Report on Binary Classification Model for Grapes and Raisins

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1 Introduction

The objective of this experiment is to develop a binary classification model using Convolutional Neural Networks (CNN) and Fully Connected Neural Networks (FCNN) to differentiate between grapes and raisins based on images. CNNs are particularly effective in image recognition tasks as they can automatically learn and identify patterns in images. FCNNs, on the other hand, are good at processing structured data, making them suitable for refining the features extracted by CNNs. Our goal is to achieve high accuracy in the classification task.

2 Dataset

The dataset used in this study has 1730 colourful pictures of grapes and raisins. These pictures were captured with different smartphones very carefully to help our computer learn better. Each subject has two or three photos taken from different angles. We also took pictures of single grapes and raisins and some group pictures of grapes and raisins. We split the dataset into three parts: the training set, the validation set, and the test set. There is no overlapping object in these sets. The resolution of the images are 32x32.

Training Set: This set has 1070 pictures, with an equal number of raisins and grapes. We made sure all these pictures have the same black and white background. We also labeled each picture, telling the computer if it's a grape (0) or a raisin (1). This labeling helps the computer learn which picture belongs to which group.

Validation Set: For fine-tuning model hyperparameters and monitoring performance during training, a separate validation set containing 240 images has been used. Similar to the training set, this subset maintains a balanced representation of raisins and grapes, with images captured against a black and white background.

Test Set: This set is the final test for our models. It has 420 pictures with different backgrounds, like black, white, red, green and blue. We made sure to have an equal number of raisins and grapes in this set too.

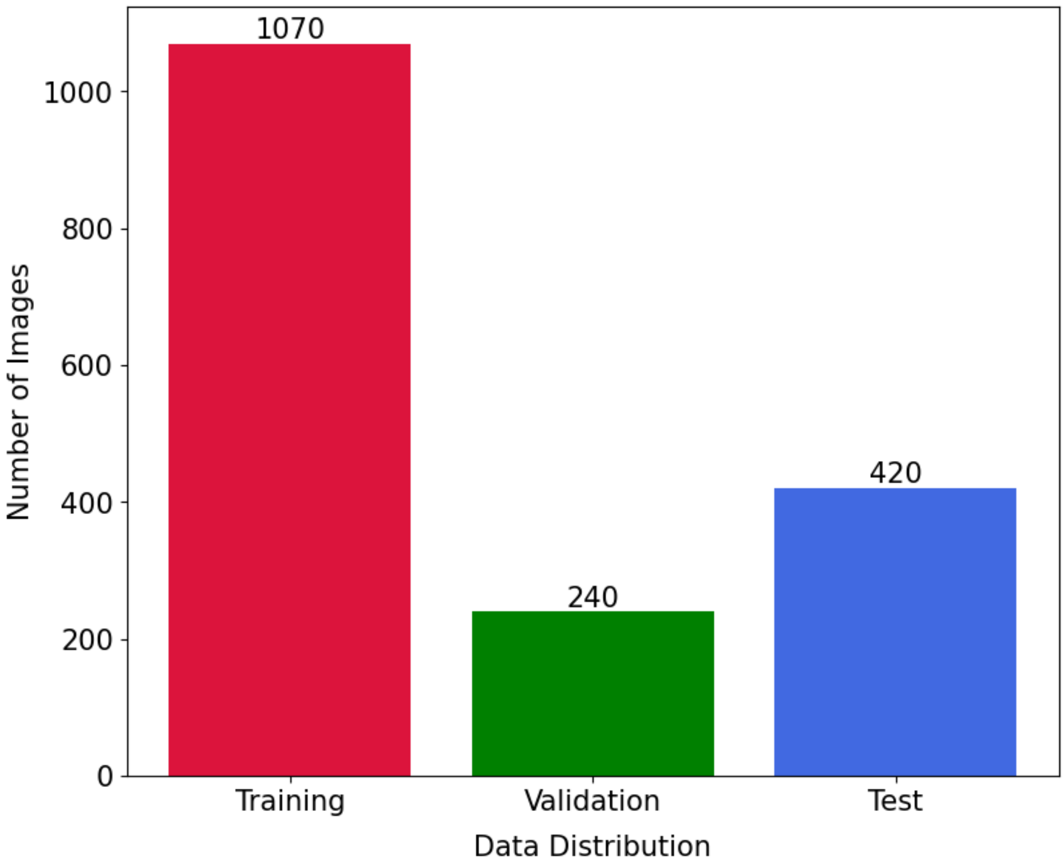


Figure 1: Number of images in the Training, Validation and Test Set

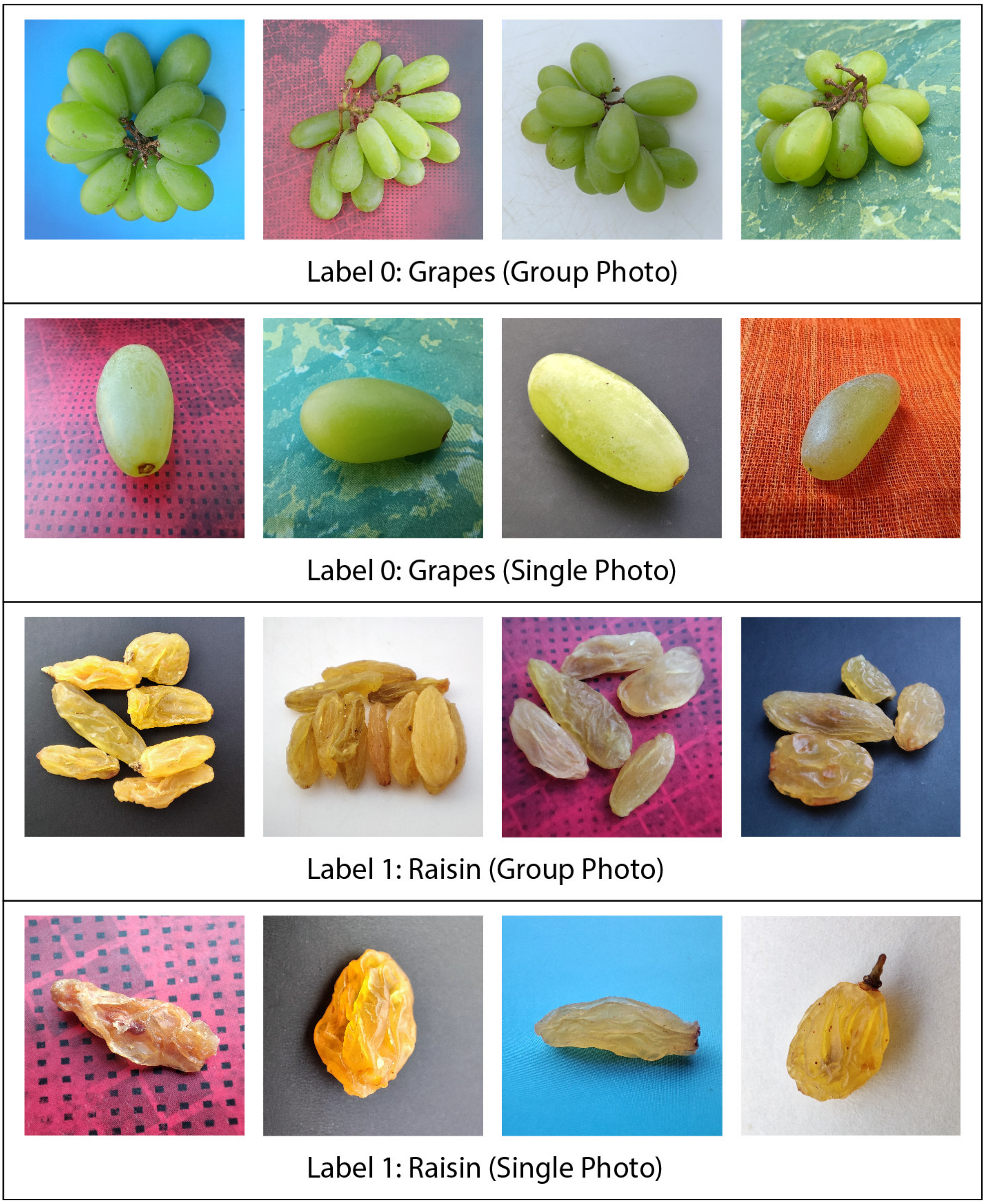


Figure 2: Some examples of images from our dataset

3 Model Architecture

Both the model architectures are designed using the Keras functional API.

3.1 Convolutional Neural Network

Three sets of Convolution layers with Max Pooling layers and lastly three set of Dense layers consisting of 512, 256, 128 neurons were used as the model architecture. The model has 349217 trainable parameters. Adam optimizer is used for parameter updates during training. Binary crossentropy is employed as the loss function, suitable for binary classification tasks. Model performance is evaluated using accuracy.

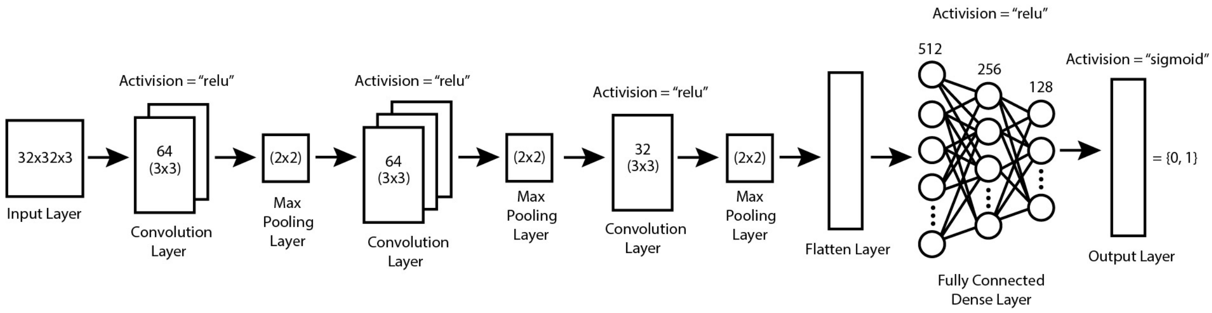


Figure 3: Our Convolutional Neural Network Architecture

3.2 Fully Connected Neural Network

Five dense layers of units(128, 256, 512, 256, 128) at first increasing then decreasing order were used. The model has 722305 trainable parameters. Adam optimizer is used for parameter updates during training. Binary crossentropy is employed as the loss function, suitable for binary classification tasks. Model performance is evaluated using accuracy.

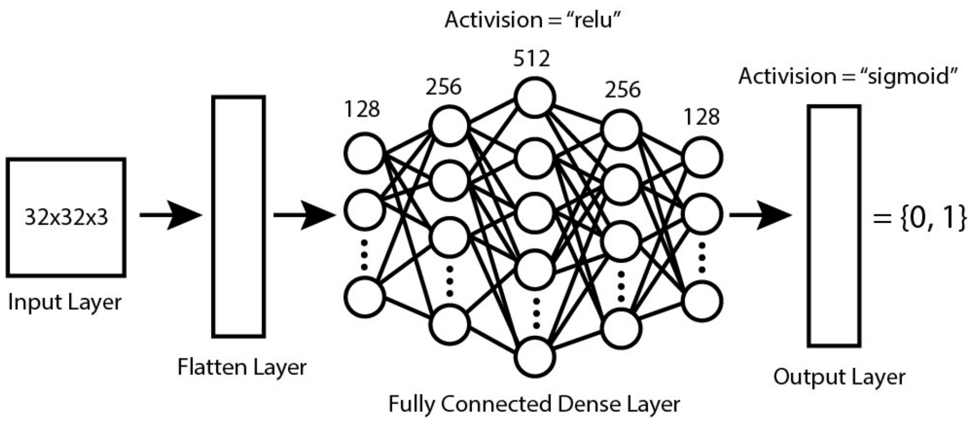


Figure 4: Our Fully Connected Neural Network Architecture

4 Result

4.1 Convolutional Neural Network

After training the model, we achieved an accuracy of 82% on the test dataset.

Learning Rate	Epochs	Validation Accuracy
0.01	10	50%
0.01	20	50%
0.01	30	50%
0.01	40	50%
0.01	50	50%
0.001	10	95%
0.001	20	98%
0.001	30	98%
0.001	40	97%
0.001	50	98%
0.0001	10	98%
0.0001	20	98%
0.0001	30	98%
0.0001	40	98%
0.0001	50	98%

Test Accuracy	82%

Figure 5: Results of different settings using CNN

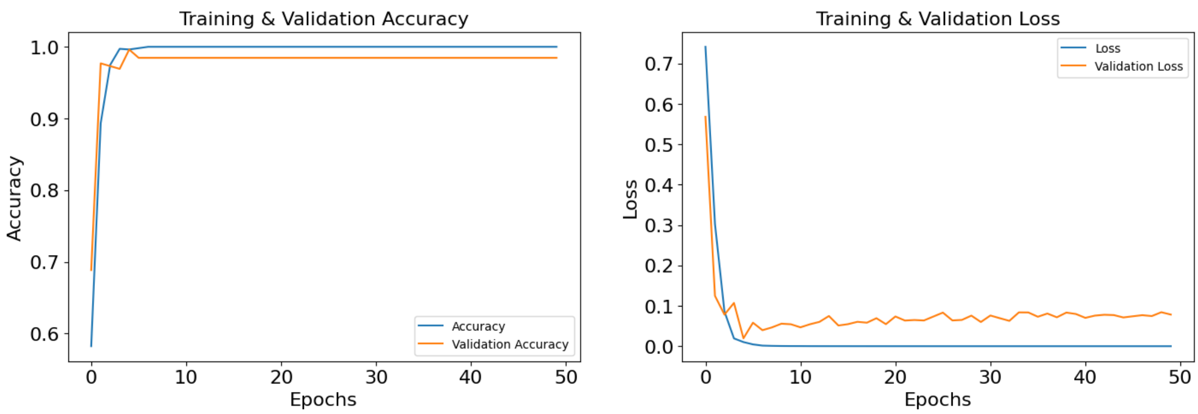


Figure 6: Accuracy and Loss Graph for CNN

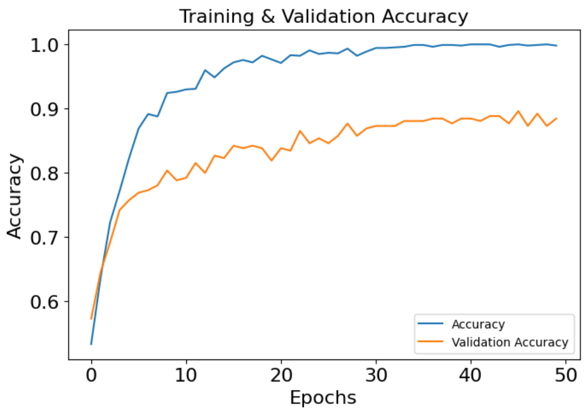
4.2 Fully Connected Neural Network

After training the model, we achieved an accuracy of 74% on the test dataset.

Learning Rate	Epochs	Validation Accuracy
0.01	10	50%
0.01	20	49%
0.01	30	49%
0.01	40	50%
0.01	50	50%
0.001	10	96%
0.001	20	50%
0.001	30	94%
0.001	40	98%
0.001	50	98%
0.0001	10	81%
0.0001	20	93%
0.0001	30	96%
0.0001	40	96%
0.0001	50	97%

Test Accuracy	74%

Figure 7: Results of different settings using FCNN



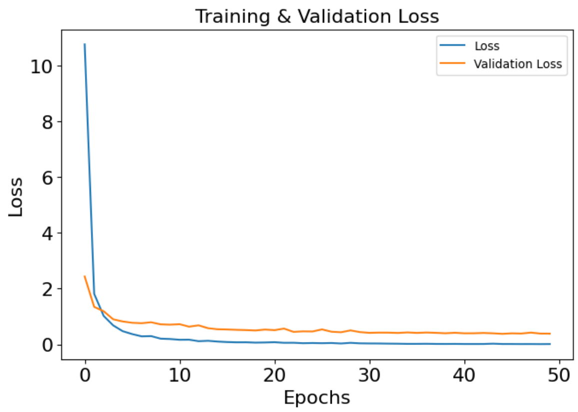


Figure 8: Accuracy and Loss Graph for FCNN

The model seems to perform well in distinguishing between grapes and raisins in the given context.

5 Discussion

Both models, the CNN and FCNN, demonstrated good results in classifying between grapes and raisins. While the CNN model outperformed the FCNN model with an accuracy of 82%, the FCNN model achieved an accuracy of 74%. The difference in accuracy between the CNN and FCNN models arises from their distinct architectures and capabilities.

CNNs are good at finding important details like shapes and colors in pictures, while FCNNs are better at handling structured data like numbers or text, but they might struggle with complex visual patterns. CNNs' complexity and ability to handle diverse image data contribute to their superior performance, especially when trained on a comprehensive dataset. Conversely, FCNNs' simpler structure and potential limitations in feature extraction may result in lower accuracy.

Both model's architectures were built after many trials and errors. We experimented both models with different learning rates and epochs. However we have also used different background images in the test set which were not present in the training set and validation set and finally got the result above 80% in our CNN model. So it can be said that the experiment was successful. If the dataset was larger, we could obtain a better result.