# Streaming Machine Learning
# Regression

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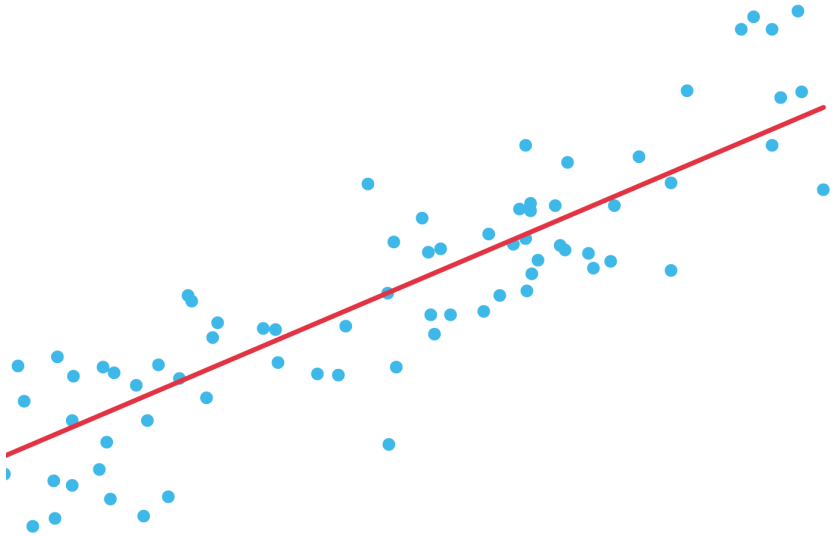
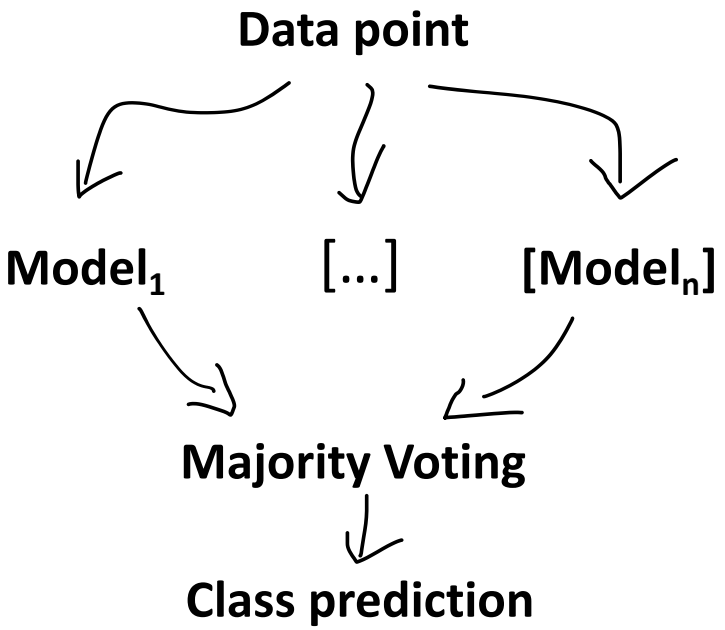
# SML Regression models



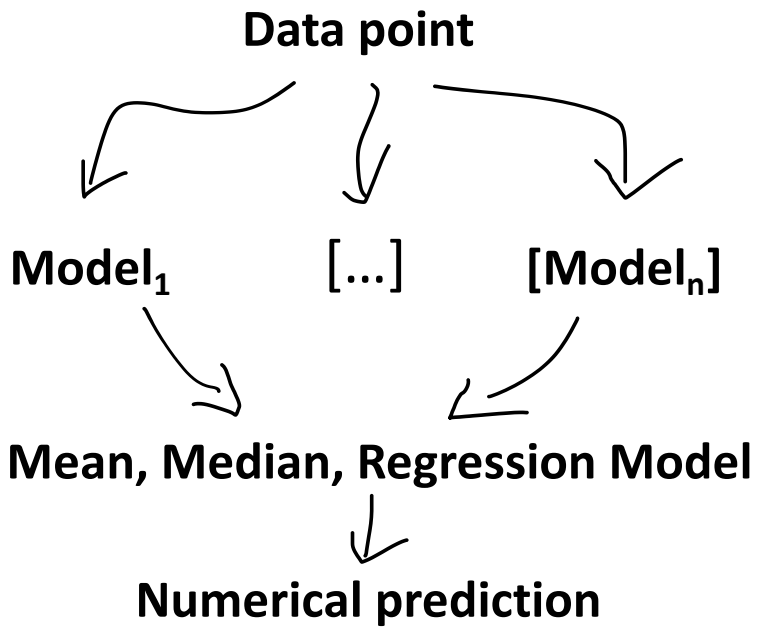
# From Classification to Regression

Instead of using a **majority voting** approach, use the **mean** or **median** or a **regression model** built over the points saved into leaves to aggregate results e compute the predicted target feature

## Classification

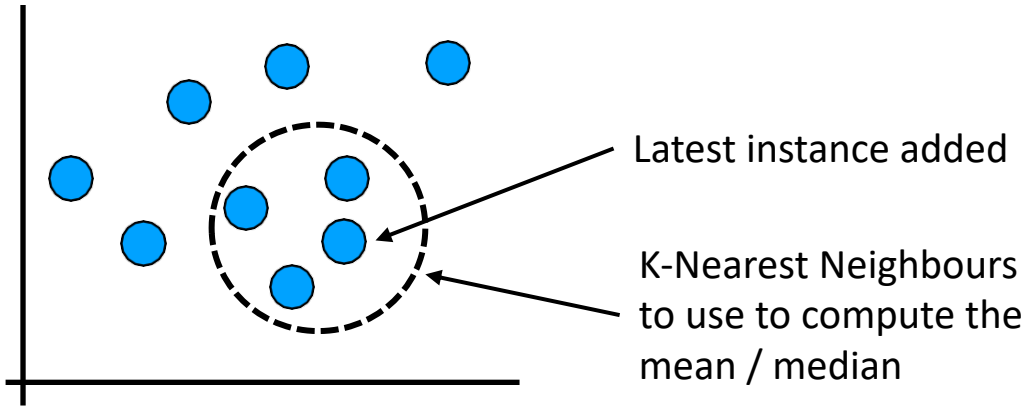



## Regression



# Online K-Nearest Neighbours Regressor

- Use a fixed size sliding window to save the instances
- Find the *k* nearest neighbours to the new sample in input
- The predicted target feature is the **mean** / **weighted mean** / **median** of the *k* nearest neighbours' target features




Bifet, A., Pfahringer, B., Read, J., & Holmes, G. **Efficient data stream classification via probabilistic adaptive windows**. ACM symposium on applied computing, 2013

# Adaptive Model Rules (AMRules)

- The **antecedent** of a rule is a **set of literals** (**conditions** based on **multiple attribute** values)
- The **consequent** of a rule is a function that **minimizes** the **mean square error** of the **target attribute** computed from the set of samples covered by rule
- Each **rule** uses a **Page-Hinkley** test to **detect changes** and react to changes by pruning the rule set
- Each **rule** is also equipped with **outliers' detection mechanisms** to avoid model adaption using anomalous examples
- **Multiple rules** form a **set** of rules, similarly to a tree. **Hoeffding Bound** is used to grow the set
- The **prediction strategy** used by decision rules can be the **mean**, a **regression** model, or **adaptive**, i.e., chooses between 'Mean' and 'Regression model' dynamically

Duarte, J., Gama, J. & Bifet, A. **Adaptive Model Rules From High-Speed Data Streams**. ACM TKDD, 2016

# HT Regressor

- **Learner**:
  - Incremental decision tree
  - Hoeffding bound to split over nodes
- **Voting**:
  - Mean
  - Regression model
  - Adaptive, i.e., chooses between ‘Mean’ and ‘Regression model’ dynamically

Pedro Domingos and Geoff Hulten**. Mining high-speed data streams.** 2000

# HAT Regressor

- **Learner**:
  - Incremental decision tree
  - Hoeffding bound to split over nodes
- **Voting**:
  - Mean
  - Regression model
  - Adaptive, i.e., chooses between ‘Mean’ and ‘Regression model’ dynamically
- **Adaptation**: Adaptive window + warning period (train background learners)

A. Bifet, R. Gavald`a. **Adaptive Parameter-free Learning from Evolving Data Streams**. IDA, 2009

# ARF Regressor

- **Base Learners**: Hoeffding Tree Regressors
- **Diversity**: Leveraging Bagging + **Local** Random Subspaces
- **Combination**:
  - Flat architecture
- **Voting:**
  - Mean, Regression model or Adaptive, i.e., chooses between 'Mean' and 'Regression model' dynamically
- **Adaptation**: Adaptive window + warning period (train background learners)

Gomes, H. M., et al. **Adaptive random forests for data stream regression**. ESANN, 2018

# SRP Regressor

- **Base Learners**: User choice
- **Diversity**: Leveraging Bagging + **Global** Random Subspaces
- **Combination**:
  - Flat architecture
- **Voting:**
  - Base learner's voting strategy
- **Adaptation**: Adaptive window + warning period (train background learners)

Gomes, Read and Bifet. **Streaming Random Patches for Evolving Data Stream Classification**. ICDM, 2019

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# Exercise 5: Stream Regression [optional]

# Credits

- Albert Bifet DATA STREAM MINING 2020-2021 course at Telecom Paris
- Alessio Bernardo & Emanuele Della Valle

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