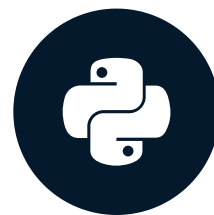


Support Vectors

LINEAR CLASSIFIERS IN PYTHON

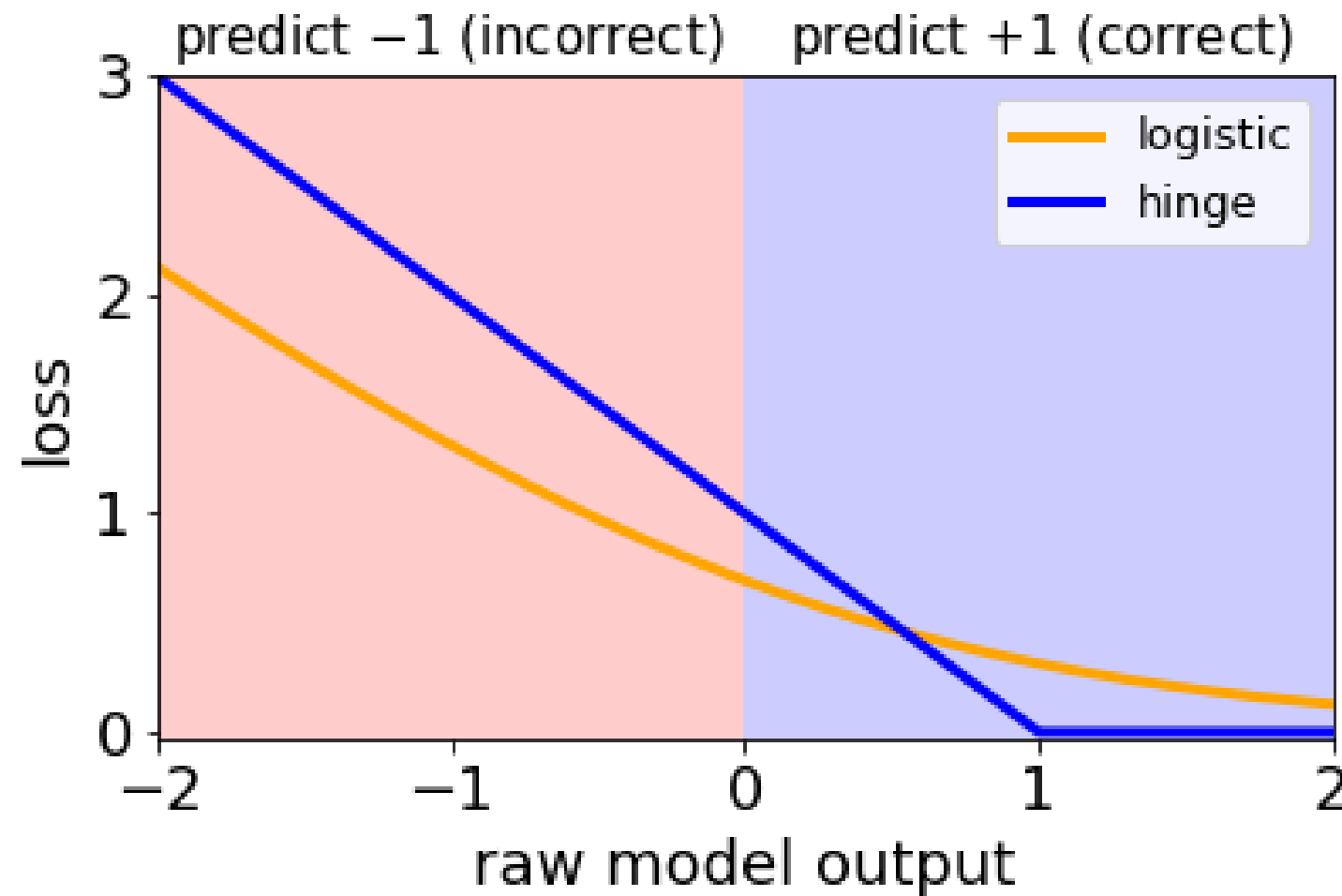


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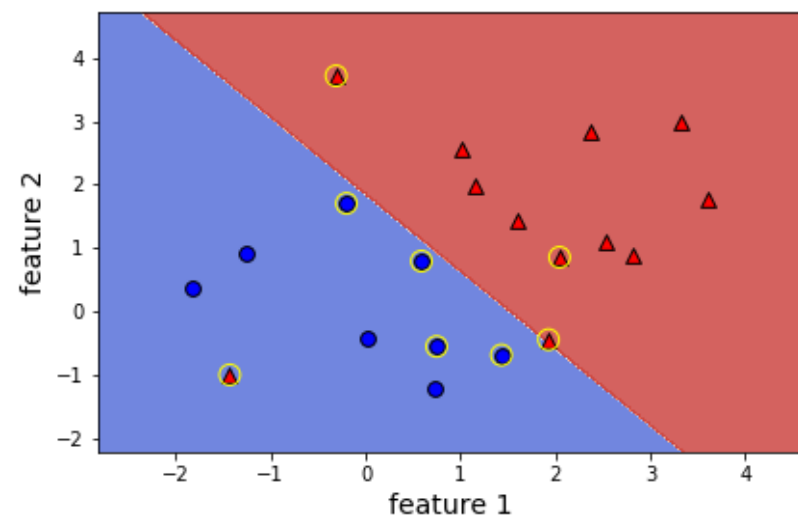
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What is an SVM?

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

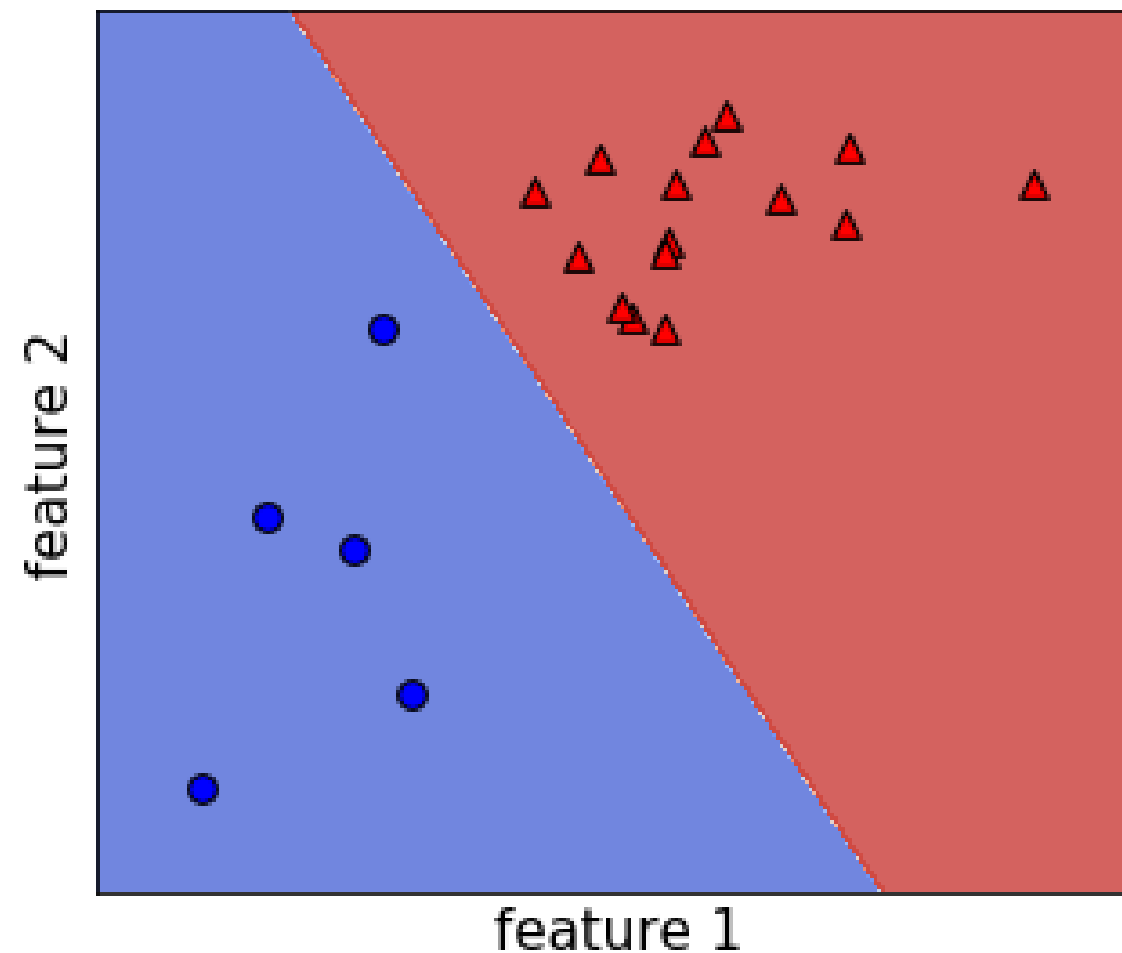


- Support vector: a training example **not** in the flat part of the loss diagram
- Support vector: an example that is incorrectly classified **or** close to the boundary
- If an example is not a support vector, removing it has no effect on the model
- Having a small number of support vectors makes kernel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



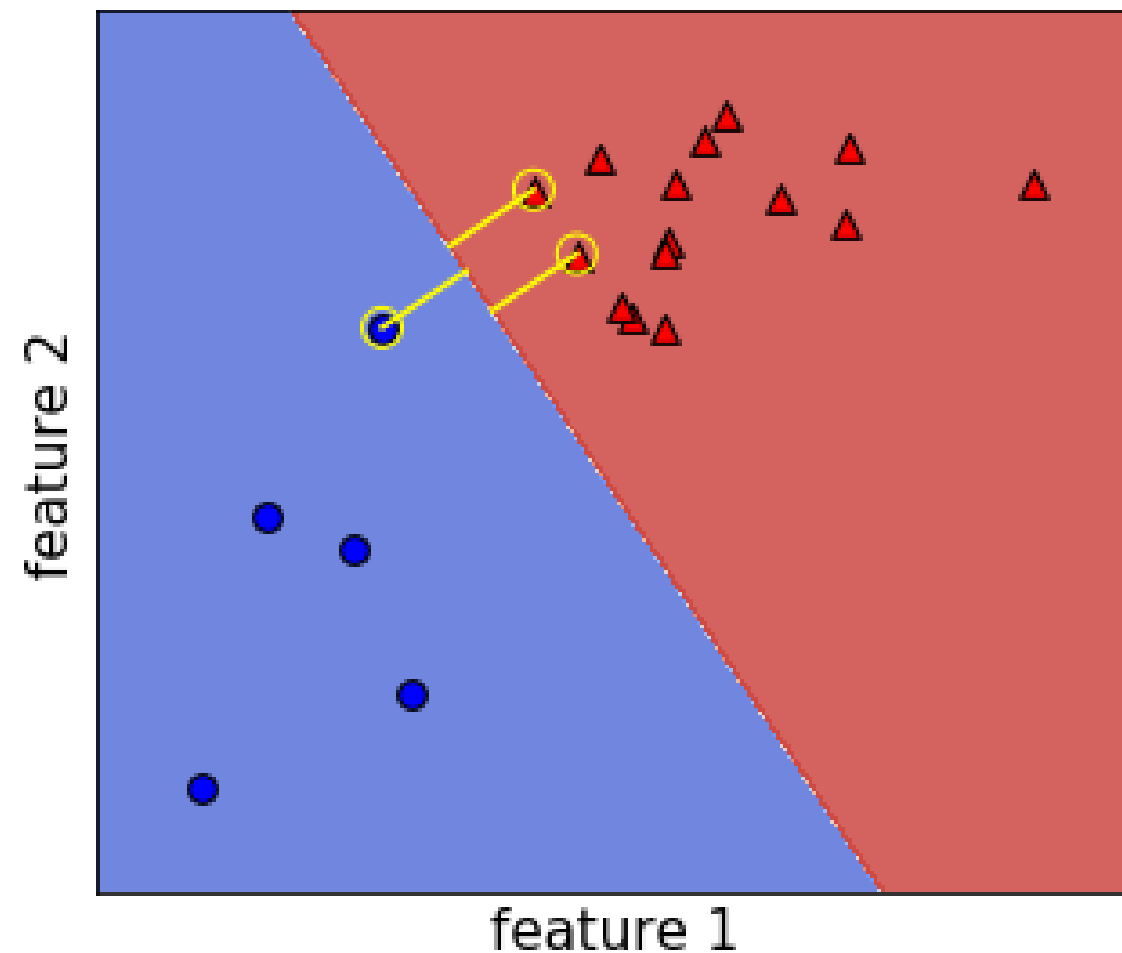
Max-margin viewpoint

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



Max-margin viewpoint

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

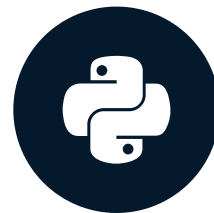


Let's practice!

LINEAR CLASSIFIERS IN PYTHON

Kernel SVMs

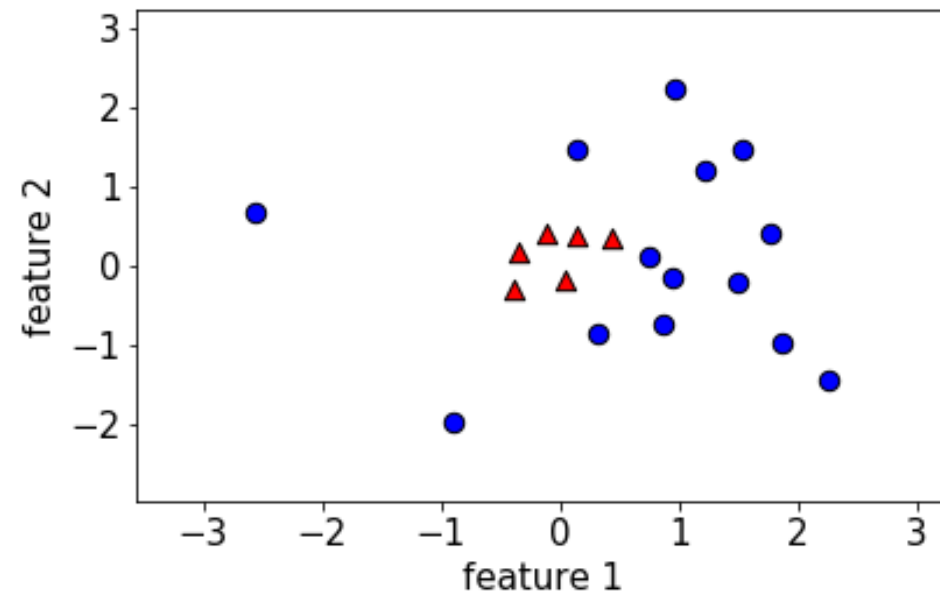
LINEAR CLASSIFIERS IN PYTHON



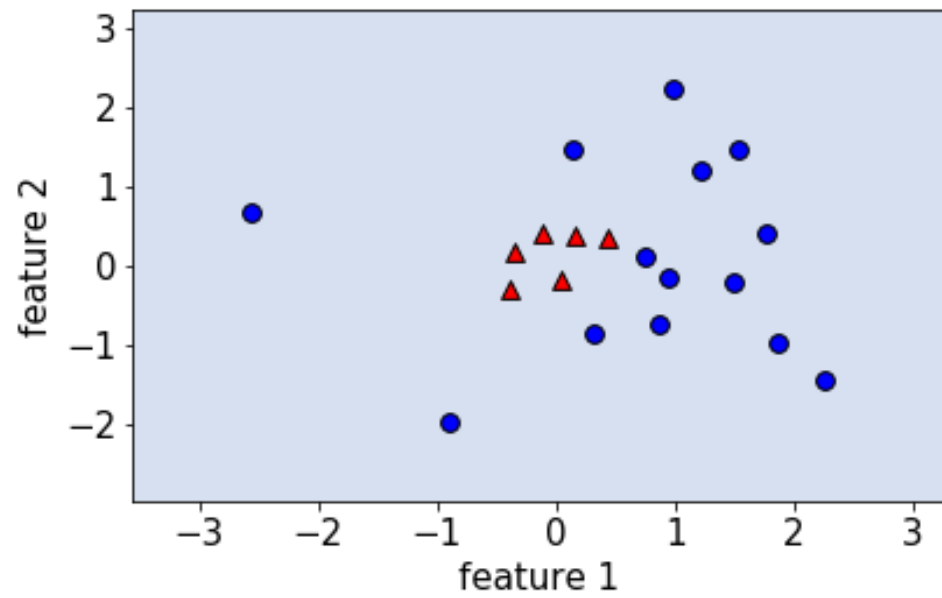
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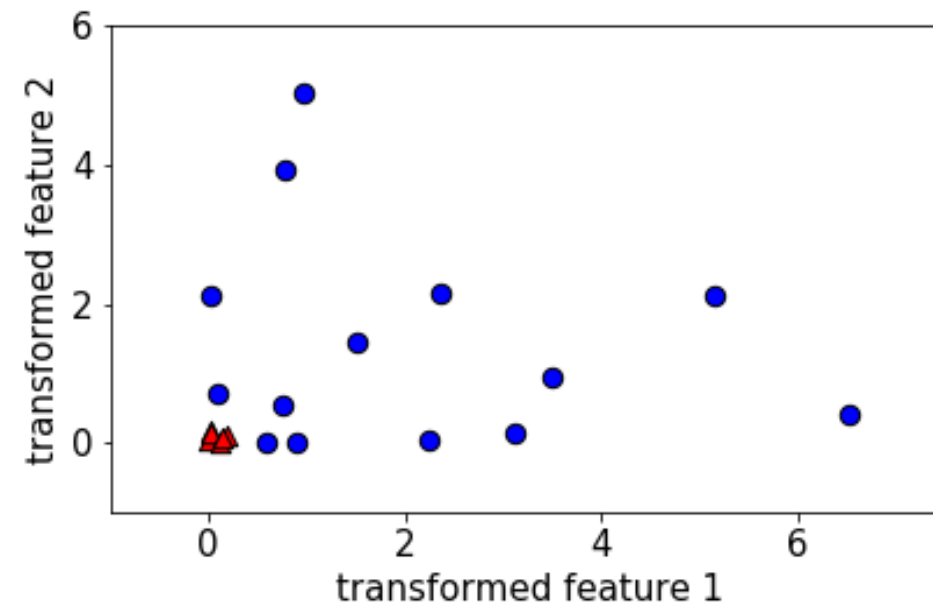
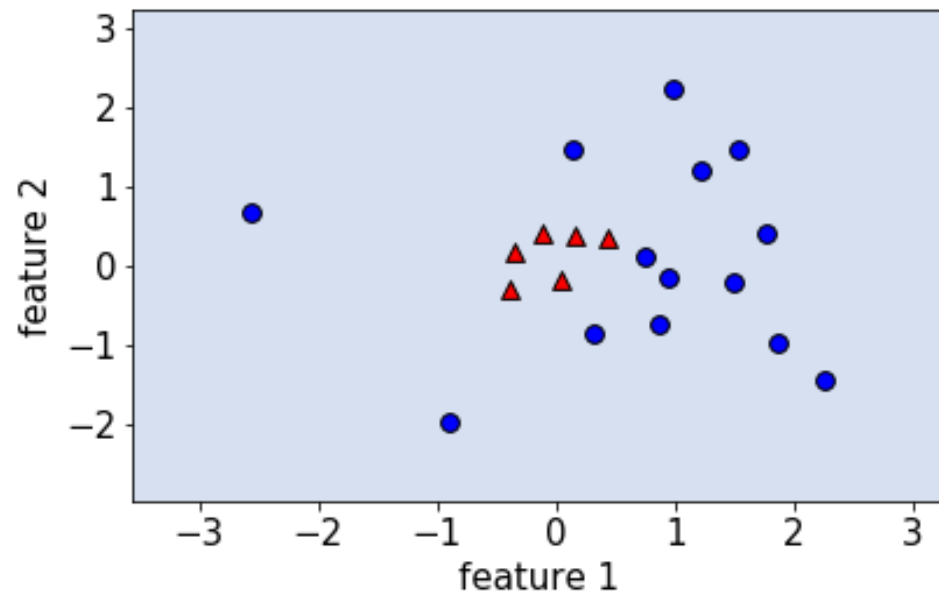
Transforming your features



Transforming your features

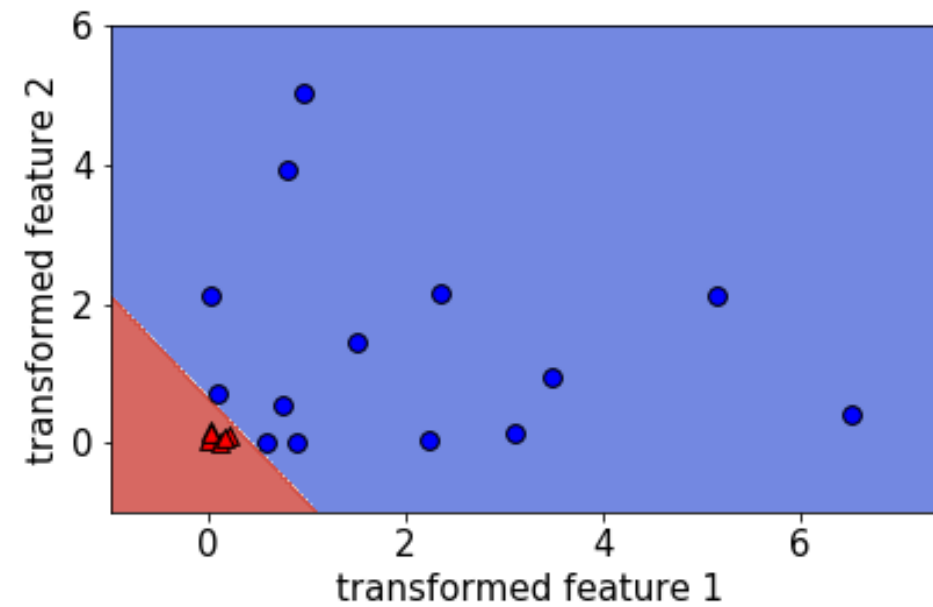
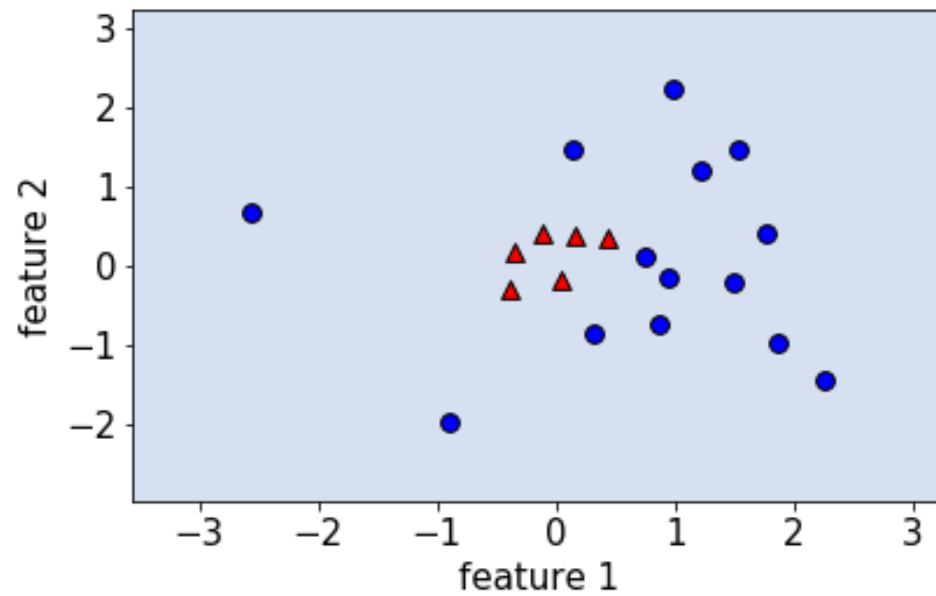


Transforming your features



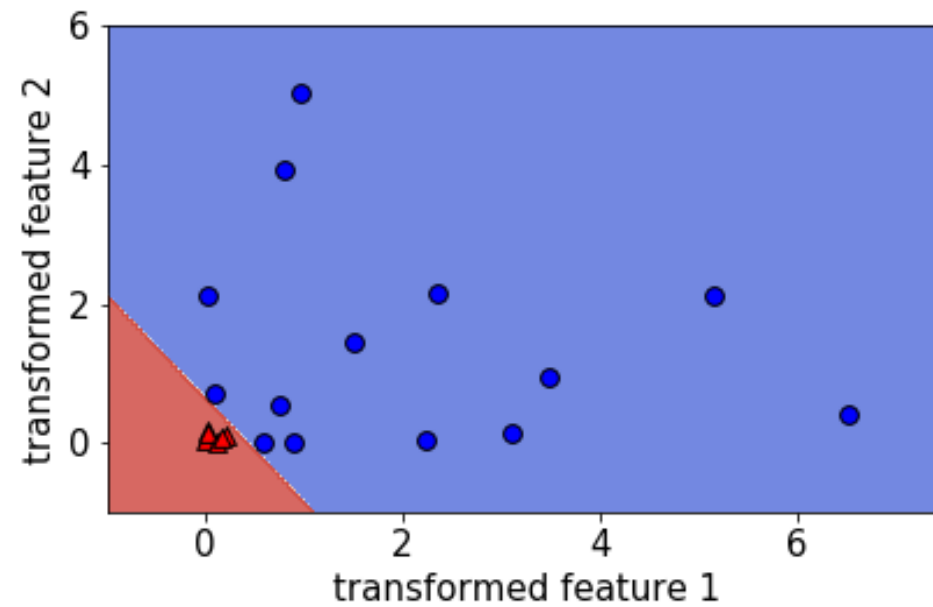
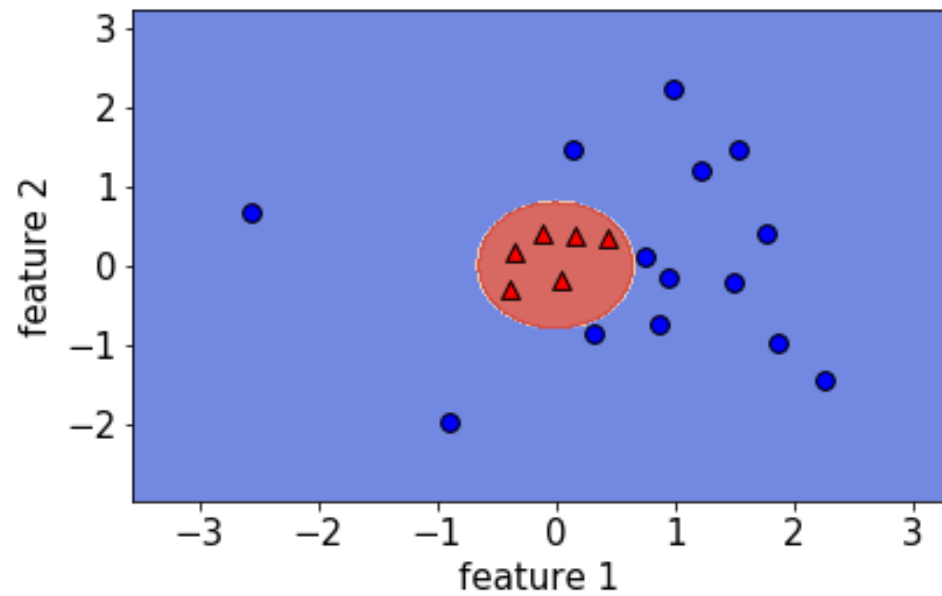
transformed feature =
 $(\text{original feature})^2$

Transforming your features



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

Transforming your features

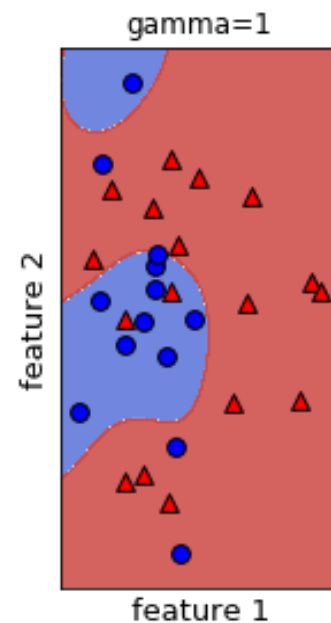


transformed feature =
 $(\text{original feature})^2$

Kernel SVMs

```
from sklearn.svm import SVC
```

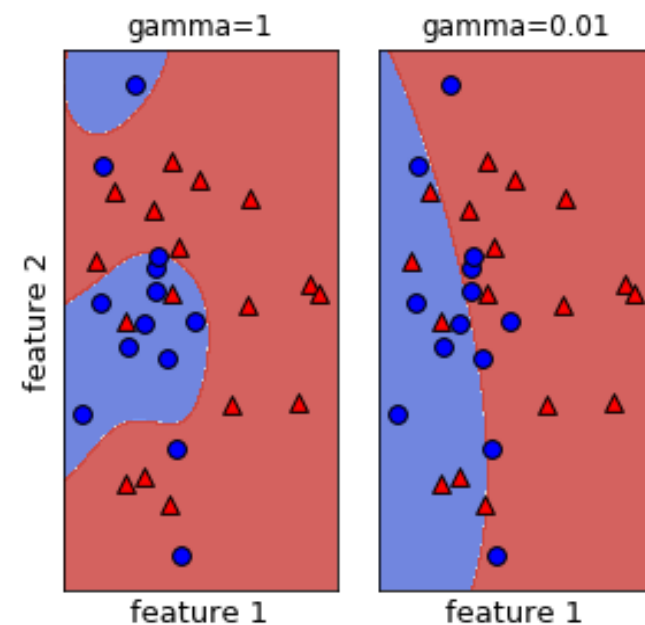
```
svm = SVC(gamma=1)      # default is kernel="rbf"
```



Kernel SVMs

```
from sklearn.svm import SVC
```

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

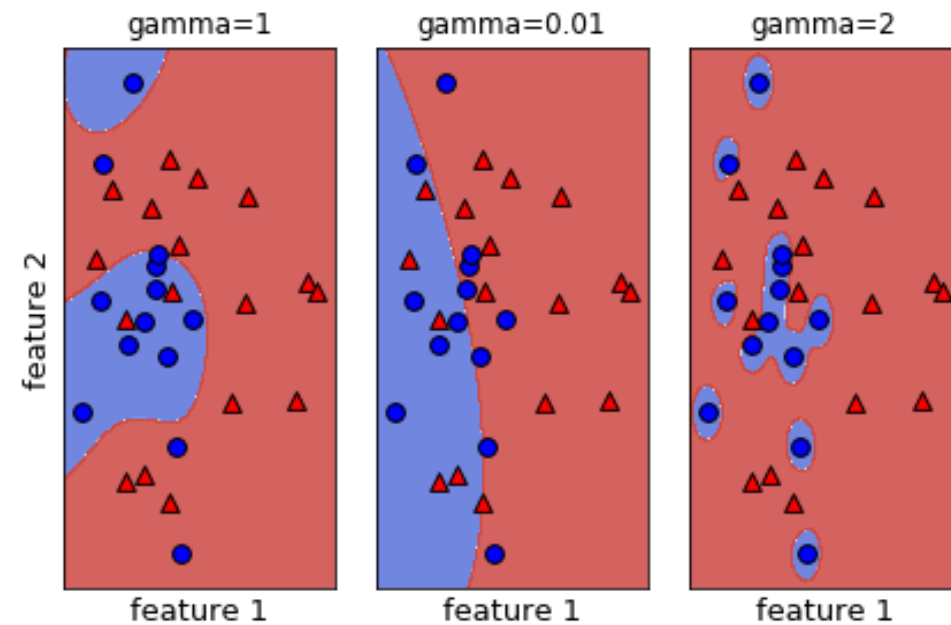


- smaller `gamma` leads to smoother boundaries

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!

LINEAR CLASSIFIERS IN PYTHON

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')
```

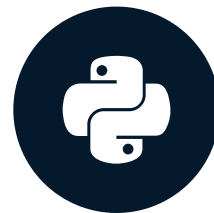
- `SGDClassifier` hyperparameter `alpha` is like $1/C$

Let's practice!

LINEAR CLASSIFIERS IN PYTHON

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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