LINEAR CLASSIFIERS IN PYTHON

# Support Vectors

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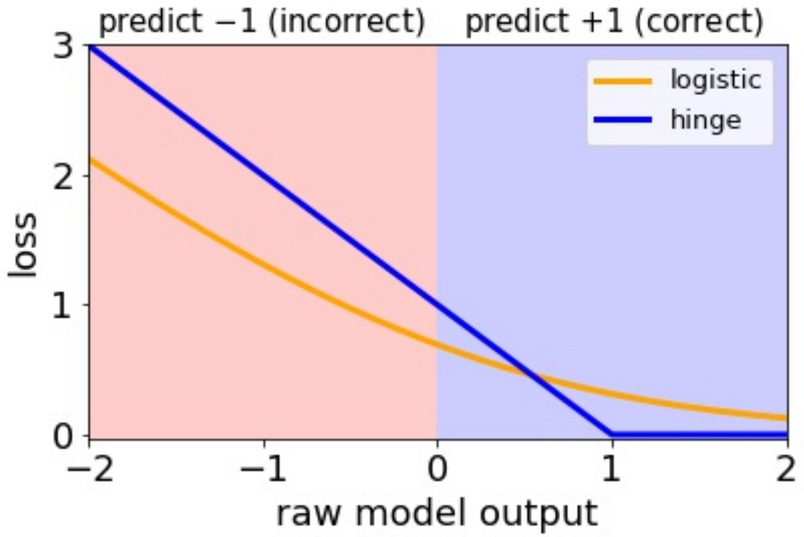
# What is an SVM?

- Linear classifiers (so far)
- Trained using the hinge loss and L2 regularization

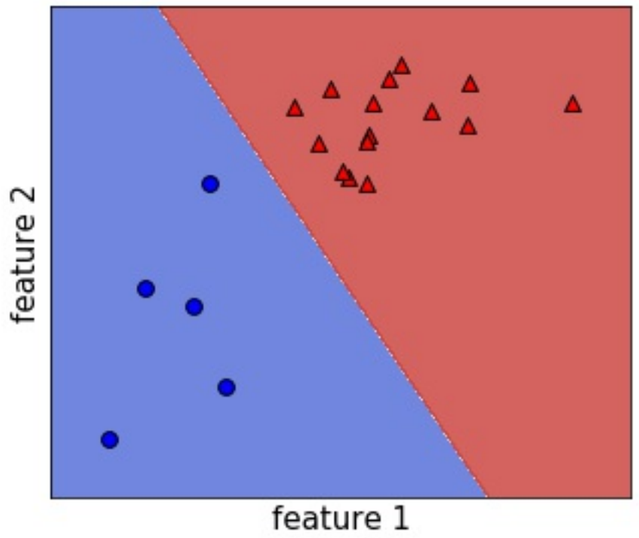


# What are support vectors?

- Support vector: a training example **not** in the flat part of the loss diagram
- Support vector: an example that is incorrectly classified **or** close to the boundary
- If an example is not a support vector, removing it has no effect on the model
- Having a small number of support vectors makes kernel SVMs really fast

# Max-margin viewpoint

- The SVM maximizes the "margin" for linearly separable datasets
- Margin: distance from the boundary to the closest points



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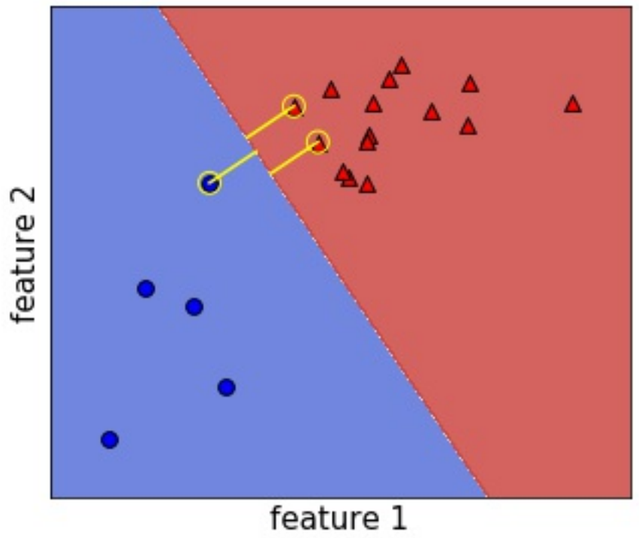

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# Let's practice!

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# Kernel SVMs

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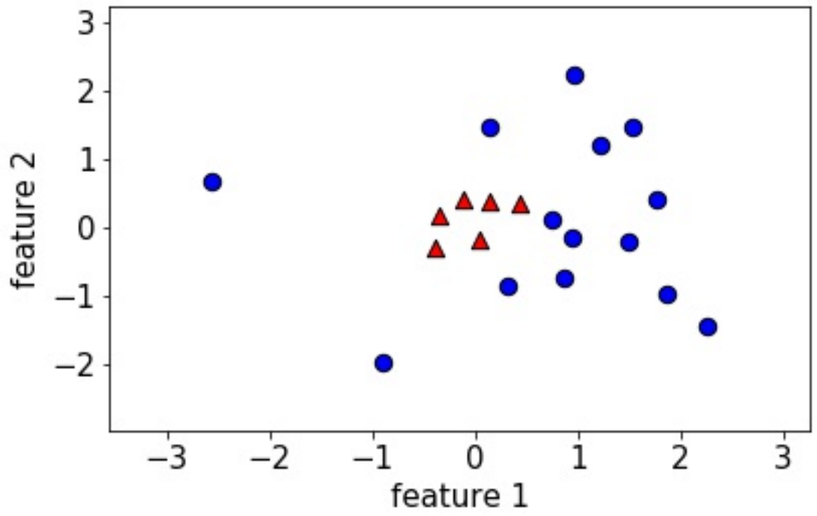
# Transforming your features



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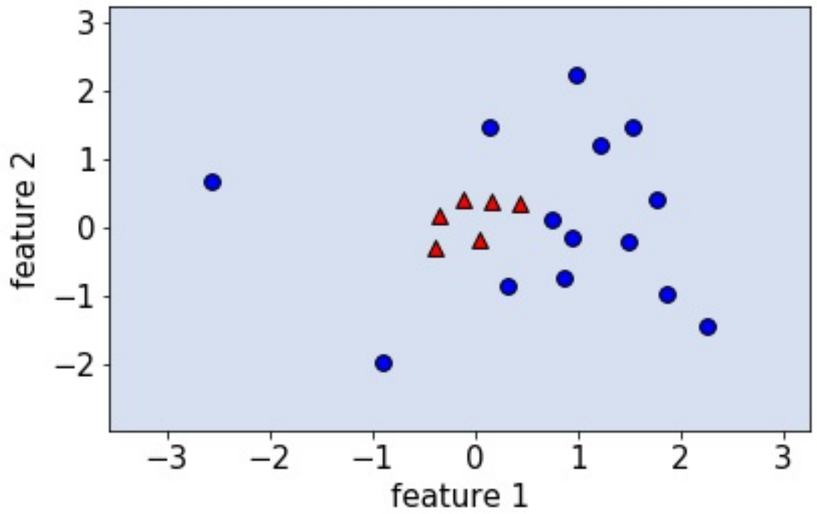

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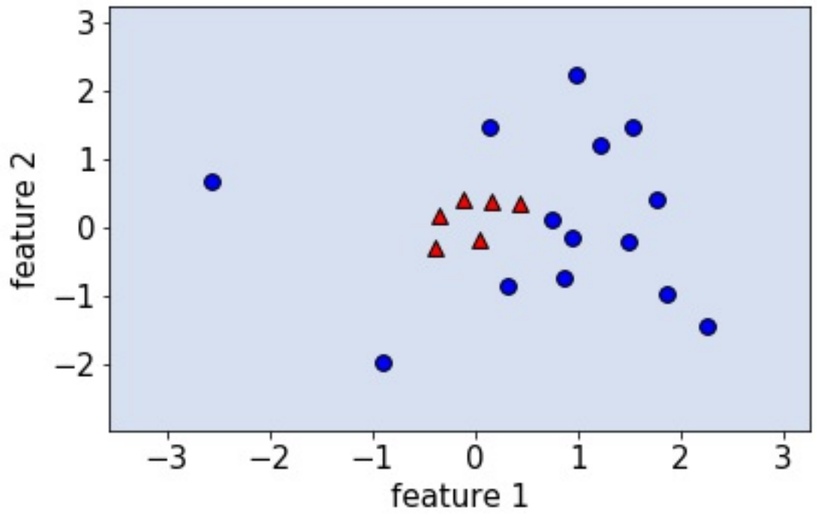
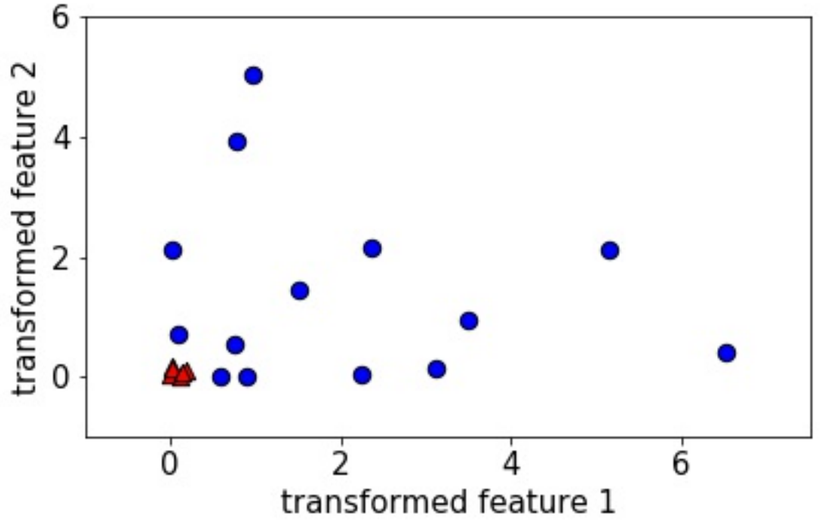
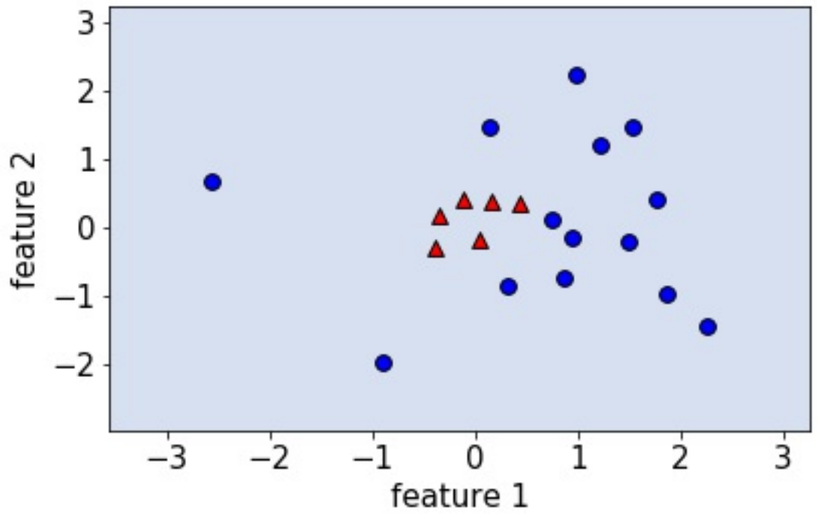
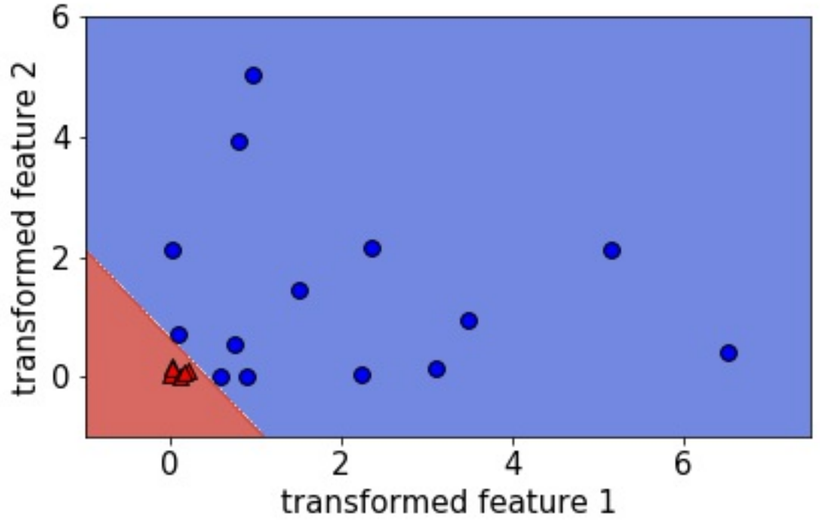



$$\text{transformed feature} = (\text{original feature})^2$$

# Transforming your features

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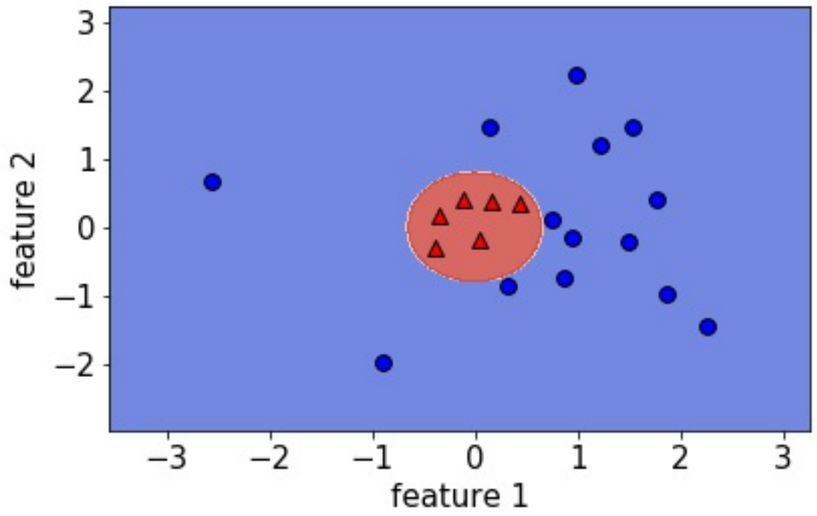
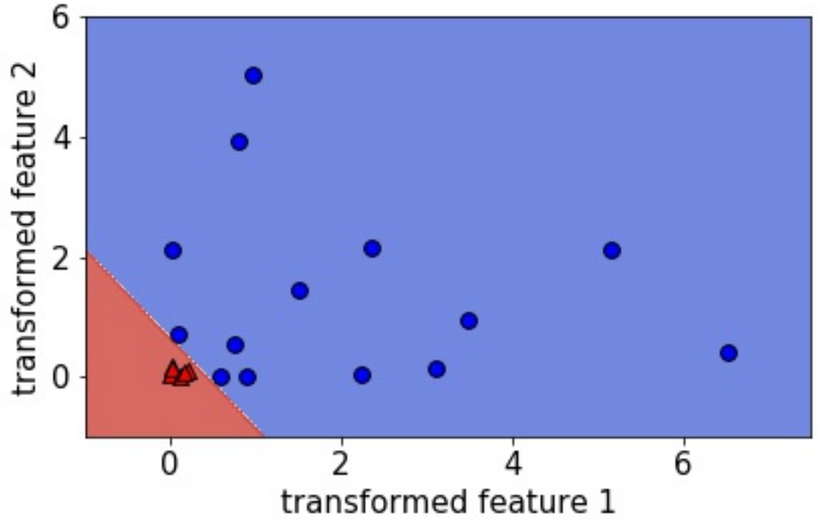
# Transforming your features

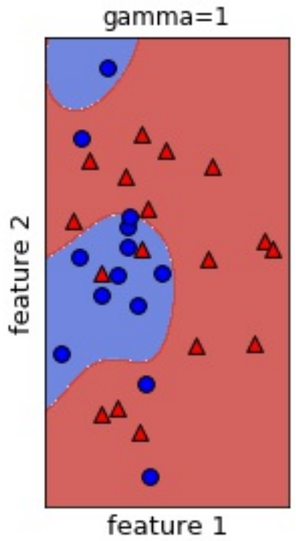



$$\text{transformed feature} = (\text{original feature})^2$$

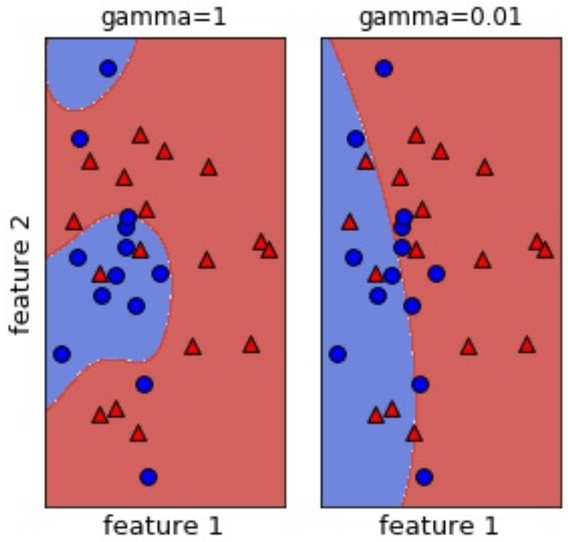
# Kernel SVMs

```
In [1]: from sklearn.svm import SVC

In [2]: svm = SVC(gamma=1)    # default is kernel="rbf"
```



# Kernel SVMs

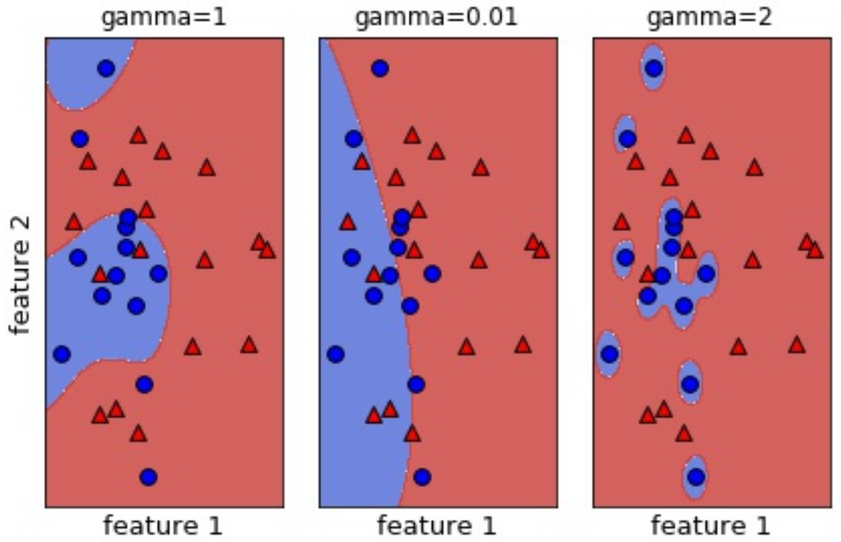
```
In [1]: from sklearn.svm import SVC

In [2]: svm = SVC(gamma=0.01) # default is kernel="rbf"
```




- smaller gamma leads to smoother boundaries

# Kernel SVMs

```
In [1]: from sklearn.svm import SVC

In [2]: svm = SVC(gamma=2)    # default is kernel="rbf"
```




- larger gamma leads to more complex boundaries

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# Comparing logistic regression and SVM

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# Pros and Cons

Logistic regression:

- Is a linear classifier
- Can use with kernels, but slow
- Outputs meaningful probabilities
- Can be extended to multi-class
- All data points affect fit
- L2 or L1 regularization

Support vector machine (SVM):

- Is a linear classifier
- Can use with kernels, and fast
- Does not naturally output probabilities
- Can be extended to multi-class
- Only "support vectors" affect fit
- Conventionally just L2 regularization

# Use in scikit-learn

Logistic regression in sklearn:

- linear_model.LogisticRegression

Key hyperparameters in sklearn:

- C (inverse regularization strength)
- penalty (type of regularization)
- multi_class (type of multi-class)

SVM in sklearn:

- svm.LinearSVC and svm.SVC

Key hyperparameters in sklearn:

- C (inverse regularization strength)
- kernel (type of kernel)
- gamma (inverse RBF smoothness)

# SGDClassifier

- SGDClassifier: scales well to large datasets

```
In [1]: from sklearn.linear_model import SGDClassifier

In [2]: logreg = SGDClassifier(loss='log')

In [3]: linsvm = SGDClassifier(loss='hinge')
```

- SGDClassifier hyperparameter alpha is like 1/C

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# Conclusion

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# How does this course fit into Data Science?

- Data science
- --> Machine learning
- --> --> Supervised learning
- --> --> --> Classification
- --> --> --> --> Linear classifiers (this course)

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# Congratulations & Thanks!