Neural Networks

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Introduction

The Multi-Layer Perceptron (MLP) and **the Convolutional Neural Network (CNN)** are two types of neural networks used for image classification. The MLP treats images as *vectors*, while the CNN exploits their *spatial structure through convolutions*. In this project, we compare their performance on the Fashion MNIST dataset in order to identify which is better suited for this task.

1 Methodology

1.1 Dataset

The Fashion MNIST dataset contains 70,000 images of 28×28 pixels (each pixel having a value between 0 and 255 representing a greyscale level), divided into ten categories of clothing (*T-shirt/top, trouser, pullover, dress, coat, sandal, shirt, sneaker, bag, and ankle boot).*

It is split into :

— 54,000 images for training
— 6,000 images for validation
— 10,000 images for testing

1.2 Model Architectures

MLP : 3 linear layers (784 → 256
→ 128
→ 10) with ReLU activation functions and a Softmax output.

CNN : 2 convolutional layers followed by 2 fully connected layers, with ReLU activations and a Softmax output.

These architectures provide a compromise between performance and training time.

1.3 Training Parameters

— Number of epochs : 50
— Batch size : 64
— Learning rate (LR) : 0.001
— Loss function : MSE
— Optimizer : Adam

2 Results and Discussion

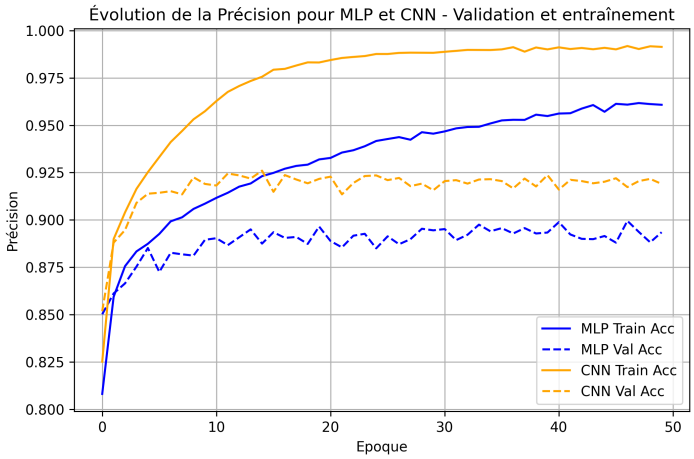

FIGURE 1 – Accuracy as a function of epochs for MLP and CNN (training and validation)

For the MLP, the training accuracy continues to increase while the validation accuracy stagnates, indicating memorization of the dataset. In contrast, for the CNN, both training and validation accuracies stagnate after about 20 epochs, showing that the model learns **general patterns**.

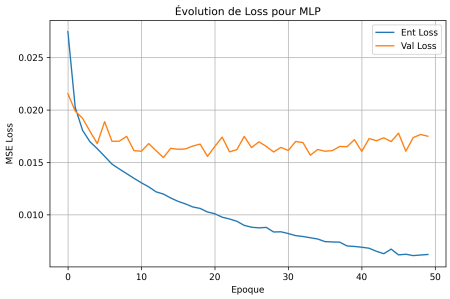

FIGURE 2 – Loss evolution for MLP

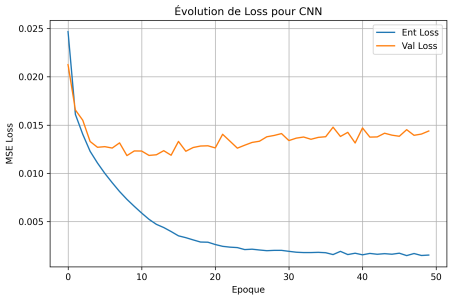

FIGURE 3 – Loss evolution for CNN

Similarly, for the MLP, the training loss decreases while the validation loss remains stable, creating two different evolutions. Unlike the MLP, the two CNN loss curves evolve similarly. This indicates that the MLP shows a slight tendency to overfit.

D'après ces graphiques, on observe que le **MLP** présente une légère tendance à l'**overfitting**, due à l'écart entre entraînement et validation.

Cepandant, en comparant les valeurs métriques d'entrainement, de validation et de test pour les deux modèles :

Model	Training (%)	Validation (%)	Test (%)	Train-Validation Gap (%)
MLP	93.09	89.34	88.65	3.75
CNN	97.25	91.98	91.17	5.27

TABLE 1 – Training, validation, and test accuracies for MLP and CNN

The final accuracy values confirm the trends observed in the curves. For **the MLP**, the **3.75% gap** between training and validation accuracy reflects s**light overfitting** : the model gradually improves on the training set but does not really improve on the validation set. For **the CNN**, even though the **5.27% gap** is slightly larger, **both curves progress together**. Thus, the CNN demonstrates a **good generalization** capacity without strong overfitting.

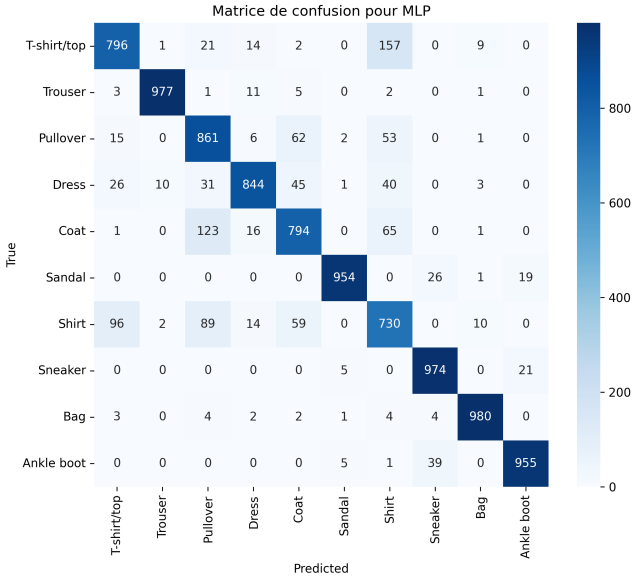

FIGURE 4 – Confusion matrix for MLP

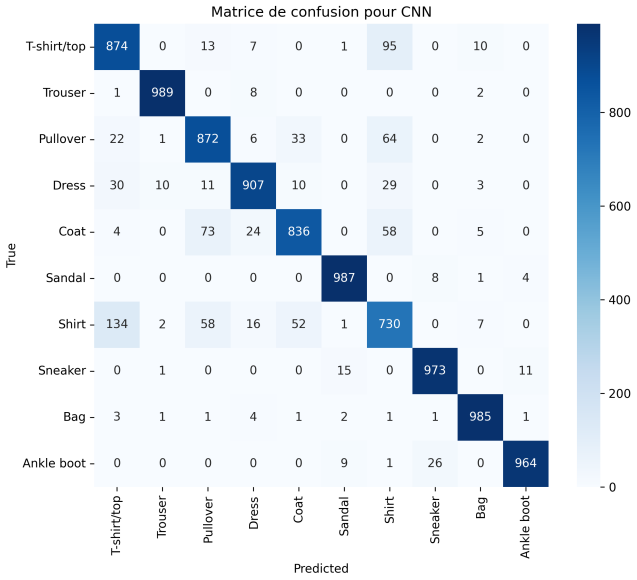

FIGURE 5 – Confusion matrix for CNN

In both confusion matrices, we observe that some types of clothing are misclassified due to confusion between categories. The most common confusions are :

- **T-shirt/top and Shirt**
- **Pullover and Shirt**
- **Pullover and Coat**
- **Shirt and Coat**

These appear as off-diagonal blocks in the confusion matrix, showing recurrent errors between certain categories.

3 Conclusion

This project compared the performance of a **Multi-Layer Perceptron (MLP)** and a **Convolutional Neural Network (CNN)** on the Fashion MNIST classification task. The results show that the **CNN outperforms the MLP** in terms of accuracy on training, validation, and test sets, confirming the effectiveness of convolutional layers for extracting relevant features from images. The analysis of curves and confusion matrices highlights slight overfitting for the MLP, while the CNN demonstrates good generalization. In conclusion, the CNN appears as a more suitable architecture for this type of data, although the MLP remains a simpler and faster-to-train solution.