Project Proposal: Improving Cardiovascular Disease Prediction Models with Explainable AI

Project Objective

To develop an advanced deep learning model for predicting cardiovascular disease (CVD) and integrate explainable AI techniques to identify which features most significantly influence the model's predictions. The goal is to compare the results from the explainable AI with the findings from an exploratory data analysis to verify the consistency of identified risk factors.

Background

From the exploratory data analysis conducted using the UCI heart disease dataset, several key factors contributing to cardiovascular disease were identified, such as chest pain type, maximum heart rate achieved, and serum cholesterol levels. Previous deep learning and machine learning models developed for predicting cardiovascular diseases showed promising results but lacked interpretability.

Tasks

Data Preparation

1. Use the UCI heart disease dataset (or an equivalent dataset) for model training and evaluation.
2. Perform data cleaning, normalization, and splitting into training, validation, and test sets.

Model Development

1. Develop and fine-tune a deep learning model architecture for predicting cardiovascular disease. Consider models such as Convolutional Neural Networks (CNN), Long Short-Term Memory networks (LSTM), or a hybrid CNN-LSTM model.
2. Experiment with various hyperparameters to optimize the model's performance.

Integration of Explainable AI

1. Implement explainable AI techniques such as SHAP (SHapley Additive exPlanations) or LIME (Local Interpretable Model-agnostic Explanations) to interpret the model's predictions.
2. Analyze the contribution of each feature to the prediction outcomes.

Comparison and Validation

1. Compare the explainable AI results with the findings from the exploratory data analysis.
2. Verify if the features identified as significant in the exploratory analysis (such as chest pain type, maximum heart rate, and serum cholesterol) are also highlighted by the explainable AI.

Documentation and Reporting

1. Document the model development process, including data preprocessing, model architecture, hyperparameter tuning, and evaluation metrics.
2. Prepare a comprehensive report summarizing the findings, including visualizations of the model's performance and the explainable AI results.

Detailed Project Plan

1. Data Preparation

1. Import necessary libraries (Pandas, NumPy, Scikit-learn, TensorFlow/Keras, SHAP, etc.).
2. Load the UCI heart disease dataset.
3. Clean the data by handling missing values, outliers, and duplicates.
4. Normalize continuous variables and one-hot encode categorical variables.
5. Split the dataset into training (70%), validation (15%), and test (15%) sets.

2. Model Development

1. **Model Architecture:**
   - Design a CNN, LSTM, or hybrid CNN-LSTM model.
   - Use ReLU activation functions, batch normalization, and dropout for regularization.
   - Implement an output layer with a softmax activation function for binary classification.
2. **Hyperparameter Tuning:**
   - Experiment with different learning rates, batch sizes, and epoch numbers.
   - Use callbacks such as EarlyStopping and LearningRateScheduler to optimize training.

3. Integration of Explainable AI

1. **SHAP Implementation:**
   - Train the model and use the SHAP library to calculate SHAP values for the test set.
   - Generate SHAP summary plots, dependence plots, and force plots to visualize feature importance.
2. **LIME Implementation (Optional):**
   - Apply LIME to interpret individual predictions and validate the consistency of the SHAP results.

4. Comparison and Validation

1. **Analysis:**
   - Compare the features identified by SHAP/LIME with the factors revealed in the exploratory data analysis.
   - Validate if features such as chest pain type, maximum heart rate, and serum cholesterol levels are consistently highlighted.

5. Documentation and Reporting

1. **Documentation:**
   - Record each step of the data preprocessing, model development, and explainable AI integration processes.
   - Maintain a detailed log of hyperparameter tuning and model performance metrics.
2. **Reporting:**
   - Prepare a report summarizing the project objectives, methodology, results, and conclusions.
   - Include visualizations of the model performance (e.g., accuracy, ROC curves) and explainable AI results (e.g., SHAP plots).

References

1. Exploratory data analysis insights from *RKANNAN_Project_Report.pdf*.
2. Machine learning model development details from *cvs_paper.pdf*.