

# HW 2

Kevin Lin

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## 1

- (a) The gradient of hinge loss with respect to  $w$ :

$$\begin{aligned}\nabla_w \ell(w^T x, y) &= \nabla_w \max\{0, 1 - yw^T x\} \\ &= \begin{cases} 0 & \text{if } yw^T x \geq 1 \\ -yx & \text{if } yw^T x < 1 \end{cases}\end{aligned}$$

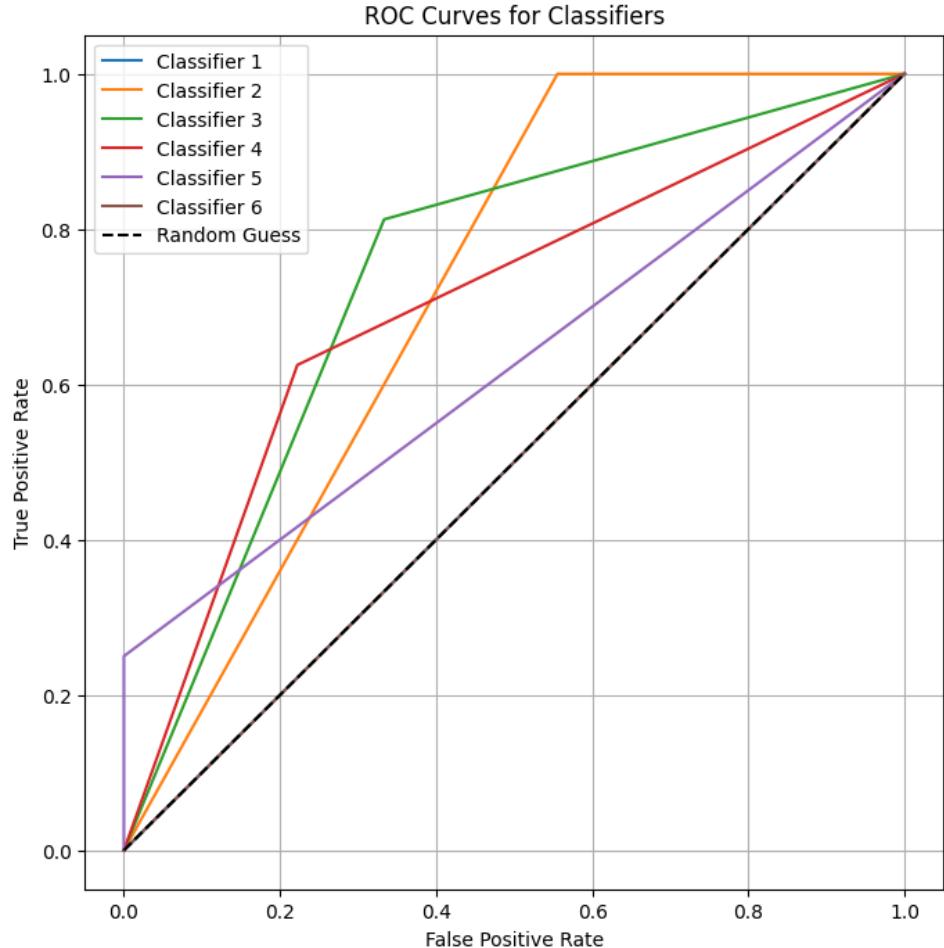
- (b) The gradient of Perceptron loss w.r.t  $w$ :

$$\begin{aligned}\nabla_w \ell(w^T x, y) &= \nabla_w \max\{0, -yw^T x\} \\ &= \begin{cases} 0 & \text{if } yw^T x \geq 0 \\ -yx & \text{if } yw^T x < 0 \end{cases}\end{aligned}$$

- (c) For hinge loss,  $w$  is updated only when the margin condition  $yw^T x < 1$  is violated, meaning the prediction is not only incorrect but also not confident enough. However, for Perceptron loss, the update occurs whenever the prediction is incorrect (when  $yw^T x < 0$ ). This means that hinge loss encourages a larger margin between classes while Perceptron loss focuses solely on correct classification.

## 2

(a) ROC plot (see Jupyter notebook for code):



- (b) Classifier 2 has the highest accuracy of 0.8, while Classifier 6 has the lowest accuracy of 0.36. See Jupyter notebook for code.
- (c) Classifier 5 has the highest precision of 1, while Classifier 1 has the lowest precision of 0.64. Classifier 6 has undefined precision as it has no true or false positives. See Jupyter notebook for code.
- (d) Classifier 1 F1 score: 0.78  
Classifier 2 F1 score: 0.86  
Classifier 3 F1 score: 0.81  
Classifier 4 F1 score: 0.71  
Classifier 5 F1 score: 0.4  
Classifier 6 F1 score: Undefined for the same reasons as precision.  
See Jupyter notebook for code.

