Fingerprint recognition model using AlexNet

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Patryk Maik [1]

Abstract. This paper examines the performance of the three different models for fingerprint recognition. Together as a teamwork, we developed three different algorithms based on AlexNet, ResNet, Logistic Regression. Each of these examples was evaluated on the same dataset. Algorithms were prepared separately by each of the group members and adjusted to an established dataset. They were discussed on three different training levels by sending 25, 50, 100 epochs. The dataset for this project contained 800 images for training and 10 real images for a test. The best performance was achieved by the AlexNet model. Further study on the AlexNet model was conducted as an individual part of this research. I used a larger dataset to compare the results of AlexNet performance. The dataset for this experiment contained 17,931 training images and 600 real images for a test. This study shows that AlexNet performs more efficient on larger datasets as the results were more significant for larger datasets.

1 Introduction

Nowadays, biometrics are widely used to enhance security measures. This way companies can divide the access to sensitive data within sectors. Big companies such as Apple or Microsoft implemented biometric recognition in their products to protect customers drives, computers or phones. These additional security measures are difficult to breach by the attacker without the physical presence of a person that biometrics are required. Common biometrics that is used as a security enhancement includes fingerprints, face, palmprints and, iris recognition. Many types of research have been conducted to develop the most efficient approach for biometrics recognition. The main purpose of this paper is to discuss the developed fingerprint recognition model. Over the years many algorithms have been developed. In minutia matching technique proposed by [6]. authors used global and local structures of minutiae for fingerprint recognition. Another example of fingerprint recognition was suggested by [5]. The authors developed an algorithm that used phase-based image matching and feature-based matching for fingerprint recognition. Although there are many approaches for fingerprint recognition, only several of them used a Convolutional neuron network(CNN). CNN is a deep learning neural network for image recognition. It will only process images in form of arrays. The usage of convolutional layers is equivalent to the structure of the human visual cortex for processing images and identifying more complex characteristics. [13]. AlexNet is a convolutional neuron network that contains five convolutional layers, three max-pooling followed by three fully connected layers whereas two of them use the Relu activation function and the output layer uses the Softmax function. [10]. The AlexNet model presented for my fingerprint model contained additional Dropout layers to prevent model overfitting. Data augmentation was applied to increase the number of training images. Also, the Gaussian Noise layer was implemented to improve the final result and prevent overfitting. The dataset that was used contained images of the fingerprints which was sliced into test dataset that contains images for final evaluation and a training data set which was fed into the model. From the training dataset, we extracted some images for data validation. The AlexNet model outperformed logistic regression and ResNet models trained on the same dataset. Furthermore, the AlexNet model was evaluated in comparison with a much bigger dataset that contained 17,931 images to improve accuracy. This paper will discuss the architecture of the AlexNet model that was developed for this project alongside possible improvements that could be implemented.

2 Background

AlexNet contains 8 layers that can take parameters. Whereas 5 of these layers were convolutional with a combination of 3 max-pooling layers and 3 fully connected layers. Two of the fully connected layers used activation function Relu and the last output layer used activation function Softmax. The model can take a total of about 60 million parameters. To prevent overfitting two dropout layers were implemented. The Dropout layer is a regularization method that is averaging the performance of the model by randomly skipping some of the output layers. [2] Batch Normalisation layers were added to standardize and normalize the input values that were transformed during the process. Flatten layer is changing images into one-dimensional arrays. In AlexNet model architecture, the number of filters increases and the size decreases while the input goes deeper. This means that model extracts more features and decrease in the future map shape.[12] In experiment 1, I had to add additional layers to prevent overfitting of the model. One of the approaches I undertook was to add a Gaussian Noise layer. This layer is a regularization layer and it is only active during training time. Another added layer was data augmentation which was defined as a variable that contained: RandomFlip, RandomRotation, RandomZoom layers. The main purpose of this layer was to produce more training data by randomly changing the zoom, flip or rotate of images. This idea was taken from [4] where the author describes in detail how to use and implement data augmentation. These techniques were added to experiment 1 as the dataset contained only 800 images for training. In experiment 2

[1] School of Computing and Mathematical Sciences, University of Greenwich, London SE10 9LS, UK, email: pm2269u@gre.ac.uk

Gaussian Noise and data augmentation were removed as the dataset was significantly larger.

2.1 Experiment 1:

Experiment 1 was proposed as a teamwork example. This project was built on the FVC2000-DB4-B dataset [7] that was based on the Fingerprint Verification Competition(FVC) 2000 dataset [3]. The dataset contains 10 real images labelled with numbers from 0-9. They represent different fingerprints that were used as test datasets for our project. Also, the dataset has 800 training fingerprints. They were split such as for each class from 0-9 they were 80 examples of fingerprints. Among these 80 fingerprints, they were 8 different fingerprints. For each of these 8 examples, they were 10 copies of the same fingerprint different in shape and quality. A part of the training dataset was split into the set for validation. The main goal of our algorithm is to train our model with a training dataset to check how accurate can it recognize examples in the test dataset that have never been seen before. My algorithm was based on the example presented by [1] where the author implemented AlexNet into a cifiar dataset.

2.2 Experiment 2:

This experiment is my approach built on a different, much bigger data set. This dataset was taken from Sokoto Coventry Fingerprint Dataset (SOCOFing) [11] and code was built on fingerprint gender classification (CNN) [9] and adjusted to AlexNet model. It contains 600 real images which were used as a test data set and 17,931 that were used as the training dataset. For validation, I used 20 percent of the training dataset. I could have used a bigger dataset as [11] contained more images of fingerprints (49270 in total) but my machine could not handle such a large dataset. The main purpose of this experiment was to see how AlexNet will perform on a much bigger dataset. In this example, the output will be the accuracy of the test dataset to establish gender classification. Therefore there were only two classes male 'M' or female 'F'.

3 Experiments and results

3.1 Experiment 1:

In experiment 1, we used three different algorithms on the same dataset to establish which one is the most efficient. The main goal of this experiment was to evaluate trained models on images never seen before (test dataset) to compare accuracy from three different algorithms. All algorithms were trained with 25, 50 and 100 epochs. The results can be observed in figure 1. AlexNet outperformed all of the algorithms with the best accuracy of 90 per cent. Then ResNet with 84 per cent and Logistic Regression with 40 per cent. Although our models were giving promising results on test datasets several factors denote the overfitting issue. In all models, accuracy, loss and validation accuracy, validation loss values were fluctuating. For the AlexNet model, I implemented techniques to overcome the overfitting problem. Nevertheless, the dataset used in this example was too small therefore validation values were better but still not ideal. That triggered the idea to expose AlexNet to a larger dataset.

3.2 Experiment 2:

In experiment 2, I exposed the same AlexNet model to a larger dataset. The main objective of this experiment was to compare how the AlexNet model will perform on a much bigger dataset. Since

No Of Epochs	AlexNet	ResNet	Logistic Regression
25	60%	65%	-
50	90%	74%	40%
100	80%	84%	40%

Figure 1.

sending one epoch for a dataset with 17, 931 images took approximately 15 minutes on my machine. I decided to conduct this experiment on 25 epochs only. The results were more accurate than in experiment 1. Figure 2, represent a comparison of accuracy and validation accuracy on FVC2000-DB4-B dataset [7](image on the right) and SOCOFing dataset [11](on the left). Figure 3, is the same comparison but on the loss and validation loss. Both comparisons showed that validation values were less fluctuating on the bigger dataset. The values were more consistent with the number of epochs trained. This means that the model improved and is more accurate. Additionally, in experiment 2 model achieved an accuracy of 84 per cent(figure4) on the test dataset whereas in experiment 1 after 25 epochs trained accuracy on the test dataset was 60 per cent(figure5). AlexNet performs better on larger datasets as it was originally developed to handle 1.2 million images with 1000 classes [8]. This experiment shows this model could be even more efficient if we increased the number of images.

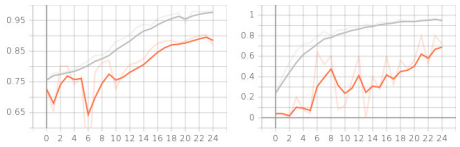

Figure 2.

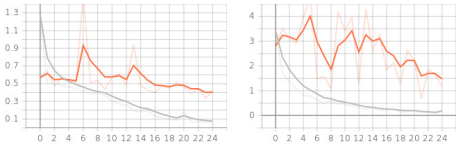

Figure 3.

4 Discussion

In this paper, I conducted two experiments. Experiment one was a teamwork effort whereas experiment 2 was individual work developed for this project.

4.1 Experiment 1:

The first experiment was to distinguish which algorithm among three: AlexNet, ResNet, Logistic Regression performs better on the same dataset. AlexNet was an algorithm proposed by me whereas ResNet and Logistic Regression were approaches presented by my team colleagues. AlexNet outperformed other algorithms with an accuracy of 90 per cent on the test dataset. Although AlexNet performed better on the test dataset it lacks consistency. This means that with more epochs sent accuracy on the test dataset should improve. However, AlexNet model figures showed that the best accuracy was accomplished after sending 50 epochs and after sending 100

Figure 4.

Figure 5.

epochs accuracy decreased to 80 per cent which was not consistent. ResNet model presented more consistent figures as with the number of epochs sent accuracy on test dataset gradually increased. The logistic regression model performed the same on each level of training due to the issues with overfitting.

4.2 Experiment 2:

I used a different larger dataset to compare it with the AlexNet algorithm from experiment 1. AlexNet performed better on a larger dataset. The validation numbers were not fluctuating which was the main objective to exclude the overfitting issue. Also, the model improved on the accuracy-test dataset. For this experiment, I did not include any additional layers that prevent the model from overfitting. This experiment showed that with an even larger dataset we could enhance the current model to recognize fingerprints efficient.

5 Conclusion and future work

In this paper, I discussed different approaches to fingerprint recognition models. I presented the issues that were evaluated and proposed solutions to overcome them. The main subject of this study was the AlexNet model that was thoroughly assessed through comparisons of performance with different models. Additionally, a performance experiment was conducted on the larger dataset for AlexNet. In the future, we could compare the performance of the same model on even larger datasets. The AlexNet model can be used for image classification among different industries. Therefore creativity in its usage is a factor that contributes to future technology development.

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