Human Activity Recognition Using Smartphones

1. Introduction

Human Activity Recognition (HAR) is an essential application of machine learning, where sensor data is used to classify human actions such as walking, sitting, and standing. This project evaluates the performance of various machine learning models on the **Human Activity Recognition Using Smartphones Dataset** from the UCI Machine Learning Repository. Our primary objective is to compare the model performance based on different feature extraction techniques:

- **Raw Inertial Data**
- **TSFEL Extracted Features**
- **Features Provided by Dataset Authors**

2. Dataset Description

The dataset consists of recordings of 30 subjects performing daily activities while wearing a smartphone on their waist. The phone captured accelerometer and gyroscope data at a frequency of 50Hz. The dataset includes:

- **Raw inertial signals** from accelerometers and gyroscopes.
- **Feature-engineered dataset** created by the original authors, containing a set of handcrafted features.

The activities classified are:

1. Walking
2. Walking Upstairs
3. Walking Downstairs
4. Sitting
5. Standing
6. Laying

3. Methodology

3.1 Evaluating Raw Inertial Data Using an LSTM Model

Long Short-Term Memory (LSTM) networks are well-suited for sequential data like sensor readings. We applied an LSTM-based deep learning model to classify activities based on raw inertial data. The output variables were **one-hot encoded** to match the classification framework.

Results:

- **Training Accuracy:** 94.29%
- **Validation Accuracy:** 95.92%
- **Test Accuracy:** 93.04%

3.2 Feature Extraction Using TSFEL

To analyze the impact of feature engineering, we extracted features from the raw inertial data using the **TSFEL (Time Series Feature Extraction Library)**. This library computes a wide range of time-domain, frequency-domain, and statistical features, converting raw sensor data into meaningful inputs for machine learning models.

We trained multiple machine learning models using the TSFEL-generated features:

- **Logistic Regression**
- **Decision Tree Classifier**
- **Random Forest Classifier**
- **Gradient Boosting Classifier**
- **K-Nearest Neighbors (KNN)**
- **XGBoost Classifier**
- **Support Vector Classifier (SVC)**

Best Performing Model:

- **SVC (Support Vector Classifier) with an accuracy of 95.31%**

3.3 Evaluating Features Provided by Dataset Authors

The dataset authors provided a feature-engineered version of the dataset containing handcrafted statistical and frequency-based features. We trained the same machine learning models on this dataset to compare performance.

Best Performing Model:

- **Logistic Regression with an accuracy of 95.86%**

4. Comparison of Model Performances

Feature Set	Best Model	Accuracy (%)
Raw Inertial Data	LSTM	93.04
TSFEL Extracted Features	SVC	95.31
Author-Provided Features	Logistic Regression	95.86

5. Conclusion

1. **TSFEL-extracted features** enhanced the performance of traditional machine learning models, with SVC achieving a high accuracy of 95.31%.
2. **Features provided by dataset authors** yielded the best results, with Logistic Regression achieving 95.86% accuracy, indicating the robustness of handcrafted features.
3. Raw inertial data performed well with **LSTM**, showing an accuracy of 93.04 on test data