1. Introduction

This report presents a comprehensive evaluation of three popular machine learning models: Neural Networks, Random Forests, and Support Vector Machines (SVM), across different cross-validation setups. The aim is to identify the model and parameter configuration that yields the highest classification accuracy in our dataset.

2. Methodology

We employed three types of cross-validation methods to evaluate the robustness of the models:

- **K-Fold Cross-Validation:** The dataset was divided into (K = 4, 5, 6, 8) subsets. Each subset was used as a training set sequentially, with the remaining subsets forming the test set.
- **Subject-Wise Cross-Validation:** The dataset was divided into sub-groups of (N = 4, 5, 6) participants. Data from each sub-group was used as a training set sequentially, with the remaining sub-groups forming the test set.
- **Trial-Wise Cross-Validation:** The dataset was divided into sub-sets of (T = 22, 24, 26) trials. Each sub-set was used as a training set sequentially, with the remaining trials forming the test set.

Model Configurations and Hyperparameters:

A. Neural Networks (NN)

- **Training Specifications:**
    - Batch Size: 32 or 64
    - Epoch: 150 or 200
    - Patience: 20 (related to validation loss)
    - Learning Rate Decay: Factor of 10 (related to validation loss)
    - Validation Split: 20%
    - Optimizer: ADAM
        - Learning Rate: 0.0001
        - Beta_1: 0.9
        - Beta_2: 0.999
    - Number of neurons in each layer:
        - (3,3), (3,8), (3,6,6), (3,16,8), (3,16,8,4), (16,8,8), (32,16,8), (32,16,16,8)
- The number of different architectures: 8

B. Random Forest

- **Training Specifications:**
    - Number of decision trees: 10, 50
    - Maximum depth of each tree: 2, 5, 10
    - Minimum number of samples required to split a node: 2, 5

- The number of different architectures: 12

C. Support Vector Machine (SVM)

- **Training Specifications:**
  - Regularization parameter: 0.1, 1, 10
  - Kernel: Polynomial, Radial Basis Function (RBF)
  - Degree: 3, 4, 5
  - Gamma: Scale, Auto
- The number of different architectures: 24

3. Results

The evaluation metrics focused on classification accuracies for each class and overall accuracy. The Random Forest model demonstrated superior performance with the following optimal configuration:

- **Number of decision trees:** 10
- **Maximum depth of each tree:** 10
- **Minimum number of samples required to split a node:** 5

This configuration achieved the highest overall accuracy, particularly when using the subject-wise, with the number of folds (k) set to 6, cross-validation setup.

4. Discussion

In our evaluation, we considered the performance of each model across all cross-validation methods (k-fold, subject-wise, and trial-wise) to ensure a comprehensive analysis. The decision on which model to employ was influenced not only by classification accuracy but also by computational efficiency.

The Random Forest model demonstrated superior performance, likely due to its robustness in handling complex data structures and its ability to avoid overfitting. When evaluating the effect of increasing the number of trees from 10 to 50, we observed only a marginal improvement in accuracy (1-2%), which did not justify the significant increase in computational cost for our specific application. Therefore, we identified the configuration with 10 trees and a maximum depth of 10 as the optimal setup. This choice strikes an effective balance between computational efficiency and model performance, ensuring robust results across different CV setups without excessive resource utilization.

While the SVM with polynomial kernels of degrees 3, 4, and 5 also showed competitive performance, their accuracies, though close, did not surpass the optimized Random Forest model. This underscores the effectiveness of the Random Forest approach, particularly when considering the ensemble's ability to provide consistent and stable results across different

testing scenarios.

Further analysis was conducted on the impact of feature selection, particularly comparing models using only 15 'force' features against models utilizing all 30 features (15 force-based + 15 torque-based). Interestingly, the accuracy results were very similar, with models using just the 'force-based features achieving nearly the same classification performance as those using the full feature set. This suggests that the force-based features alone carry substantial predictive power, and the addition of torque-based features does not significantly enhance the model's ability to predict outcomes. Consequently, this minimal difference in accuracy highlights a potential redundancy in the torque-based features, suggesting that a model employing only force-based features can be both computationally more efficient and just as effective.

This holistic approach allowed us to not only assess the effectiveness of the models in various validation contexts but also to consider the practical implications of deploying these models in real-world scenarios, where computational resources and time are often critical constraints. Our findings emphasize the importance of strategic feature selection in developing efficient and effective predictive models, particularly in settings where simplicity and speed are valued alongside accuracy.

5. Summarized Results

We searched for the best set of hyperparameters that maximize the model's performance as measured by the cross-validation process. Hence, for each hyperparameter configuration, the average classification accuracy of each ML model was calculated based on the cross-validation methods discussed above. Table 1 reports the results for each model with the best hyperparameter configuration. Based on these results, we selected Random Forest as our ML classifier.

Model	WH Accuracy	CD Accuracy	CP Accuracy	Total Accuracy
ANN	0.894	0.838	0.883	0.868
Random Forest	0.909	0.826	0.888	0.875
SVM	0.908	0.834	0.897	0.872

Table 1. Averaged Cross-Validation Performances of ML Models for the Best Hyperparameter Configuration

6. Detailed Results

This section provides a detailed overview of the classification accuracies achieved by each model under various cross-validation setups. Tables and graphs will illustrate the performance metrics for each class and the overall accuracy, highlighting the strengths and weaknesses of each model configuration.

K-Fold Cross-Validation

K-fold cross-validation was used to evaluate neural networks, random forests, and SVM models across multiple hyperparameters. Classification accuracies were reported for each class as well as the overall accuracy.

Neural Network - Hyperparameters

- Training Specifications
  - Batch Size: 32 or 64
  - Epoch: 150 or 200
  - Patience: 20 (related validation loss)
  - Learning Rate Decay: 10 (related validation loss)
  - Validation Split: 20%
  - ADAM optimizer
    - Learning Rate: 0.0001
    - Beta_1: 0.9
    - Beta_2: 0.999

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	All	3,3	150	32	0.88	0.75	0.81	0.81
4	All	3,8	150	32	0.87	0.60	0.74	0.73
4	All	3,6,6	150	32	0.87	0.65	0.86	0.78
4	All	3,16,8	150	32	0.88	0.79	0.86	0.84
4	All	3,16,8,4	150	32	0.87	0.78	0.81	0.82
4	All	16,8,8	150	32	0.87	0.78	0.87	0.84
4	All	32,16,8	150	32	0.88	0.78	0.89	0.85
4	All	32,16,16,8	150	32	0.88	0.78	0.87	0.84

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	Force	3,3	150	32	0.85	0.84	0.61	0.77
4	Force	3,8	150	32	0.86	0.84	0.71	0.80
4	Force	3,6,6	150	32	0.85	0.80	0.73	0.79
4	Force	3,16,8	150	32	0.87	0.75	0.80	0.81
4	Force	3,16,8,4	150	32	0.90	0.69	0.86	0.81
4	Force	16,8,8	150	32	0.89	0.79	0.86	0.85
4	Force	32,16,8	150	32	0.91	0.83	0.90	0.88
4	Force	32,16,16,8	150	32	0.91	0.83	0.88	0.87

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	All	3,3	150	32	0.84	0.75	0.81	0.79
5	All	3,8	150	32	0.86	0.76	0.85	0.83
5	All	3,6,6	150	32	0.85	0.75	0.80	0.80
5	All	3,16,8	150	32	0.85	0.79	0.75	0.80
5	All	3,16,8,4	150	32	0.86	0.75	0.74	0.78
5	All	16,8,8	150	32	0.86	0.81	0.83	0.84
5	All	32,16,8	150	32	0.86	0.81	0.84	0.83
5	All	32,16,16,8	150	32	0.88	0.82	0.86	0.85

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	Force	3,3	150	32	0.83	0.68	0.80	0.77
5	Force	3,8	150	32	0.85	0.78	0.85	0.83
5	Force	3,6,6	150	32	0.86	0.78	0.85	0.83
5	Force	3,16,8	150	32	0.84	0.80	0.71	0.78
5	Force	3,16,8,4	150	32	0.86	0.81	0.84	0.84
5	Force	16,8,8	150	32	0.87	0.82	0.86	0.85
5	Force	32,16,8	150	32	0.90	0.85	0.88	0.87
5	Force	32,16,16,8	150	32	0.90	0.84	0.89	0.88

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	All	3,3	150	32	0.82	0.56	0.47	0.67
6	All	3,8	150	32	0.87	0.78	0.81	0.81
6	All	3,6,6	150	32	0.87	0.68	0.83	0.79
6	All	3,16,8	150	32	0.87	0.76	0.77	0.80
6	All	3,16,8,4	150	32	0.87	0.80	0.75	0.80
6	All	16,8,8	150	32	0.89	0.81	0.81	0.84
6	All	32,16,8	150	32	0.88	0.81	0.81	0.83
6	All	32,16,16,8	150	32	0.88	0.83	0.82	0.84

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	Force	3,3	150	32	0.85	0.76	0.80	0.81
6	Force	3,8	150	32	0.86	0.80	0.86	0.83
6	Force	3,6,6	150	32	0.88	0.79	0.85	0.83
6	Force	3,16,8	150	32	0.86	0.79	0.85	0.83
6	Force	3,16,8,4	150	32	0.84	0.80	0.79	0.80
6	Force	16,8,8	150	32	0.89	0.83	0.89	0.86
6	Force	32,16,8	150	32	0.89	0.85	0.88	0.88
6	Force	32,16,16,8	150	32	0.90	0.82	0.89	0.87

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
8	All	3,3	150	32	0.67	0.70	0.65	0.67
8	All	3,8	150	32	0.86	0.73	0.83	0.80
8	All	3,6,6	150	32	0.85	0.69	0.81	0.78
8	All	3,16,8	150	32	0.86	0.75	0.83	0.81
8	All	3,16,8,4	150	32	0.75	0.82	0.72	0.76
8	All	16,8,8	150	32	0.89	0.80	0.87	0.85
8	All	32,16,8	120	32	0.91	0.81	0.83	0.85
8	All	32,16,16,8	200	32	0.88	0.82	0.80	0.83

K - Fold Cross-Validation: Neural Network

# of Folds	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
8	Force	3,3	150	32	0.85	0.76	0.80	0.81
8	Force	3,8	150	32	0.86	0.80	0.86	0.83
8	Force	3,6,6	150	32	0.88	0.79	0.85	0.83
8	Force	3,16,8	150	32	0.86	0.79	0.85	0.83
8	Force	3,16,8,4	150	32	0.84	0.80	0.79	0.80
8	Force	16,8,8	150	32	0.89	0.83	0.89	0.86
8	Force	32,16,8	150	32	0.89	0.85	0.88	0.88
8	Force	32,16,16,8	150	32	0.91	0.82	0.89	0.88

Randomforest - Hyperparameters

- Training Specifications
  - n_estimator: the number of decision trees
    - 10, 50
  - max_depth: the maximum depth allowed for each decision tree
    - 2, 5, 10
  - min_samples_split: the minimum number of samples required to split a node (related overfit)
    - 2, 5

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	Force	10	5	2	0.86	0.79	0.86	0.83
4	Force	10	5	5	0.87	0.77	0.87	0.83
4	Force	10	10	2	0.90	0.82	0.88	0.86
4	Force	10	10	5	0.91	0.81	0.88	0.87
4	Force	10	None	2	0.92	0.81	0.87	0.87
4	Force	10	None	5	0.92	0.82	0.87	0.87
4	Force	50	5	2	0.87	0.77	0.88	0.83
4	Force	50	5	5	0.87	0.77	0.89	0.84
4	Force	50	10	2	0.92	0.82	0.90	0.87
4	Force	50	10	5	0.91	0.81	0.88	0.87
4	Force	50	None	2	0.93	0.80	0.89	0.87
4	Force	50	None	5	0.93	0.81	0.88	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	All	10	5	2	0.84	0.77	0.86	0.83
4	All	10	5	5	0.84	0.77	0.84	0.82
4	All	10	10	2	0.90	0.82	0.88	0.87
4	All	10	10	5	0.89	0.83	0.87	0.87
4	All	10	None	2	0.92	0.84	0.86	0.87
4	All	10	None	5	0.90	0.83	0.85	0.86
4	All	50	5	2	0.85	0.77	0.89	0.84
4	All	50	5	5	0.84	0.78	0.88	0.84
4	All	50	10	2	0.90	0.83	0.89	0.87
4	All	50	10	5	0.90	0.83	0.90	0.87
4	All	50	None	2	0.91	0.83	0.89	0.88
4	All	50	None	5	0.91	0.82	0.89	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	Force	10	5	2	0.84	0.77	0.86	0.83
5	Force	10	5	5	0.84	0.77	0.84	0.82
5	Force	10	10	2	0.89	0.82	0.88	0.86
5	Force	10	10	5	0.90	0.83	0.89	0.87
5	Force	10	None	2	0.92	0.84	0.86	0.87
5	Force	10	None	5	0.90	0.83	0.85	0.86
5	Force	50	5	2	0.85	0.77	0.89	0.84
5	Force	50	5	5	0.84	0.78	0.88	0.84
5	Force	50	10	2	0.90	0.83	0.89	0.87
5	Force	50	10	5	0.90	0.83	0.89	0.87
5	Force	50	None	2	0.91	0.83	0.88	0.88
5	Force	50	None	5	0.91	0.82	0.89	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	All	10	5	2	0.87	0.76	0.86	0.83
5	All	10	5	5	0.85	0.77	0.86	0.82
5	All	10	10	2	0.90	0.82	0.86	0.85
5	All	10	10	5	0.91	0.83	0.88	0.87
5	All	10	None	2	0.91	0.82	0.86	0.86
5	All	10	None	5	0.91	0.81	0.84	0.85
5	All	50	5	2	0.87	0.77	0.88	0.83
5	All	50	5	5	0.87	0.78	0.87	0.84
5	All	50	10	2	0.91	0.82	0.88	0.87
5	All	50	10	5	0.91	0.83	0.88	0.87
5	All	50	None	2	0.92	0.80	0.87	0.86
5	All	50	None	5	0.92	0.81	0.88	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	Force	10	5	2	0.87	0.77	0.86	0.83
6	Force	10	5	5	0.87	0.78	0.86	0.83
6	Force	10	10	2	0.91	0.83	0.89	0.87
6	Force	10	10	5	0.91	0.83	0.90	0.88
6	Force	10	None	2	0.91	0.82	0.87	0.87
6	Force	10	None	5	0.91	0.82	0.88	0.87
6	Force	50	5	2	0.87	0.78	0.88	0.84
6	Force	50	5	5	0.87	0.78	0.88	0.84
6	Force	50	10	2	0.92	0.83	0.89	0.88
6	Force	50	10	5	0.91	0.81	0.89	0.86
6	Force	50	None	2	0.90	0.83	0.88	0.87
6	Force	50	None	5	0.91	0.82	0.89	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	All	10	5	2	0.87	0.76	0.86	0.83
6	All	10	5	5	0.85	0.77	0.86	0.82
6	All	10	10	2	0.89	0.82	0.86	0.85
6	All	10	10	5	0.91	0.81	0.88	0.87
6	All	10	None	2	0.91	0.82	0.86	0.86
6	All	10	None	5	0.91	0.81	0.84	0.85
6	All	50	5	2	0.87	0.77	0.88	0.83
6	All	50	5	5	0.87	0.78	0.87	0.84
6	All	50	10	2	0.91	0.82	0.88	0.87
6	All	50	10	5	0.91	0.83	0.88	0.87
6	All	50	None	2	0.92	0.80	0.87	0.86
6	All	50	None	5	0.92	0.81	0.88	0.87

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
8	Force	10	5	2	0.85	0.77	0.88	0.83
8	Force	10	5	5	0.87	0.76	0.88	0.83
8	Force	10	10	2	0.90	0.82	0.90	0.87
8	Force	10	10	5	0.91	0.83	0.89	0.88
8	Force	10	None	2	0.92	0.84	0.88	0.88
8	Force	10	None	5	0.92	0.82	0.88	0.87
8	Force	50	5	2	0.88	0.78	0.88	0.84
8	Force	50	5	5	0.88	0.78	0.88	0.84
8	Force	50	10	2	0.92	0.82	0.90	0.88
8	Force	50	10	5	0.92	0.82	0.91	0.88
8	Force	50	None	2	0.93	0.83	0.89	0.88
8	Force	50	None	5	0.92	0.83	0.89	0.88

# of Folds	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
8	All	10	5	2	0.86	0.79	0.86	0.83
8	All	10	5	5	0.87	0.77	0.87	0.83
8	All	10	10	2	0.90	0.82	0.87	0.86
8	All	10	10	5	0.91	0.81	0.88	0.86
8	All	10	None	2	0.92	0.81	0.87	0.87
8	All	10	None	5	0.92	0.82	0.87	0.87
8	All	50	5	2	0.87	0.77	0.88	0.83
8	All	50	5	5	0.87	0.77	0.88	0.84
8	All	50	10	2	0.91	0.82	0.89	0.87
8	All	50	10	5	0.91	0.82	0.88	0.87
8	All	50	None	2	0.93	0.81	0.89	0.87
8	All	50	None	5	0.93	0.81	0.89	0.88

SVM - Hyperparameters

- Training Specifications
  - C: The regularization parameter (controls the trade-off between maximizing the margin and minimizing the classification error)
    - 0.1, 1, 10
  - Kernel: Type of kernel function
    - Polynomial, Radial Basis Function (RBF)
  - Degree: The degree of the polynomial function
    - 3, 4, 5
  - Gamma: defines the influence of a single training example (related overfit)
    - Scale: 1 / (n_features * X.var())
    - Auto: 1 / n_features

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	All	0.1	poly	3	auto	0.82	0.69	0.66	0.72
4	All	0.1	poly	4	auto	0.79	0.84	0.41	0.69
4	All	0.1	poly	5	auto	0.74	0.79	0.60	0.71
4	All	0.1	poly	3	scale	0.005	0.99	0.004	0.37
4	All	0.1	poly	4	scale	0.007	0.99	0.001	0.37
4	All	0.1	poly	5	scale	0.007	0.99	0.01	0.37
4	All	1	poly	3	auto	0.85	0.56	0.92	0.77
4	All	1	poly	4	auto	0.87	0.66	0.86	0.79
4	All	1	poly	5	auto	0.82	0.67	0.85	0.78
4	All	1	poly	3	scale	0.79	0.68	0.81	0.76
4	All	1	poly	4	scale	0.91	0.81	0.90	0.87
4	All	1	poly	5	scale	0.91	0.87	0.91	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	All	10	poly	3	auto	0.92	0.81	0.90	0.88
4	All	10	poly	4	auto	0.91	0.84	0.91	0.88
4	All	10	poly	5	auto	0.88	0.76	0.86	0.81
4	All	10	poly	3	scale	0.84	0.75	0.85	0.80
4	All	10	poly	4	scale	0.82	0.73	0.81	0.77
4	All	10	poly	5	scale	0.92	0.81	0.91	0.88
4	All	0.1	rbf	-	auto	0.85	0.76	0.84	0.82
4	All	0.1	rbf	-	scale	0.22	0.87	0.22	0.45
4	All	1	rbf	-	auto	0.87	0.69	0.87	0.80
4	All	1	rbf	-	scale	0.23	0.87	0.24	0.47
4	All	10	rbf	-	auto	0.89	0.86	0.86	0.87
4	All	10	rbf	-	scale	0.44	0.89	0.26	0.56

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	Force	0.1	poly	3	auto	0.82	0.60	0.88	0.76
4	Force	0.1	poly	4	auto	0.79	0.65	0.81	0.74
4	Force	0.1	poly	5	auto	0.74	0.79	0.60	0.71
4	Force	0.1	poly	3	scale	0.91	0.78	0.87	0.85
4	Force	0.1	poly	4	scale	0.92	0.81	0.90	0.88
4	Force	0.1	poly	5	scale	0.91	0.84	0.91	0.88
4	Force	1	poly	3	auto	0.87	0.66	0.86	0.79
4	Force	1	poly	4	auto	0.85	0.67	0.85	0.78
4	Force	1	poly	5	auto	0.81	0.68	0.81	0.76
4	Force	1	poly	3	scale	0.92	0.81	0.91	0.88
4	Force	1	poly	4	scale	0.93	0.84	0.91	0.89
4	Force	1	poly	5	scale	0.92	0.85	0.90	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	Force	10	poly	3	auto	0.89	0.76	0.86	0.83
4	Force	10	poly	4	auto	0.88	0.74	0.85	0.82
4	Force	10	poly	5	auto	0.87	0.74	0.84	0.81
4	Force	10	poly	3	scale	0.91	0.84	0.91	0.89
4	Force	10	poly	4	scale	0.92	0.85	0.90	0.89
4	Force	10	poly	5	scale	0.92	0.85	0.89	0.88
4	Force	0.1	rbf	-	auto	0.87	0.60	0.90	0.78
4	Force	0.1	rbf	-	scale	0.90	0.76	0.87	0.84
4	Force	1	rbf	-	auto	0.89	0.67	0.90	0.81
4	Force	1	rbf	-	scale	0.93	0.80	0.88	0.87
4	Force	10	rbf	-	auto	0.91	0.77	0.87	0.85
4	Force	10	rbf	-	scale	0.92	0.83	0.91	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	All	0.1	poly	3	auto	0.79	0.60	0.86	0.75
5	All	0.1	poly	4	auto	0.76	0.66	0.78	0.73
5	All	0.1	poly	5	auto	0.71	0.77	0.61	0.71
5	All	0.1	poly	3	scale	0.90	0.78	0.89	0.86
5	All	0.1	poly	4	scale	0.91	0.82	0.90	0.88
5	All	0.1	poly	5	scale	0.90	0.85	0.90	0.89
5	All	1	poly	3	auto	0.84	0.67	0.85	0.79
5	All	1	poly	4	auto	0.82	0.67	0.83	0.77
5	All	1	poly	5	auto	0.79	0.69	0.80	0.76
5	All	1	poly	3	scale	0.91	0.82	0.90	0.88
5	All	1	poly	4	scale	0.91	0.85	0.91	0.89
5	All	1	poly	5	scale	0.91	0.86	0.89	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	All	10	poly	3	auto	0.88	0.76	0.87	0.84
5	All	10	poly	4	auto	0.87	0.76	0.85	0.83
5	All	10	poly	5	auto	0.85	0.75	0.83	0.81
5	All	10	poly	3	scale	0.91	0.84	0.91	0.89
5	All	10	poly	4	scale	0.91	0.86	0.89	0.89
5	All	10	poly	5	scale	0.91	0.86	0.88	0.88
5	All	0.1	rbf	-	auto	0.82	0.55	0.91	0.75
5	All	0.1	rbf	-	scale	0.16	0.96	0.06	0.44
5	All	1	rbf	-	auto	0.85	0.70	0.88	0.81
5	All	1	rbf	-	scale	0.18	0.90	0.19	0.47
5	All	10	rbf	-	auto	0.88	0.77	0.87	0.84
5	All	10	rbf	-	scale	0.49	0.86	0.40	0.59

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	Force	0.1	poly	3	auto	0.79	0.60	0.86	0.75
5	Force	0.1	poly	4	auto	0.76	0.66	0.78	0.73
5	Force	0.1	poly	5	auto	0.71	0.77	0.61	0.71
5	Force	0.1	poly	3	scale	0.90	0.78	0.89	0.86
5	Force	0.1	poly	4	scale	0.91	0.82	0.90	0.88
5	Force	0.1	poly	5	scale	0.90	0.85	0.90	0.89
5	Force	1	poly	3	auto	0.84	0.67	0.85	0.79
5	Force	1	poly	4	auto	0.82	0.67	0.83	0.77
5	Force	1	poly	5	auto	0.79	0.69	0.80	0.76
5	Force	1	poly	3	scale	0.91	0.82	0.90	0.88
5	Force	1	poly	4	scale	0.91	0.85	0.91	0.89
5	Force	1	poly	5	scale	0.91	0.86	0.89	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	Force	10	poly	3	auto	0.88	0.76	0.87	0.84
5	Force	10	poly	4	auto	0.87	0.76	0.85	0.83
5	Force	10	poly	5	auto	0.85	0.75	0.83	0.81
5	Force	10	poly	3	scale	0.91	0.84	0.91	0.89
5	Force	10	poly	4	scale	0.91	0.86	0.89	0.89
5	Force	10	poly	5	scale	0.91	0.86	0.88	0.88
5	Force	0.1	rbf	-	auto	0.85	0.60	0.89	0.78
5	Force	0.1	rbf	-	scale	0.89	0.76	0.87	0.84
5	Force	1	rbf	-	auto	0.87	0.69	0.89	0.81
5	Force	1	rbf	-	scale	0.91	0.81	0.89	0.87
5	Force	10	rbf	-	auto	0.90	0.77	0.89	0.85
5	Force	10	rbf	-	scale	0.91	0.84	0.91	0.89

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	All	0.1	poly	3	auto	0.83	0.83	0.83	0.83
6	All	0.1	poly	4	auto	0.83	0.83	0.83	0.83
6	All	0.1	poly	5	auto	0.83	0.83	0.83	0.83
6	All	0.1	poly	3	scale	0.83	0.83	0.83	0.83
6	All	0.1	poly	4	scale	0.83	0.83	0.83	0.83
6	All	0.1	poly	5	scale	0.83	0.83	0.83	0.83
6	All	1	poly	3	auto	0.83	0.83	0.83	0.83
6	All	1	poly	4	auto	0.83	0.83	0.83	0.83
6	All	1	poly	5	auto	0.83	0.83	0.83	0.83
6	All	1	poly	3	scale	0.83	0.83	0.83	0.83
6	All	1	poly	4	scale	0.83	0.83	0.83	0.83
6	All	1	poly	5	scale	0.83	0.83	0.83	0.83

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	All	10	poly	3	auto	0.89	0.76	0.87	0.84
6	All	10	poly	4	auto	0.89	0.75	0.86	0.83
6	All	10	poly	5	auto	0.87	0.74	0.84	0.81
6	All	10	poly	3	scale	0.93	0.84	0.92	0.89
6	All	10	poly	4	scale	0.92	0.85	0.90	0.89
6	All	10	poly	5	scale	0.92	0.85	0.89	0.89
6	All	0.1	rbf	-	auto	0.84	0.55	0.88	0.74
6	All	0.1	rbf	-	scale	0.15	0.90	0.14	0.43
6	All	1	rbf	-	auto	0.87	0.70	0.88	0.81
6	All	1	rbf	-	scale	0.15	0.91	0.16	0.44
6	All	10	rbf	-	auto	0.89	0.77	0.87	0.84
6	All	10	rbf	-	scale	0.60	0.88	0.30	0.59

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	Force	0.1	poly	3	auto	0.83	0.59	0.89	0.75
6	Force	0.1	poly	4	auto	0.79	0.66	0.77	0.73
6	Force	0.1	poly	5	auto	0.75	0.79	0.53	0.68
6	Force	0.1	poly	3	scale	0.91	0.80	0.89	0.86
6	Force	0.1	poly	4	scale	0.90	0.82	0.88	0.86
6	Force	0.1	poly	5	scale	0.91	0.84	0.89	0.87
6	Force	1	poly	3	auto	0.87	0.67	0.86	0.79
6	Force	1	poly	4	auto	0.85	0.68	0.84	0.78
6	Force	1	poly	5	auto	0.82	0.70	0.80	0.76
6	Force	1	poly	3	scale	0.90	0.80	0.89	0.86
6	Force	1	poly	4	scale	0.89	0.81	0.88	0.86
6	Force	1	poly	5	scale	0.88	0.82	0.89	0.85

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	Force	10	poly	3	auto	0.89	0.77	0.86	0.84
6	Force	10	poly	4	auto	0.88	0.76	0.85	0.83
6	Force	10	poly	5	auto	0.87	0.75	0.82	0.81
6	Force	10	poly	3	scale	0.91	0.82	0.88	0.85
6	Force	10	poly	4	scale	0.90	0.80	0.89	0.84
6	Force	10	poly	5	scale	0.89	0.83	0.88	0.85
6	Force	0.1	rbf	-	auto	0.87	0.61	0.90	0.78
6	Force	0.1	rbf	-	scale	0.90	0.76	0.86	0.84
6	Force	1	rbf	-	auto	0.88	0.70	0.90	0.82
6	Force	1	rbf	-	scale	0.90	0.81	0.89	0.86
6	Force	10	rbf	-	auto	0.91	0.80	0.89	0.85
6	Force	10	rbf	-	scale	0.89	0.84	0.90	0.86

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
8	All	0.1	poly	3	auto	0.89	0.76	0.86	0.83
8	All	0.1	poly	4	auto	0.88	0.74	0.85	0.82
8	All	0.1	poly	5	auto	0.87	0.74	0.84	0.81
8	All	0.1	poly	3	scale	0.90	0.84	0.91	0.86
8	All	0.1	poly	4	scale	0.89	0.83	0.90	0.85
8	All	0.1	poly	5	scale	0.90	0.82	0.89	0.85
8	All	1	poly	3	auto	0.87	0.60	0.90	0.78
8	All	1	poly	4	auto	0.90	0.76	0.87	0.84
8	All	1	poly	5	auto	0.89	0.67	0.90	0.81
8	All	1	poly	3	scale	0.91	0.80	0.88	0.86
8	All	1	poly	4	scale	0.91	0.80	0.87	0.85
8	All	1	poly	5	scale	0.90	0.83	0.89	0.86

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
8	All	10	poly	3	auto	0.79	0.65	0.81	0.74
8	All	10	poly	4	auto	0.74	0.79	0.60	0.71
8	All	10	poly	5	auto	0.91	0.80	0.87	0.85
8	All	10	poly	3	scale	0.89	0.81	0.90	0.86
8	All	10	poly	4	scale	0.90	0.82	0.88	0.85
8	All	10	poly	5	scale	0.87	0.66	0.86	0.79
8	All	0.1	rbf	-	auto	0.86	0.52	0.94	0.75
8	All	0.1	rbf	-	scale	0.11	0.92	0.14	0.41
8	All	1	rbf	-	auto	0.88	0.70	0.89	0.81
8	All	1	rbf	-	scale	0.11	0.93	0.13	0.43
8	All	10	rbf	-	auto	0.90	0.77	0.88	0.85
8	All	10	rbf	-	scale	0.73	0.89	0.40	0.68

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
8	Force	0.1	poly	3	auto	0.83	0.60	0.89	0.76
8	Force	0.1	poly	4	auto	0.79	0.65	0.82	0.75
8	Force	0.1	poly	5	auto	0.75	0.76	0.65	0.72
8	Force	0.1	poly	3	scale	0.91	0.79	0.89	0.86
8	Force	0.1	poly	4	scale	0.92	0.82	0.91	0.85
8	Force	0.1	poly	5	scale	0.92	0.84	0.92	0.86
8	Force	1	poly	3	auto	0.87	0.67	0.87	0.79
8	Force	1	poly	4	auto	0.85	0.67	0.85	0.78
8	Force	1	poly	5	auto	0.82	0.68	0.82	0.76
8	Force	1	poly	3	scale	0.91	0.81	0.90	0.86
8	Force	1	poly	4	scale	0.90	0.84	0.88	0.86
8	Force	1	poly	5	scale	0.91	0.82	0.89	0.85

# of Folds	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
8	Force	10	poly	3	auto	0.89	0.76	0.87	0.84
8	Force	10	poly	4	auto	0.89	0.75	0.86	0.83
8	Force	10	poly	5	auto	0.87	0.74	0.84	0.81
8	Force	10	poly	3	scale	0.90	0.84	0.89	0.85
8	Force	10	poly	4	scale	0.89	0.85	0.90	0.86
8	Force	10	poly	5	scale	0.88	0.85	0.89	0.85
8	Force	0.1	rbf	-	auto	0.87	0.61	0.91	0.78
8	Force	0.1	rbf	-	scale	0.90	0.76	0.87	0.84
8	Force	1	rbf	-	auto	0.89	0.68	0.90	0.81
8	Force	1	rbf	-	scale	0.89	0.81	0.88	0.86
8	Force	10	rbf	-	auto	0.90	0.80	0.87	0.85
8	Force	10	rbf	-	scale	0.90	0.81	0.89	0.85

1. Introduction

This report presents a comprehensive evaluation of three popular machine learning models: Neural Networks, Random Forests, and Support Vector Machines (SVM), across different cross-validation setups. The aim is to identify the model and parameter configuration that yields the highest classification accuracy in our dataset.

2. Methodology

We employed three types of cross-validation methods to evaluate the robustness of the models:

- **K-Fold Cross-Validation:** The dataset was divided into the subsets of (K = 4, 5, 6, 8). Each subset was used as a training set sequentially, with the remaining subsets forming the test set.
- **Subject-Wise Cross-Validation:** The dataset was divided into the subsets of (N = 4, 5, 6) participants. Each subset was used as a training set sequentially, with the remaining subsets forming the test set.
- **Trial-Wise Cross-Validation:** The dataset was divided into the subsets of (T = 22, 24, 26) trials. Each subset was used as a training set sequentially, with the remaining trials forming the test set.

Model Configurations and Hyperparameters:

A. Neural Networks (NN)

- **Training Specifications:**
    - Batch Size: 32 or 64
    - Epoch: 150 or 200
    - Patience: 20 (related to validation loss)
    - Learning Rate Decay: Factor of 10 (related to validation loss)
    - Validation Split: 20%
    - Optimizer: ADAM
        - Learning Rate: 0.0001
        - Beta_1: 0.9 | Beta_2: 0.999
    - Number of neurons in each layer:
        - (3,3), (3,8), (3,6,6), (3,16,8), (3,16,8,4), (16,8,8), (32,16,8), (32,16,16,8)
- The number of different architectures: 8

B. Random Forest

- **Training Specifications:**
    - Number of decision trees: 10, 50
    - Maximum depth of each tree: 2, 5, 10
    - Minimum number of samples required to split a node: 2, 5
- The number of different architectures: 12

C. Support Vector Machine (SVM)

- **Training Specifications:**
    - Regularization parameter: 0.1, 1, 10
    - Kernel: Polynomial, Radial Basis Function (RBF)
    - Degree: 3, 4, 5
    - Gamma: Scale, Auto
- The number of different architectures: 24

3. Results

The evaluation metrics focused on classification accuracies for each class and overall accuracy. The Random Forest model demonstrated superior performance with the following optimal configuration:

- **Number of decision trees:** 10
- **Maximum depth of each tree:** 10
- **Minimum number of samples required to split a node:** 5

This configuration achieved the highest overall accuracy, particularly when using the subject-wise, with the number of folds (k) set to 6, cross-validation setup.

4. Discussion

In our evaluation, we considered the performance of each model across all cross-validation methods (k-fold, subject-wise, and trial-wise) to ensure a comprehensive analysis. The decision on which model to employ was influenced not only by classification accuracy but also by computational efficiency.

The Random Forest model demonstrated superior performance, likely due to its robustness in handling complex data structures and its ability to avoid overfitting. When evaluating the effect of increasing the number of trees from 10 to 50, we observed only a marginal improvement in accuracy (1-2%), which did not justify the significant increase in computational cost for our specific application. Therefore, we identified the configuration with 10 trees and a maximum depth of 10 as the optimal setup. This choice strikes an effective balance between computational efficiency and model performance, ensuring robust results across different CV setups without excessive resource utilization.

While the SVM with polynomial kernels of degrees 3, 4, and 5 also showed competitive performance, their accuracies, though close, did not surpass the optimized Random Forest model. This underscores the effectiveness of the Random Forest approach, particularly when considering the ensemble's ability to provide consistent and stable results across different testing scenarios.

Further analysis was conducted on the impact of feature selection, particularly comparing models using only 15 'force' features against models utilizing all 30 features (15 force-based + 15 torque-based). Interestingly, the accuracy results were very similar, with models using just the 'force-based features achieving nearly the same classification performance as those using the full feature set. This suggests that the force-based features alone carry substantial predictive power, and the addition of torque-based features does not significantly enhance the model's ability to predict outcomes. Consequently, this minimal difference in accuracy highlights a potential redundancy in the torque-based features, suggesting that a model employing only force-based features can be both computationally more efficient and just as effective.

This holistic approach allowed us to not only assess the effectiveness of the models in various validation contexts but also to consider the practical implications of deploying these models in real-world scenarios, where computational resources and time are often critical constraints. Our findings emphasize the importance of strategic feature selection in developing efficient and effective predictive models, particularly in settings where simplicity and speed are valued alongside accuracy.

5. Summarized Results

We searched for the best set of hyperparameters that maximize the model's performance as measured by the cross-validation process. Hence, for each hyperparameter configuration, the average classification accuracy of each ML model was calculated based on the cross-validation methods discussed above. Table 1 reports the results for each model with the best hyperparameter configuration. Based on these results, we selected Random Forest as our ML classifier.

Model	WH Accuracy	CD Accuracy	CP Accuracy	Total Accuracy
ANN	0.894	0.838	0.883	0.868
Random Forest	0.909	0.826	0.888	0.875
SVM	0.908	0.834	0.897	0.872

Table 1. Averaged Cross-Validation Performances of ML Models for the Best Hyperparameter Configuration

6. Detailed Results

This section provides a detailed overview of the classification accuracies achieved by each model under various cross-validation setups. Tables and graphs will illustrate the performance metrics for each class and the overall accuracy, highlighting the strengths and weaknesses of each model configuration.

Subject Wise Cross-Validation

Subject wise cross-validation was used to evaluate neural networks, random forests, and SVM models across multiple hyperparameters. Classification accuracies were reported for each class as well as the overall accuracy.

Neural Network - Hyperparameters

- Training Specifications
  - Batch Size: 32 or 64
  - Epoch: 150 or 200
  - Patience: 20 (related validation loss)
  - Learning Rate Decay: 10 (related validation loss)
  - Validation Split: 20%
  - ADAM optimizer
    - Learning Rate: 0.0001
    - Beta_1: 0.9
    - Beta_2: 0.999

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	All	3,3	150	32	0.63	0.84	0.46	0.66
4	All	3,8	150	32	0.86	0.75	0.77	0.79
4	All	3,6,6	150	32	0.86	0.57	0.80	0.73
4	All	3,16,8	150	32	0.88	0.67	0.77	0.76
4	All	3,16,8,4	150	32	0.87	0.58	0.76	0.73
4	All	16,8,8	150	32	0.86	0.70	0.75	0.77
4	All	32,16,8	150	32	0.89	0.79	0.84	0.84
4	All	32,16,16,8	150	32	0.89	0.79	0.82	0.84

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	Force	3,3	150	32	0.88	0.68	0.86	0.80
4	Force	3,8	150	32	0.89	0.62	0.77	0.76
4	Force	3,6,6	150	32	0.85	0.46	0.82	0.69
4	Force	3,16,8	150	32	0.86	0.61	0.78	0.74
4	Force	3,16,8,4	150	32	0.87	0.76	0.86	0.83
4	Force	16,8,8	150	32	0.89	0.81	0.85	0.85
4	Force	32,16,8	150	32	0.90	0.82	0.87	0.86
4	Force	32,16,16,8	150	32	0.87	0.82	0.86	0.85

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	All	3,3	150	32	0.81	0.56	0.75	0.70
5	All	3,8	150	32	0.69	0.74	0.62	0.69
5	All	3,6,6	150	32	0.87	0.65	0.57	0.69
5	All	3,16,8	150	32	0.85	0.64	0.68	0.72
5	All	3,16,8,4	150	32	0.83	0.70	0.72	0.75
5	All	16,8,8	150	32	0.85	0.77	0.82	0.81
5	All	32,16,8	150	32	0.87	0.77	0.83	0.82
5	All	32,16,16,8	150	32	0.87	0.78	0.81	0.82

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	Force	3,3	150	32	0.87	0.57	0.63	0.68
5	Force	3,8	150	32	0.85	0.70	0.81	0.78
5	Force	3,6,6	150	32	0.87	0.73	0.79	0.79
5	Force	3,16,8	150	32	0.83	0.62	0.81	0.75
5	Force	3,16,8,4	150	32	0.87	0.68	0.86	0.79
5	Force	16,8,8	150	32	0.85	0.81	0.77	0.81
5	Force	32,16,8	150	32	0.88	0.83	0.78	0.83
5	Force	32,16,16,8	150	32	0.88	0.81	0.88	0.86

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	All	3,3	150	32	0.85	0.73	0.85	0.80
6	All	3,8	150	32	0.86	0.83	0.86	0.85
6	All	3,6,6	150	32	0.87	0.76	0.84	0.82
6	All	3,16,8	150	32	0.83	0.76	0.84	0.81
6	All	3,16,8,4	150	32	0.88	0.80	0.82	0.84
6	All	16,8,8	150	32	0.88	0.79	0.84	0.84
6	All	32,16,8	150	32	0.90	0.79	0.86	0.85
6	All	32,16,16,8	150	32	0.88	0.76	0.88	0.84

Subject Wise Cross-Validation: Neural Network

# of Subjects	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	Force	3,3	150	32	0.87	0.79	0.80	0.82
6	Force	3,8	150	32	0.86	0.78	0.81	0.80
6	Force	3,6,6	150	32	0.84	0.81	0.80	0.82
6	Force	3,16,8	150	32	0.87	0.79	0.85	0.84
6	Force	3,16,8,4	150	32	0.88	0.75	0.86	0.83
6	Force	16,8,8	150	32	0.92	0.84	0.88	0.88
6	Force	32,16,8	150	32	0.88	0.83	0.87	0.86
6	Force	32,16,16,8	150	32	0.88	0.83	0.89	0.87

Randomforest - Hyperparameters

- Training Specifications
  - n_estimator: the number of decision trees
    - 10, 50
  - max_depth: the maximum depth allowed for each decision tree
    - 2, 5, 10
  - min_samples_split: the minimum number of samples required to split a node (related overfit)
    - 2, 5

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	All	10	5	2	0.86	0.75	0.88	0.83
4	All	10	5	5	0.89	0.74	0.87	0.83
4	All	10	10	2	0.91	0.81	0.88	0.87
4	All	10	10	5	0.91	0.82	0.88	0.88
4	All	10	None	2	0.93	0.82	0.87	0.87
4	All	10	None	5	0.92	0.81	0.87	0.87
4	All	50	5	2	0.87	0.76	0.89	0.84
4	All	50	5	5	0.88	0.77	0.88	0.84
4	All	50	10	2	0.92	0.82	0.90	0.87
4	All	50	10	5	0.92	0.81	0.90	0.87
4	All	50	None	2	0.94	0.81	0.89	0.88
4	All	50	None	5	0.94	0.81	0.89	0.88

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
4	Force	10	5	2	0.88	0.76	0.88	0.84
4	Force	10	5	5	0.87	0.75	0.88	0.83
4	Force	10	10	2	0.91	0.81	0.90	0.87
4	Force	10	10	5	0.91	0.81	0.90	0.87
4	Force	10	None	2	0.92	0.84	0.86	0.86
4	Force	10	None	5	0.92	0.80	0.88	0.86
4	Force	50	5	2	0.87	0.76	0.88	0.84
4	Force	50	5	5	0.87	0.76	0.89	0.84
4	Force	50	10	2	0.92	0.82	0.91	0.88
4	Force	50	10	5	0.92	0.81	0.91	0.88
4	Force	50	None	2	0.92	0.81	0.90	0.88
4	Force	50	None	5	0.92	0.81	0.90	0.88

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	All	10	5	2	0.88	0.76	0.88	0.84
5	All	10	5	5	0.87	0.77	0.85	0.83
5	All	10	10	2	0.91	0.80	0.89	0.85
5	All	10	10	5	0.91	0.81	0.88	0.86
5	All	10	None	2	0.92	0.80	0.87	0.86
5	All	10	None	5	0.92	0.82	0.86	0.86
5	All	50	5	2	0.88	0.76	0.89	0.84
5	All	50	5	5	0.84	0.78	0.88	0.84
5	All	50	10	2	0.89	0.77	0.85	0.83
5	All	50	10	5	0.92	0.82	0.88	0.87
5	All	50	None	2	0.93	0.84	0.88	0.88
5	All	50	None	5	0.93	0.82	0.87	0.87

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
5	Force	10	5	2	0.86	0.77	0.89	0.83
5	Force	10	5	5	0.88	0.77	0.88	0.84
5	Force	10	10	2	0.91	0.82	0.90	0.87
5	Force	10	10	5	0.91	0.82	0.89	0.87
5	Force	10	None	2	0.91	0.82	0.87	0.87
5	Force	10	None	5	0.91	0.82	0.87	0.87
5	Force	50	5	2	0.88	0.76	0.88	0.84
5	Force	50	5	5	0.88	0.76	0.89	0.84
5	Force	50	10	2	0.91	0.82	0.90	0.88
5	Force	50	10	5	0.92	0.82	0.90	0.88
5	Force	50	None	2	0.92	0.83	0.89	0.88
5	Force	50	None	5	0.91	0.82	0.89	0.87

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	All	10	5	2	0.88	0.75	0.87	0.83
6	All	10	5	5	0.88	0.76	0.88	0.84
6	All	10	10	2	0.92	0.83	0.88	0.87
6	All	10	10	5	0.92	0.85	0.87	0.88
6	All	10	None	2	0.93	0.83	0.87	0.87
6	All	10	None	5	0.92	0.83	0.86	0.87
6	All	50	5	2	0.89	0.77	0.88	0.84
6	All	50	5	5	0.88	0.78	0.89	0.85
6	All	50	10	2	0.92	0.83	0.89	0.88
6	All	50	10	5	0.92	0.82	0.88	0.87
6	All	50	None	2	0.93	0.82	0.88	0.88
6	All	50	None	5	0.93	0.83	0.89	0.88

# of Subjects	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
6	Force	10	5	2	0.89	0.77	0.88	0.84
6	Force	10	5	5	0.89	0.76	0.89	0.84
6	Force	10	10	2	0.92	0.82	0.87	0.88
6	Force	10	10	5	0.92	0.84	0.87	0.89
6	Force	10	None	2	0.92	0.83	0.88	0.87
6	Force	10	None	5	0.91	0.83	0.88	0.87
6	Force	50	5	2	0.87	0.77	0.89	0.85
6	Force	50	5	5	0.89	0.76	0.89	0.85
6	Force	50	10	2	0.92	0.83	0.89	0.88
6	Force	50	10	5	0.91	0.84	0.90	0.88
6	Force	50	None	2	0.92	0.84	0.89	0.88
6	Force	50	None	5	0.92	0.84	0.89	0.88

SVM - Hyperparameters

- Training Specifications
  - C: The regularization parameter (controls the trade-off between maximizing the margin and minimizing the classification error)
    - 0.1, 1, 10
  - Kernel: Type of kernel function
    - Polynomial, Radial Basis Function (RBF)
  - Degree: The degree of the polynomial function
    - 3, 4, 5
  - Gamma: defines the influence of a single training example (related overfit)
    - Scale: 1 / (n_features * X.var())
    - Auto: 1 / n_features

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	All	0.1	poly	3	auto	0.82	0.58	0.87	0.75
4	All	0.1	poly	4	auto	0.81	0.68	0.68	0.72
4	All	0.1	poly	5	auto	0.78	0.84	0.49	0.68
4	All	0.1	poly	3	scale	0.002	0.99	0.001	0.38
4	All	0.1	poly	4	scale	0.003	0.99	0.001	0.37
4	All	0.1	poly	5	scale	0.004	0.99	0.03	0.37
4	All	1	poly	3	auto	0.87	0.59	0.92	0.78
4	All	1	poly	4	auto	0.85	0.59	0.91	0.77
4	All	1	poly	5	auto	0.84	0.58	0.91	0.77
4	All	1	poly	3	scale	0.25	0.88	0.23	0.48
4	All	1	poly	4	scale	0.003	0.99	0.001	0.38
4	All	1	poly	5	scale	0.004	0.99	0.03	0.37

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	All	10	poly	3	auto	0.89	0.71	0.88	0.82
4	All	10	poly	4	auto	0.89	0.72	0.87	0.82
4	All	10	poly	5	auto	0.88	0.75	0.87	0.82
4	All	10	poly	3	scale	0.80	0.70	0.63	0.71
4	All	10	poly	4	scale	0.30	0.87	0.27	0.50
4	All	10	poly	5	scale	0.24	0.95	0.15	0.48
4	All	0.1	rbf	-	auto	0.86	0.52	0.94	0.75
4	All	0.1	rbf	-	scale	0.11	0.92	0.14	0.41
4	All	1	rbf	-	auto	0.88	0.70	0.89	0.81
4	All	1	rbf	-	scale	0.11	0.93	0.13	0.43
4	All	10	rbf	-	auto	0.90	0.77	0.88	0.85
4	All	10	rbf	-	scale	0.73	0.89	0.40	0.68

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	Force	0.1	poly	3	auto	0.82	0.60	0.88	0.76
4	Force	0.1	poly	4	auto	0.79	0.65	0.81	0.74
4	Force	0.1	poly	5	auto	0.74	0.79	0.60	0.71
4	Force	0.1	poly	3	scale	0.90	0.80	0.88	0.85
4	Force	0.1	poly	4	scale	0.90	0.82	0.90	0.86
4	Force	0.1	poly	5	scale	0.92	0.83	0.89	0.86
4	Force	1	poly	3	auto	0.87	0.66	0.86	0.79
4	Force	1	poly	4	auto	0.85	0.67	0.85	0.78
4	Force	1	poly	5	auto	0.81	0.68	0.81	0.77
4	Force	1	poly	3	scale	0.92	0.81	0.91	0.88
4	Force	1	poly	4	scale	0.93	0.84	0.91	0.89
4	Force	1	poly	5	scale	0.92	0.85	0.90	0.89

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
4	Force	10	poly	3	auto	0.89	0.76	0.86	0.83
4	Force	10	poly	4	auto	0.88	0.74	0.85	0.82
4	Force	10	poly	5	auto	0.87	0.74	0.84	0.81
4	Force	10	poly	3	scale	0.90	0.84	0.91	0.87
4	Force	10	poly	4	scale	0.91	0.83	0.90	0.87
4	Force	10	poly	5	scale	0.90	0.85	0.89	0.86
4	Force	0.1	rbf	-	auto	0.87	0.60	0.90	0.78
4	Force	0.1	rbf	-	scale	0.90	0.76	0.87	0.84
4	Force	1	rbf	-	auto	0.89	0.67	0.90	0.81
4	Force	1	rbf	-	scale	0.93	0.80	0.88	0.87
4	Force	10	rbf	-	auto	0.91	0.77	0.90	0.85
4	Force	10	rbf	-	scale	0.91	0.83	0.90	0.87

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	All	0.1	poly	3	auto	0.82	0.60	0.88	0.76
5	All	0.1	poly	4	auto	0.79	0.65	0.81	0.74
5	All	0.1	poly	5	auto	0.74	0.79	0.60	0.71
5	All	0.1	poly	3	scale	0.91	0.78	0.87	0.85
5	All	0.1	poly	4	scale	0.92	0.81	0.88	0.86
5	All	0.1	poly	5	scale	0.90	0.84	0.90	0.87
5	All	1	poly	3	auto	0.87	0.66	0.86	0.79
5	All	1	poly	4	auto	0.85	0.67	0.85	0.78
5	All	1	poly	5	auto	0.81	0.68	0.81	0.76
5	All	1	poly	3	scale	0.92	0.81	0.91	0.88
5	All	1	poly	4	scale	0.91	0.84	0.89	0.87
5	All	1	poly	5	scale	0.90	0.85	0.88	0.86

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	All	10	poly	3	auto	0.89	0.76	0.86	0.83
5	All	10	poly	4	auto	0.88	0.74	0.85	0.82
5	All	10	poly	5	auto	0.87	0.74	0.84	0.81
5	All	10	poly	3	scale	0.90	0.81	0.91	0.88
5	All	10	poly	4	scale	0.89	0.82	0.90	0.87
5	All	10	poly	5	scale	0.91	0.84	0.89	0.87
5	All	0.1	rbf	-	auto	0.82	0.55	0.91	0.75
5	All	0.1	rbf	-	scale	0.16	0.96	0.06	0.44
5	All	1	rbf	-	auto	0.85	0.70	0.88	0.81
5	All	1	rbf	-	scale	0.18	0.90	0.19	0.47
5	All	10	rbf	-	auto	0.88	0.77	0.87	0.84
5	All	10	rbf	-	scale	0.49	0.86	0.40	0.59

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	Force	0.1	poly	3	auto	0.79	0.60	0.86	0.75
5	Force	0.1	poly	4	auto	0.76	0.66	0.78	0.73
5	Force	0.1	poly	5	auto	0.71	0.77	0.61	0.71
5	Force	0.1	poly	3	scale	0.90	0.80	0.89	0.86
5	Force	0.1	poly	4	scale	0.89	0.82	0.90	0.85
5	Force	0.1	poly	5	scale	0.90	0.81	0.89	0.86
5	Force	1	poly	3	auto	0.84	0.67	0.85	0.79
5	Force	1	poly	4	auto	0.82	0.67	0.83	0.77
5	Force	1	poly	5	auto	0.79	0.69	0.80	0.76
5	Force	1	poly	3	scale	0.91	0.82	0.90	0.88
5	Force	1	poly	4	scale	0.89	0.85	0.90	0.87
5	Force	1	poly	5	scale	0.90	0.82	0.89	0.86

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
5	Force	10	poly	3	auto	0.88	0.76	0.87	0.84
5	Force	10	poly	4	auto	0.87	0.76	0.85	0.83
5	Force	10	poly	5	auto	0.85	0.75	0.83	0.81
5	Force	10	poly	3	scale	0.91	0.84	0.90	0.85
5	Force	10	poly	4	scale	0.90	0.86	0.89	0.86
5	Force	10	poly	5	scale	0.91	0.86	0.88	0.87
5	Force	0.1	rbf	-	auto	0.85	0.60	0.89	0.78
5	Force	0.1	rbf	-	scale	0.89	0.76	0.87	0.84
5	Force	1	rbf	-	auto	0.87	0.69	0.89	0.81
5	Force	1	rbf	-	scale	0.91	0.81	0.89	0.87
5	Force	10	rbf	-	auto	0.90	0.77	0.89	0.85
5	Force	10	rbf	-	scale	0.89	0.82	0.90	0.86

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	All	0.1	poly	3	auto	0.79	0.60	0.86	0.75
6	All	0.1	poly	4	auto	0.76	0.66	0.78	0.73
6	All	0.1	poly	5	auto	0.71	0.77	0.61	0.71
6	All	0.1	poly	3	scale	0.90	0.78	0.89	0.86
6	All	0.1	poly	4	scale	0.89	0.82	0.88	0.85
6	All	0.1	poly	5	scale	0.90	0.82	0.89	0.86
6	All	1	poly	3	auto	0.84	0.71	0.85	0.81
6	All	1	poly	4	auto	0.82	0.73	0.83	0.80
6	All	1	poly	5	auto	0.81	0.69	0.86	0.76
6	All	1	poly	3	scale	0.83	0.71	0.78	0.80
6	All	1	poly	4	scale	0.74	0.83	0.77	0.80
6	All	1	poly	5	scale	0.91	0.80	0.89	0.86

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	All	10	poly	3	auto	0.89	0.82	0.86	0.84
6	All	10	poly	4	auto	0.90	0.82	0.85	0.84
6	All	10	poly	5	auto	0.87	0.80	0.85	0.83
6	All	10	poly	3	scale	0.90	0.84	0.87	0.88
6	All	10	poly	4	scale	0.89	0.83	0.86	0.84
6	All	10	poly	5	scale	0.90	0.85	0.89	0.88
6	All	0.1	rbf	-	auto	0.84	0.55	0.88	0.74
6	All	0.1	rbf	-	scale	0.15	0.90	0.14	0.43
6	All	1	rbf	-	auto	0.87	0.70	0.88	0.81
6	All	1	rbf	-	scale	0.15	0.91	0.16	0.44
6	All	10	rbf	-	auto	0.89	0.77	0.87	0.84
6	All	10	rbf	-	scale	0.60	0.88	0.30	0.59

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	Force	0.1	poly	3	auto	0.83	0.59	0.89	0.75
6	Force	0.1	poly	4	auto	0.79	0.66	0.77	0.73
6	Force	0.1	poly	5	auto	0.75	0.79	0.53	0.68
6	Force	0.1	poly	3	scale	0.91	0.80	0.89	0.86
6	Force	0.1	poly	4	scale	0.92	0.82	0.90	0.86
6	Force	0.1	poly	5	scale	0.91	0.84	0.91	0.87
6	Force	1	poly	3	auto	0.87	0.67	0.86	0.79
6	Force	1	poly	4	auto	0.85	0.68	0.84	0.78
6	Force	1	poly	5	auto	0.82	0.70	0.80	0.76
6	Force	1	poly	3	scale	0.89	0.83	0.90	0.86
6	Force	1	poly	4	scale	0.90	0.80	0.88	0.85
6	Force	1	poly	5	scale	0.90	0.81	0.89	0.86

# of Subjects	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
6	Force	10	poly	3	auto	0.89	0.77	0.86	0.84
6	Force	10	poly	4	auto	0.88	0.76	0.85	0.83
6	Force	10	poly	5	auto	0.87	0.75	0.82	0.81
6	Force	10	poly	3	scale	0.89	0.81	0.90	0.87
6	Force	10	poly	4	scale	0.90	0.85	0.88	0.86
6	Force	10	poly	5	scale	0.89	0.83	0.89	0.86
6	Force	0.1	rbf	-	auto	0.87	0.61	0.90	0.78
6	Force	0.1	rbf	-	scale	0.90	0.76	0.86	0.84
6	Force	1	rbf	-	auto	0.88	0.70	0.90	0.82
6	Force	1	rbf	-	scale	0.92	0.81	0.90	0.87
6	Force	10	rbf	-	auto	0.91	0.77	0.89	0.85
6	Force	10	rbf	-	scale	0.90	0.82	0.88	0.86

Trial Wise Cross-Validation

Trial wise cross-validation was used to evaluate neural networks, random forests, and SVM models across multiple hyperparameters. Classification accuracies were reported for each class as well as the overall accuracy.

Neural Network - Hyperparameters

- Training Specifications
  - Batch Size: 32 or 64
  - Epoch: 150 or 200
  - Patience: 20
  - Learning Rate Decay: 10
  - Validation Split: 20%
  - ADAM optimizer
    - Learning Rate: 0.0001
    - Beta_1: 0.9
    - Beta_2: 0.999

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
22	All	3,3	150	32	0.88	0.75	0.81	0.81
22	All	3,8	150	32	0.87	0.60	0.74	0.73
22	All	3,6,6	150	32	0.87	0.65	0.86	0.78
22	All	3,16,8	150	32	0.88	0.79	0.86	0.84
22	All	3,16,8,4	150	32	0.87	0.78	0.81	0.82
22	All	16,8,8	150	32	0.87	0.78	0.87	0.84
22	All	32,16,8	150	32	0.88	0.78	0.89	0.85
22	All	32,16,16,8	150	32	0.88	0.78	0.87	0.84

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
22	Force	3,3	150	32	0.85	0.84	0.61	0.77
22	Force	3,8	150	32	0.86	0.84	0.71	0.80
22	Force	3,6,6	150	32	0.85	0.80	0.73	0.79
22	Force	3,16,8	150	32	0.87	0.75	0.80	0.81
22	Force	3,16,8,4	150	32	0.90	0.69	0.86	0.81
22	Force	16,8,8	150	32	0.89	0.79	0.86	0.85
22	Force	32,16,8	150	32	0.91	0.83	0.90	0.88
22	Force	32,16,16,8	150	32	0.91	0.83	0.88	0.87

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
24	All	3,3	150	32	0.31	0.83	0.12	0.48
24	All	3,8	150	32	0.86	0.76	0.85	0.83
24	All	3,6,6	150	32	0.85	0.75	0.80	0.80
24	All	3,16,8	150	32	0.85	0.79	0.75	0.80
24	All	3,16,8,4	150	32	0.86	0.75	0.74	0.78
24	All	16,8,8	150	32	0.86	0.81	0.83	0.84
24	All	32,16,8	150	32	0.86	0.81	0.84	0.83
24	All	32,16,16,8	150	32	0.88	0.82	0.86	0.85

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
24	Force	3,3	150	32	0.83	0.68	0.80	0.77
24	Force	3,8	150	32	0.85	0.78	0.85	0.83
24	Force	3,6,6	150	32	0.86	0.78	0.85	0.83
24	Force	3,16,8	150	32	0.84	0.80	0.71	0.78
24	Force	3,16,8,4	150	32	0.86	0.81	0.84	0.84
24	Force	16,8,8	150	32	0.87	0.82	0.86	0.85
24	Force	32,16,8	150	32	0.90	0.85	0.88	0.87
24	Force	32,16,16,8	150	32	0.90	0.84	0.89	0.88

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
26	All	3,3	150	32	0.72	0.56	0.47	0.57
26	All	3,8	150	32	0.87	0.78	0.81	0.81
26	All	3,6,6	150	32	0.87	0.68	0.83	0.79
26	All	3,16,8	150	32	0.87	0.76	0.77	0.80
26	All	3,16,8,4	150	32	0.87	0.80	0.75	0.80
26	All	16,8,8	150	32	0.89	0.81	0.81	0.84
26	All	32,16,8	150	32	0.88	0.81	0.81	0.83
26	All	32,16,16,8	150	32	0.88	0.83	0.82	0.84

Trial Wise Cross-Validation: Neural Network

# of Trials	Feature Type	Layer Size	Epoch	Batch Size	Class Accuracy			Total Accuracy
					WH	CD	CP	
26	Force	3,3	150	32	0.85	0.76	0.80	0.81
26	Force	3,8	150	32	0.86	0.80	0.86	0.83
26	Force	3,6,6	150	32	0.88	0.79	0.85	0.83
26	Force	3,16,8	150	32	0.86	0.79	0.85	0.83
26	Force	3,16,8,4	150	32	0.84	0.80	0.79	0.80
26	Force	16,8,8	150	32	0.89	0.83	0.89	0.86
26	Force	32,16,8	150	32	0.89	0.85	0.88	0.88
26	Force	32,16,16,8	150	32	0.90	0.82	0.89	0.87

Randomforest - Hyperparameters

- Training Specifications
  - n_estimator: the number of decision trees
    - 10, 50
  - max_depth: the maximum depth allowed for each decision tree
    - 2, 5, 10
  - min_samples_split: the minimum number of samples required to split a node
    - 2, 5

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
22	Force	10	5	2	0.86	0.79	0.86	0.83
22	Force	10	5	5	0.87	0.77	0.87	0.83
22	Force	10	10	2	0.90	0.82	0.88	0.86
22	Force	10	10	5	0.91	0.84	0.88	0.88
22	Force	10	None	2	0.92	0.83	0.87	0.87
22	Force	10	None	5	0.92	0.82	0.87	0.87
22	Force	50	5	2	0.87	0.77	0.88	0.83
22	Force	50	5	5	0.87	0.77	0.89	0.84
22	Force	50	10	2	0.92	0.82	0.90	0.87
22	Force	50	10	5	0.91	0.81	0.88	0.87
22	Force	50	None	2	0.93	0.80	0.89	0.87
22	Force	50	None	5	0.93	0.81	0.88	0.87

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
22	All	10	5	2	0.84	0.77	0.86	0.83
22	All	10	5	5	0.84	0.77	0.84	0.82
22	All	10	10	2	0.90	0.82	0.88	0.87
22	All	10	10	5	0.89	0.83	0.87	0.87
22	All	10	None	2	0.92	0.84	0.86	0.87
22	All	10	None	5	0.90	0.83	0.85	0.86
22	All	50	5	2	0.85	0.77	0.89	0.84
22	All	50	5	5	0.84	0.78	0.88	0.84
22	All	50	10	2	0.90	0.83	0.89	0.87
22	All	50	10	5	0.90	0.83	0.90	0.87
22	All	50	None	2	0.91	0.83	0.89	0.88
22	All	50	None	5	0.91	0.82	0.89	0.87

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
24	Force	10	5	2	0.84	0.77	0.86	0.83
24	Force	10	5	5	0.84	0.77	0.84	0.82
24	Force	10	10	2	0.90	0.82	0.88	0.87
24	Force	10	10	5	0.90	0.83	0.87	0.87
24	Force	10	None	2	0.92	0.84	0.86	0.87
24	Force	10	None	5	0.90	0.83	0.85	0.86
24	Force	50	5	2	0.85	0.77	0.89	0.84
24	Force	50	5	5	0.84	0.78	0.88	0.84
24	Force	50	10	2	0.90	0.83	0.89	0.87
24	Force	50	10	5	0.90	0.83	0.89	0.87
24	Force	50	None	2	0.91	0.83	0.88	0.88
24	Force	50	None	5	0.91	0.82	0.89	0.87

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
24	All	10	5	2	0.87	0.76	0.86	0.83
24	All	10	5	5	0.85	0.77	0.86	0.82
24	All	10	10	2	0.90	0.82	0.86	0.86
24	All	10	10	5	0.91	0.81	0.86	0.86
24	All	10	None	2	0.91	0.82	0.86	0.86
24	All	10	None	5	0.91	0.81	0.84	0.85
24	All	50	5	2	0.87	0.77	0.88	0.83
24	All	50	5	5	0.87	0.78	0.87	0.84
24	All	50	10	2	0.91	0.82	0.88	0.87
24	All	50	10	5	0.91	0.83	0.88	0.87
24	All	50	None	2	0.92	0.80	0.87	0.86
24	All	50	None	5	0.92	0.81	0.88	0.87

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
26	Force	10	5	2	0.87	0.77	0.86	0.83
26	Force	10	5	5	0.87	0.78	0.86	0.83
26	Force	10	10	2	0.91	0.83	0.89	0.87
26	Force	10	10	5	0.91	0.82	0.89	0.87
26	Force	10	None	2	0.91	0.82	0.87	0.87
26	Force	10	None	5	0.91	0.82	0.88	0.87
26	Force	50	5	2	0.87	0.78	0.88	0.84
26	Force	50	5	5	0.87	0.78	0.88	0.84
26	Force	50	10	2	0.92	0.83	0.89	0.88
26	Force	50	10	5	0.91	0.83	0.90	0.88
26	Force	50	None	2	0.92	0.83	0.88	0.88
26	Force	50	None	5	0.91	0.82	0.89	0.87

# of Trials	Feature Type	N estimator	Max Depth	Min Sample Split	Class Accuracy			Total Accuracy
					WH	CD	CP	
26	All	10	5	2	0.87	0.76	0.86	0.83
26	All	10	5	5	0.85	0.77	0.86	0.82
26	All	10	10	2	0.90	0.82	0.86	0.86
26	All	10	10	5	0.91	0.81	0.86	0.86
26	All	10	None	2	0.91	0.82	0.86	0.86
26	All	10	None	5	0.91	0.81	0.84	0.85
26	All	50	5	2	0.87	0.77	0.88	0.83
26	All	50	5	5	0.87	0.78	0.87	0.84
26	All	50	10	2	0.91	0.82	0.88	0.87
26	All	50	10	5	0.91	0.83	0.88	0.87
26	All	50	None	2	0.92	0.80	0.87	0.86
26	All	50	None	5	0.92	0.81	0.88	0.87

SVM - Hyperparameters

- Training Specifications
  - C: The regularization parameter (controls the trade-off between maximizing the margin and minimizing the classification error)
    - 0.1, 1, 10
  - Kernel: Type of kernel function
    - Polynomial, Radial Basis Function (RBF)
  - Degree: The degree of the polynomial function
    - 3, 4, 5
  - Gamma: defines the influence of a single training example
    - Scale: 1 / (n_features * variance)
    - Auto: 1 / n_features

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
22	All	0.1	poly	3	auto	0.82	0.69	0.66	0.72
22	All	0.1	poly	4	auto	0.79	0.84	0.41	0.69
22	All	0.1	poly	5	auto	0.74	0.79	0.60	0.71
22	All	0.1	poly	3	scale	0.005	0.99	0.004	0.37
22	All	0.1	poly	4	scale	0.007	0.99	0.001	0.37
22	All	0.1	poly	5	scale	0.007	0.99	0.01	0.37
22	All	1	poly	3	auto	0.85	0.56	0.92	0.77
22	All	1	poly	4	auto	0.85	0.69	0.84	0.76
22	All	1	poly	5	auto	0.84	0.70	0.80	0.75
22	All	1	poly	3	scale	0.79	0.72	0.82	0.76
22	All	1	poly	4	scale	0.91	0.83	0.92	0.88
22	All	1	poly	5	scale	0.93	0.82	0.89	0.87

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
22	All	10	poly	3	auto	0.85	0.77	0.88	0.83
22	All	10	poly	4	auto	0.87	0.76	0.88	0.83
22	All	10	poly	5	auto	0.90	0.82	0.91	0.88
22	All	10	poly	3	scale	0.91	0.81	0.89	0.87
22	All	10	poly	4	scale	0.92	0.84	0.88	0.88
22	All	10	poly	5	scale	0.92	0.82	0.88	0.87
22	All	0.1	rbf	-	auto	0.85	0.57	0.93	0.75
22	All	0.1	rbf	-	scale	0.22	0.87	0.22	0.45
22	All	1	rbf	-	auto	0.87	0.69	0.87	0.80
22	All	1	rbf	-	scale	0.23	0.87	0.24	0.47
22	All	10	rbf	-	auto	0.89	0.86	0.86	0.87
22	All	10	rbf	-	scale	0.44	0.89	0.26	0.56

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
22	Force	0.1	poly	3	auto	0.82	0.60	0.88	0.76
22	Force	0.1	poly	4	auto	0.79	0.65	0.81	0.74
22	Force	0.1	poly	5	auto	0.74	0.79	0.60	0.71
22	Force	0.1	poly	3	scale	0.91	0.78	0.87	0.85
22	Force	0.1	poly	4	scale	0.89	0.81	0.89	0.86
22	Force	0.1	poly	5	scale	0.90	0.84	0.89	0.85
22	Force	1	poly	3	auto	0.87	0.66	0.86	0.79
22	Force	1	poly	4	auto	0.85	0.67	0.85	0.78
22	Force	1	poly	5	auto	0.81	0.68	0.81	0.76
22	Force	1	poly	3	scale	0.89	0.83	0.89	0.86
22	Force	1	poly	4	scale	0.91	0.84	0.90	0.87
22	Force	1	poly	5	scale	0.90	0.85	0.89	0.86

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
22	Force	10	poly	3	auto	0.89	0.76	0.86	0.83
22	Force	10	poly	4	auto	0.88	0.74	0.85	0.82
22	Force	10	poly	5	auto	0.87	0.74	0.84	0.81
22	Force	10	poly	3	scale	0.90	0.84	0.88	0.85
22	Force	10	poly	4	scale	0.90	0.85	0.90	0.86
22	Force	10	poly	5	scale	0.91	0.85	0.89	0.86
22	Force	0.1	rbf	-	auto	0.87	0.60	0.90	0.78
22	Force	0.1	rbf	-	scale	0.90	0.76	0.87	0.84
22	Force	1	rbf	-	auto	0.89	0.67	0.90	0.81
22	Force	1	rbf	-	scale	0.93	0.80	0.88	0.87
22	Force	10	rbf	-	auto	0.91	0.77	0.87	0.85
22	Force	10	rbf	-	scale	0.90	0.83	0.91	0.88

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
24	All	0.1	poly	3	auto	0.80	0.62	0.86	0.76
24	All	0.1	poly	4	auto	0.81	0.64	0.83	0.74
24	All	0.1	poly	5	auto	0.76	0.81	0.62	0.71
24	All	0.1	poly	3	scale	0.89	0.80	0.86	0.85
24	All	0.1	poly	4	scale	0.90	0.81	0.88	0.86
24	All	0.1	poly	5	scale	0.90	0.82	0.90	0.87
24	All	1	poly	3	auto	0.88	0.72	0.84	0.81
24	All	1	poly	4	auto	0.81	0.69	0.85	0.79
24	All	1	poly	5	auto	0.84	0.71	0.83	0.77
24	All	1	poly	3	scale	0.89	0.80	0.88	0.85
24	All	1	poly	4	scale	0.88	0.82	0.88	0.87
24	All	1	poly	5	scale	0.90	0.84	0.89	0.86

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
24	All	10	poly	3	auto	0.89	0.80	0.86	0.83
24	All	10	poly	4	auto	0.86	0.80	0.85	0.82
24	All	10	poly	5	auto	0.87	0.75	0.82	0.81
24	All	10	poly	3	scale	0.88	0.78	0.88	0.84
24	All	10	poly	4	scale	0.88	0.78	0.88	0.84
24	All	10	poly	5	scale	0.92	0.84	0.90	0.86
24	All	0.1	rbf	-	auto	0.82	0.55	0.91	0.75
24	All	0.1	rbf	-	scale	0.16	0.96	0.06	0.44
24	All	1	rbf	-	auto	0.85	0.70	0.88	0.81
24	All	1	rbf	-	scale	0.18	0.90	0.19	0.47
24	All	10	rbf	-	auto	0.88	0.77	0.87	0.84
24	All	10	rbf	-	scale	0.49	0.86	0.40	0.59

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
24	Force	0.1	poly	3	auto	0.79	0.60	0.86	0.75
24	Force	0.1	poly	4	auto	0.76	0.66	0.78	0.73
24	Force	0.1	poly	5	auto	0.71	0.77	0.61	0.71
24	Force	0.1	poly	3	scale	0.88	0.78	0.86	0.83
24	Force	0.1	poly	4	scale	0.87	0.80	0.86	0.84
24	Force	0.1	poly	5	scale	0.88	0.81	0.89	0.85
24	Force	1	poly	3	auto	0.84	0.67	0.85	0.79
24	Force	1	poly	4	auto	0.82	0.67	0.83	0.77
24	Force	1	poly	5	auto	0.79	0.69	0.80	0.76
24	Force	1	poly	3	scale	0.91	0.82	0.88	0.86
24	Force	1	poly	4	scale	0.90	0.85	0.90	0.87
24	Force	1	poly	5	scale	0.91	0.85	0.89	0.88

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
24	Force	10	poly	3	auto	0.88	0.76	0.87	0.84
24	Force	10	poly	4	auto	0.87	0.76	0.85	0.83
24	Force	10	poly	5	auto	0.85	0.75	0.83	0.81
24	Force	10	poly	3	scale	0.86	0.82	0.91	0.85
24	Force	10	poly	4	scale	0.89	0.84	0.88	0.86
24	Force	10	poly	5	scale	0.88	0.84	0.86	0.85
24	Force	0.1	rbf	-	auto	0.85	0.60	0.89	0.78
24	Force	0.1	rbf	-	scale	0.89	0.76	0.87	0.84
24	Force	1	rbf	-	auto	0.87	0.69	0.89	0.81
24	Force	1	rbf	-	scale	0.91	0.81	0.89	0.87
24	Force	10	rbf	-	auto	0.90	0.77	0.89	0.85
24	Force	10	rbf	-	scale	0.91	0.83	0.89	0.87

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
26	All	0.1	poly	3	auto	0.83	0.60	0.89	0.76
26	All	0.1	poly	4	auto	0.79	0.65	0.82	0.75
26	All	0.1	poly	5	auto	0.75	0.76	0.65	0.72
26	All	0.1	poly	3	scale	0.91	0.79	0.89	0.86
26	All	0.1	poly	4	scale	0.92	0.81	0.90	0.87
26	All	0.1	poly	5	scale	0.92	0.84	0.90	0.87
26	All	1	poly	3	auto	0.87	0.67	0.87	0.79
26	All	1	poly	4	auto	0.85	0.67	0.85	0.78
26	All	1	poly	5	auto	0.82	0.68	0.82	0.76
26	All	1	poly	3	scale	0.90	0.81	0.88	0.84
26	All	1	poly	4	scale	0.91	0.82	0.91	0.86
26	All	1	poly	5	scale	0.90	0.80	0.90	0.85

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
26	All	10	poly	3	auto	0.90	0.82	0.86	0.85
26	All	10	poly	4	auto	0.87	0.80	0.88	0.83
26	All	10	poly	5	auto	0.87	0.81	0.88	0.84
26	All	10	poly	3	scale	0.90	0.82	0.86	0.85
26	All	10	poly	4	scale	0.90	0.82	0.88	0.86
26	All	10	poly	5	scale	0.91	0.81	0.89	0.88
26	All	0.1	rbf	-	auto	0.84	0.55	0.88	0.74
26	All	0.1	rbf	-	scale	0.15	0.90	0.14	0.43
26	All	1	rbf	-	auto	0.87	0.70	0.88	0.81
26	All	1	rbf	-	scale	0.15	0.91	0.16	0.44
26	All	10	rbf	-	auto	0.89	0.77	0.87	0.84
26	All	10	rbf	-	scale	0.60	0.88	0.30	0.59

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
26	Force	0.1	poly	3	auto	0.83	0.59	0.89	0.75
26	Force	0.1	poly	4	auto	0.79	0.66	0.77	0.73
26	Force	0.1	poly	5	auto	0.75	0.79	0.53	0.68
26	Force	0.1	poly	3	scale	0.91	0.78	0.89	0.86
26	Force	0.1	poly	4	scale	0.92	0.83	0.90	0.87
26	Force	0.1	poly	5	scale	0.91	0.83	0.89	0.86
26	Force	1	poly	3	auto	0.87	0.67	0.86	0.79
26	Force	1	poly	4	auto	0.85	0.68	0.84	0.78
26	Force	1	poly	5	auto	0.82	0.70	0.80	0.76
26	Force	1	poly	3	scale	0.92	0.82	0.91	0.88
26	Force	1	poly	4	scale	0.92	0.82	0.90	0.88
26	Force	1	poly	5	scale	0.91	0.84	0.90	0.87

# of Trials	Feature Type	C	Kernel	Degree	Gamma	Class Accuracy			Total Accuracy
						WH	CD	CP	
26	Force	10	poly	3	auto	0.89	0.77	0.86	0.84
26	Force	10	poly	4	auto	0.88	0.76	0.85	0.83
26	Force	10	poly	5	auto	0.87	0.75	0.82	0.81
26	Force	10	poly	3	scale	0.92	0.81	0.88	0.83
26	Force	10	poly	4	scale	0.92	0.82	0.89	0.85
26	Force	10	poly	5	scale	0.90	0.84	0.87	0.88
26	Force	0.1	rbf	-	auto	0.87	0.61	0.90	0.78
26	Force	0.1	rbf	-	scale	0.90	0.76	0.86	0.84
26	Force	1	rbf	-	auto	0.88	0.70	0.90	0.82
26	Force	1	rbf	-	scale	0.92	0.81	0.90	0.87
26	Force	10	rbf	-	auto	0.91	0.77	0.89	0.85
26	Force	10	rbf	-	scale	0.92	0.83	0.89	0.86