MONASH University
Information Technology

GROUP ASSIGNMENT COVER SHEET

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***** Please include the names of all other group members.

Unit name and code	FIT3081		
Title of assignment	ASSIGNMENT 3		
Lecturer/tutor	Raveendran Paramesran		
Tutorial day and time	Workshop #1	**Campus**	Malaysia
Is this an authorised group assignment?	☑ **Yes** ☐ **No**		
Has any part of this assignment been previously submitted as part of another unit/course?	☐ **Yes** ☑ **No**		
Due Date 2/6/2023		**Date submitted**	2/6/2023

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Extension granted until (date) .... **Signature of lecturer/tutor** ....

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* delete (iii) if not applicable

Signature Han Wei Date: 2/6/2023 Signature ________________________ Date:________

Signature Ze Peng Date: 2/6/2023 Signature ________________________ Date:_______

Signature __________________ Date:____________________ Signature ________________________ Date:_______

Overall Methodology

Our methodology has been divided into two main parts, training model and car plate classification. The details of these parts will be discussed in the following subsections.

Training Model

The training model is a simple three-layer neural network. The purpose of this neural network is to pre-train it using 200 images of characters. It will be used to classify the car plate in the subsequent step. Figure 1 shows a high-level flowchart of the training model.

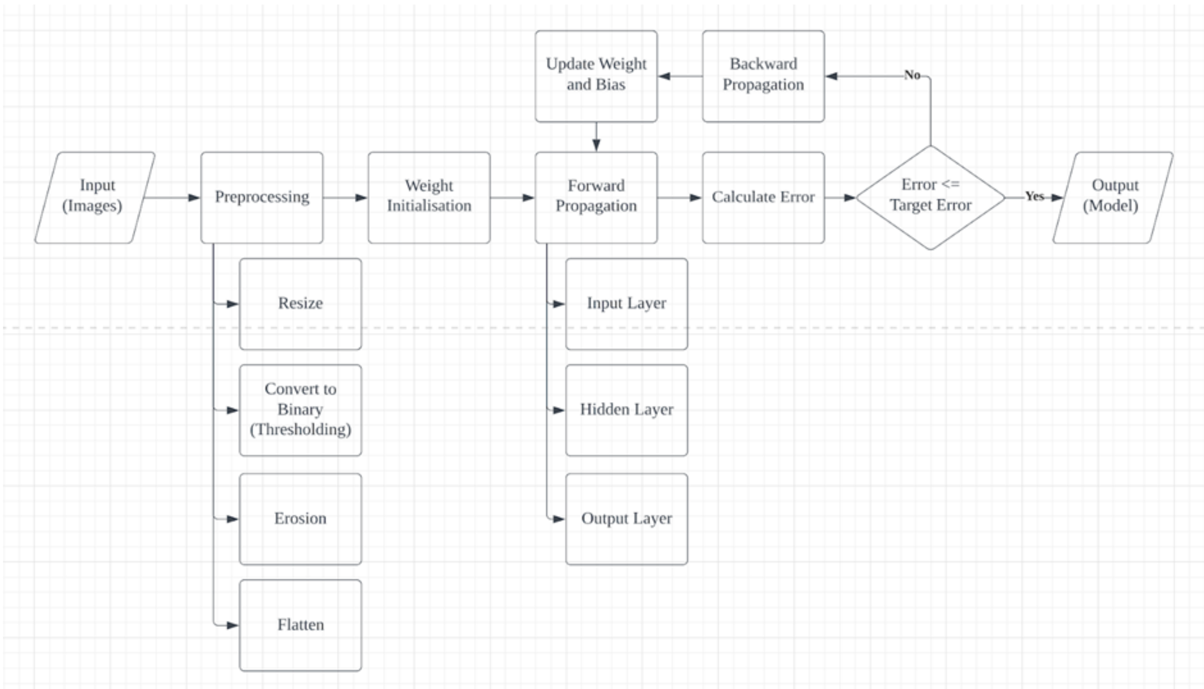

Figure 1: Flowchart of Training Model

Dataset

The input images are 200 images of the character, which are the numbers 0 to 9, and letters B, F, L, M, P, Q, T, U, V, W. There are 10 images for each character. The dataset is prepared by manually cropping the images from the Combined Car Plate dataset prepared by the teaching team. During training, we realise the importance of good training images. Thus, we ensure that all of our images are big and clear enough in terms of brightness.

Preprocess Images

A series of transformations are performed on the image. After reading the images, they are resized to a fixed dimension of (35, 70). Next, the images are first converted to greyscale, and subsequently converted to binary images. Morphological erosion operation is next applied to the binarized image to make the edges thinner. This is because it makes the edges more obvious. Finally, the 2D image array is flattened to 1D and clipped to (0, 1) value.

After preparing the input images, they are split into 80-20 ratios for training and testing images. For simplicity, we use the first 8 images as training images and the last 2 images as testing images.

Model Architecture

The neural network only has three layers: the input, hidden, and output layers. The input layer has 2450 neurons, as the image size is 35 * 70; the hidden layer has 128 neurons; the output layer has 20 neurons as there are 20 classes (or characters).

The steps for training are as follows:

1. Read and preprocess the images to obtain train_X, train_y, test_X, and test_y
2. Initialise the weight and biases with random values.
3. Forward propagation
4. Check the error, if the error is greater than the global error, continue to step 5. Else skip to step 7.
5. Backpropagation
6. Update weight and biases. Repeat step 3.
7. Save the model parameters.

The steps for testing are as follows:

1. Load back weight and biases.
2. Using test_X, perform forward propagation.
3. Calculate the accuracy by comparing it against test_y.

Car Plate Classification

The next task is to classify the car plate. The car plate undergoes segmentation to segment into individual characters to be fed into the model. Figure 2 shows a high-level flowchart for classifying the car plate.

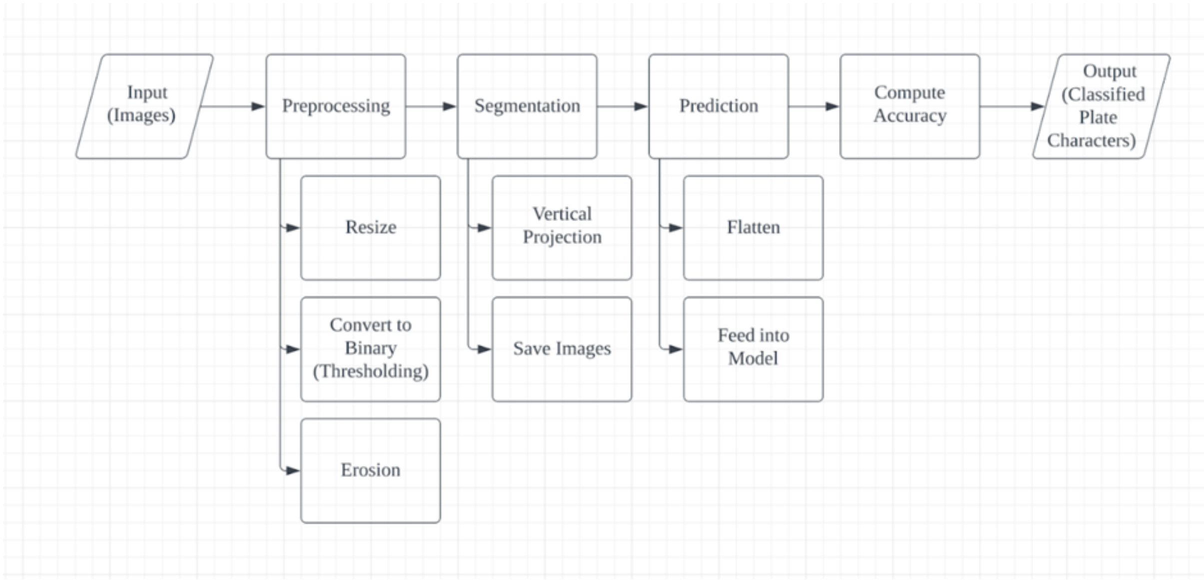

Figure 2: Flowchart of Car Plate Classification

Preprocess Image

Similarly, a series of transformations are performed on the image. After reading the images, they are resized to a fixed dimension of (300, 60). Next, the images are converted to greyscale, then to binary images. Morphological erosion operation is next applied to the binarized image to make the edges thinner. This is because some of the characters are very close to each other, making it hard for the subsequent segmentation.

Segmentation

To segment the characters from the car plate image, vertical projection is used to plot out the histogram of images. Thus, we can identify the position of the characters (i.e., white pixels) and slice it from starting point to ending point. This will result in the segmentation of characters, wherein we save the segmented images into the "SegmentData" folder.

Classification

Now we are ready for classification. The images are loaded from the "SegmentData" folder first. Here it is similar to the preprocessing steps in model training, the images are read, resized, and converted to binary images. However, there are a few additional transformations. We decided to remove some pixels top and bottom of the image, as well as add pixels right and left of the image. This is to mimic the example images in the training images. Next, we use Gaussian Blur to remove noise and perform morphological erosion. Finally, the array is flattened to be fed into the model. As before, the data is forward propagated to get the output. Next is to evaluate the performance of classification. Since our output is in a probability matrix, we will choose the index with the highest probability as the predicted index. The accuracy will be calculated by the total number of correct classifications of each character from the plate.

Evaluation of Results

Model Training

Table 1 shows the probability of the target output after model training.

Probability	Number of Training Images
0.5 - 0.59	1
0.6 - 0.69	1
0.8 - 0.89	9
0.9 - 0.99	76
1	73

Table 1: Table showing probability of target output

Next we look into images that have probability less than 0.9. Table 2 depicts the details.

Character	Number of Images	Probability
2	1	0.8946394115717078
8	2	[0.8679764331482587, 0.8525800093626396]
B	1	0.48299311889539265
F	1	0.8888548205545216
M	5	[0.8680385261962018, 0.8882024432102283, 0.8658602914572725, 0.8233556555762122, 0.572763031914859]
T	1	0.8927229755373228

Table 2: Details of output with less than 0.9 probability

It seems that most of the outputs have a probability close to 0.9, except for one instance of character B and one instance of character M. The model cannot predict character M that well as compared to other characters.

Model Testing

Table 3 shows the testing results. The accuracy of the testing images is 0.88, with the model being able to correctly predict 35/40 images correctly.

Prediction	Number of Images
Successful	35
Fail	5

Table 3: Results of Prediction

Table 4 shows the details for the failed images.

Predicted Character	Actual Character	Prediction Probability
B	3	0.311539340157514
W	4	0.2041610020159913
6	5	0.11920280287691844
B	8	0.1501748323227226
B	8	0.5162044530997228

Table 4: Tables depicting details for failed cases.

It is clear that our model has difficulty predicting character ‘8’, and tends to predict ‘8’ as ‘B’.

Testing Segmented Car Plate

Table 5 shows the classification results for the car plate.

Classification Status	Number	Actual Plate	Expected Plate	Overall Accuracy
Fully Classified	4	VBU3878	VBU3878	0.79
		VBT2597	VBT2597	
		PPV7422	PPV7422	
		WUM207	WUM207	
Partially Classified	6	WTF6868	WTF6B6B	
		PLW7969	FLW79M9	
		BPU9859	BPU9889	
		BMT8628	BMT8B29	

		BMB8262	UMBB766	
		BQP8189	BQM61B9	

Table 5: Classification Result for Car Plate

Based on the result, we can see that the most common error from our model is the classification of "8" and "B". Since both of them are quite similar, it is normal for a machine learning algorithm to wrongly classify these characters. Besides that, our model only has a single hidden layer, it is limited to extracting sufficient information from the input and classifying the exact result accurately. Overall, our model achieved an accuracy of 79.71% which is a satisfying result as the model only contains one hidden layer.

Recommendation and Conclusion

To further improve the model, there are a few recommendations. Firstly, we can increase the model depth by adding more hidden layers. More hidden layers mean that the model can capture more minute details of the characters. As discussed earlier, our model fails to differentiate between 'B' and '8' clearly. Having extra hidden layers might help in differentiating the minute details, thus improving the prediction accuracy. Secondly, neural networks always benefit from having more training samples. In this project, we only have 200 images, with each class only having 8 samples for training and 2 samples for testing. Since the character can be represented slightly differently in the way it is written, having different variations can benefit the prediction. Besides, having more samples is always great to help the network to learn more representations. Thirdly, we can improve the accuracy by fine-tuning the hyperparameters. This includes model weight, bias, and learning rate.

In conclusion, we managed to train our classification network using 200 samples. In the training phase, our validation accuracy is around 0.88. To test the car licence plate, we first segment into characters before feeding into the model, which gives an accuracy of around 0.79.

Task Allocation

Member	Task Allocated
Lim Han Wei	Cropping 100 Training Images Segmentation of License Plate Testing of Model and Segmented License Plate Report Writing
Tan Ze Peng	Cropping 100 Training Images Training of Model Report Writing