King Mongkut's University of Technology **Name:** _____

Machine Learning **I.D. Number:** _____

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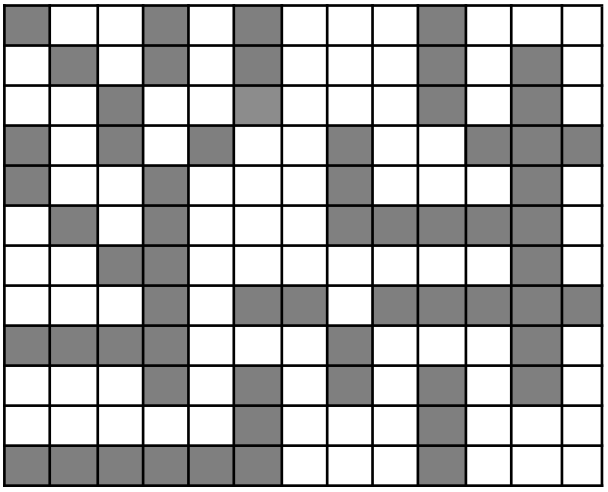
Take Home Quiz 3 due Sat Feb 10, 2024 **Score:** _____ / 85

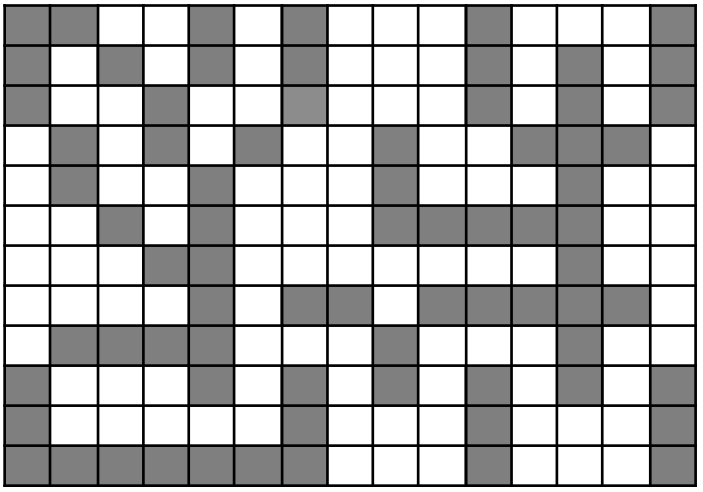
1. **Connected Components.** Non-programming exercise. Label the following image with colors starting 1.

   a. *5 points.* 0.5 hrs. Use 4 connected to label the background (white) regions. Show the equivalence table and the final color in each box.

Your Output for 4-connected Labeling:



Your Output for 8-connected Labeling:



   b. *5 points.* 0.5 hrs. Use 8 connected to label foreground (black) regions. Show the equivalence table and the final color in each box.

2. **Handwritten Digit Recognition.** Use the **digits.png** file as templates for digits 0, 1, …, 9. Write a python program to cut out each digit as a labeled dataset from 0..9, each of which is 20x20. Note: You may also use this *exact same dataset* with 100 samples of each digit 0..9 using 20 x 20 pixels from the internet along with libraries to read/load the dataset, if that's easier for you.

Load all the character data into a python class. Then rescale each character from 20 x 20 to 24 x 24 using OpenCV. Use 80% of the data as the training set, reserving 20% for testing.

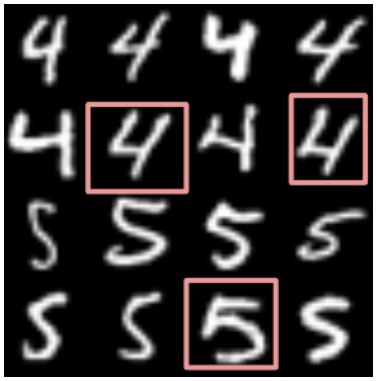
   a. *10+10+10+10 pts.* 5 hrs. Then try recognition by using the test images and report the accuracy percent for these 4 (classifier, feature type) combinations: (KNN K = 5, gray scale features), (KNN K = 5, HOG features), (KNN K = 1, gray scale features), (KNN K = 1, HOG features). For HOG, use 20° histogram orientations of non-directional gradients (ie., 9 bins) with 16 x 16 overlapping pixel windows for each 24 x 24 digit. Each digit will, thus, have 144 HOG features from 4 x 4 x 9, with 9 histogram values x 4 per 16 by 16 block x 4 such blocks per 24 x 24 image.

b. Use KNN K = 1 with HOG features to report:

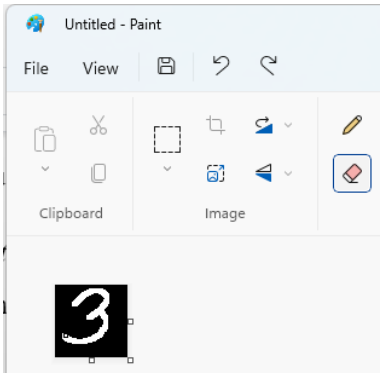
i. *5 pts.* 1.0 hrs. Result for 2 test images *per digit 0..9* cropped out from **digits.png** but not aligned at the original 20 x 20 image, so you may have smaller or bigger input image sizes. You must rescale each test image to 24 x 24 because HOG requires this scaling.

ii. *5 pts.* 1.0 hrs. Result for 2 test images *per digit 0..9* you create in a Paint program to see if you can find your character. Each test image should be big to start with such as 50x50, but you should rescale it to 24 x 24 before testing.

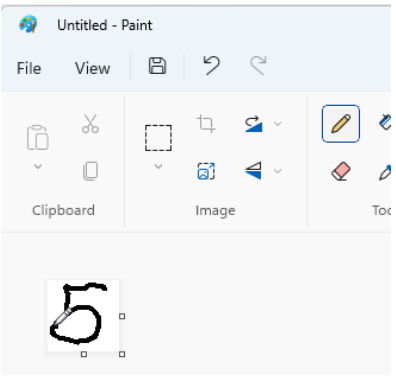
iii. *5 pts.* 1.0 hrs. Result for 4 test images of digit 5 you create in Paint with white background.



2. b. i. Cut digits at different sizes



2. b. ii. Create your own digits 0-9.

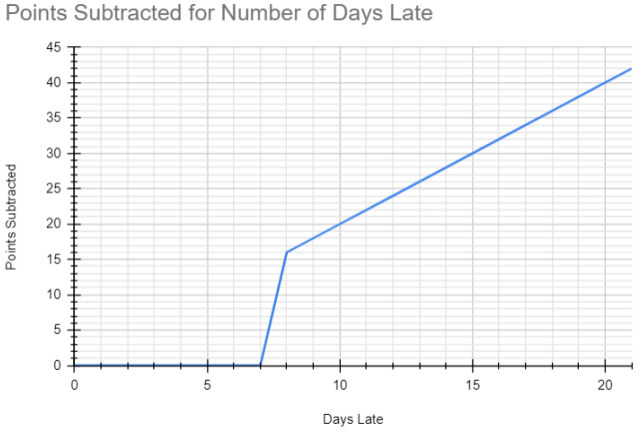


2. c. ii. "5" in white background.

c. *20 pts.* 2 hrs. For each 0..9 digit in your dataset of 100 characters, use OpenCV's auto threshold (Otsu's algorithm) and then the connected components to find the bounding box. Use that bounding box to cut out each **original** gray-scale image (not the thresholded image) and resize each back to 24 x 24. This will be your new dataset (training and testing, combined). Report the accuracy percent for KNN K = 1 using HOG features. Is the result here better than in problem 2a for KNN = 1 using HOG features?

digits.png (h: 1,000, w: 2,000) **Image Format:**

- 0: Uses rows 1-5 (i = 0..99), each 100 characters, each 20 x 20.
- 1: Uses rows 6-10 (i = 100..199), each 100 characters, each 20 x 20.
- ...
- 9: Uses rows 46..50 (i = 900..999), each 100 characters, each 20 x 20.



Submission. All your work should be put into 1 pdf file and uploaded to the LMS before the due date.

Reminder Honor Code Agreement. Work copied from others is cheating, resulting in an F grade.