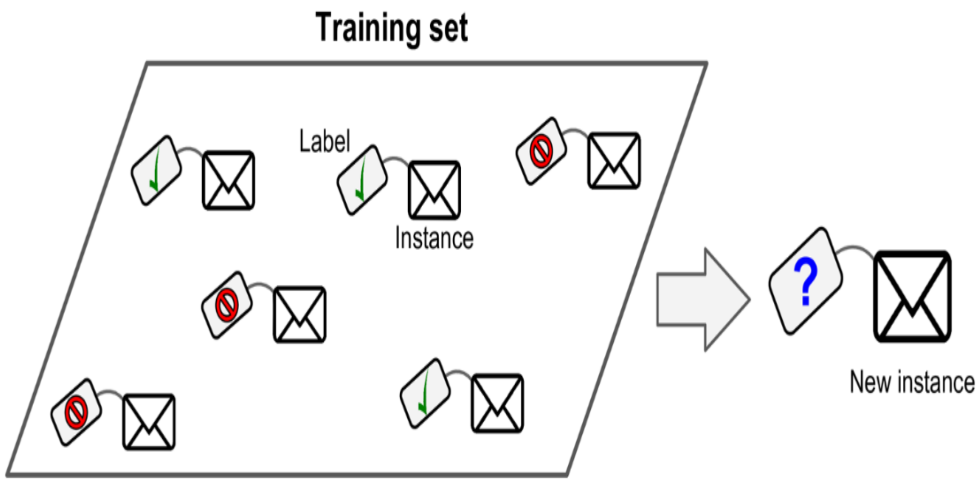
- Problems that require a lot of fine-tuning and long list of rules
- Problems that traditional approaches do not yield good results
- Problems where data distribution changes over time
- Getting insights about complex problems from large volume of data

Types of Machine Learning Systems

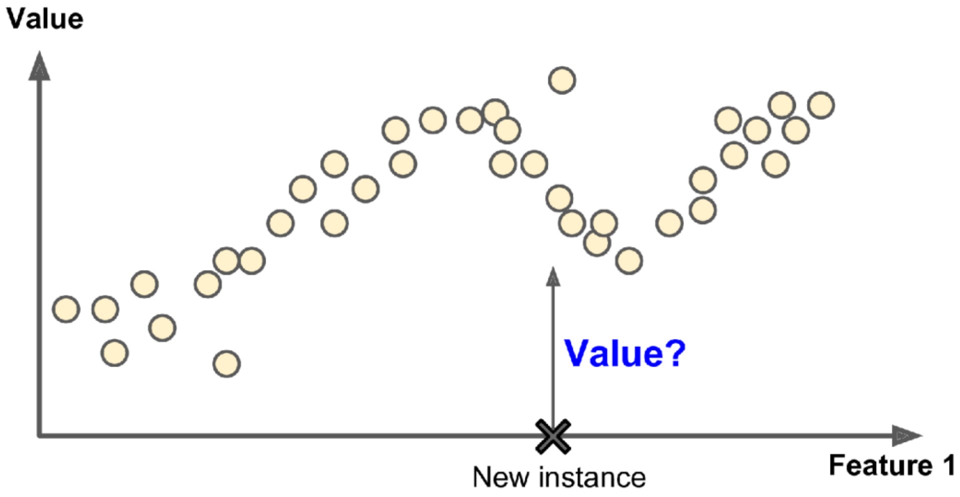
Whether learning requires human supervision	Whether learning is incremental	Whether learning is to compare or to detect pattern and/or predict
• Supervised Learning • Semi-supervised Systems • Unsupervised Learning • Reinforcement Learning	• Batch Learning • Online Learning	• Instance-based Learning • Model-based Learning

Types of Machine Learning Systems (Cont.)

Classification & Regression in Supervised Learning



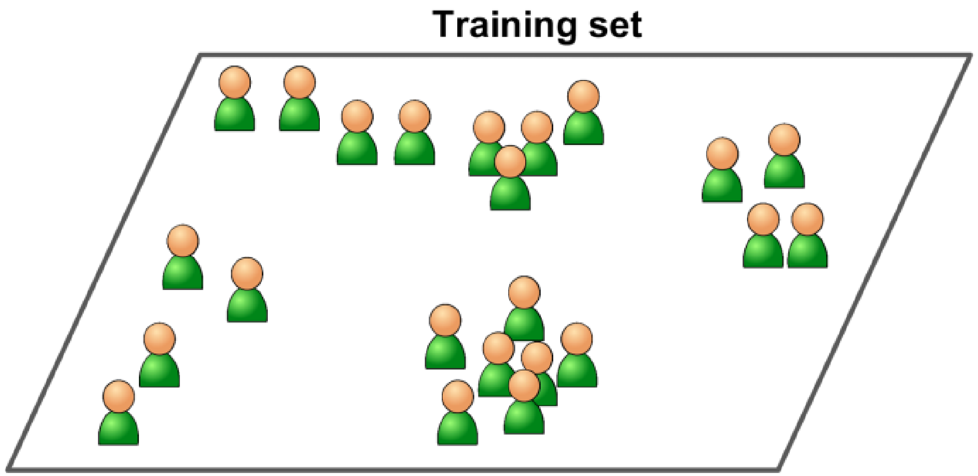
A labeled training set for spam classification



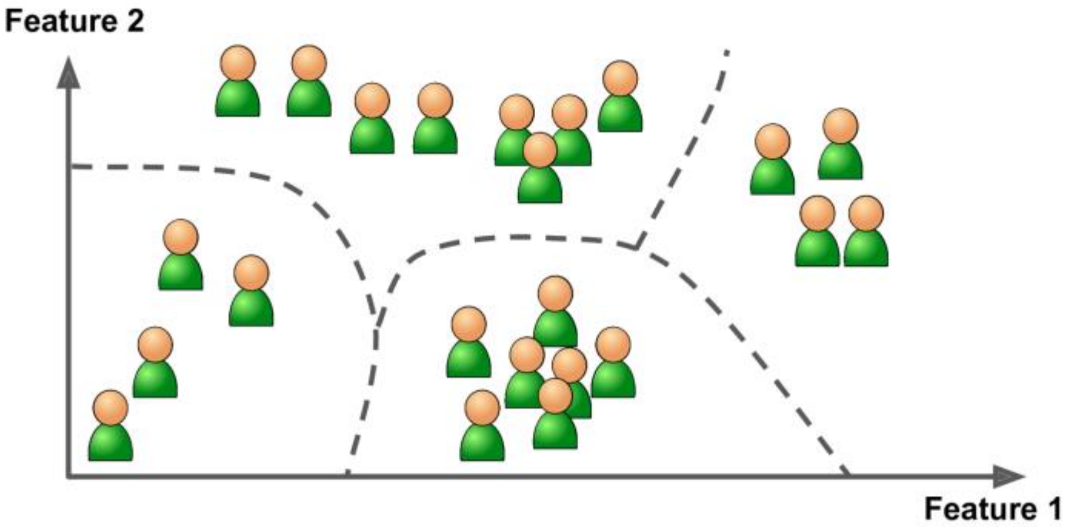
Predicting a continuous value in regression problem

Types of Machine Learning Systems (Cont.)

Clustering in Unsupervised Learning



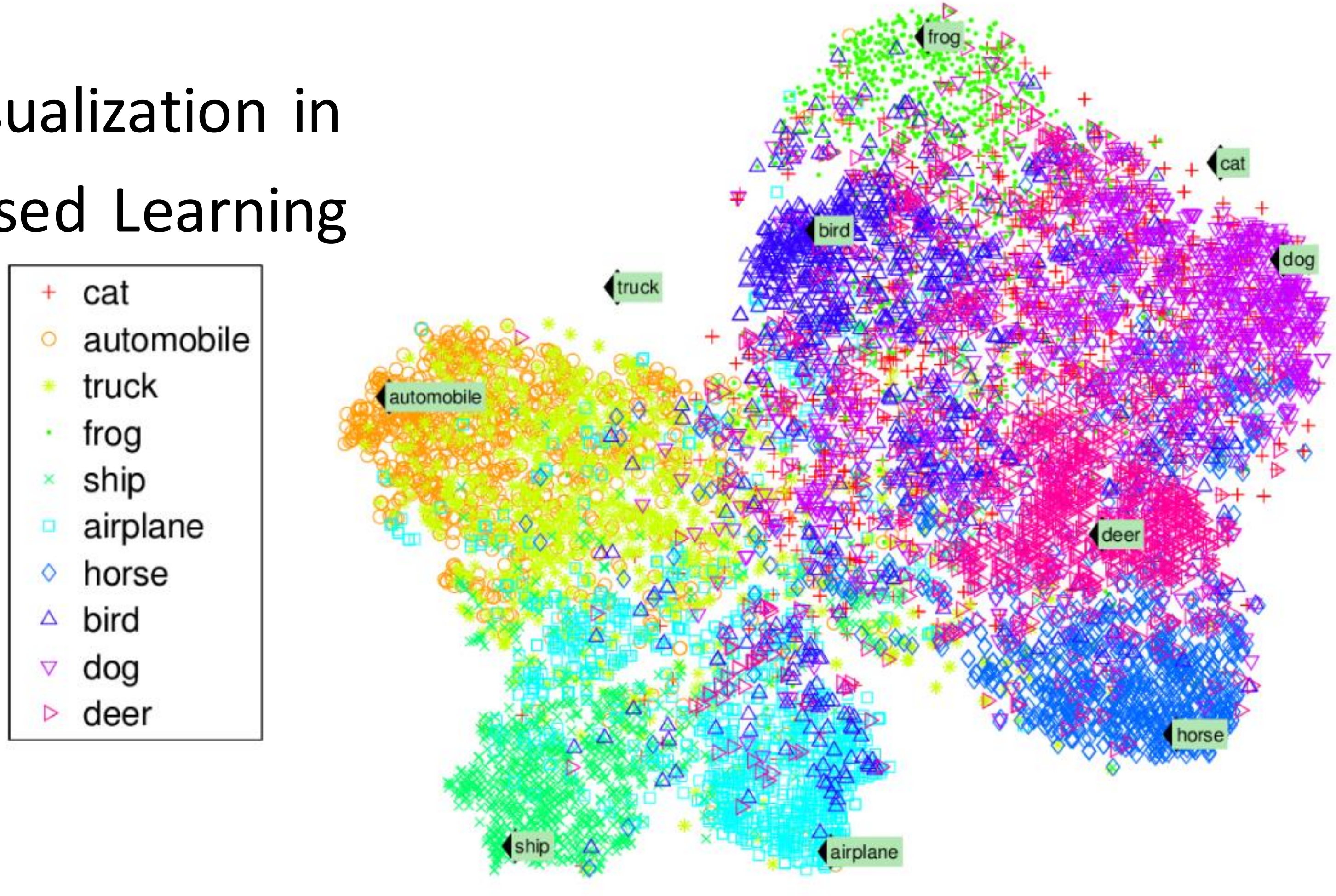
An unlabeled training set for clustering



Detecting groups of similar visitor in clustering

Types of Machine Learning Systems (Cont.)

Cluster Visualization in Unsupervised Learning



Cluster visualization in unsupervised learning

Types of Machine Learning Systems (Cont.)

Dimensionality Reduction in Unsupervised Learning

- Simplifying data without losing too much information
- Merging correlated features into one
- Feature extraction

Types of Machine Learning Systems (Cont.)

Anomaly and Novelty Detection in Unsupervised Learning

Detection of an anomaly

Types of Machine Learning Systems (Cont.)

Association Rule Learning in Unsupervised Learning

{Potatoes, Onions} => {Burger}

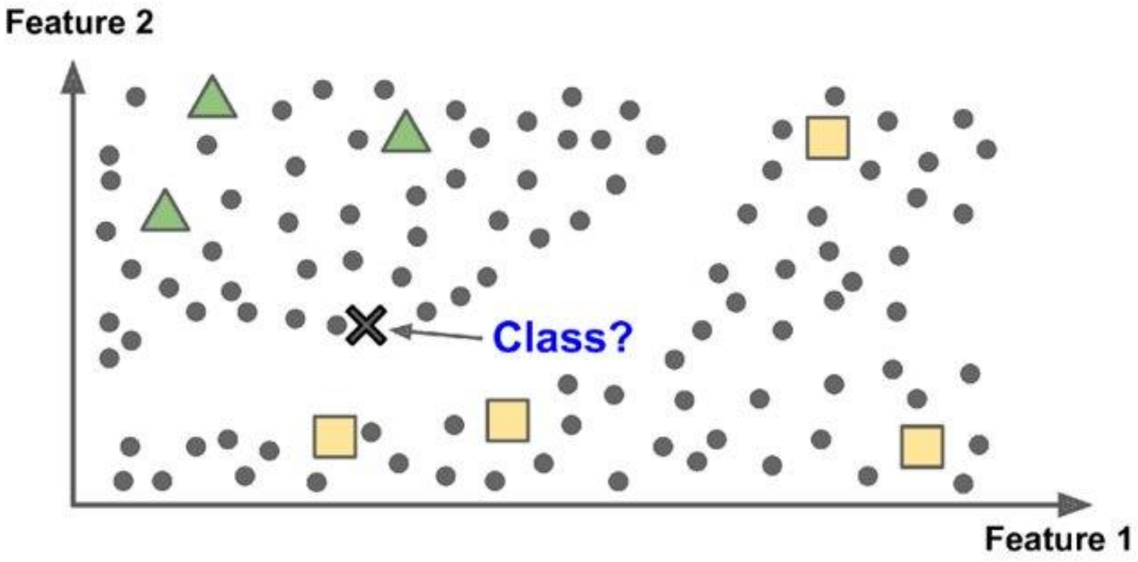
{Barbeque sauce, Potato chips} => {Steak}

Results in Promotional Pricing and/or Appropriate Product Placement

Sales logs revealing customers' buying pattern

Types of Machine Learning Systems (Cont.)

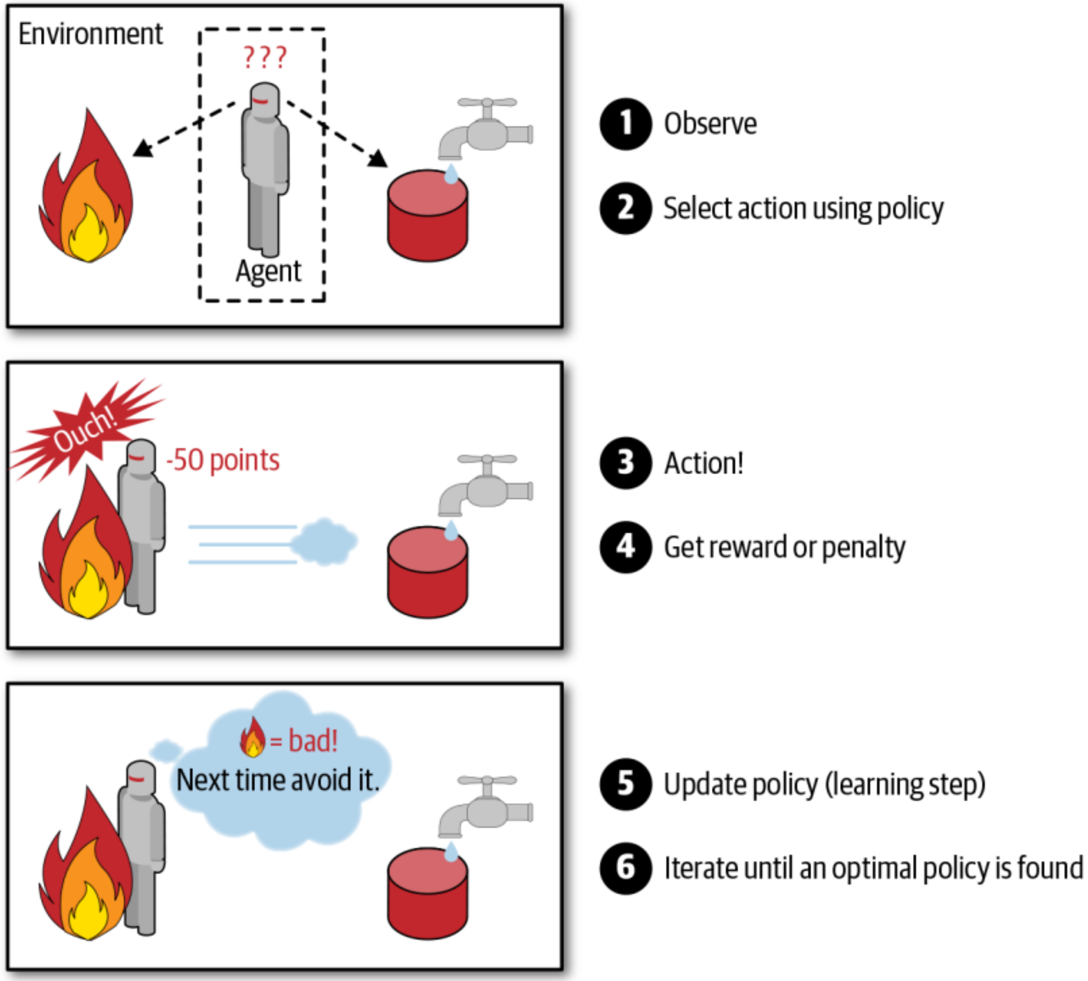
Classification in Semisupervised Learning



Few labeled examples help classifying new instances

Types of Machine Learning Systems (Cont.)

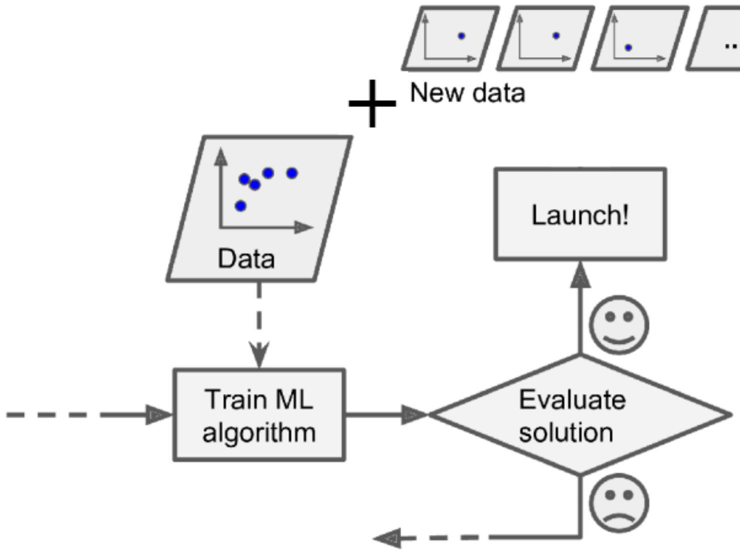
Building Strategy in Reinforcement Learning



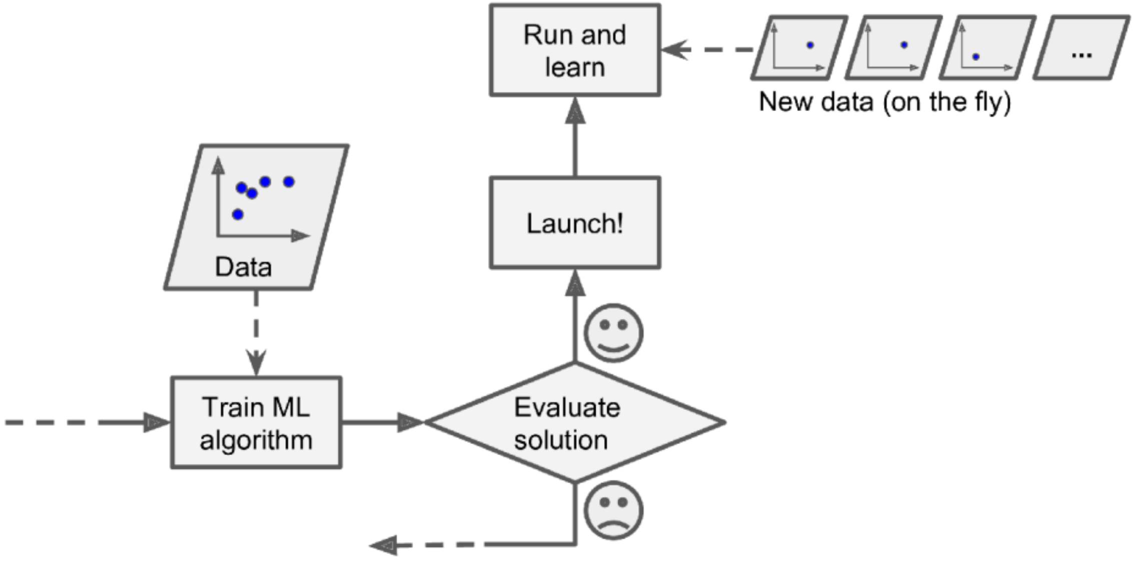
Receiving reward or penalty against its actions and fine-tuning its strategy

Types of Machine Learning Systems (Cont.)

Batch and Online Learning

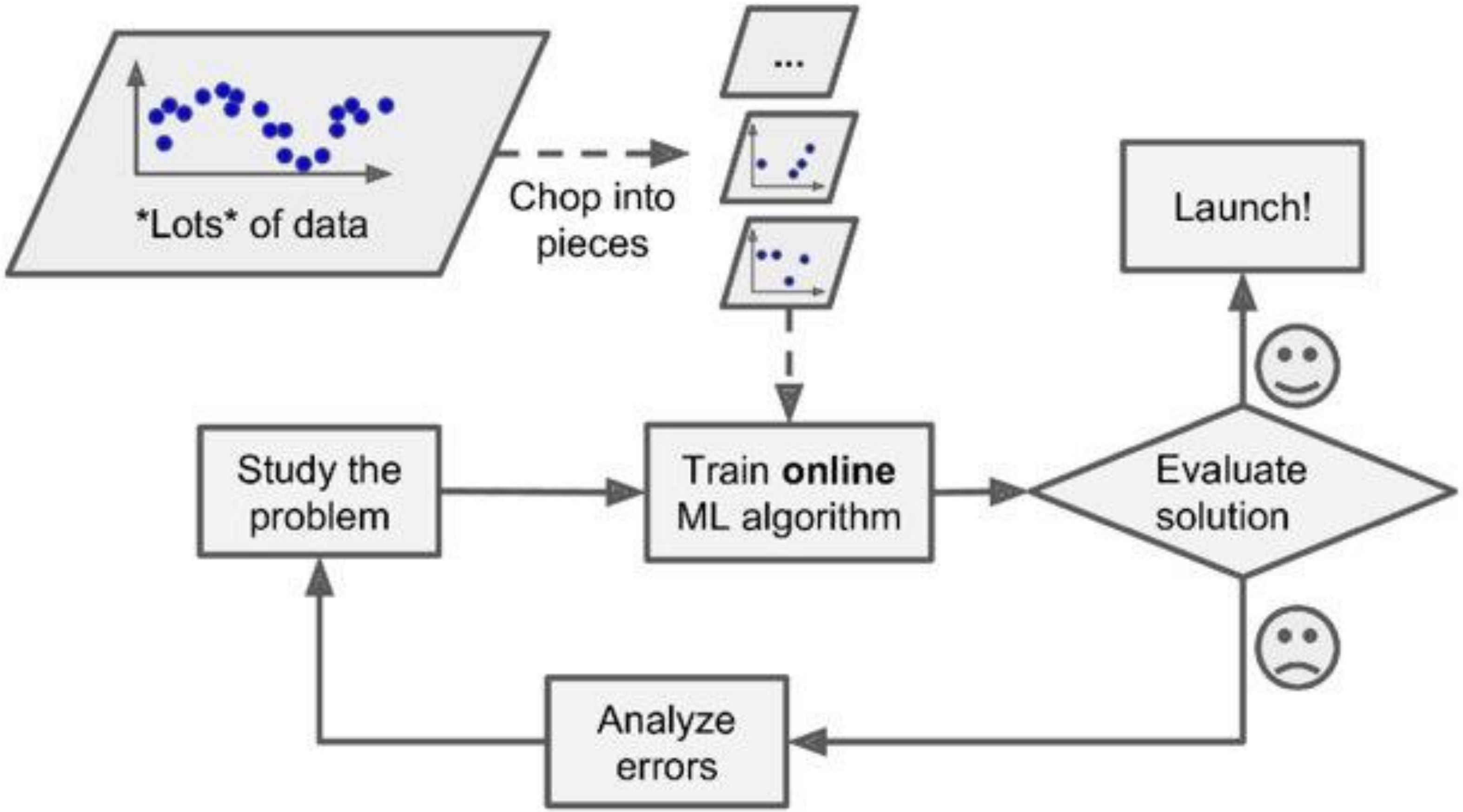


Relearning from scratch on full dataset (old and new data) in Batch Learning



Learning is incremental for new data in Online Learning

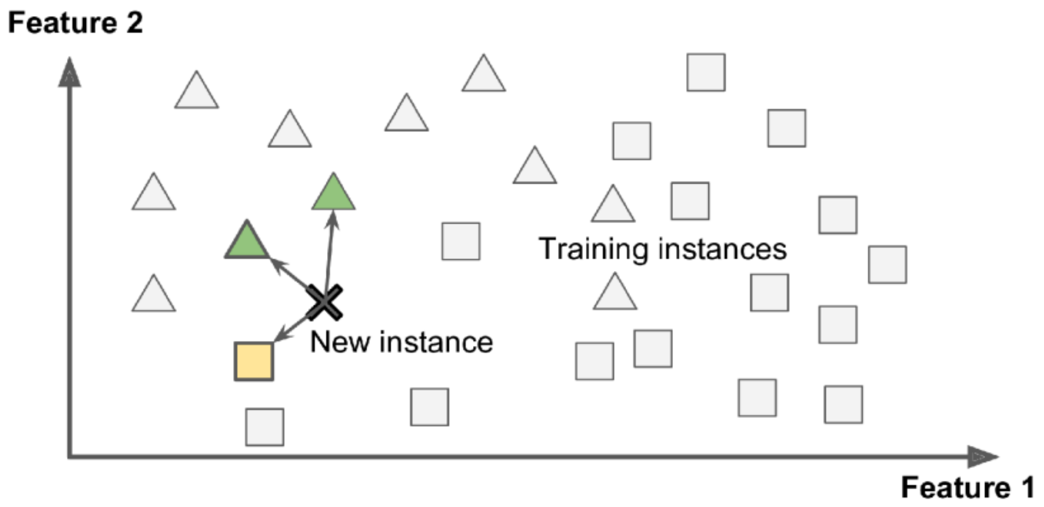
Types of Machine Learning Systems (Cont.)



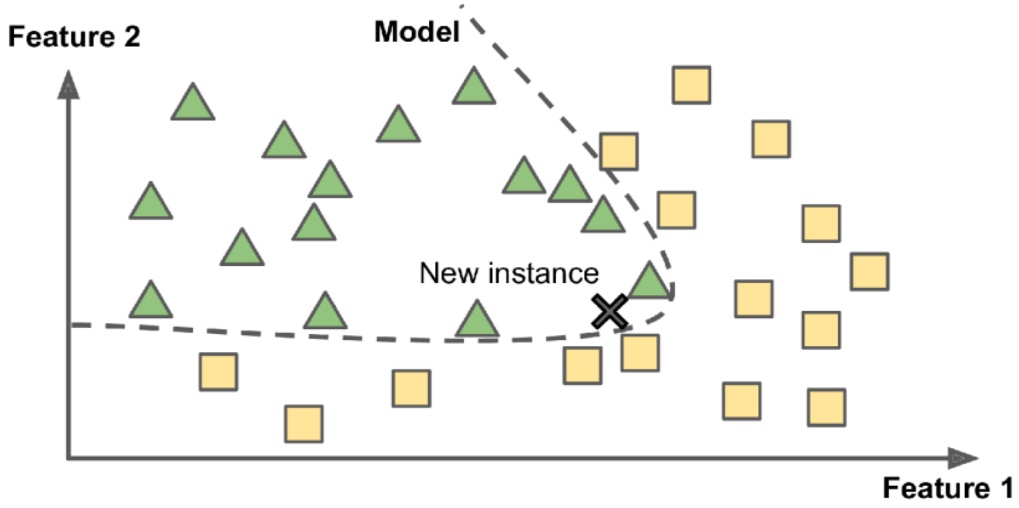
Handling huge dataset in Online Learning

Types of Machine Learning Systems (Cont.)

Instance-based or Model-based Learning systems on how they generalized



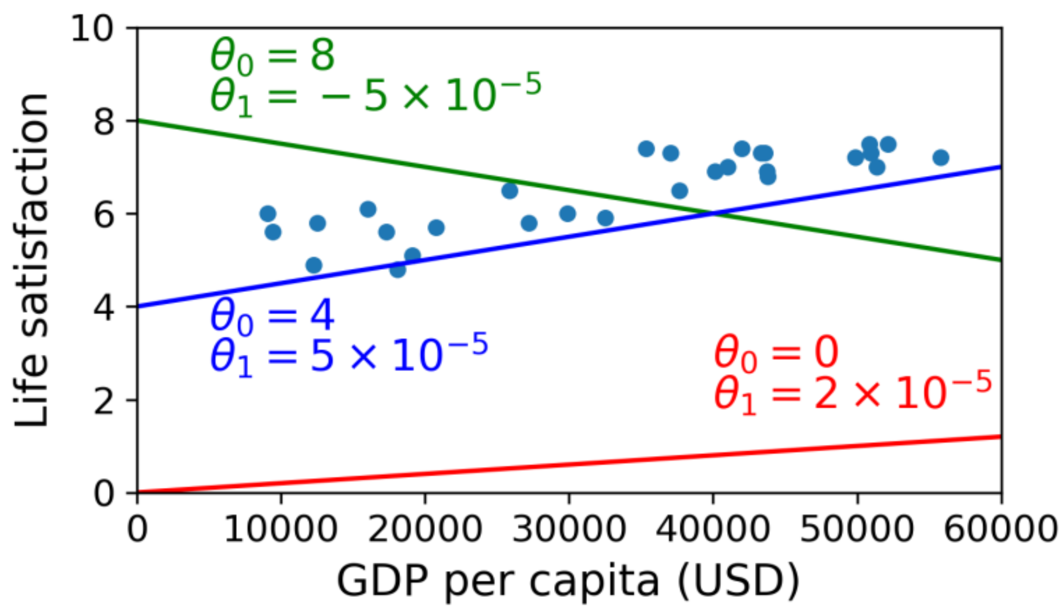
Instance-based Learning is by heart and it then generalizes to new cases by using similarity measures



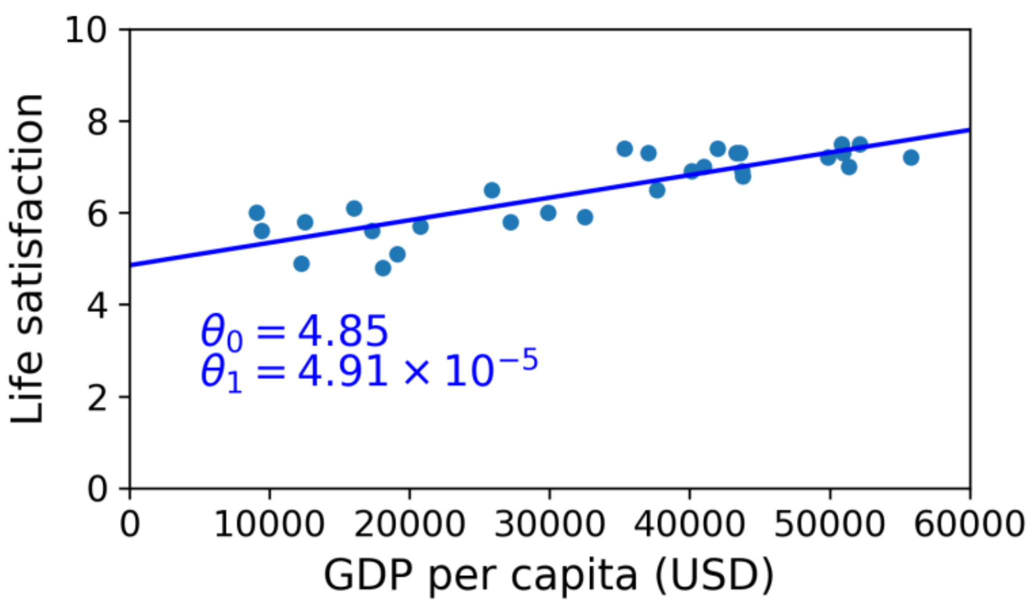
Model is created in Model-based Learning and then it make predictions

Types of Machine Learning Systems (Cont.)

Fitting Model to Data in Model-based Learning



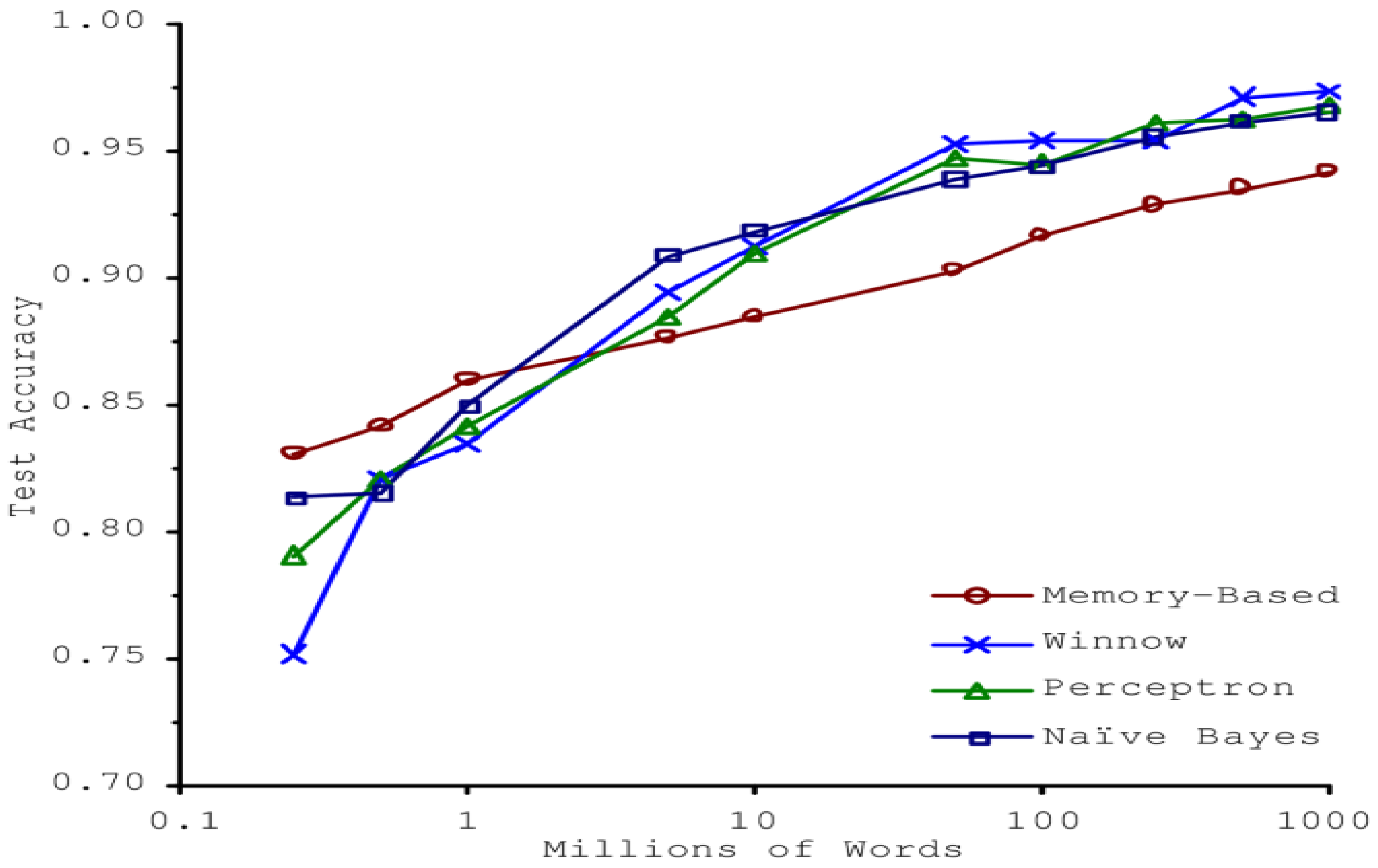
Possible linear models



Fitted linear model

Main Challenges in Machine Learning

Insufficient Quantity of Training Data

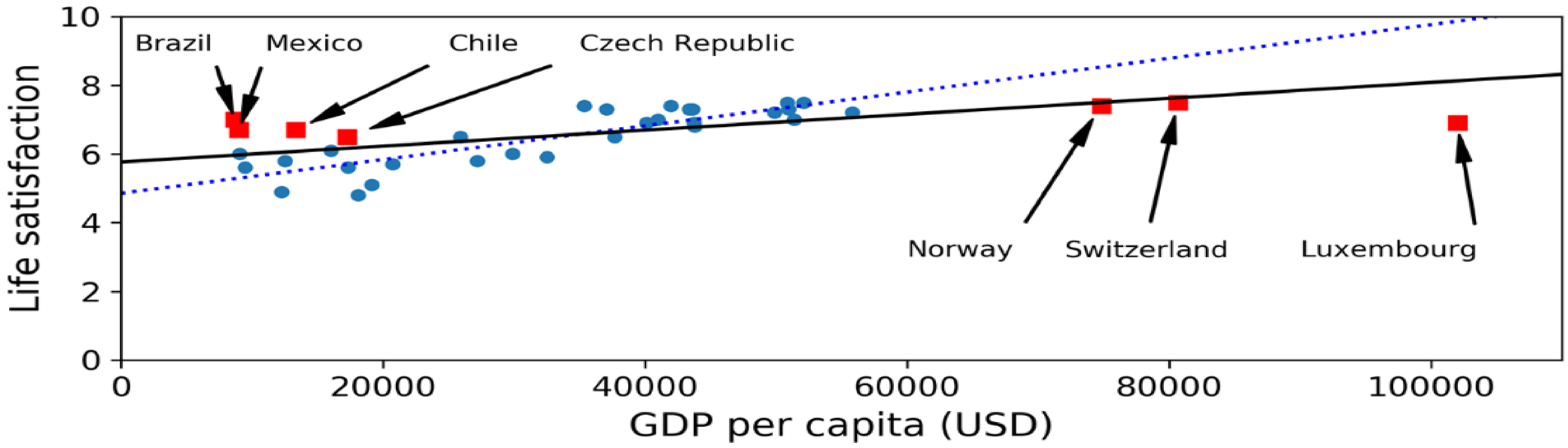


Trade-off between spending time and money on algorithm development and spending these on corpus development

Main Challenges in Machine Learning (Cont.)

Nonrepresentative Training Data

- Sampling Noise
- Sampling Bias



A better model fitted over more representative training data

Main Challenges in Machine Learning (Cont.)

Poor-Quality Data

- Errors
- Missing values
- Outliers

Main Challenges in Machine Learning (Cont.)

Irrelevant Features

Applying Feature Engineering involving the following steps

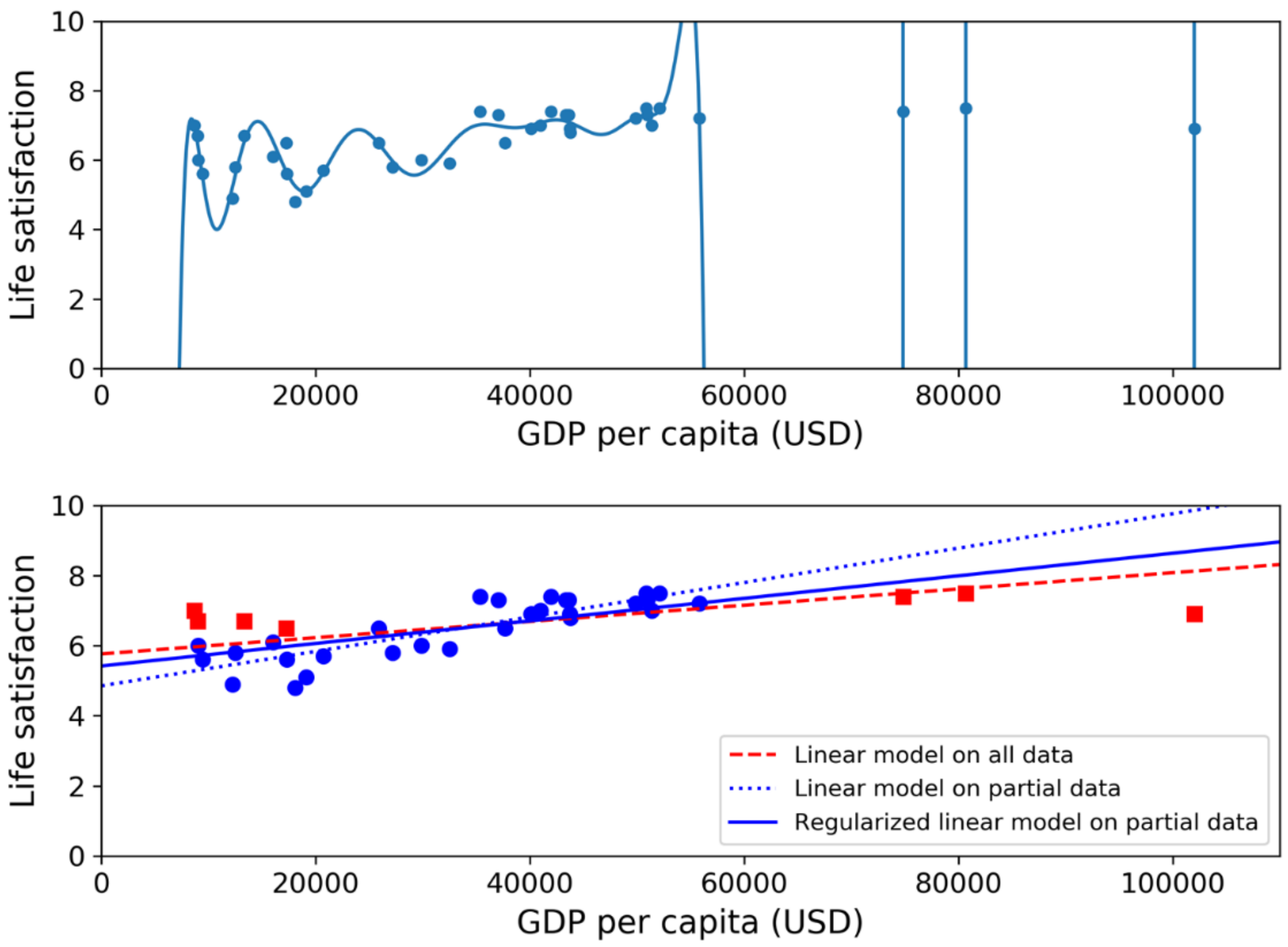
- Feature selection
- Feature extraction
- Creating new features

Main Challenges in Machine Learning (Cont.)

Overfitting the Training Data

Resolving by

- Simplifying model
- Applying constraints (regularization)
- Gathering more training data
- Fixing data quality issues



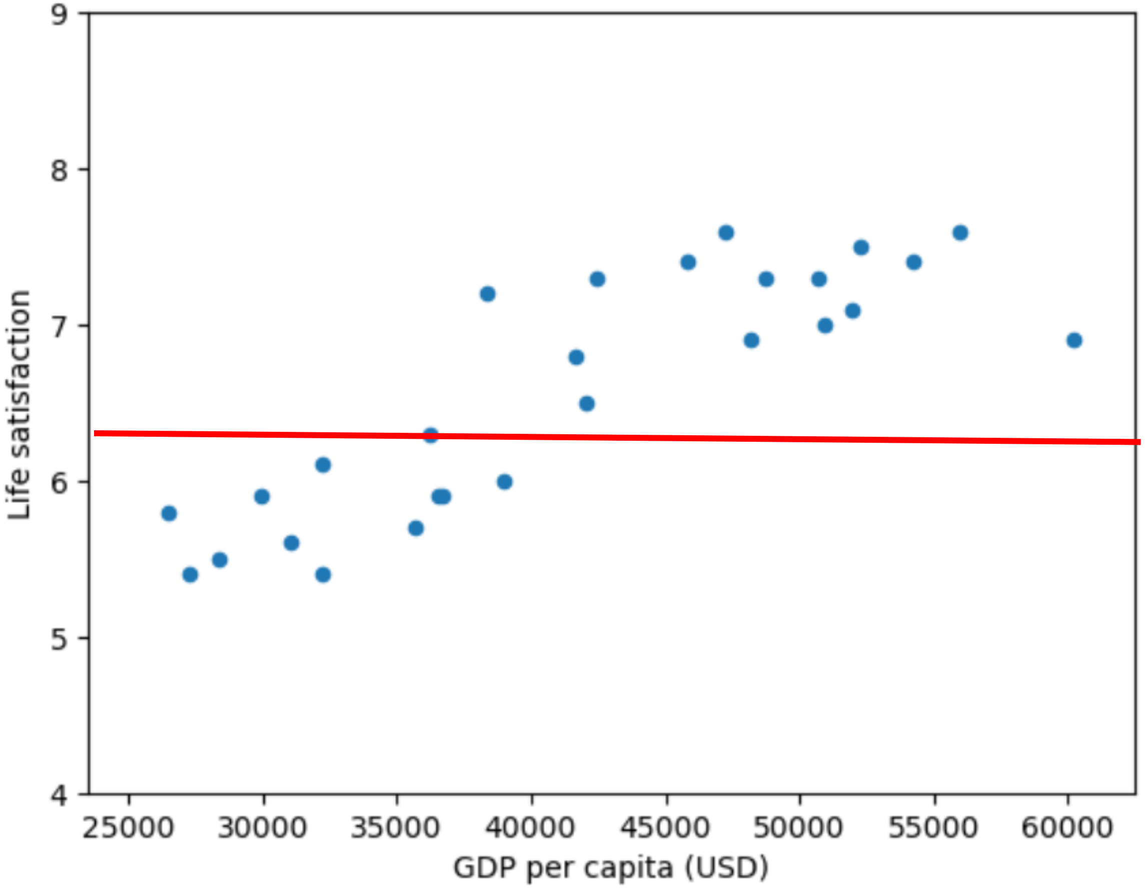
Overfitting and applying regularization to avoid it

Main Challenges in Machine Learning (Cont.)

Underfitting the Training Data

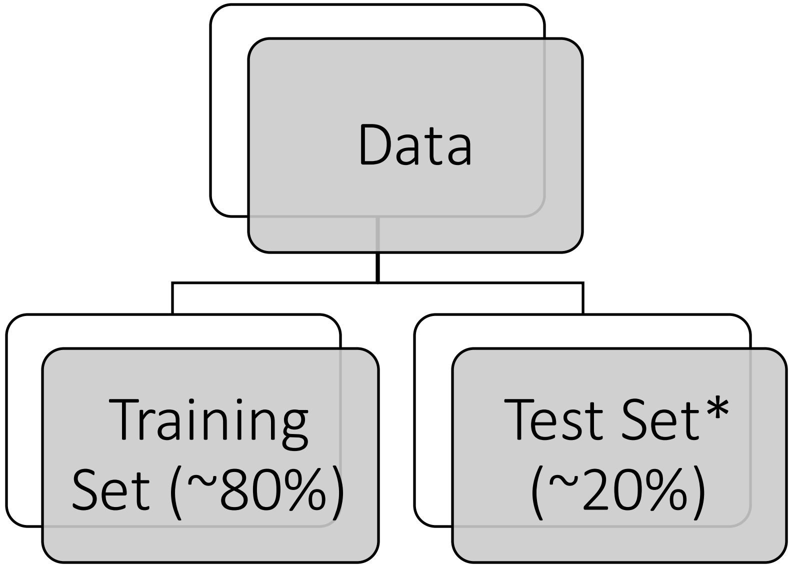
Resolving by

- Selecting more powerful model
- Feeding better features
- Reducing constraints or regularization



Testing and Validating

Ensuring Model Generalizes Well



1 Model is built by fitting it on the training data

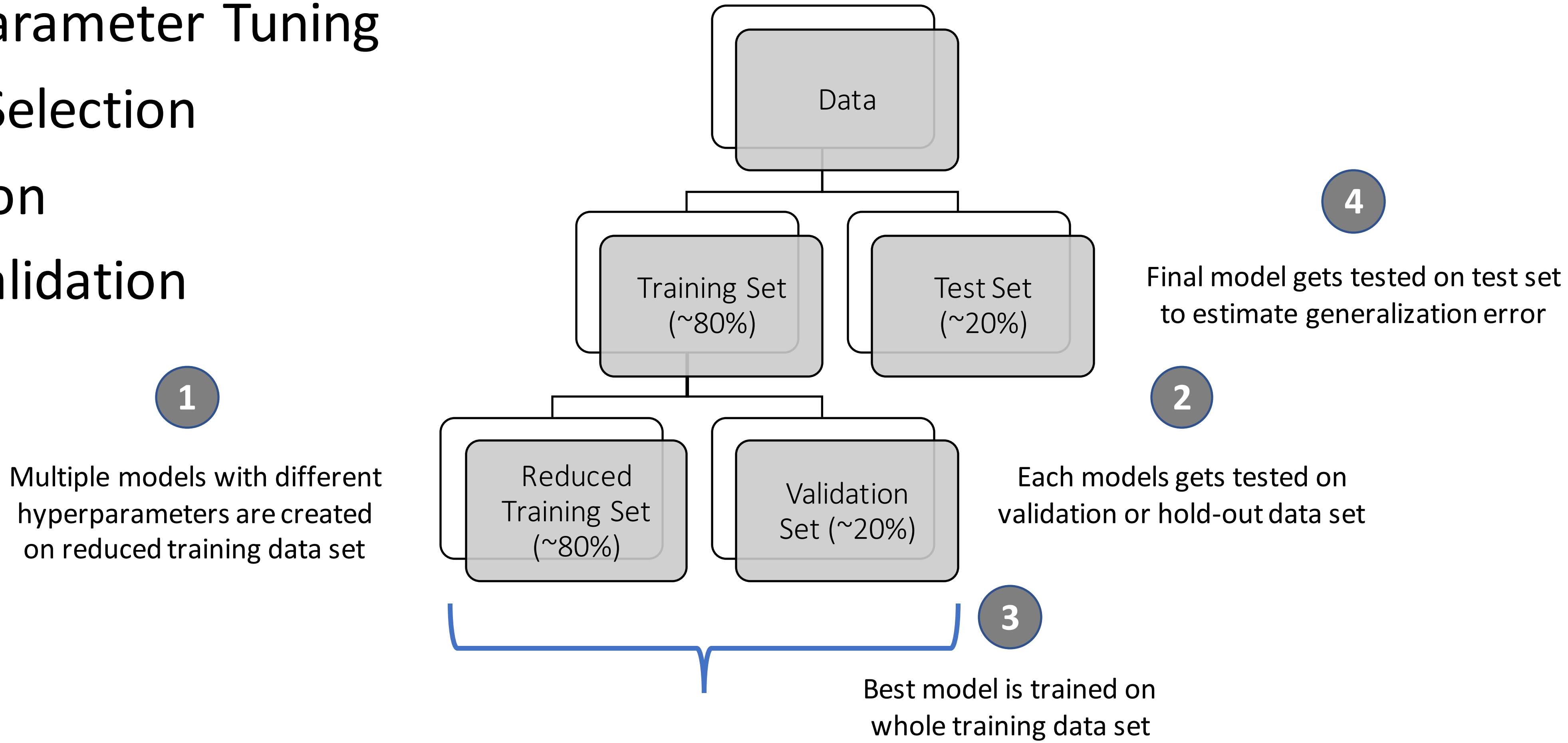
2 Test data helps estimating how the model generalizes

a.k.a. Hold-out set

A better model fitted over more representative training data

Testing and Validating (Cont.)

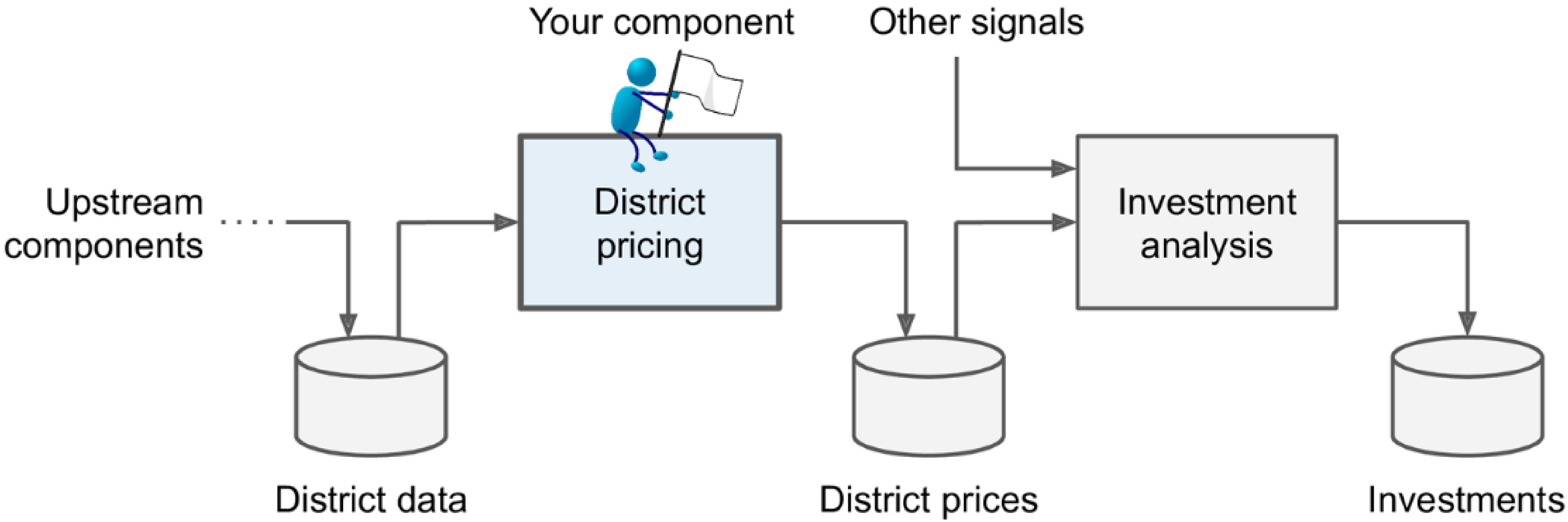
- Hyperparameter Tuning
- Model Selection
- Validation
- Cross-validation



No Free Lunch (NFL) Theorem

- No model that is *a priori* guarantees to be a better one
- Evaluating all models is only way to know which one works best – *Not practical*
- Hence, making *reasonable assumption about data* and *evaluating few reasonable models* is better option

The Pipeline



High-level machine learning pipeline for real estate investment

End-to-End Machine Learning Project

Major Steps Involved

1. Looking at the big picture.
2. Getting the data.
3. Discovering and visualizing the data to gain insights.
4. Preparing the data for Machine Learning algorithms.
5. Selecting a model and train it.
6. Fine-tuning your model.
7. Presenting your solution.
8. Launching, monitoring, and maintaining your system.

The Big Picture

- **The Context:** Automatic prediction of district's median house prices using census data
- **Framing the Problem:**
  - Understanding current business problem
    - Time consuming and costly manual operations
    - Performance is not always good
  - Proposed solution
    - A model to predict house price
      - Considering if it should be a <u>supervised</u>, unsupervised or reinforcement learning
      - Considering if it should be classification, (<u>univariate</u> or multivariate) <u>regression</u> or any other type of task
      - Whether it should be <u>batch</u> or online learning
    - Downstream apps to consume the predictions for further business processes and to decide on investments

The Big Picture (Cont.)

- **Deciding on performance metrics:**
  - <u>Root Mean Squared Error (RMSE)</u>
  - Mean Absolute Error (MAE)
- Choosing candidate algorithms
- Realizing development effort