

CMPE 544: Pattern Recognition (Fall 2020)

Homework #3

Due January 17, 2020 by 11:59pm on Moodle

- Please type your answers and submit your homework as PDF. Any other file format will not be accepted.
- Handwritten homework will not be accepted.
- Show your steps to get full points.
- Any homework sent via email after the deadline will NOT be accepted (even if it is 1 min past the deadline). Please make sure to submit your homework before the cutoff time.
- If you have difficulty in accessing Moodle email your homework to me before the deadline.
- Remember you can use one extension if you need. Please let me know beforehand if you plan to use an extension.
- Cheating by copying answers from internet, from a friend, not citing references you use in your homework is forbidden. If a cheating behavior is detected, your grade will be -100.

Question

1. Solve the XOR problem giving below using hard margin dual SVM with kernel trick. You are not allowed to use any online tool for the solution. You need to solve it by hand. You can use **numpy** for linear algebra operations. Please show the following steps clearly.

- (a) (5 pts) Write the dual problem for the following dataset and kernel function.

$$X = \begin{bmatrix} -1 & -1 \\ -1 & 1 \\ 1 & 1 \\ 1 & -1 \end{bmatrix}, \quad y = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}, \quad K(x, x_2) = (x_1^T x_2 + 1)^2$$

- (b) (10 pts) Write the kernel matrix which represents the inner product. Show that the kernel matrix satisfies the Mercer's condition.
 - (c) (20 pts) Find the solution for dual variable α_n .
 - (d) (5 pts) Write $\Phi(x)$ vectors of the second order polynomial non-linear transformation for the data.
 - (e) (10 pts) Write the primal solutions.
2. (50 pts) Implement logistic regression using stochastic gradient descent algorithm and classify the data provided to you. Report the train and test classification accuracy. You are not allowed to use an in-built function. You can use **numpy** functions to implement linear algebra operations.