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BATCH- AIML with Python Program | InternsElite

November/December 2025

Image Classification Using Convolutional Neural Network (CNN)

Colab Link:

https://colab.research.google.com/drive/1T3aW8RZAls4N_IlT0tQqjrCe-Jcs7AlG?usp=sharing

Introduction

With the rapid growth of computer vision applications, image classification has become one of the most important problems in the field of Artificial Intelligence. Image classification involves assigning a label or category to an image based on its visual content. This technology is widely used in real-world applications such as facial recognition, medical imaging, autonomous vehicles, and object detection systems.

Traditional machine learning algorithms struggle to handle raw image data efficiently because images contain a large number of pixels and spatial information. Convolutional Neural Networks (CNNs) are specially designed to overcome this limitation. CNNs automatically extract important features from images using convolution and pooling operations, making them highly effective for image-related tasks.

The objective of this project is to build an image classification system using a Convolutional Neural Network to classify images into different categories accurately.

Problem Statement

The main objective of this project is to design and implement a **Convolutional Neural Network (CNN)** that can classify images into predefined categories based on their visual features.

The problem is formulated as a **multi-class classification task**, where each image belongs to one of several possible classes. The dataset used contains grayscale images of clothing items, and the CNN model is trained to correctly identify the category of each image.

The problem statement can be defined as follows:

Given a dataset of labeled images, design a Convolutional Neural Network that learns visual features and classifies images into their correct categories.

Dataset Description

The dataset used in this project is the **Fashion-MNIST dataset**, which is a standard benchmark dataset for image classification tasks. It consists of grayscale images of fashion items such as shirts, trousers, shoes, bags, and coats.

Each image in the dataset is of size **28 × 28 pixels**, and each image belongs to one of **10 different classes**. The dataset is divided into a training set and a testing set, allowing the model to be evaluated on unseen data.

Fashion-MNIST was chosen for this project because it is well-structured, widely accepted in academia, and suitable for understanding the working principles of Convolutional Neural Networks.

Methodology

The following steps were followed to implement the CNN-based image classification system:

1. **Data Loading and Preprocessing**
   The Fashion-MNIST dataset was loaded directly using TensorFlow. The pixel values were normalized to improve training performance, and the images were reshaped to meet the input requirements of the CNN.
2. **CNN Architecture Design**
   A Convolutional Neural Network was constructed consisting of convolutional layers for feature extraction, pooling layers for dimensionality reduction, and fully connected layers for classification. Dropout was used to reduce overfitting.
3. **Model Compilation**
   The model was compiled using the Adam optimizer and sparse categorical cross-entropy loss function, which is suitable for multi-class classification problems.
4. **Model Training**
   The CNN model was trained on the training dataset for multiple epochs, with a portion of the data reserved for validation to monitor performance during training.
5. **Evaluation and Visualization**
   The trained model was evaluated on the test dataset. Accuracy and loss curves were plotted, and misclassified images were visualized to analyze model behavior.

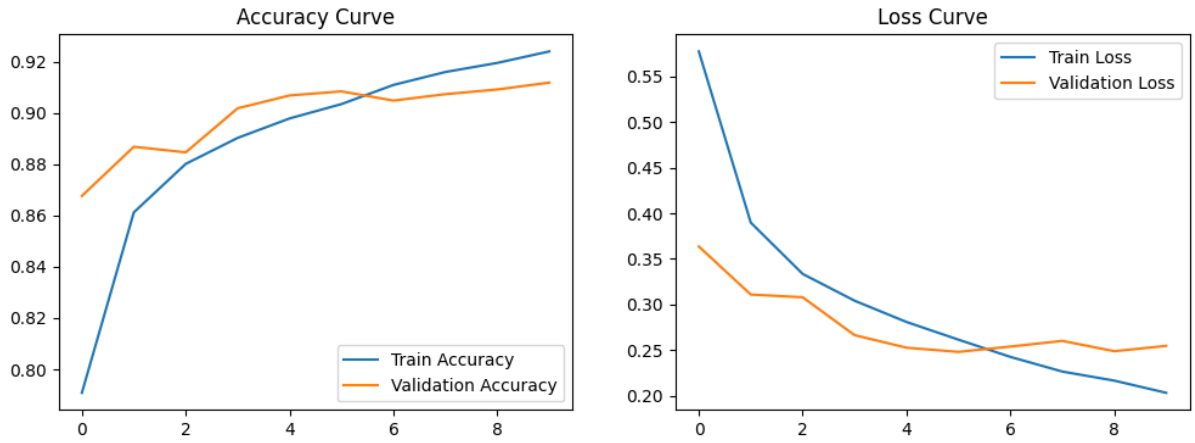
Results and Discussion

The Convolutional Neural Network demonstrated effective learning behavior during training, with increasing accuracy and decreasing loss across epochs. The validation results indicated that the model generalized well to unseen data without significant overfitting.

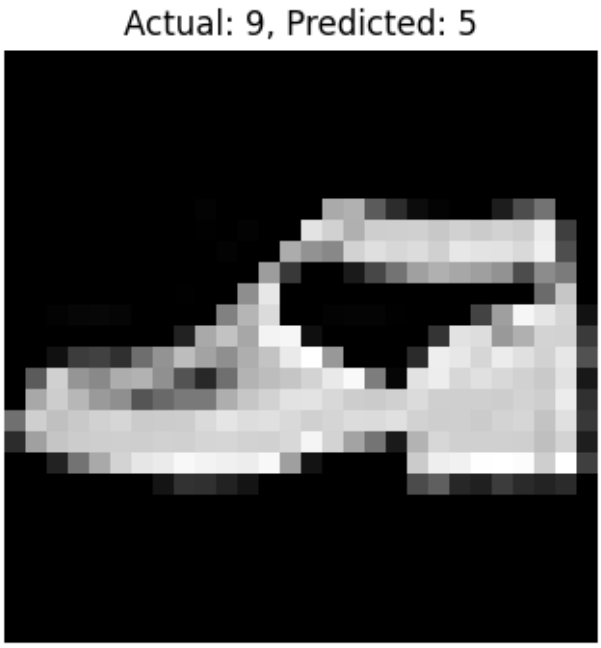
The test accuracy achieved by the model shows that CNNs are highly effective for image classification tasks. The convolutional layers successfully extracted important visual features such as edges, shapes, and patterns, which contributed to accurate classification.

Visualization of misclassified images revealed that most errors occurred between visually similar classes, such as shirts and coats, which is expected due to their overlapping features.

Accuracy Curve & Loss Curve



Misclassified Images



Conclusion

In this project, a Convolutional Neural Network was successfully implemented to classify fashion images into multiple categories. The CNN model efficiently extracted spatial features from images and achieved good classification accuracy on the test dataset.

This project demonstrates the strength of CNNs in handling image data and highlights their importance in real-world computer vision applications. Future improvements may include using data augmentation techniques, deeper network architectures, or transfer learning to further improve accuracy.

Reference

Xiao, H., Rasul, K., & Vollgraf, R. (2017). *Fashion-MNIST: a Novel Image Dataset for Benchmarking Machine Learning Algorithms*. arXiv preprint arXiv:1708.07747.