DSP577: Project Proposal

Project Title:
Performance and Resource Trade-Off Analysis of Neural Networks and Support Vector Machines on Pneumonia Detection

Project Group:
Leonardo Pinheiro, Sedat Touray, Mary Klimasewiski

Aims of the Project

The title of the project is: Performance and Resource Trade-Off Analysis of Neural Networks and Support Vector Machines on Pneumonia Detection. The objective of this project is to analyze the trade-offs between computational efficiency and model performance in medical imaging applications. Using the RSNA Pneumonia Detection 2018 dataset, this project will address two key questions:

1. Will a deep learning model always outperform a traditional machine learning model?

2. When should computational efficiency influence model selection?

To answer these questions, this project will compare the performance of two classification models: a multi-layer Feed-Forward Neural Network (FFNN) and a Support Vector Machine (SVM). Both models will be evaluated based on key classification metrics and computational efficiency. The expected solution is that the SVM model will be able to perform comparatively well to the FFNN model in resource-constrained environments. By providing a quantitative comparison of FFNN and SVM models, this study aims to offer practical recommendations for selecting machine learning models in healthcare data analysis.

Methods

The RSNA Pneumonia Detection Challenge 2018 dataset is a multivariate dataset. This project will analyze a subset of the dataset, specifically 5,840 frontal view chest radiographs. The data set consists of six features designed to classify evidence of pneumonia from analysis of patient chest X-ray images. The analysis will begin with exploratory data analysis (EDA) to gain insights into the dataset. The dataset contains 1,575 images of a normal chest X-ray and 4,265 images of a chest X-ray with evidence of pneumonia. As a result, there is evidence of class imbalance. During the preprocessing, class imbalance, and missing values and inconsistencies will be identified and addressed. Specifically, oversampling and under sampling techniques will be considered to address the class imbalance and removal of data inconsistences will be considered to address any missing values in the data set. Additionally, the images will be resized and normalized to ensure compatibility with the models. The dataset will then be split into

training, validation, and test sets for evaluation. Two classification models will be developed and analyzed: A FFNN developed using TensorFlow and an SVM classifier developed using scikit-learn. These models were selected because a FFNN can learn and analyze complex patterns, specifically related to image analysis. However, FFNN perform best on large datasets and rely heavily on hyperparameter tuning. As a result, the FFNN model will undergo hyperparameter tuning and will be trained on the training set. The SVM model can perform well on smaller datasets where deep learning models can often overfit the data. Further, SVM models also require hyperparameter tuning to be successful and more resistant to overfitting. Our analysis will include dimensionality reduction techniques like Principal Component Analysis (PCA) applied before evaluation to improve model performance. In addition, the SVM model will have key hyperparameters tuned, including the kernel type and the regularization parameter. The SVM model will be trained on the training set. After tuning and training both models, their performance will be evaluated on the test set. The outputs of interest are model performance and computational efficiency metrics. Model performance will be evaluated using standard classification metrics such as accuracy, precision, recall, and F1-score. Computational efficiency, including training time, runtime, and resource utilization (CPU/GPU), will be analyzed and compared.

Feature	Description
patiendID	Each patient idea is associated with a unique X-ray image
X	Upper left x-coordinate of the bounding box
Y	Upper left y-coordinate of the bounding box
Width	Width of the bounding box
Height	Height of the bounding box
Target	Binary target: 1 = evidence of pneumonia, 0 = no evidence of pneumonia

Possible Outcomes

The result of our analysis of both the FFNN and SVM models will provide valuable insights into use cases for deep learning and traditional machine learning approaches in healthcare data analysis. One potential outcome is that the deep learning model will achieve higher classification accuracy but at the cost of increased computational requirements. Conversely, the analysis could support evidence that in resource-constrained settings, traditional machine learning models such as SVM are able to deliver

comparable performance metrics to deep learning models. The metrics for success for this project will be a comparative analysis of the key classification metrics and computational performance metrics. Specifically, accuracy, precision, recall, and F1-score will be analyzed and compared for each model. Further, computational efficiency, including training time, runtime, and resource utilization (CPU/GPU), will be analyzed and compared. A comparative analysis will provide insight into the strengths and limitations of deep learning and traditional machine learning models in the context of healthcare applications. Our project deliverables are as follows: by the end of Week 3 we will have completed our data wrangling and EDA. For Week 4 our deliverables include model implementation of the FFNN and SVM models. Specifically, we plan to have hyperparameters tuned for each model and evaluate both models on the trained data. For Week 5 our deliverables include a performance evaluation, computing the evaluation metrics, analyzing training and runtimes and recording resource usage of both models. For Week 6 our deliverables include a completed trade-off analysis, documentation and presentation. Specifically documenting the methodologies, results and key finding in a report and creating a presentation summarizing the project goals, implementation, results and recommendations. For Week 7 we expect our deliverables to be complete and to have a quantitative comparison of FFNN and SVM in pneumonia detection, a detailed analysis of computational costs associated with each model and practical recommendations for selecting machine learning models in the healthcare field. The analysis will help determine whether a deep learning model is necessary for complex tasks such as pneumonia detection using medical imaging data.

Implications

The findings of this project will offer a comprehensive quantitative comparison between a FFNN and a SVM model for pneumonia detection using medical imaging data. By analyzing both classification performance and computational efficiency, this study will provide practical recommendations for selecting machine learning approaches in healthcare applications. The results of this study will be informative to resource-constrained environments where the cost of computational efficiency is premium.

With large amounts of data being collected and analyzed in the healthcare field, this study will highlight model trade-offs and help guide healthcare professionals to make informed decisions when selecting models for medical imaging analysis. In addition, this project collectively applies each team members expertise and will positively impact each of our careers. Leonardo has a background in mathematics and is proficient in mainstream supervised and unsupervised machine learning techniques. This project will provide Leonardo with a practical application of those machine learning techniques by developing a project to add to his portfolio. In addition, this project will expand and diversify Leonardo's professional portfolio by including a project that works with deep learning as well as machine learning. Sedat has a professional background as a technology analyst. This project will be beneficial to his own learning and career because he is hoping to expand his data science portfolio. Sedat has academic and professional experience in technical writing, coding and presenting and this project serves as a valuable tool to demonstrate each of those skills. Mary has a background in data preprocessing and analysis. This project will positively impact Mary's learning and career as an addition to her portfolio. Specifically, adding a deep learning and image processing project to her portfolio will help demonstrate the range of her technical expertise. Further, this project will provide a practical application of data analysis to her portfolio. Being able to use data analysis as a tool to solve real-world problems connects closely to her professional career.

<div align="center">**<u>Conclusion</u>**</div>

This project will provide a comprehensive quantitative comparison of FFNN and SVM models by analyzing medical imaging data to classify pneumonia detection using patient chest X-ray images. By evaluating classification performance metrics and computation efficiency, this study will provide valuable insights into model selection for practical healthcare applications. Specifically, this study will determine whether deep learning models are necessary to achieve high classification accuracy in medical imaging analysis. Additionally, this study will compare the computational efficiency of both models to provide practical recommendations for model selection in resource-constrained environments. The findings of this

study will provide actionable recommendations for optimizing machine learning model performance in healthcare data analysis.