**282893 Advanced Machine Learning report**

**Task 1: Spam Detection** [task1 main.py](task1%20main.py)

Preprocessing

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Feature representation

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Prediction method

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Results

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Failure cases and potential biases

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**Task 2: Face Alignment** [task2 main .py](task2%20main%20.py)

Preprocessing

The ideal image for feature detection would:

1. Have no background,
2. Be grayscale,
3. Be unobstructed,
4. Be filtered to only show contrast lines.

Because using image detection to remove background noise is both paradoxical and would only improve performance marginally, we will not be removing them and the CNN will have to adapt. Therefore, the full preprocessing is:

1. The kernel in Figure 1 is applied, to show only contrast lines
2. The image is resized to 128x128, to reduce the number of operations 4x
3. The image is made monochrome to show only pixel intensity and reduce overfitting
4. The intensity value for each pixel is divided by 255, so the intensities range from 0-1.

Image representation

The image is passed as a numpy array of shape (1, 128, 128, 1), which was calculated to fit the format (1 image, 128px wide, 128px tall, 1 brightness value). This layout was chosen because it is the arrangement used by Tensorflow. Each “pixel” is a 32-bit float between 0-1 representing its intensity, calculated grayscaling and dividing each pixel by 255.

Prediction method

The two algorithms I considered were SIFT and a CNN. SIFT is excellent for finding patterns, and is resilient to rotations and variable contrast, but cannot be “trained” in the way that CNNs can. While using every bit of training data as a template for every image would probably work, the efficiency of CNNs meant they were a more appropriate choice. This also means the model only needs training once before it will work on any image presented.

The loss function I chose was Mean Squared Error (MSE), as is standard for computer vision tasks. The only regularizations were the preprocessing steps, which should allow every image to be compared regardless of relative intensity, scale or colours.

Designs / Parameters

Systematically I tried batch sizes of 16, 32, 48 and 64, and recorded the loss at each epoch up to 50. This data can be found in ‘<batch\_size> lossdata.xlsx’. Generally, smaller batch sizes will lead to a higher accuracy, but can lead to overfitting if done excessively. I did not factor the time taken to train or predict for each batch size, because this has a negligible effect on performance between tested values when considering individual pictures. As per the results shown in Figure 2, the final parameters were determined as 50 epochs and a batch size of 64.

Result Analysis

The amount of time taken for the model to train and predict is correlated to the number of epochs. Although training and prediction time is of low concern as mentioned above, I also measured these to find the point at which increased training becomes detrimental overall, as another efficiency metric.

The relative ‘score’ of each prediction has been calculated as -log(loss), resulting in visibly comparable positive numbers. When plotted, we can see that smaller batch sizes begin overfitting very quickly, but tend to higher accuracy. The peak score was at a batch size of 32, but that begins a pattern of overfitting at 15 epochs. Higher batch sizes showed much more stable high scores, seemingly with the best balance between accuracy and reliability at a batch size of 64 and all 50 epochs.

The figures for the results of these tests are in files named ‘<batch size> lossdata.xlsx’, and the graphs are shown below.

Figure 2 y-axis: Relative score. x-axis: Epoch count.

Y-axis: Relative score, calculated -log(loss). X-axis: Epoch count.

A graph with a line

AI-generated content may be incorrect.A graph with a line

AI-generated content may be incorrect.

Figure 2.1: Overfitting @12, Peak @47 Figure 2.2: Overfitting @16, Peak @43

A graph with a line

AI-generated content may be incorrect.A graph with a line

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Figure 2.3: Overfitting n/a, Peak @50 Figure 2.4: Overfitting n/a, Peak @50