Support Vectors

LINEAR CLASSIFIERS IN PYTHON

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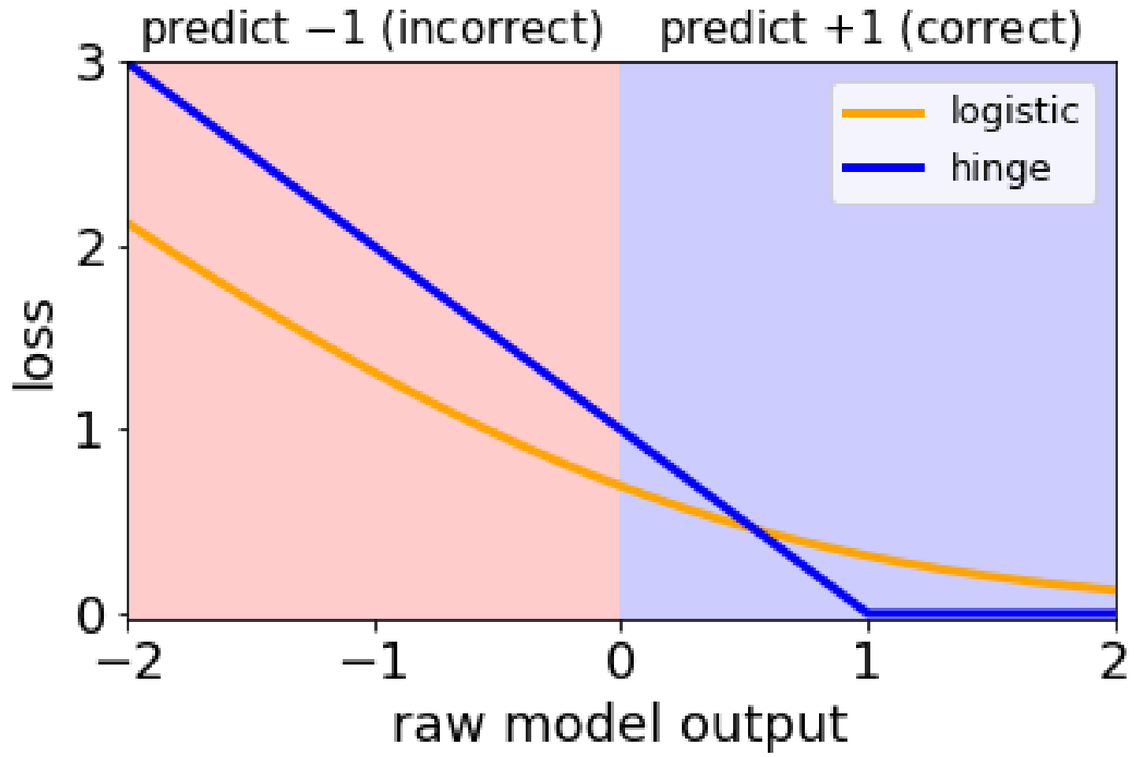
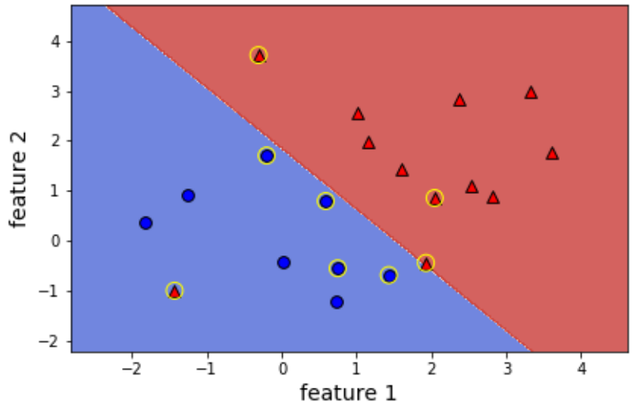
What is an SVM?

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

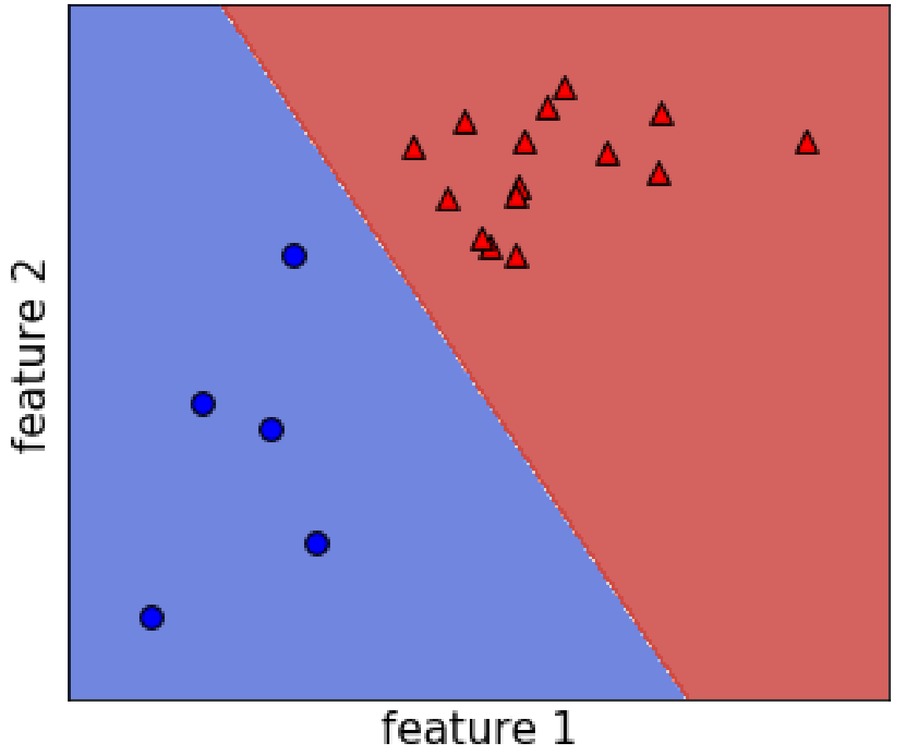


- Support vector: a training example **not** in the flat part of the loss diagram
- Support vector: an example that is incorrectly classified **or** close to the boundary
- If an example is not a support vector, removing it has no effect on the model
- Having a small number of support vectors makes kernel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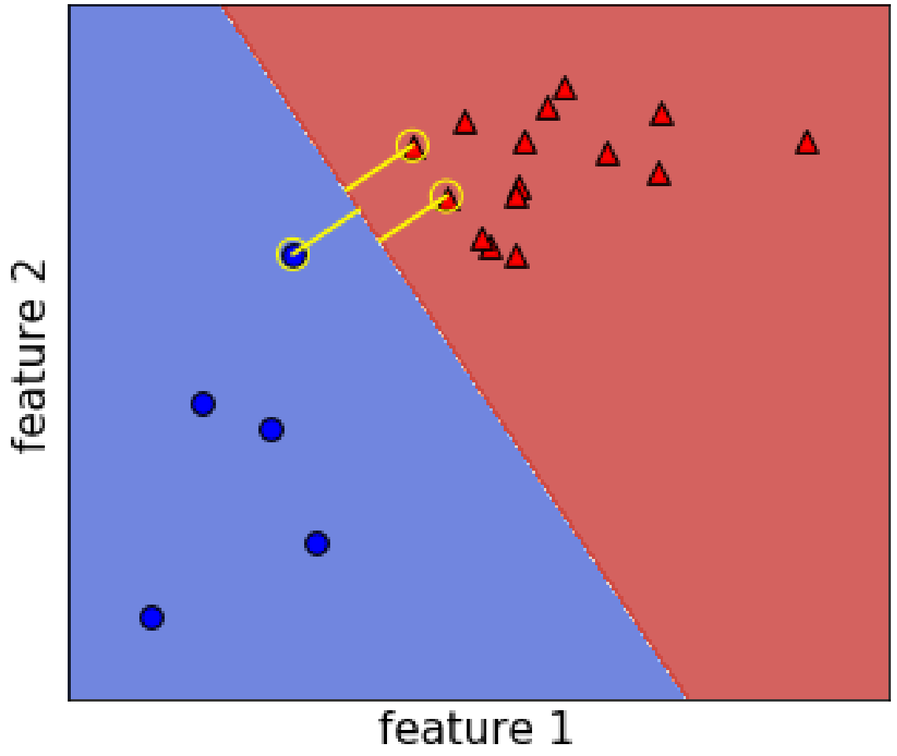

Let's practice!

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Kernel SVMs

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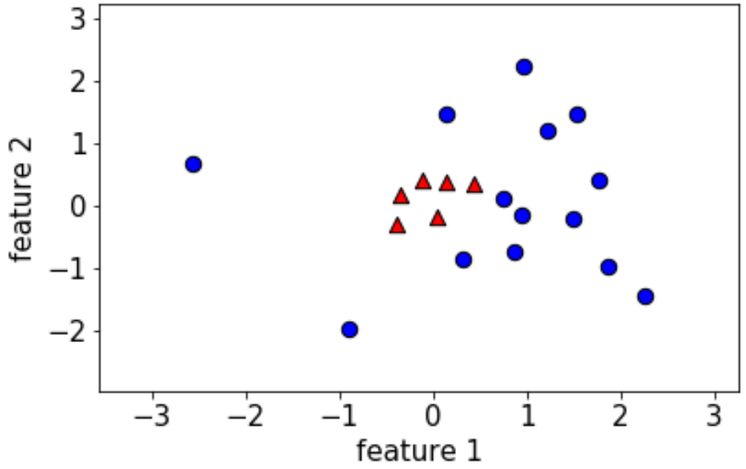
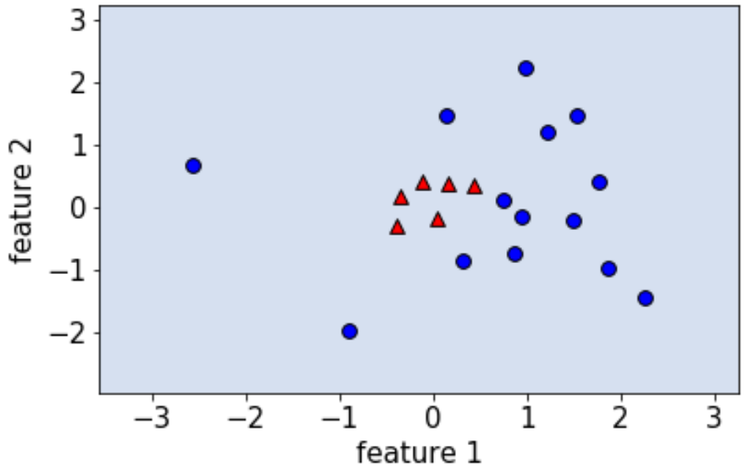
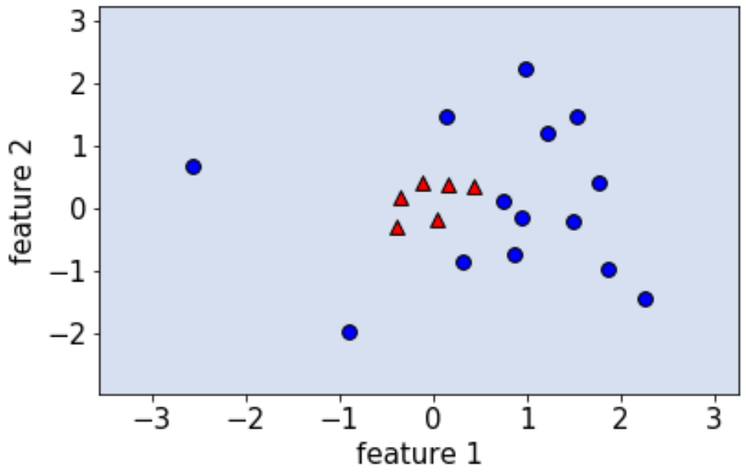
Transforming your features

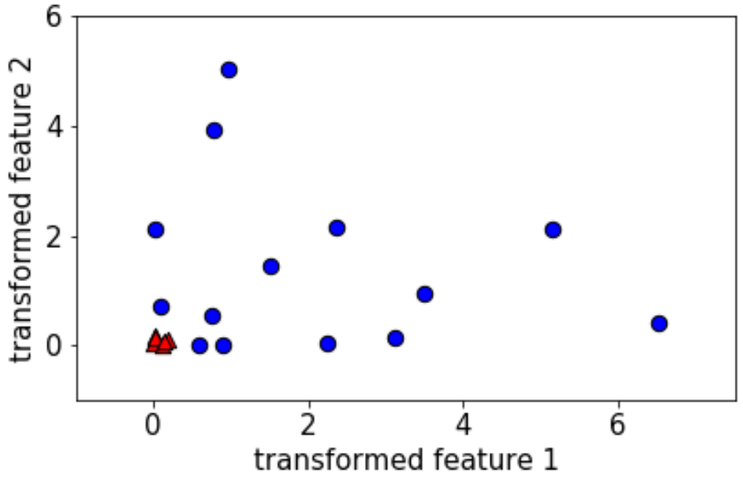


Transforming your features



Transforming your features

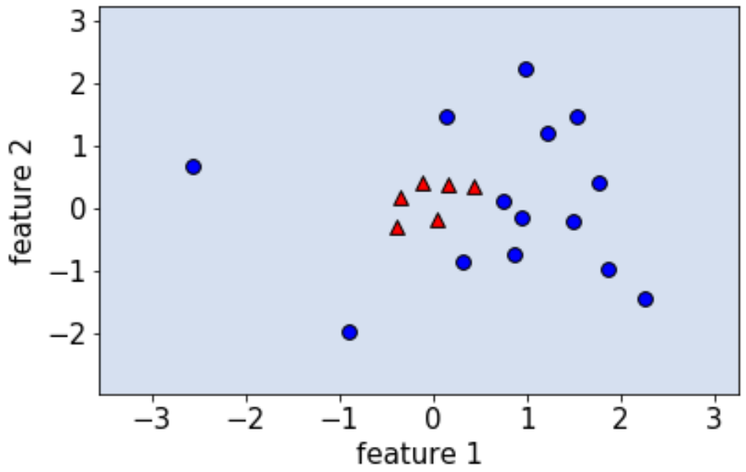


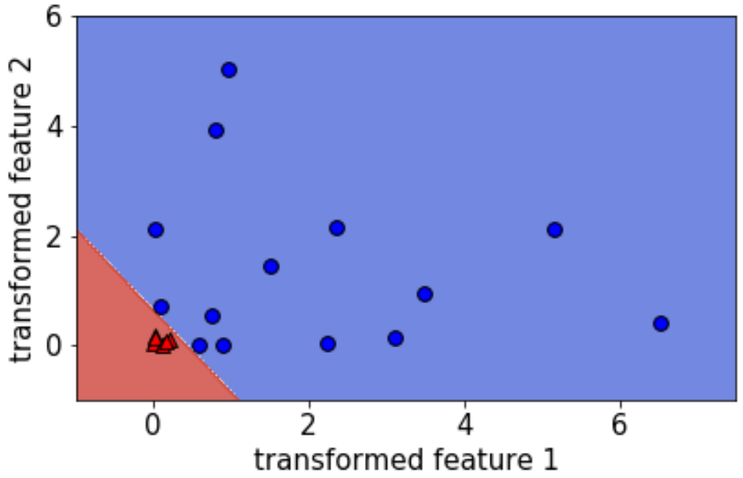


$$\text{transformed feature} =$$

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

Transforming your features





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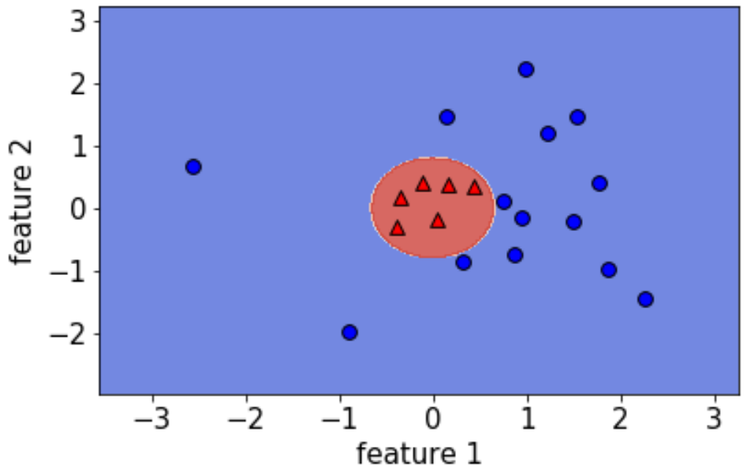
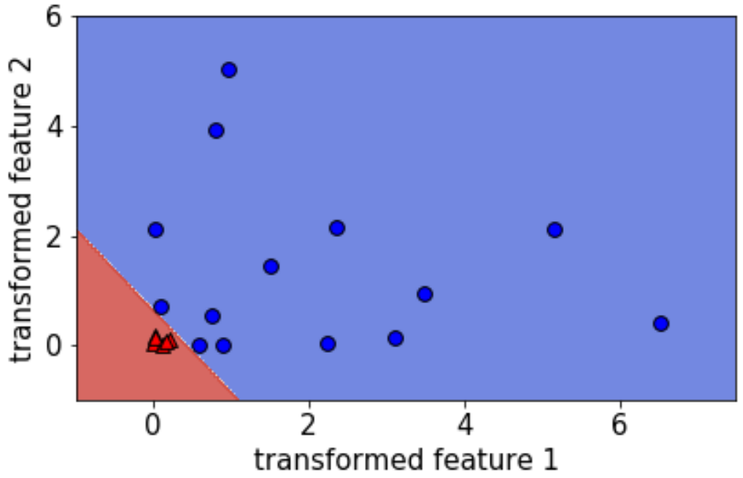
Transforming your features





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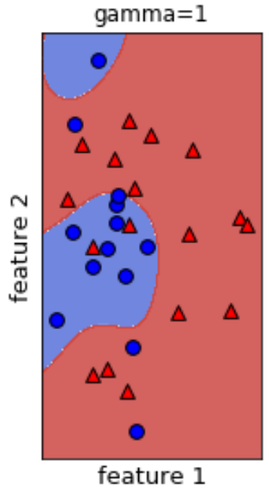
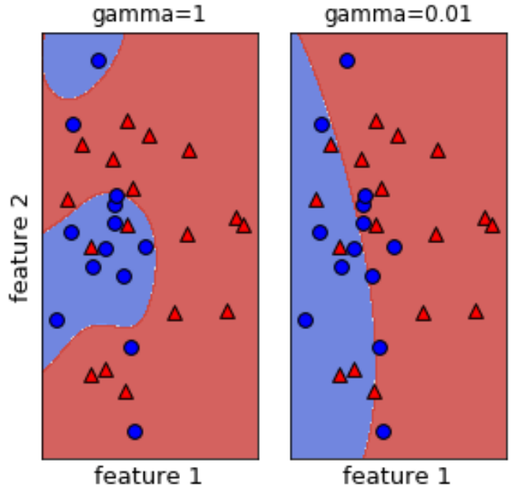
Kernel SVMs

```
from sklearn.svm import SVC

svm = SVC(gamma=1)    # default is kernel="rbf"
```



Kernel SVMs

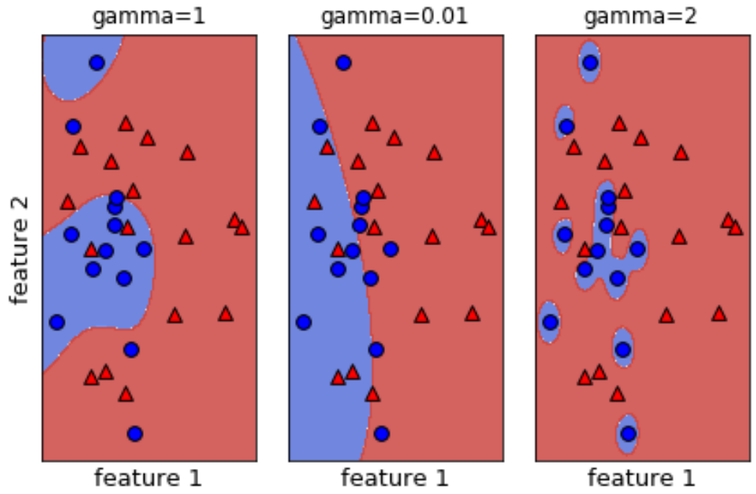
```
from sklearn.svm import SVC

svm = SVC(gamma=0.01) # default is kernel="rbf"
```



- smaller `gamma` leads to smoother boundaries

Kernel SVMs

```
from sklearn.svm import SVC

svm = SVC(gamma=2)    # default is kernel="rbf"
```



- larger `gamma` leads to more complex boundaries

Let's practice!

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Comparing logistic regression and SVM

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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`

Use in scikit-learn (cont.)

Key hyperparameters in sklearn:

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

SGDClassifier

`SGDClassifier` : scales well to large datasets

```
from sklearn.linear_model import SGDClassifier

logreg = SGDClassifier(loss='log')

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)

Congratulations & thanks!

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