Aprententatge Automàtic per a Xarxes (ML4Net)

Seminar 2 - Support Vector Machine

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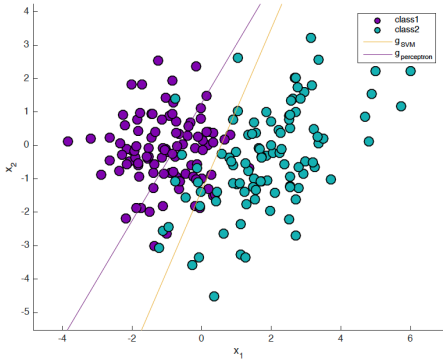
Classification

Key concepts:

- Features (x): Input information for the predictions.
- Labels (y): Variables to be predicted (a discrete class).
- Model (h): Function $h(x) = y$ (set of weights and parameters) that maps x to y.
- Goal: Find the hyperplane that minimizes the classification error.



Support Vector Machine (SVM)

- We want to maximize the minimum distance between classes
- We do it optimizing the following:

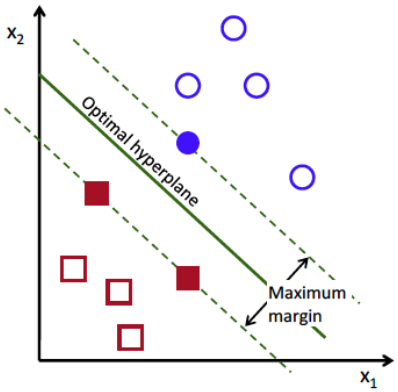
$$\omega^T x + b,$$

where $\omega \in \mathbb{R}^d$ is a weight vector and $b \in \mathbb{R}$ is a bias term

- How?

$$\text{Minimize} \frac{1}{2}||\omega||^2,$$

s.t., $y_i(\omega^T x_i + b) \geq 1, \forall i = 1, ..., n$



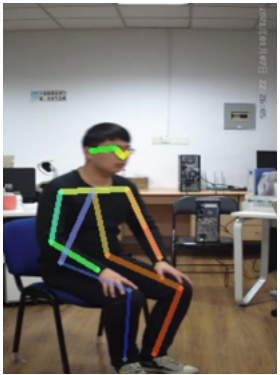
Cherkassky and Mulier, 1998

Check `https://kwichmann.github.io/ml_sandbox/linear_regression_diagnostics/`

Dataset (I)

How were the data generated?[a]

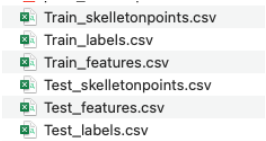
- Real Wi-Fi measurements were taken when people were doing specific poses.
  - Walk, sit down, run, stand up, bend...
- The features are the Wi-Fi measurements (the CSI, in this case).
- The labels (poses) were taken using cameras (Alphapose).



[a] Zhou, Y., Xu, C., Zhao, L., Zhu, A., Hu, F., & Li, Y. (2022). CSI-former: Pay more attention to pose estimation with WiFi. Entropy, 25(1), 20.

Dataset (II)

- Train features (`Train_features.csv`): CSI measurements in the training dataset.
  - 1000 samples $\times$ 270 (a flattened CSI matrix of $30\times3\times3$)
- Train labels (`Train_labels.csv`): actual pose in the training dataset.
  - 1000 samples of an integer between 1 and 5 ({'wave', 'push', 'crouch', 'sitdown', 'bend'})
- Test features (`Test_features.csv`): CSI measurements in the test dataset.
  - 200 samples $\times$ 270 (a flattened CSI matrix of $30\times3\times3$)
- Test labels (`Test_labels.csv`): actual pose in the test dataset.
  - 200 samples of an integer between 1 and 5 ({'wave', 'push', 'crouch', 'sitdown', 'bend'})



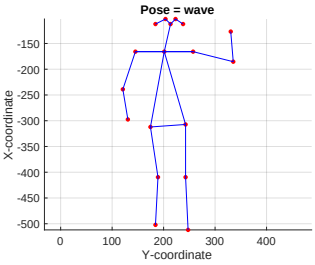
In this seminar, we will use a simplified version of a dataset that can be found at: `https://github.com/NjtechCVLab/Wi-PoseDataset?tab=readme-ov-file`

Dataset (III)

In addition, `SkelletonPoints` are provided:

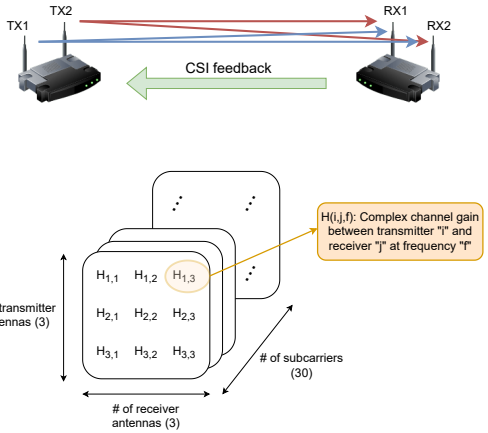
- Only for visualization purposes
- Each skeleton contains 54 points:
  - x coordinates (from 1 to 18)
  - y coordinates (from 19 to 36)
  - Confidence of each coordinate (from 37 to 56)
- Pose data are encoded using MPII[a]

[a] `https://www.mpi-inf.mpg.de/departments/computer-vision-and-machine-learning/software-and-datasets/mpii-human-pose-dataset`



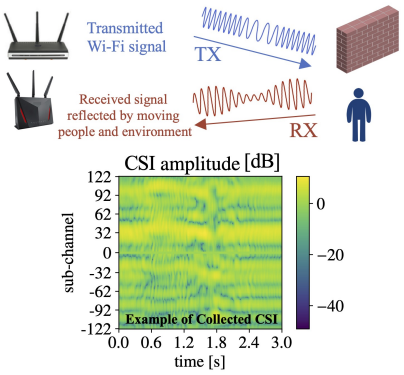

```
% Define connections between the 18 keypoints
connections_18 = [
    1, 2;    % Nose – Neck
    2, 3;    % Neck – Right Shoulder
    3, 4;    % Right Shoulder – Right Elbow
    4, 5;    % Right Elbow – Right Wrist
    2, 6;    % Neck – Left Shoulder
    6, 7;    % Left Shoulder – Left Elbow
    7, 8;    % Left Elbow – Left Wrist
    2, 9;    % Neck – Right Hip
    9, 10;   % Right Hip – Right Knee
    10, 11;  % Right Knee – Right Ankle
    2, 12;   % Neck – Left Hip
    12, 13;  % Left Hip – Left Knee
    13, 14;  % Left Knee – Left Ankle
    1, 15;   % Nose – Right Eye
    1, 16;   % Nose – Left Eye
    15, 17;  % Right Eye – Right Ear
    16, 18;  % Left Eye – Left Ear
    3, 6;    % Right Shoulder – Left Shoulder
    9, 12;   % Right Hip – Left Hip
];
```

Channel State Information (I)

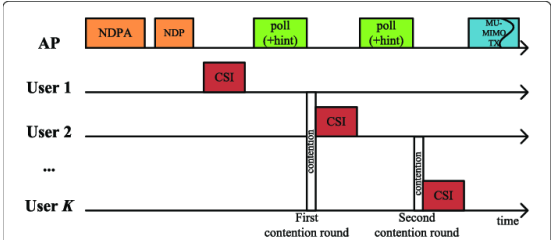


- Each element contains the channel gain for each antenna pair and subcarrier
- In the dataset, we have 5 CSI data packets of $30 \times 3 \times 3$ corresponding to 1 image (1 pose)
  - 30 are the number of subcarriers
  - 3×3 are the 3 Wi-Fi transmitter and receiver antennas

Channel State Information (II)



Wi-Fi sensing: detect movement, presence, and other characteristics of people and objects in a given environment thanks to CSI feedback, RSSI, or other measurements (e.g., packet arrival time).



https://ieee-dataport.org/documents/csi-dataset-wireless-human-sensing-80-mhz-wi-fi-channels