Noemi Cicala noemi.cicala@estudiantat.upc.edu
Matteo Mazzini matteo.mazzini@estudiantat.upc.edu

Project Proposal: Exploring Image Classification Using CNNs and Kernel Methods

1 Overview

This project aims to explore image classification task by combining two distinct machine learning paradigms: Convolutional Neural Networks (CNNs), known for their effectiveness in image recognition, and kernel-based methods (e.g., Support Vector Machines, SVMs), which excel at classifying data in high-dimensional spaces.

The proposed combination of CNNs and kernel methods involves the following steps:

- Feature Extraction: Train a CNN on an image dataset, leveraging its convolutional layers to learn local features from the images.
- Kernel-Based Classification: Use the features extracted from the CNN (typically from the fully connected layers) as input to an SVM with a kernel for classification. This step will include experimentation to identify the most suitable kernel type (e.g., RBF, polynomial, or linear).
- Comparison: Benchmark the combined CNN-SVM approach against a standard CNN classifier to evaluate performance improvements.

2 Motivation and Benefits

This hybrid approach is promising due to several potential advantages:

- Improved Non-Linear Separation: Kernel methods enable non-linear class separation, which can be beneficial in scenarios where CNNs alone struggle to fully separate complex classes.
- Flexibility: The approach allows for experimentation with different kernel types and configurations, adapting to the specific complexity of the classification task.

3 Challenges and Considerations

Despite its potential, this approach presents certain challenges:

- Computational Complexity: Training a SVM with kernels on high-dimensional CNN embedding features can be computationally expensive, especially for large datasets. Balancing accuracy and computational cost will be a key focus.
- Robustness of the model: Ensuring that the hybrid model maintains strong performance across different scenarios and real-world conditions is essential for practical deployment.

4 Conclusions

This project aims to bridge the gap between neural networks and kernel methods, providing insights into their complementary strengths in image classification tasks.

References

[1] Niu, Xiao-Xiao and Suen, Ching Y. *A novel hybrid CNN–SVM classifier for recognizing handwritten digits*. Pattern Recognition, 45(4):1318–1325, 2012. Elsevier.

[2] Jiang, Shihao and Hartley, Richard and Fernando, Basura. *Kernel Support Vector Machines and Convolutional Neural Networks*. In: 2018 Digital Image Computing: Techniques and Applications (DICTA), pp. 1-7, 2018.

[3] Cortes Corinna, Vladimir Vapkin. *Support-Vector Networks*. Machine Learning, 1995.