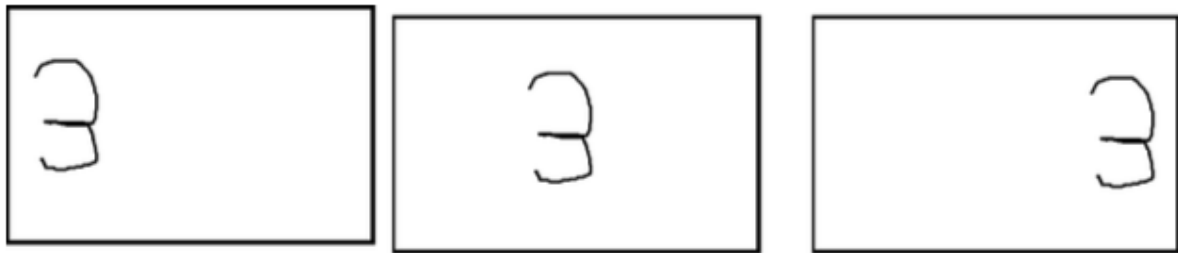


Q1: Is there anything we need to know to get your code to work? If you did not get your code working or handed in an incomplete solution please let us know what you did complete (0-4 sentences)

For ModelPart3, out of 10 runs on my local machine, the average test accuracy of my 2-layer CNN is 75.78% with max 76.65% and min 75.25%; the average running time is 260.59 seconds.

Q2: Consider the three following 28x28 images of the digit 3.

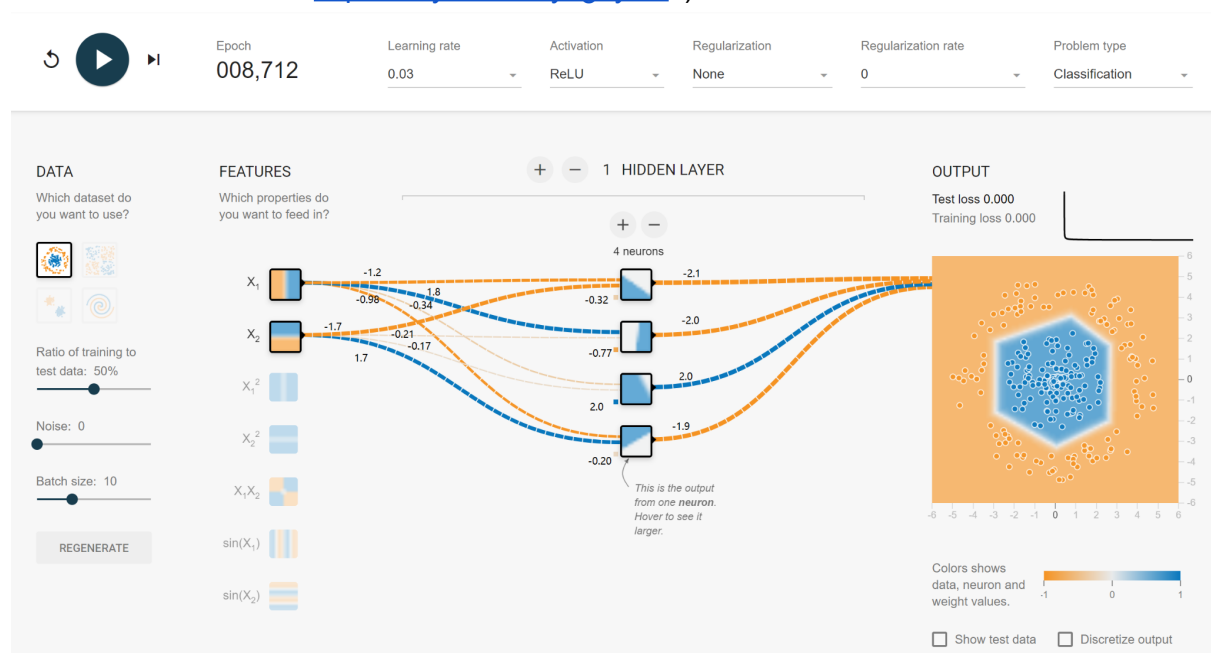


Which neural net is better suited for identifying the digit in each image: a convolutional neural net or a feed-forward (multi-layer linear+ReLU) neural network? Explain your reasoning. (2-3 sentences)

Convolutional Neural net (CNN) is better for identifying all three images because CNN can capture local spatial features hence the position of the digit in the image does not matter. Whereas feed-forward (FF) depends on the distribution of the training data. If the training data are all aligned in the center position like the digit in the second image, then FF can correctly classify the digit in the second image but not the other two images.

Q3: Consider the dataset shown in this scatterplot:

The orange points are labeled with class label 0, and the blue points are labeled with class label 1. Write out a mathematical expression in terms of the inputs, using linear layers and ReLUs, that will correctly classify all of these points. (We expect something like output = ... x_1 + ... x_2 . Hint: Use <https://tinyurl.com/y5gayl5b> .)



1 hidden layer, 4 neurons, $\text{ReLU}(X) = \max(0, X)$
output = $-2.1 * \text{ReLU}(-1.2 * X_1 - 1.7 * X_2 - 0.32) - 2.0 * \text{ReLU}(1.8 * X_1 - 0.21 * X_2 - 0.77)$
 $+ 2.0 * \text{ReLU}(-0.34 * X_1 - 0.17 * X_2 + 2.0) - 1.9 * \text{ReLU}(-0.98 * X_1 + 1.7 * X_2 - 0.20)$

Q4: Read about [this algorithm](#), which claims to predict “criminality” based on people’s faces, and was created by researchers in China. (If interested, you can click through to the arxiv link where the researchers publish a response to criticism & media about their original paper).

- (a) What factors do the researchers claim contribute to “criminality?” (1-3 sentences)
 - (b) What’s one potential confounding variable/feature that their algorithm learned? What’s your evaluation of the “effectiveness” of this algorithm? (2-4 sentences)
 - (c) If this algorithm were actually deployed, what are the consequences of this algorithm making a mistake (misclassification)? (1-3 sentences)
- (a) The researchers claim that certain facial features could contribute to criminality. In particular, criminals tend to have larger curvature of upper lip, shorter distance between two inner corners of the eyes and smaller angle between two lines drawn from the tip of the nose to the corners of the mouth. And body features, ages, sexes and ethnicities could potentially influence criminality as well.
- (b) The potential confounding variable that their algorithm learned is the criminal’s facial feature. The algorithm may not be very effective. Since there are great variances in criminal’s facial features, it is hard to reassemble a standard criminal face, and very likely that the algorithm will incorrectly classify a criminal. Not to mention there are other factors like social influence that could contribute to criminality and skew their training dataset as well.
- (c) Incorrect classification of criminals made by this algorithm will cause serious ethical and legal issues as it stigmatizes people who are already overpoliced and may put innocent people into jail just because of their criminal alike facial features. This algorithm is statistically significant, but nevertheless misleading and there are many other factors that we should take into account when classifying a criminal.