

## Assignment 3 (Due: Dec. 28, 2025)

1. **(Math)** Please prove the Proposition 20 mentioned in our lecture.

### Proposition 20:



Suppose that  $\mathbf{x}^*$  and  $(\alpha^*, \beta^*)$  are primal feasible and dual feasible respectively. If the duality gap associated with them is 0, i.e.,

$$f_0(\mathbf{x}^*) - g(\alpha^*, \beta^*) = 0$$

Then,  $\mathbf{x}^*$  and  $(\alpha^*, \beta^*)$  should be primal optimal and dual optimal, respectively, and the primal problem has strong duality

2. **(Programming)** On the website, I provide you a Matlab program which demonstrates how to train a soft-margin SVM model from simulated data. Please add comments, as detailed as possible, to the code.
3. **(Programming)** RT-DETR is a modern transformer-based real-time object detector. It has been implemented in Ultralytics (<https://docs.ultralytics.com/models/rtdetr/#usage-examples>). Please try to use Ultralytics to train an RT-DETR model to detect speed-bumps and persons in a video. The training data can be downloaded from <https://github.com/csLinZhang/CVBook/tree/main/chapter-15-YOLO/For-yolov4>. Test your model on the provided test video (on the course website). For this question, you only need to hand in your video with detected bounding-boxes to the TA. A sample frame of our result video may like the following image.

