

What is Statistical Learning?

Concepts and Framework

MUTLU LEARNING HUB

- 1 What is Statistical Learning?
- 2 Supervised vs. Unsupervised Learning
- 3 Parametric vs. Non-Parametric

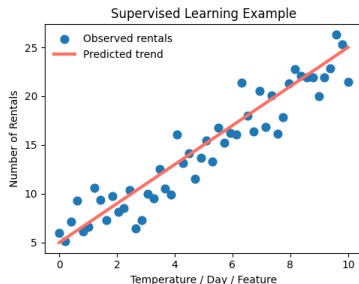
Question:

How many bikes will be rented tomorrow if it's sunny and 25°C?

- **Goal:** Predict an outcome (Y) from influencing factors (X).
- **Inputs (X):** Temperature, weather, day of the week
- **Output (Y):** Number of bike rentals
- **Model:**

$$Y = f(X) + \epsilon$$

- $f(X)$: Predictable pattern from data
- ϵ : Random noise / uncertainty



Observed bike rentals (dots) and underlying trend (line).

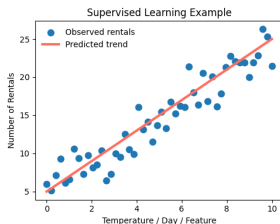
Supervised vs. Unsupervised Learning

Question:

Do we have labeled data to learn from, or only raw data to explore?

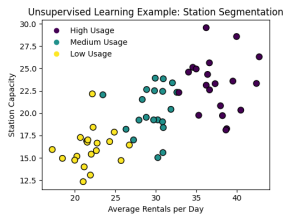
Supervised Learning

- Predict an outcome (Y) from known inputs (X)



Unsupervised Learning

- Find patterns using only inputs (X)

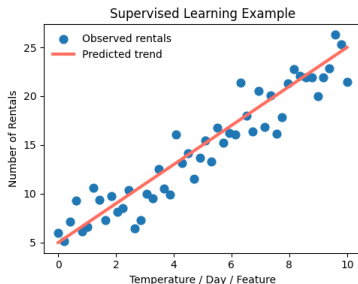


Supervised Learning: Predicting Outcomes

Question:

How can you predict bike rentals for tomorrow using past data?

- **Inputs (X):** temperature, weather, day of week
- **Outputs (Y):** number of rentals
- **Goal:** Learn the relationship $X \mapsto Y$ to predict future rentals
- **Intuition:** Like using yesterday's data to forecast tomorrow

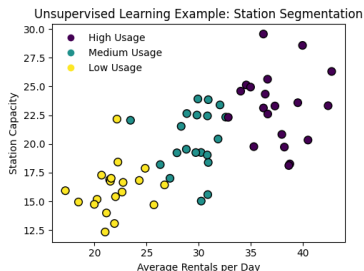


Unsupervised Learning: Station Segmentation

Question:

How can you group bike stations based on similar rental behavior?

- **Only inputs (X) are available:**
 - Average rentals per day
 - Station capacity
- **Goal:** Discover hidden patterns or clusters in the data
- **Intuition:** Identify stations with similar usage without knowing outputs
- **Practical insight:** Optimize resource allocation and maintenance schedules



Clusters of stations based on average rentals and station capacity.

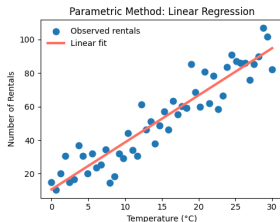
Two Main Approaches to Find $f(X)$

Question:

Should we assume a shape for $f(X)$, or let the data decide?

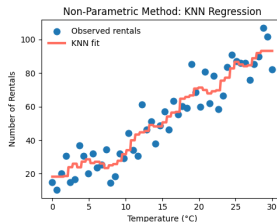
Parametric Methods

- *Assumption*: a specific functional form for $f(X)$



Non-Parametric Methods

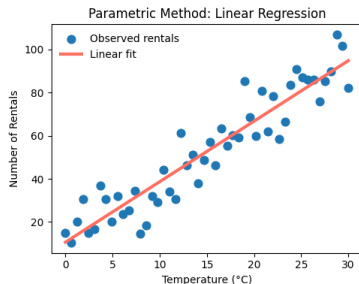
- *No assumption* about the form of $f(X)$



Question:

How can you predict bike rentals based on temperature using a simple model.

- **Assumption:** specific functional form for $f(X)$
- **Example:** Linear regression ($f(X) = \beta_0 + \beta_1 X$)
- **Pros:** Simple, interpretable, fast
- **Cons:** May underfit if the true relationship is complex



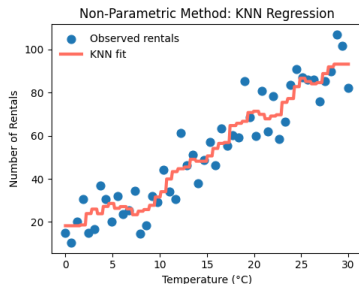
Red line: Linear (parametric) fit.

Non-Parametric Methods

Question:

How can you predict bike rentals based on temperature without assuming a fixed trend.

- **No assumption** about the functional form of $f(X)$
- **Example:** k-Nearest Neighbors
- **Pros:** Flexible, can capture complex patterns
- **Cons:** Requires more data, less interpretable
- **Intuition:** The model adapts to local patterns in the data



Red line: KNN (non-parametric) fit.

Summary & What's Next

- **Statistical learning** studies how to estimate $f(X)$ from data.
- **Two main settings:** supervised vs. unsupervised.
- **Approaches:** parametric vs. non-parametric.

Coming Up Next:

We'll dive deeper into **Supervised Learning in Action:**

- Regression
- Classification
- Model evaluation with train/test split

Thank You!

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