

SVM

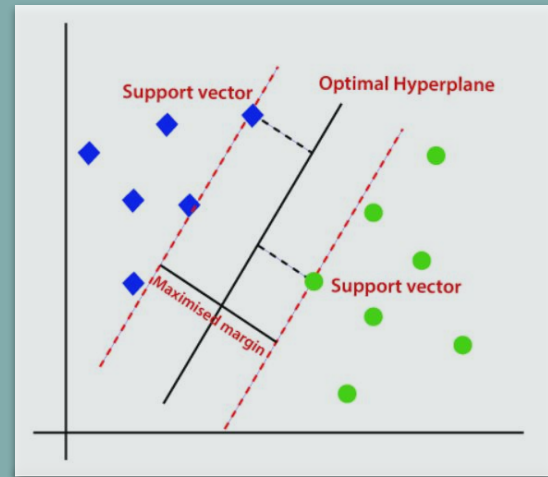
Support Vector Machines

By Adam Brewer, Robert Stewart, Tarick Mehanna



How the SVM works

- A classification method.
 - Supervised
- Draws a **hyperplane** that separates the points.
 - Hyperplane? It's a 2-D line or 3-D plane that is drawn to try and guarantee all points of one category are on one side of the plane/line and the other points are on the other side.
- Algorithm attempts to **maximize the margin**
 - Margin? The distance from the points in each classified group. We attempt to get as large of a distance from the hyperplane to each group of points.
- **Kernels!**





Advantages and disadvantages of SVM

Advantages:

- Ideal when we have no idea about the data
- Handles non-linear data efficiently (**Kernel trick**)
 - SVM is the only linear model that can **classify data that is not linearly separable!**
- Stable models
- Works very well with **high dimensional data**

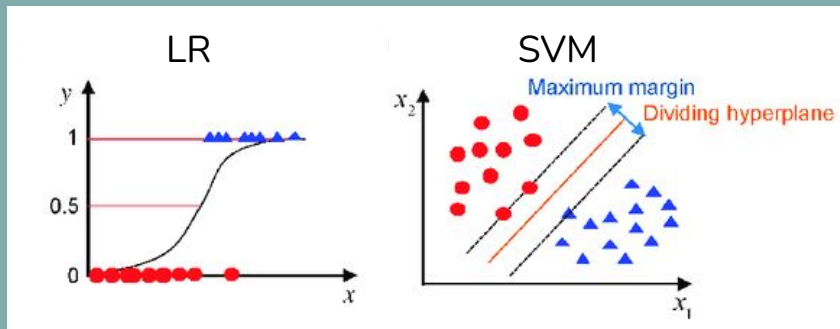
Disadvantages:

- Choosing an **appropriate Kernel function** is relatively difficult
- Performance suffers when the data set has more noise, or overlap among target variables
- Long training time for larger datasets
- Difficult to understand and interpret the **final model, variable weights, and individual impact**

SVM vs Logistic Regression

While both are classification algorithms, **logistic regression (LR)** models are used to predict the odds in favour of a particular event. **SVM** models are used to draw hyperplanes that separate data points with the largest margin (distance).

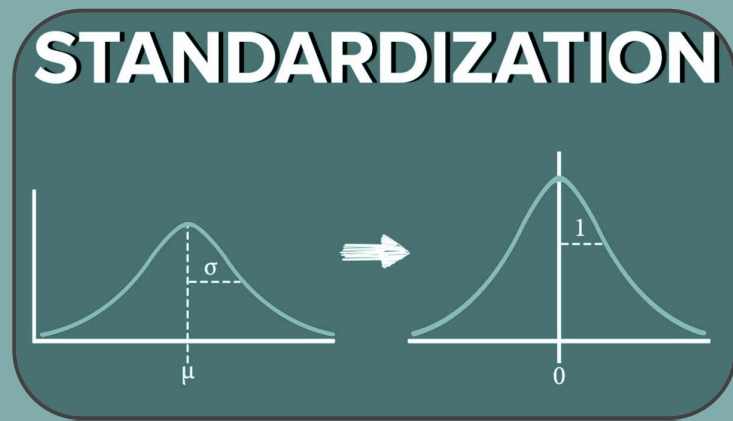
- LR chooses a decision boundary based on a more statistical approach, SVM chooses the decision boundary that maximizes the margin
- SVM also works with unstructured or semi structured data (texts / images)
- LR is more vulnerable to overfitting and outliers than SVM



Data processing steps SVM require

- Standard data cleaning procedures
 - Find and handle NaNs and outliers
 - Using feature engineering to look for proper data.

- Be sure to **standardize data!**
 - Working with distances.
 - Things like **StandardScaler()** from sklearn



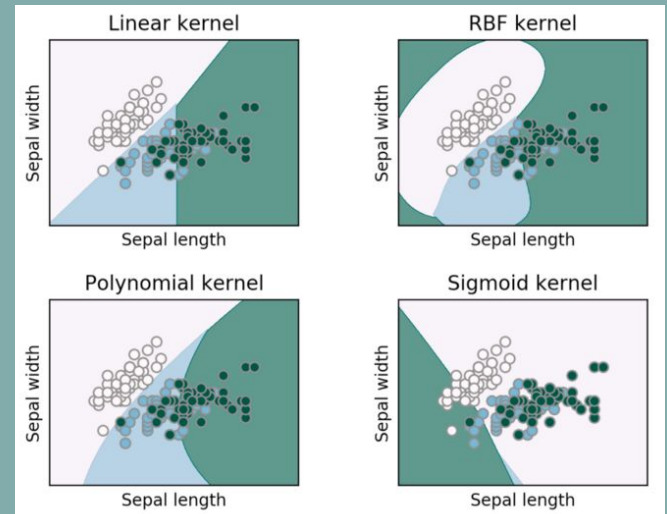
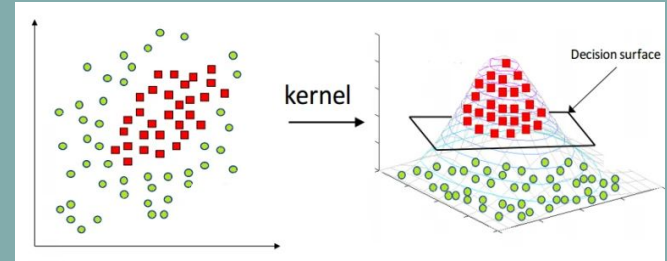


SVM

Hyperparameters

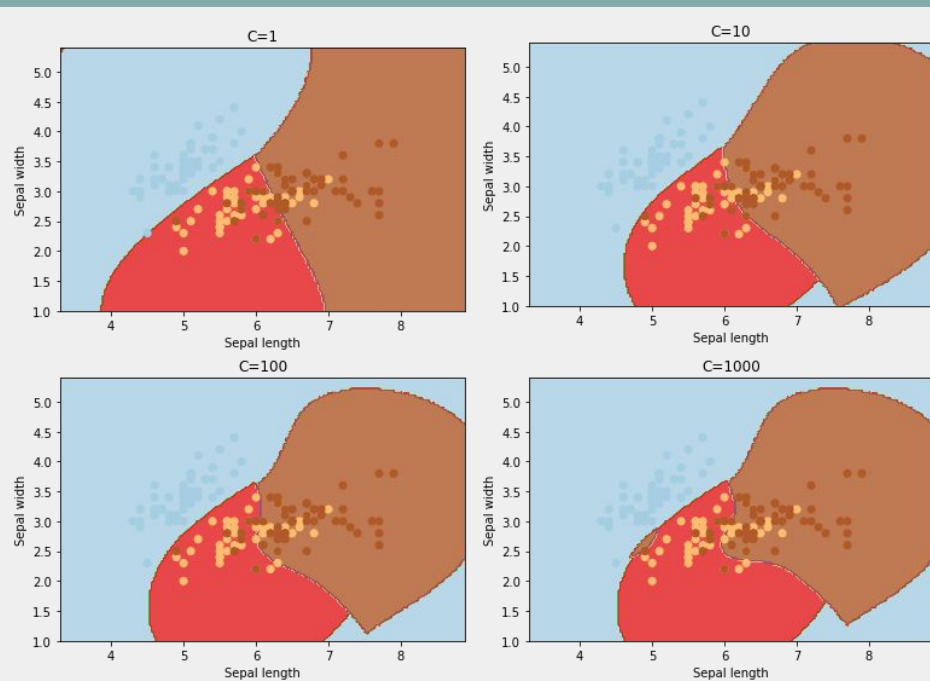
Kernel | (Types - linear, poly, rbf, sigmoid, precomputed)

The main function of the kernel is to transform the given dataset input data into the required form. There are various types of functions such as **linear**, **polynomial**, and **radial basis function (RBF)**. Polynomial and RBF are useful for non-linear hyperplane. Polynomial and RBF kernels compute the separation line in the higher dimension. This transformation can lead to more accurate classifiers. Some less used kernels are **sigmoid** kernels which act similarly to logistic regression, and **precomputed** kernels where the kernel is an $n \times n$ matrix of scalars known as a Kernel matrix or a Gram matrix.



Regularization (C)

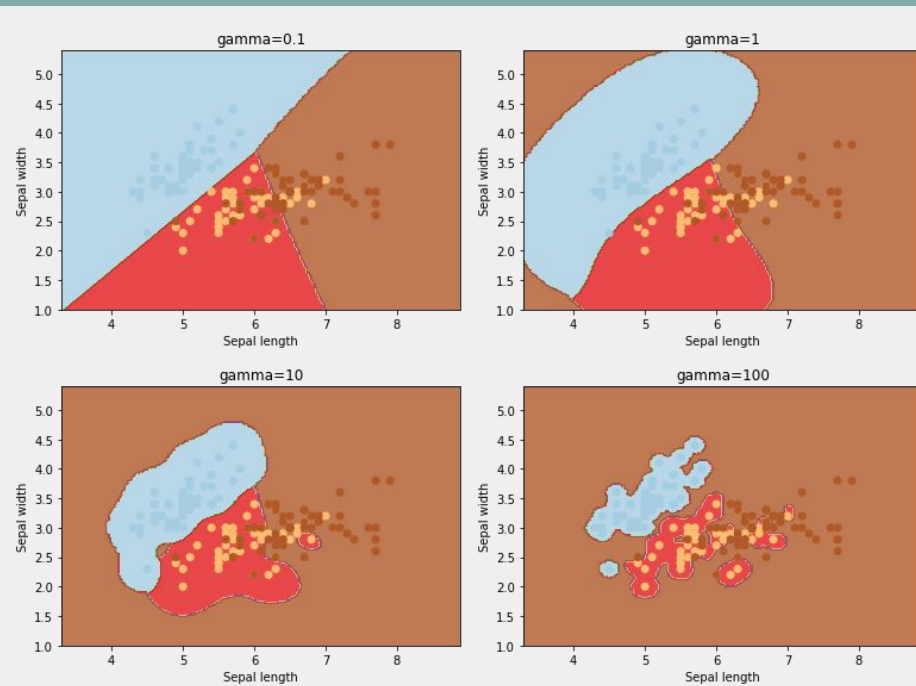
Regularization parameter in python's Scikit-learn **C parameter** used to maintain regularization. Here C is the **penalty parameter**, which represents misclassification or error term. The misclassification or error term tells the SVM optimization how much error is bearable. This is how you can control the trade-off between decision boundary and misclassification term. A **smaller value of C** creates a **larger-margin hyperplane** and a **larger value of C** creates a **smaller-margin hyperplane**. The C parameter default is 1.0 but it can be changed to any positive value, however, **increasing C values can lead to overfitting**.



Gamma

Gamma hyperparameter only available for kernels **polynomial**, **RBF**, and **sigmoid**.

Gamma helps classify how strong of a fit we use. Gamma's default is 'scale' equal to $1 / (n_features * X.var())$ as value of gamma. Gamma can also be set to 'auto' equal to $1 / n_features$, or a positive float value. A **lower value of Gamma** will **loosely fit** the training dataset, whereas a **higher value of gamma** will **exactly fit** the training dataset, which causes overfitting. In other words, you can say a low value of gamma considers only nearby points in calculating the separation line, while the a value of gamma considers all the data points in the calculation of the separation line. **Increasing gamma leads to overfitting** as the classifier tries to perfectly fit the training data.





Appendix

Code Demos & Technical Breakdowns of SVM:

Advantages and Disadvantages of SVM: [Very simple bullet point breakdown]

<https://statinfer.com/204-6-8-svm-advantages-disadvantages-applications/>

Link with Demo and Lower level Explanation:

<https://www.datacamp.com/tutorial/svm-classification-scikit-learn-python>

Coding Demo showing how all hyperparameters are used:

<https://www.kaggle.com/code/maxl11/svm-demo/notebook>

Link with High level Explanation and LR Comparison:
[potentially too light on useful info?]

<https://medium.com/axum-labs/logistic-regression-vs-support-vector-machines-svm-c335610a3d16>

Code along using sklearn.svm.SVC with visuals:

<https://www.analyticsvidhya.com/blog/2021/04/insight-into-svm-support-vector-machine-along-with-code/>

Advantages of SVM: [Has some mathematical details]

<https://iq.opengenus.org/advantages-of-svm/>

Low Level Explanation, C and Gamma Parameters:

<https://towardsdatascience.com/hyperparameter-tuning-for-support-vector-machines-c-and-gamma-parameters-6a5097416167>

Hyperparameter Tuning Code demo with GridSearchCV:

<https://www.geeksforgeeks.org/svm-hyperparameter-tuning-using-gridsearchcv-ml/>

Link with Implementation and Higher level Explanation:

<https://scikit-learn.org/stable/modules/svm.html>

Low Level Explanation, Includes Some Data Cleaning Details:

<https://towardsdatascience.com/svm-implementation-from-scratch-python-2db2fc52e5c2>

Hypertuning parameters code along:

<https://medium.com/all-things-ai/in-depth-parameter-tuning-for-svc-758215394769>



Appendix

Video Tutorials:

General technical and abstract breakdown on SVM: (2 min)

https://www.youtube.com/watch?v=_YPScrckx28

Mathematical/technical Breakdown with fantastic visuals: (15 min)

<https://www.youtube.com/watch?v=ny1iZ5A8iIA>

Hyper parameter kernel and gamma breakdown on SVM: (3 min)

https://www.youtube.com/watch?v=_YPScrckx28

SVM technical breakdown & code along demo: (23 min)

<https://www.youtube.com/watch?v=FB5EdxAGxQg>