Augmentation of Small Training Data Using GANs for Enhancing the Performance of Image Classification

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Introduction / Background

- The convolutional neural networks (CNNs) can automatically extract features from the given training images, which significantly improve the accuracy of image classification. However, the traditional deep learning requires a large number of labelled samples for the CNNs to learn sufficient features to prevent the problem of overfitting.
- Methods for data augmentation have been proved capable to increase the diversification from a limited number of image data. The commonly used techniques of data augmentation include geometric transformation, such as reflection, rotation, translation, scaling, cropping and so on, aiming to enlarge the variations of the existing images as augmented training data so that the neural networks can learn from the augmented difference to increase the diversification of classification.
- Proposing a GAN structure can generate high-quality diverse images using a single or very few original images, in which a transformation matrix can be designed to normalise the original image and generate multiple images as simulated original images.

Objectives

Balancing the quality and diversity of the images generated by GANs from one original image only, which overcomes the drawback of traditional GANs that need plenty of original images to generate high-quality images.

Model Designing

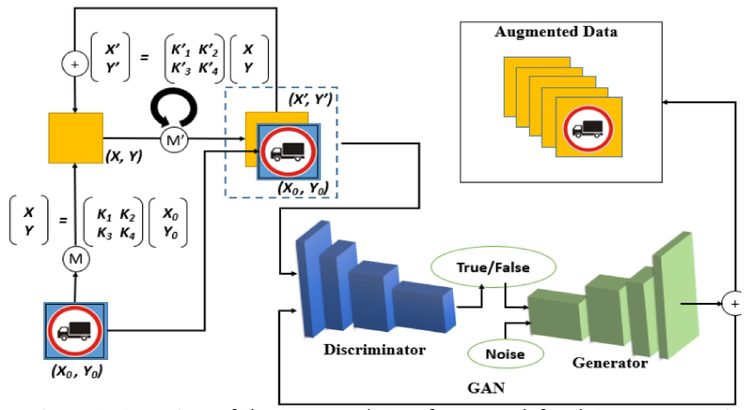

Figure 1. Overview of the proposed GAN framework for data augmentation from a single original image.

- It can augment a single original image or a very small original image dataset.
- The updating of transformation matrices in each batch to the discriminator can be regarded as new images.
- The proposed framework will be able to balance the similarity and diversity of the images generated from input image.

Transformation Matrix *M'*

There are different methods available for designing the transformation matrices *M'*, which can be adaptive or fixed with values assigned based on prior knowledge or experience. In our results, we demonstrated the effect of some simple transformation matrices *M'* with an identity matrix.

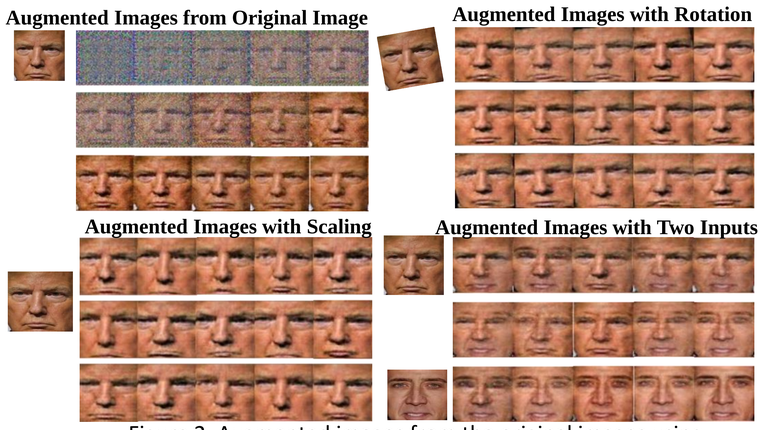

Figure 2. Augmented images from the original images using different transformation matrices *M'*.

Augmentation Results

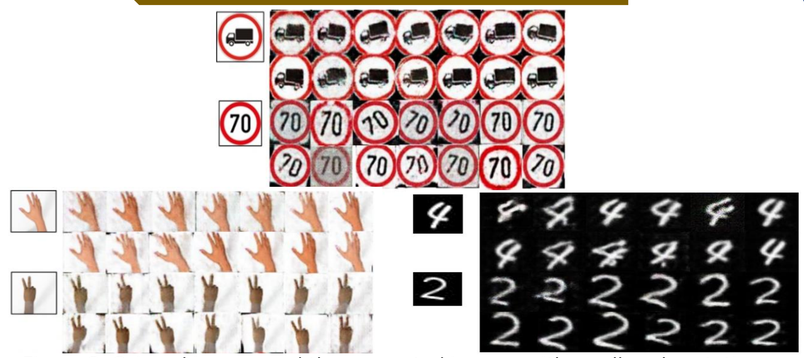

Figure 3. Original images and the generated images with small-scale rotations implemented by matrix M' and larger-scale rotations implemented by matrix M.

Evaluation of Training Data Augmentation for Image Classification

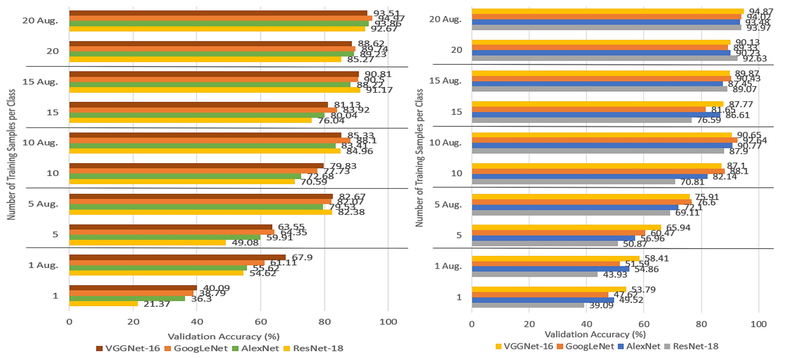

Figure 4. Comparison of validation accuracy of DCNNs on dataset of (a) MNIST and (b) RPS

Conclusion

- It is a new GAN framework with transformation matrices for synthesising images with a good balance between diversity and similarity with original images, which is desirable for training data augmentation with the purpose of enhancing image classification performance of deep neural networks.
- The proposed method for training data augmentation can significantly improve the image classification performance of deep neural networks with limited original training data.