

Week 4 Exercises: Margin Maximization

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These exercises will prepare you for understanding how to maximize margins, as discussed in the lecture notes. You may want to review the definition of the margin γ .

1) Margin definition

Recall that the signed distance to a point x from a hyperplane θ, θ_0 is $sd(x, \theta, \theta_0) = \frac{\theta^T x + \theta_0}{\|\theta\|}$.

Ex1a:

You start with a hyperplane θ, θ_0 and a point x . Suppose a new separator is given, where $\hat{\theta} = -\theta$ and $\hat{\theta}_0 = -\theta_0$.

Which of the following is true? the signed distance changes sign but not magnitude

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Ex1b:

You start with a hyperplane θ, θ_0 and a point x . Suppose a new separator is given, where $\hat{\theta} = \theta$ and $\hat{\theta}_0 = -\theta_0$.

Which of the following is true: both the sign and the magnitude may change

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Ex1c:

The margin of labeled point x, y with respect to separator θ, θ_0 is:

$$\gamma(x, y, \theta, \theta_0) = \frac{y(\theta^T x + \theta_0)}{\|\theta\|}$$

Let sd stand for $sd(x, \theta, \theta_0)$, the signed distance from the separator to x . Define the margin in terms of sd and y , the label of x . Note that both of these are scalars. Provide an expression in Python syntax.

$\gamma(x, y, \theta, \theta_0) =$

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Your entry was parsed as:

$$sd \times y$$

Ex1d:

What is the sign of the signed distance when the prediction is incorrect?

Which of the following is true: could be either

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Ex1e:

What is the sign of the margin when the prediction is incorrect?

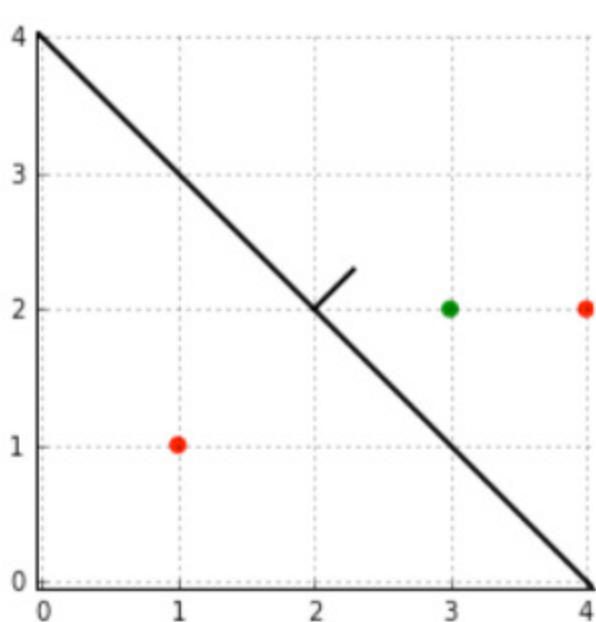
Which of the following is true: negative

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2) Margin practice

What are the margins of the labeled points $(x,y) = ((3, 2), +1), ((1, 1), -1)$, and $((4, 2), -1)$ with respect to the separator defined by $\theta = (1, 1), \theta_0 = -4$? The situation is illustrated in the figure below.



Enter the three margins in order as a Python list of three numbers. Note that you can enter sqrt(x) as x**0.5 in Python.

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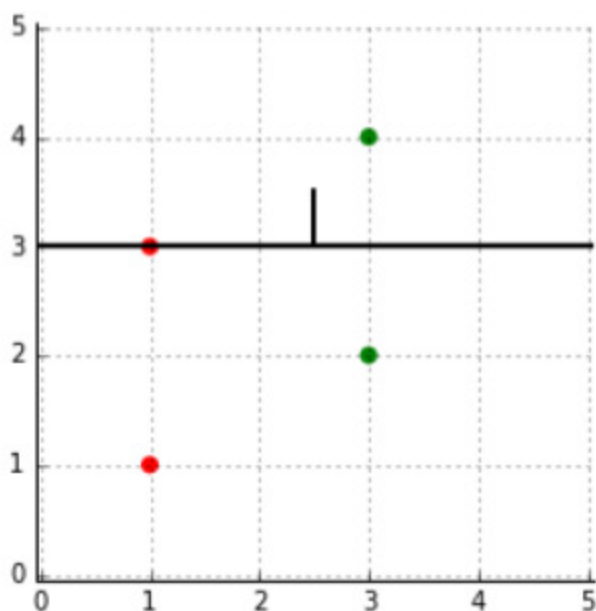
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3) Max Margin Separator

Consider the four points and separator:

```
data = np.array([[1, 1, 3, 3],[3, 1, 4, 2]])
labels = np.array([[ -1, -1, 1, 1]])
th = np.array([[0, 1]]).T
th0 = -3
```

The situation is shown below:



Ex3a:

Enter the four margins in order as a Python list of four numbers.

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Ex3b:

A maximum margin separator is a separator that maximizes the minimum margin between that separator and all points in the dataset.

Enter θ and θ_0 for a maximum margin separator as a Python list of three numbers.

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Ex3c:

If you scaled this separator by a positive constant k (i.e., replace θ by $k\theta$, and θ_0 by $k\theta_0$), would it still be a maximum margin separator? Yes

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