PH-227
AI and Data Science

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Support Vector Machines (SVMs)

- Support Vector Machines (SVMs) are supervised machine learning algorithms used for classification and regression tasks.
- **Hyperplane:** A hyperplane is a decision boundary that separates data points different classes in the feature space.
- **A typical mathematical representation:**

$$\vec{\mathbf{w}}.\vec{\mathbf{x}} + \mathbf{C} = \mathbf{0}$$

Example:

- If we classify shapes of a set of objects into triangles(+1) and squares(-1), based on the # of their edges and vertices, the hyperplance could be : $3\times\text{Edge} + 4\times\text{Vert} - 50 = 0$

Support Vector Machines (SVMs): Few Definitions

- **Margin:** The margin is the distance between the hyperplane and the nearest data point of either class. SVM tries to maximize this margin to improve classification confidence.
- **Hard Margin:** Assumes data is perfectly separable by the hyperplane. All points must lie outside the margin.
- **Soft Margin:** Allows some misclassification or margin violations for non-linearly separable data.
- **Support Vectors:** These are the data points that are closest to the hyperplane. These points influence the orientation and position of the hyperplane.
- **Kernel Function:** A kernel function transforms data into a higher dimensional space to make it linearly separable.

Types of Kernels:

Linear Kernels: Suitable for linearly separable data.

Polynomial Kernel: Suitable for Curves boundaries.

Radial Basis Function (RBF) Kernel: Captures complex relationships

An Example (SVM)

- Consider the following set of data points

(1,1); (5.5,0); (1,0.5); (5,-1); (1,0.5); (-0.5,0.5); (2,0); (0.5,0.5); (4.5,1); (4,0); (4.5,0.5)

Construct the optimal hyperplane corresponding to these data points

Steps:

Step1: Draw the points on a 2D plane

Step2: Find the support vectors

S1(2 0); S2(4,0)

Step3: Add the bias(b) value in vectors to convert from 2D to 3D form.

Step4: Consider parameters for every support vectors e.g. a_1, a_2.. etc.

Step5: Find the linear equations and hence solve them to find the parameter values

Step6: Find the equation of the hyperplane.