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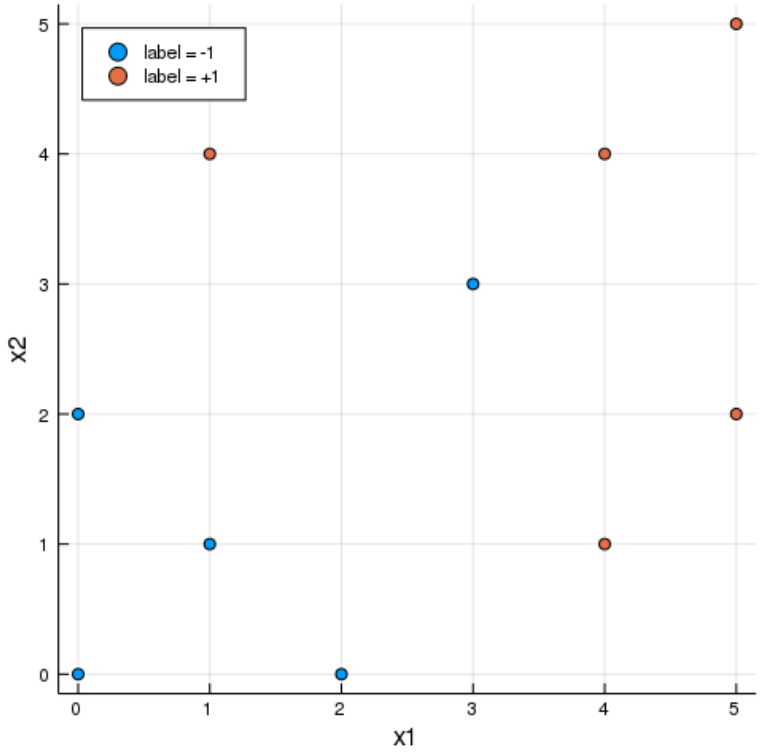
# Problem 2

Midterm due Nov 9, 2020 18:59 EST

**Problem 2. Kernel Methods**

In this problem, we want to do classification over a different training dataset, as shown in plot below:




## 2. (1)

1 point possible (graded, results hidden)

If we again use the linear perceptron algorithm to train the classifier, what will happen?

**Note:** In the choices below ,“converge" means given a certain input, the algorithm will terminate with a fixed output within finite steps (assume $T$ is very large: the output of the algorithm will not change as we increase $T$). Otherwise we say the algorithm diverges (even for an extremely large $T$, the output of the algorithm will change as we increase $T$ further).

- The algorithm always converges and we get a classifier that perfectly classifies the training dataset.
- The algorithm always converges and we get a classifier that does not perfectly classifies the training dataset.
- The algorithm will never converge.
- The algorithm might converge for some initial input of $\theta, \theta_0$ and certain sequence of the data, but will diverge otherwise. When it converges, we always get a classifier that does not perfectly classifies the training dataset.
- The algorithm might converge for some initial input of $\theta, \theta_0$ and certain sequence of the data, but will diverge otherwise. When it converges, we always get a classifier that perfectly classifies the training dataset.

Submit You have used 0 of 3 attempts

## 2. (2)

2 points possible (graded, results hidden)

We decide to run the kernel perceptron algorithm over this dataset using the quadratic kernel. The number of mistakes made on each point is displayed in the table below. (These points correspond to those in the plot above.)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Label | -1 | -1 | -1 | -1 | -1 | +1 | +1 | +1 | +1 | +1 |
| Coordinates | (0,0) | (2,0) | (1,1) | (0,2) | (3,3) | (4,1) | (5,2) | (1,4) | (4,4) | (5,5) |
| Perceptron mistakes | 1 | 65 | 11 | 31 | 72 | 30 | 0 | 21 | 4 | 15 |

Define the feature map of our quadratic kernel to be:

$$\phi(x) = [x_1^2, \sqrt{2}x_1x_2, x_2^2]^T.$$

Assume all parameters are set to zero before running the algorithm.

Based on the table, what is the output of $\theta$ and $\theta_0$?

(Enter $\theta_0$ accurate to at least 2 decimal places.)

$\theta_0 =$

(Enter $\theta$ as a vector, enclosed in square brackets, and components separated by commas, e.g. type `[0,1]` for $\begin{bmatrix} 0 & 1 \end{bmatrix}^T$. Note that this sample vector input may not be of the same dimension of the answer. Enter each component accurate to at least 2 decimal places.)

$\theta =$

STANDARD NOTATION

Submit You have used 0 of 3 attempts

## 2. (3)

1 point possible (graded, results hidden)

Based on the calculation of $\theta$ and $\theta_0$, does the decision boundary $\theta^T\phi(x) + \theta_0 = 0$ correctly classify all the points in the training dataset?

- Yes
- No

Submit You have used 0 of 3 attempts

## 2. (4)

1 point possible (graded, results hidden)

Recall for $x = \begin{bmatrix} x_1 & x_2 \end{bmatrix}^T$

$$\phi(x) = [x_1^2,\ \sqrt{2}x_1x_2,\ x_2^2]^T.$$

Define the kernel function

$$K(x, x') = \phi(x)^T \phi(x').$$

Write $K(x, x')$ as a function of the dot product $x \cdot x'$. To answer, let $z = x \cdot x'$, and enter $K(x, x')$ in terms of $z$.

$K(x, x') =$

STANDARD NOTATION

Submit You have used 0 of 3 attempts

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[Staff] : Perceptron mistakes 1

My algorithm's number of perceptron mistakes till convergence varies from the given in the ques...

- [x] Invalid Input: z_{1} not permitted in answer as a variable — 3

  Why is it every formula is not permitted even the answer is being generated valid in below cell, It ...

- [x] [Staff] Q 2(4) How do we input x'? — 2

  Hello @Staff, Question 2 (part 4) asks for a solution to a question which requires the use of x "pri...