ML PROJECT REPORT

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TOPIC - Freezing of gait detection in parkinson’s disease

FOG is a condition often experienced by individuals with Parkinson's disease, where they temporarily feel unable to move, particularly while walking. Detecting these episodes is crucial for improving patient safety and mobility.

Symptoms:

- Sudden stopping while walking.
- Difficulty starting to walk, often described as a "frozen" sensation.
- Short, shuffling steps.

OBJECTIVE:

The primary objective of this project is to develop a comprehensive ensemble learning model for analyzing and predicting freezing of gait (FOG) in patients with Parkinson's Disease. By integrating various data types—including medical records, movement patterns, and sensor data—this model aims to identify patterns and key indicators that signal FOG episodes. The use of ensemble learning techniques allows for improved prediction accuracy by combining the strengths of multiple algorithms, thereby enhancing the model's ability to capture the complex interplay of factors contributing to FOG. Ultimately, this project seeks to provide insights that could lead to better management and treatment strategies for patients experiencing FOG.

DATASETS USED FOR IMPLEMENTATION:

1.Daphnet Dataset -

The dataset comprises 3 wearable wireless acceleration sensors recording 3D acceleration at 64 Hz. The sensors are placed at the ankle (shank), on the thigh just above the knee, and on the hip.

1.Mendley Dataset-

Sensors used – **Accelerometers:** (X,Y,Z axes on L,R shank, arm , waist)

Gyroscopes: (X,Y,Z axes on L,R shank, arm , waist)

Electromyography (EMG): Placed on muscles involved in gait

Electroencephalography (EEG): Electrodes placed on the scalp.

Skin Conductance Sensors: Measures the electrical conductance of the skin

3.**physionet dataset-** Available but not implemented due to lack of labelled FOG events .

METHODOLOGY

1.Dataset collection

2.Data pre-processing (handling missing values , balancing the data, removing outliers , removing duplicates in the data , normalization/standardization)

3.Approaches used :-

- Bagstacking(5 lightGBM base models, random forest meta learner) (using k—fold cross validation)
- Bagstacking (lightgbm , logistic regression , SVM , Random Forest are the base models , and Random forest as the meta learner) (using k—fold cross validation)
- Using models like lightgbm , svm , random forest , XGboost individually to compare the results (k-fold cross validation is used)

4.Final evaluation using evaluation metrics like Accuacy , precesion , recall , F1 score , MAP (Mean absolute prediction) etc…

K-Fold Cross Validation (In Bootstrap sampling) :-

- After dividing the data into train and test dataset (80:20 , 70:30,60:40,50:50 respectively) we apply k-fold (k=5) cross validation on the training dataset .
- The models (particularly the base models in bagstacking) were trained on the 4-fold of the training data and validated on the remaining data .
- The base models make predictions on all fold of the data finally creating a new predictions dataset for training the meta learner in case of bagstacking

Evaluation metrics Table (for Dataset -1)

1.Bagstacking approach (5 lighGBM models and 1-Random Forest

Train-Test Split	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error (MAE)
80:20	0.9440	0.9441	0.9440	0.9441	0.0653
70:30	0.9432	0.9433	0.9432	0.9432	0.0661
60:40	0.9437	0.9438	0.9437	0.9437	0.0656
50:50	0.9432	0.9433	0.9432	0.9432	0.0660

2. BagStacking with a Mix of Models (LightGBM, SVM, Random Forest, Logistic Regression as Base Models, and Random Forest as Meta-Learner)

	A	B	C	D	E	F	G	H
1	ain-Test Sp	Model	Accuracy	Precision	Recall	F1 Score	solute Error (MAE)	
2	50:50	Base Mod	0.5943	0.5997	0.5943	0.5877	0.5177	
3	50:50	Base Mod	0.5929	0.6004	0.5929	0.5844	0.5235	
4	50:50	Base Mod	0.8438	0.8543	0.8438	0.8412	0.1819	
5	50:50	Base Mod	0.9347	0.9349	0.9347	0.9348	0.0763	
6	50:50	Meta-Lear	0.9352	0.9354	0.9352	0.9353	0.0758	
7	80:20	Base Mod	0.5937	0.5993	0.5937	0.5872	0.5189	
8	80:20	Base Mod	0.5929	0.6006	0.5929	0.5844	0.5238	
9	80:20	Base Mod	0.8452	0.8568	0.8452	0.843	0.1817	
10	80:20	Base Mod	0.9348	0.935	0.9348	0.9348	0.0765	
11	80:20	Meta-Lear	0.9356	0.9358	0.9356	0.9357	0.0757	
12	70:30	Base Mod	0.594	0.5996	0.594	0.5875	0.5183	
13	70:30	Base Mod	0.5928	0.6006	0.5928	0.5842	0.524	
14	70:30	Base Mod	0.84	0.8508	0.84	0.8374	0.187	
15	70:30	Base Mod	0.9363	0.9366	0.9363	0.9364	0.0749	
16	70:30	Meta-Lear	0.9365	0.9367	0.9365	0.9365	0.0747	
17	60:40	Base Mod	0.594	0.5995	0.594	0.5875	0.518	
18	60:40	Base Mod	0.593	0.6005	0.593	0.5844	0.5234	
19	60:40	Base Mod	0.8468	0.8564	0.8468	0.8447	0.1786	
20	60:40	Base Mod	0.9353	0.9355	0.9353	0.9354	0.0758	
21	60:40	Meta-Lear	0.9358	0.9359	0.9358	0.9358	0.0753	
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3.XGBoost

	A	B	C	D	E	F	G	H
1	ain-Test Sp	Dataset	Accuracy	Precision	Recall	F1 Score	solute Error (MAE)	
2	80:20	Out-of-Fol	0.9042	0.906	0.9042	0.9039	0.112	
3	80:20	Test	0.9031	0.9047	0.9031	0.9029	0.1118	
4	70:30	Out-of-Fol	0.9042	0.9059	0.9042	0.9039	0.1124	
5	70:30	Test	0.9034	0.9049	0.9034	0.9032	0.1116	
6	60:40	Out-of-Fol	0.9035	0.9054	0.9035	0.9033	0.1129	
7	60:40	Test	0.9028	0.9043	0.9028	0.9025	0.1123	
8	50:50	Out-of-Fol	0.904	0.9058	0.904	0.9037	0.112	
9	50:50	Test	0.9035	0.9051	0.9035	0.9032	0.1113	
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4.Random forest

RF_Train_Accuracy

L	M	N	O	P	Q	R	S	T	U
Train_Accu	Train_Preci	Train_Rec	F_Train_F	_Train_M	Test_Accu	Test_Preci	_Test_Rec	RF_Test_F1	F_Test_
0.8448	0.8553	0.8448	0.8422	0.1809	0.844	0.8536	0.844	0.8416	0.18
0.845	0.8558	0.845	0.8425	0.1806	0.8436	0.8533	0.8436	0.8411	0.18
0.8449	0.856	0.8449	0.8424	0.1811	0.8436	0.8535	0.8436	0.8411	0.18
0.8452	0.8562	0.8452	0.8426	0.1802	0.8442	0.8542	0.8442	0.8417	0

5.lightGBM

Train-Test Split	Average Accuracy (Train)	Average Precision (Train)	Average Recall (Train)	Average F1 Score (Train)	Average Mean Absolute Error (Train)	Accuracy (Test)	Precision (Test)	Recall (Test)	F1 Score (Test)	Mean Absolute Error (Test)
80:20	0.9362	0.9364	0.9362	0.9363	0.0748	0.9348	0.9350	0.9348	0.9348	0.0765
70:30	0.9360	0.9362	0.9360	0.9360	0.0750	0.9363	0.9366	0.9363	0.9364	0.0749
60:40	0.9362	0.9364	0.9362	0.9363	0.0747	0.9353	0.9355	0.9353	0.9354	0.0758
50:50	0.9358	0.9360	0.9358	0.9359	0.0750	0.9347	0.9349	0.9347	0.9348	0.0763

6.SVM

Train-Test Split	Average Accuracy (Train)	Average Precision (Train)	Average Recall (Train)	Average F1 Score (Train)	Average Mean Absolute Error (Train)	Accuracy (Test)	Precision (Test)	Recall (Test)	F1 Score (Test)	Mean Absolute Error (Test)
80:20	0.5930	0.6003	0.5930	0.5844	0.5230	0.5929	0.6006	0.5929	0.5844	0.5238
70:30	0.5927	0.6000	0.5927	0.5840	0.5234	0.5928	0.6006	0.5928	0.5842	0.5240
60:40	0.5932	0.6005	0.5932	0.5845	0.5230	0.5930	0.6005	0.5930	0.5844	0.5234
50:50	0.5930	0.6002	0.5930	0.5843	0.5231	0.5929	0.6004	0.5929	0.5844	0.5235

FOR Dataset-2

1. .Bagstacking approach (5 lightGBM models and 1-Random Forest)

Train-Test Split	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	0.9929	0.9929	0.9929	0.9929	0.0071
50:50	0.9943	0.9943	0.9943	0.9943	0.0057

2.XGBoost

Train-Test Split	Type	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	Cross-Validation (Training)	0.9982	0.9983	0.9982	0.9982	0.0018
	Test Set Results	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	Cross-Validation (Training)	0.9980	0.9980	0.9980	0.9980	0.0020
	Test Set Results	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	Cross-Validation (Training)	1.0000	1.0000	1.0000	1.0000	0.0000
	Test Set Results	0.9929	0.9929	0.9929	0.9929	0.0071
50:50	Cross-Validation (Training)	0.9944	0.9947	0.9944	0.9944	0.0056
	Test Set Results	0.9943	0.9943	0.9943	0.9943	0.0057

3.Random Forest

Train-Test Split	Type	SS Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	Cross-Validation (Training)	0.9982	0.9983	0.9982	0.9982	0.0018
	Test Set Results	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	Cross-Validation (Training)	0.9960	0.9960	0.9960	0.9960	0.0040
	Test Set Results	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	Cross-Validation (Training)	0.9976	0.9977	0.9976	0.9976	0.0024
	Test Set Results	0.9929	0.9929	0.9929	0.9929	0.0071
50:50	Cross-Validation (Training)	0.9944	0.9947	0.9944		

4.SVM

Train-Test Split	Type	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	Cross-Validation (Training)	0.9952	0.9952	0.9952	0.9952	0.0048
	Test Set Results	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	Cross-Validation (Training)	0.9962	0.9962	0.9962	0.9962	0.0038
	Test Set Results	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	Cross-Validation (Training)	0.9970	0.9970	0.9970	0.9970	0.0030
	Test Set Results	0.9929	0.9929	0.9929	0.9929	0.0071
50:50	Cross-Validation (Training)	0.9937	0.9938	0.9937	0.9937	0.0063
	Test Set Results	0.9943	0.9943	0.9943	0.9943	0.0057

5.LightGBM

Train-Test Split	Type	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	Cross-Validation (Training)	0.9982	0.9983	0.9982	0.9982	0.0018
	Test Set Results	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	Cross-Validation (Training)	0.9960	0.9960	0.9960	0.9960	0.0040
	Test Set Results	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	Cross-Validation (Training)	0.9976	0.9977	0.9976	0.9976	0.0024
	Test Set Results	0.9929	0.9929	0.9929	0.9929	0.0071
50:50	Cross-Validation (Training)	0.9944	0.9947	0.9944		

6.BagStacking with a Mix of Models (LightGBM, SVM, Random Forest, Logistic Regression as Base Models, and Random Forest as Meta-Learner):

Train-Test Split	Model	Accuracy	Precision	Recall	F1 Score
80:20	LogisticRegression	0.9930	0.9931	0.9930	0.9930
80:20	SVC	0.9930	0.9931	0.9930	0.9930
80:20	RandomForestClassifier	0.9930	0.9931	0.9930	0.9930
80:20	LGBMClassifier	0.9930	0.9931	0.9930	0.9930

Train-Test Split	Model	Accuracy	Precision	Recall	F1 Score
70:30	LogisticRegression	0.9953	0.9953	0.9953	0.9953
70:30	SVC	0.9953	0.9953	0.9953	0.9953
70:30	RandomForestClassifier	0.9953	0.9953	0.9953	0.9953
70:30	LGBMClassifier	0.9953	0.9953	0.9953	0.9953

Train-Test Split	Model	Accuracy	Precision	Recall	F1 Score
60:40	LogisticRegression	0.9965	0.9965	0.9965	0.9965
60:40	SVC	0.9965	0.9965	0.9965	0.9965
60:40	RandomForestClassifier	0.9929	0.9929	0.9929	0.9929
60:40	LGBMClassifier	0.9929	0.9929	0.9929	0.9929

Train-Test Split	Model	Accuracy	Precision	Recall	F1 Score
50:50	LogisticRegression	0.9972	0.9972	0.9972	0.9972
50:50	SVC	0.9972	0.9972	0.9972	0.9972
50:50	RandomForestClassifier	0.9943	0.9943	0.9943	0.9943
50:50	LGBMClassifier	0.9972	0.9972	0.9972	0.9972

Meta-model performance

Train-Test Split	Accuracy	Precision	Recall	F1 Score	Mean Absolute Error
80:20	0.9930	0.9931	0.9930	0.9930	0.0070
70:30	0.9953	0.9953	0.9953	0.9953	0.0047
60:40	0.9965	0.9965	0.9965	0.9965	0.0035
50:50	0.9972	0.9972	0.9972	0.9972	0.0028

Overall Performance:

Dataset-1:

Performance varied more significantly across models. Random Forest with BagStacking was the strongest performer, with an accuracy of 0.9440, while XGBoost had 0.9031. LightGBM was also strong with 0.9363.

Other models, such as SVM, performed notably weaker, with SVM achieving a maximum accuracy of 0.5930.

Dataset-2:

The performance was more consistent across all models. Most models achieved high metrics, with accuracy ranging from 0.9930 to 0.9972.

No model showed a drastic difference from others, indicating uniformity in performance and more stable results across different algorithms.