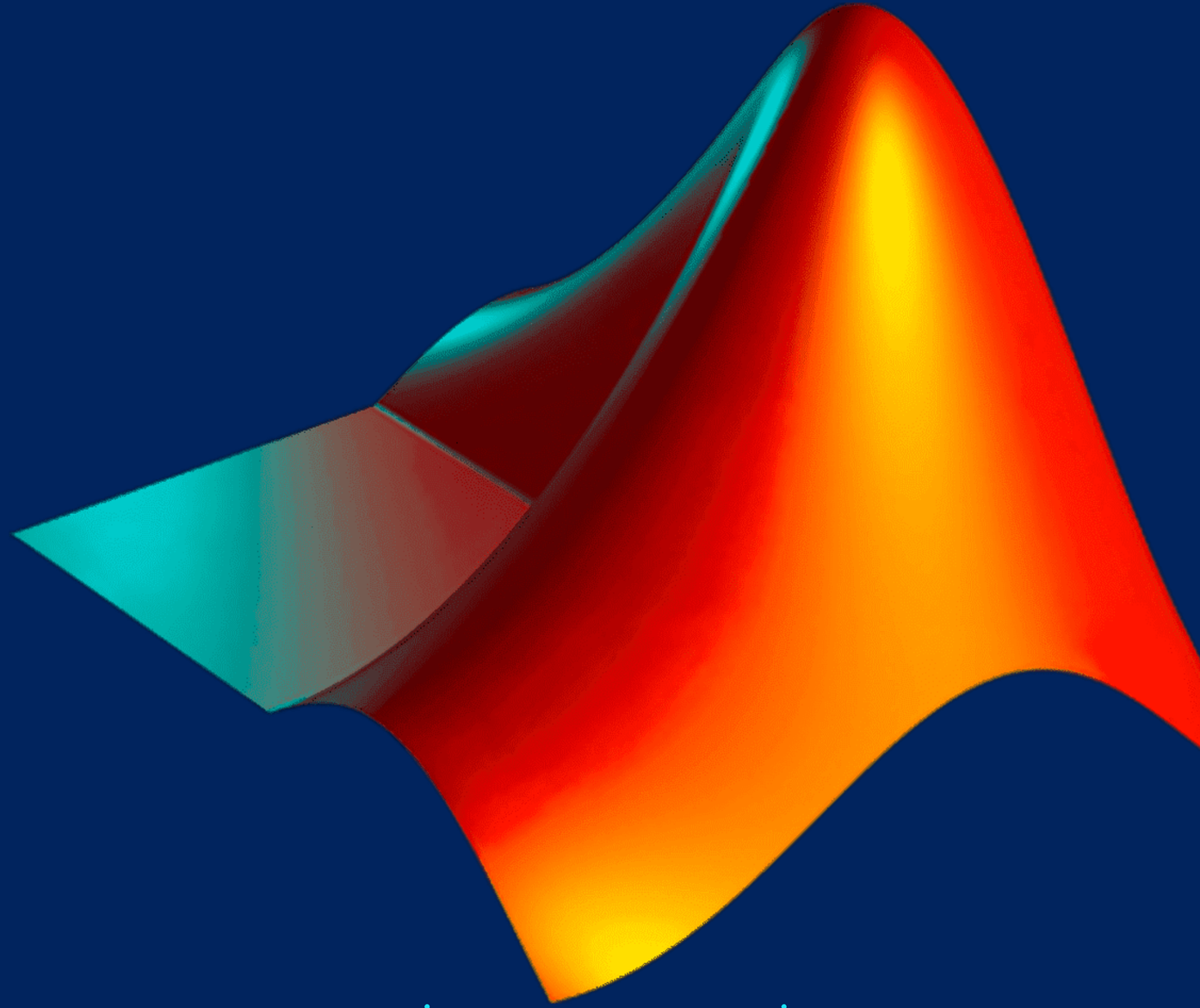
ARM ANGLES PREDICTION



1 MOSTAFA TAREK

2 MOHAMED EZZ AL-REGAL

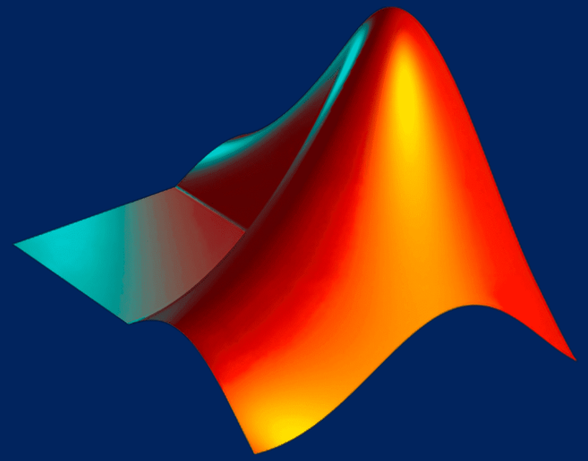
3 ABD EL-RAHMAN AHMED

4 NOUR EHAB

5 FARAH WALEED

Abstract

- We used 3 models of NN using MATLAB and by changing the parameters we found the best model accuracy is (Generalized Regression Neural Network)
- With the Python code, We used 3 models NN and 5 machine learning models, and also by changing the parameters like (activation function) and (number of hidden layers and neurons) we found that the best model accuracy in NN Models is (feed-forward sklearn) and in the Machine Models is (Decision tree regression)



MATLAB

Introduction

- First of all, we decided to use MATLAB and Python code to get the best accuracy for our project
- In MATLAB we used many models like (Feedforward Neural Network) & (Generalized Regression Neural Network)& (Radial Basis Function) but the (Generalized Regression Neural Network) OR (GRNN) has the best accuracy

- And With the Python code, We used 3 models of (NN)
  (feed forward sklearn) & (normal neural network by TensorFlow) & (neural network with 1 conv1D)
  In the end, we found that the best model accuracy In (NN) is (feed-forward sklearn)

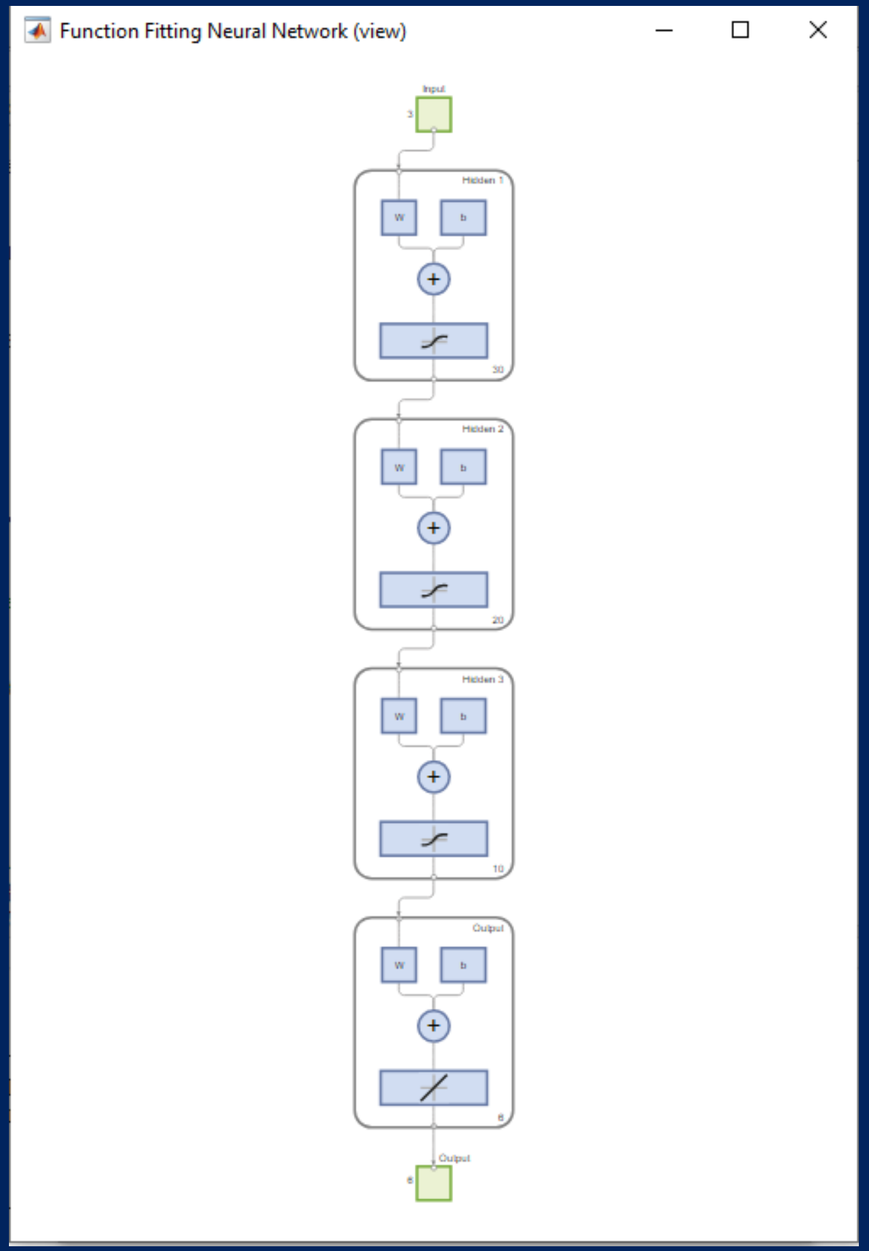
- And 5 machine learning models, (Decision tree regression) & (Extreme Gradient Boosting) & (Extra LeesRegressor) & (CatBoost Regressor) & (Light Gradient Boosting Machine) In the end we found that the best model accuracy In (ML) is (Decision tree regression)

- Input Size of the Neural Network: 3
- Output Size of the Neural Network: 6

Feedforward Neural Network

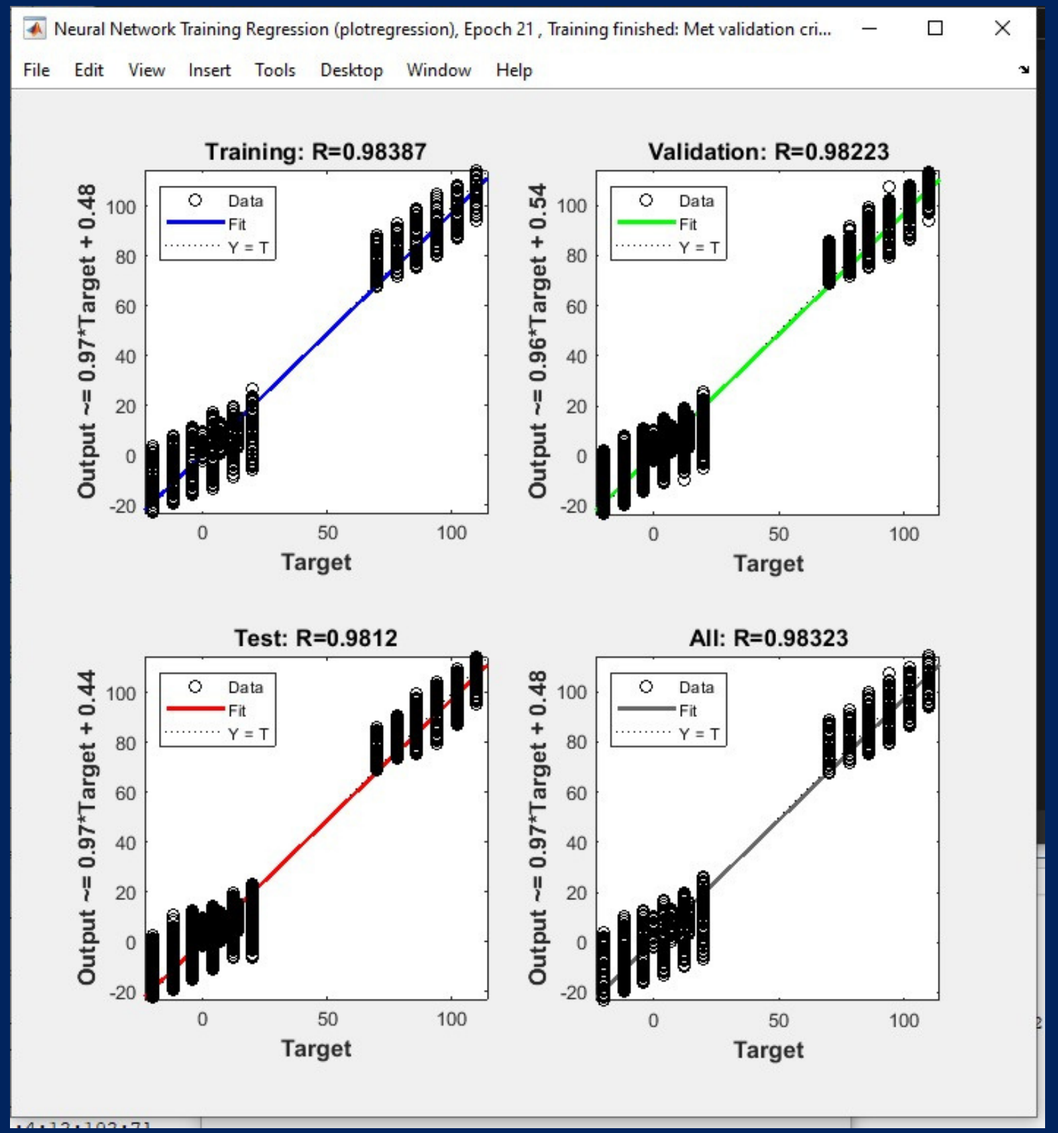
Model Architecture

- The specific activation functions used in the model are tansig and purelin.
- The type of training algorithm used backpropagation using trainlm as output layer
- The size of neurons is [30, 20, 10]



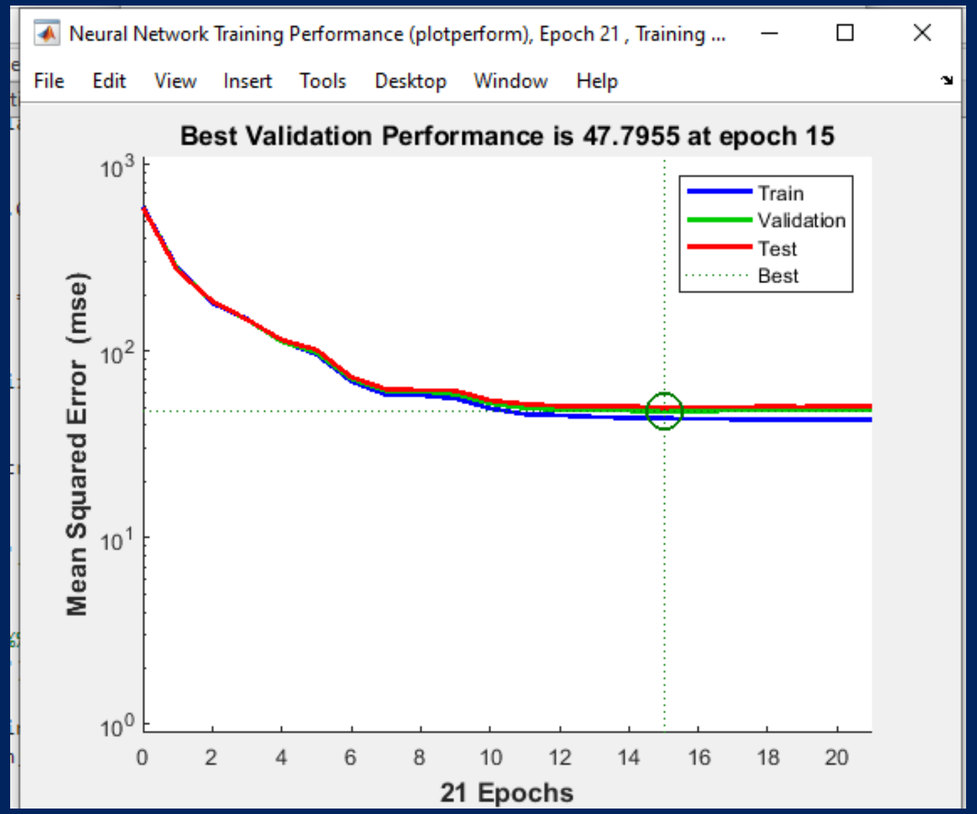
Model fitting

- The feed-forward network was trained for 21 epochs, and it achieved a correlation coefficient of 0.98387 on the training data and 0.98223 on the validation data.
- The test data correlation coefficient is 0.9812
- The bottom right graph reveals error distribution for test data, similar to training data, indicating good generalization.



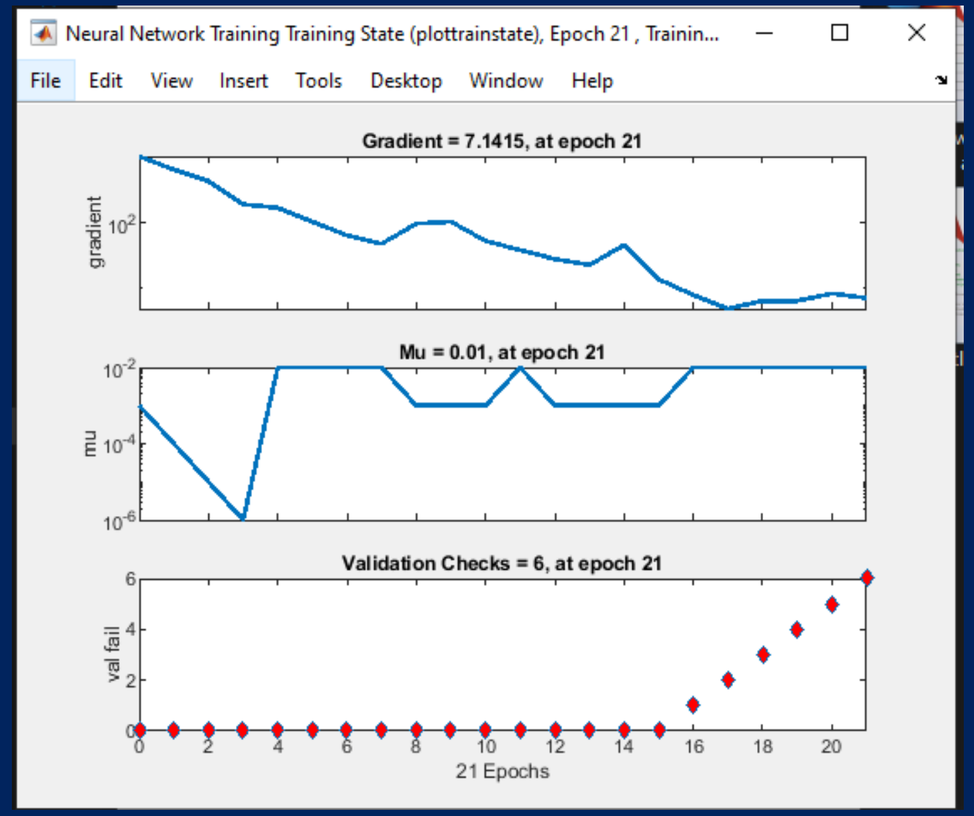
Feed Forward Model Validation

- The MSE of the network on the training data decreases steadily over the first few epochs but then starts to increase again.
- The MSE of the network on the validation data also decreases initially, but it starts to increase sooner than the MSE on the training data.
- the neural network is performing well. It is not overfitting to the training data, and it is generalizing well to unseen data.



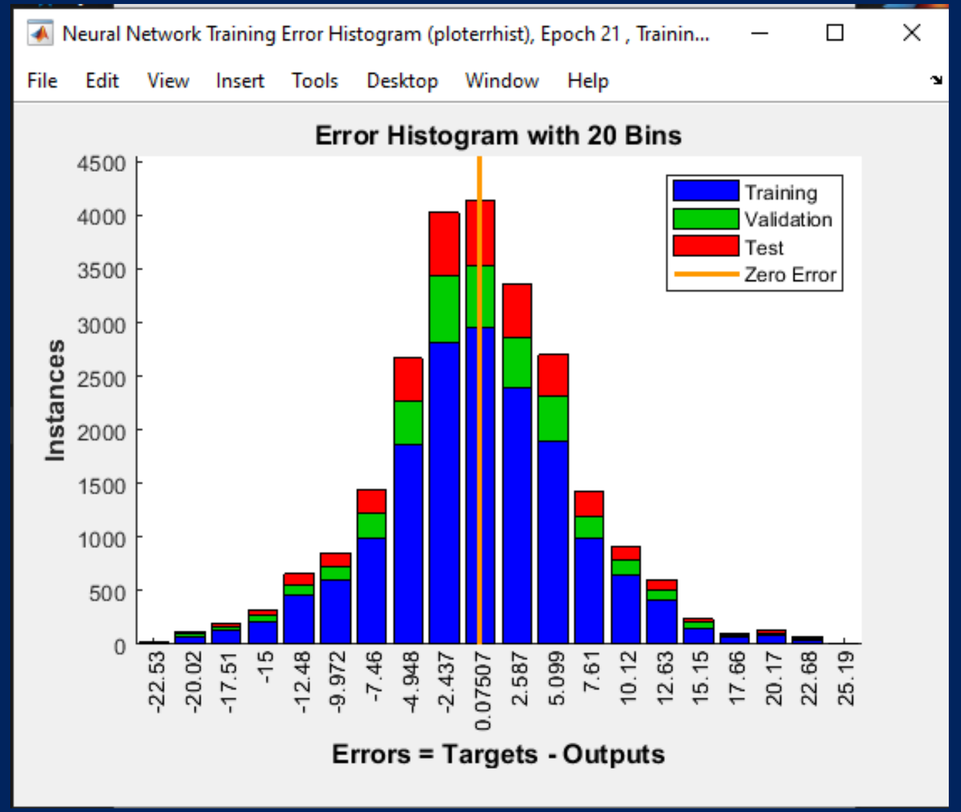
model hyperparameters

- the average value of the derivatives of the loss function for the weights of the network is 7.1415.
- The gradient is still relatively high, and the validation checks are not yet very accurate.
- the neural network is being trained using the Mu learning algorithm, with a learning rate of 0.01.



Error Histogram

- The error histogram shows that the model is making mostly small errors, as indicated by the peak near the center of the x-axis.
- The width of the peak is relatively narrow, which means that the errors are fairly consistent.
- The tails of the histogram are small, which means that the model is not making any large mistakes.



True and Predicted Values for the First 5 Data Points:
Data Point 1
Input Values: [17.6501758086464;9.19801248678441;0.476756596580092]
True Values: [-20;4;20;-20;110;14]
Predicted Values: [-14.7567689270453;-8.88609126256307;18.7519936540866;-6.4245920167895;112.780434383668;13.7398122850662]

Data Point 2
Input Values: [14.4174431646692;-7.64438021477108;42.4531881636444]
True Values: [-20;20;4;-12;78;7]
Predicted Values: [-17.3493617255066;0.347935918591297;2.50593473045962;4.5773995389794;78.6744693379017;8.75702048645851]

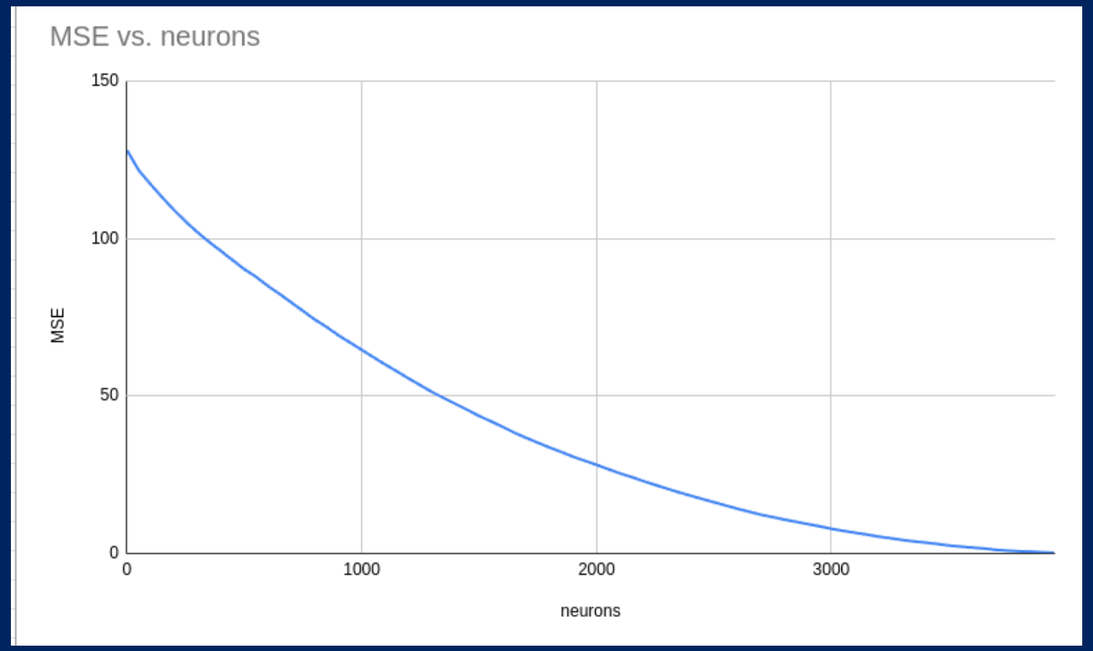
Data Point 3
Input Values: [11.6946376726245;-27.5534670338399;14.2285297134609]
True Values: [-20;20;4;12;110;14]
Predicted Values: [-21.1098734885271;16.743358557599;10.5613846242286;16.4438031826847;103.920199885773;9.72120384884727]

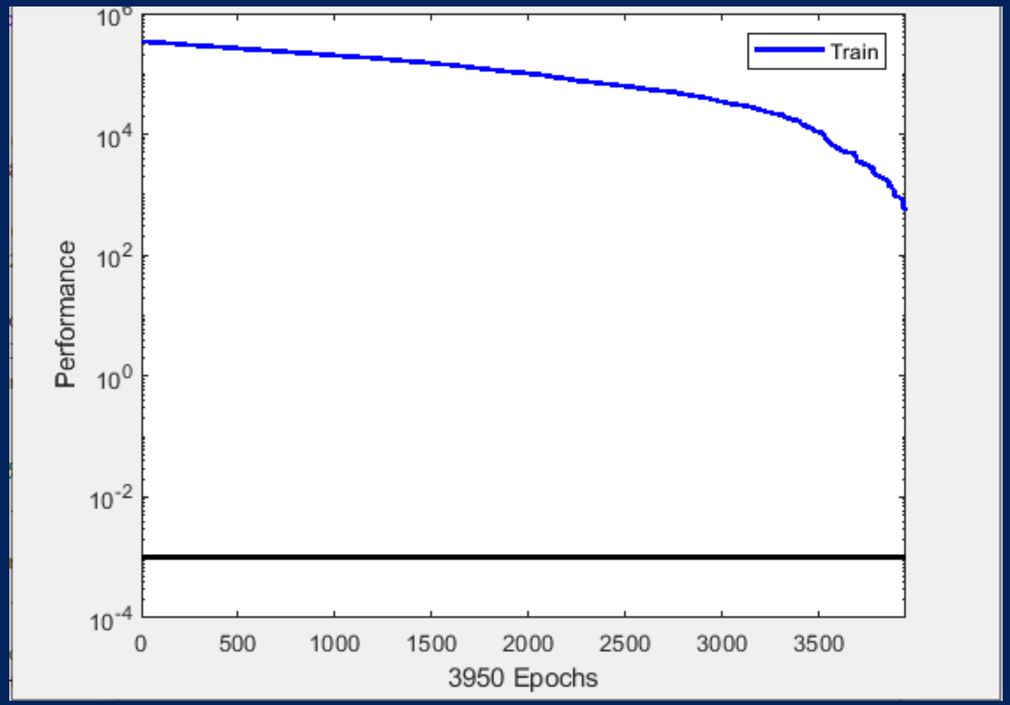
Data Point 4
Input Values: [39.7445631662175;-1.27783701261293;50.7949589136699]
True Values: [-20;4;-12;-20;78;0]
Predicted Values: [-15.295485888189;-1.69766452601961;-14.5285298202504;-13.3706123258608;82.4540200367458;2.00707127058088]

Data Point 5
Input Values: [14.6188545526042;-13.0424019855474;23.1645019235109]
True Values: [-20;-4;4;12;102;7]
Predicted Values: [-18.0217588530402;2.37893763563736;5.83072991875171;8.80884579795476;100.590055720885;5.66829280336165]

Radial Basis

- The decrease in Mean Squared Error (MSE) with an increasing number of neurons underscores the network's improved capacity to accurately model complex relationships within the training data.





True and Predicted Values for the First 5 Data Points:
Data Point 1
Input Values: [17.6501758086464;9.19801248678441;0.476756596580092]
True Values: [-20;4;20;-20;110;14]
Predicted Values: [-20.2719941217958;-2.24062469490428;20.0907146204609;6.33275297314212;83.1252904422028;8.02337717422795]

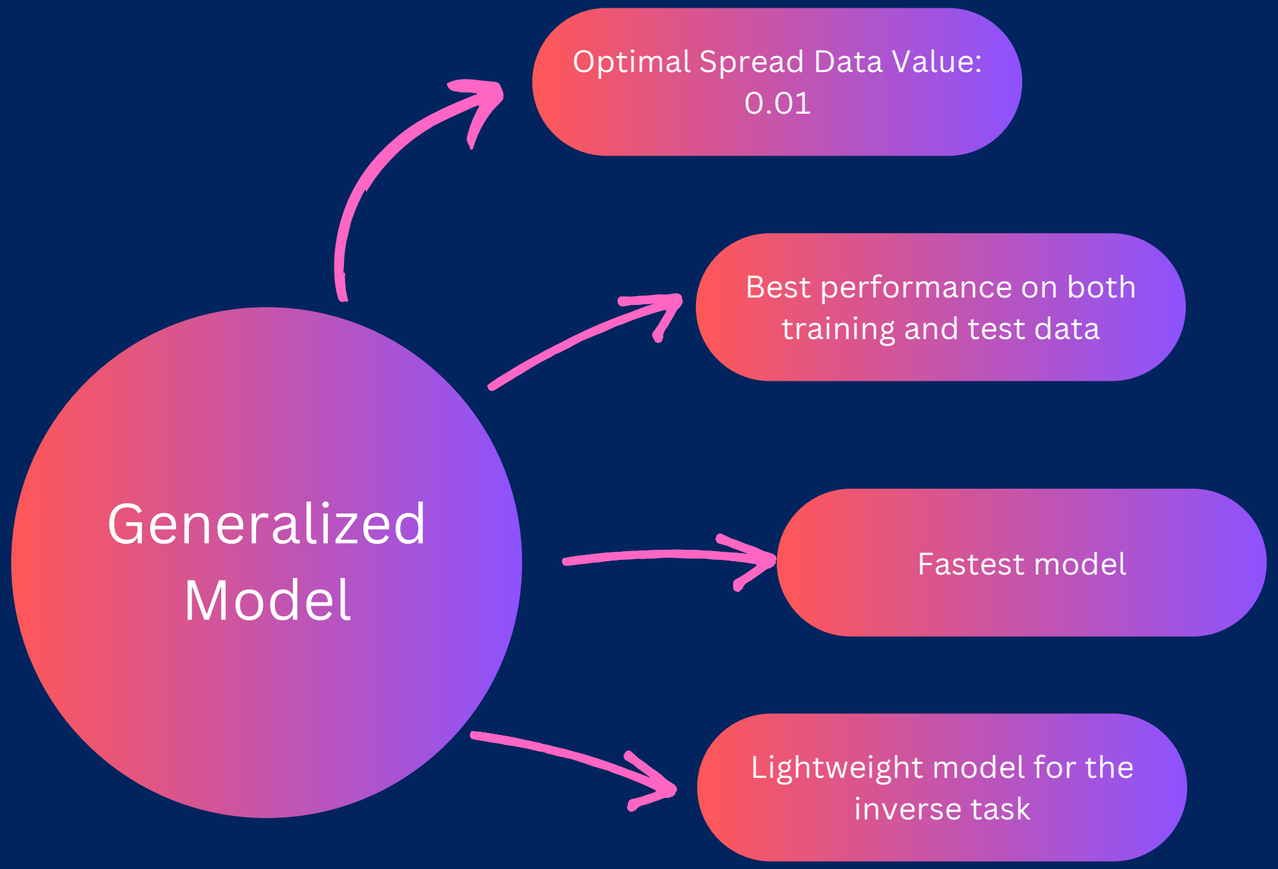
Data Point 2
Input Values: [14.4174431646692;-7.64438021477108;42.4531881636444]
True Values: [-20;20;4;-12;78;7]
Predicted Values: [-16.8587979325675;-16.1078853651957;4.05940374870229;15.9017105127498;77.8951006385846;6.91945867670959]

Data Point 3
Input Values: [11.6946376726245;-27.5534670338399;14.2285297134609]
True Values: [-20;20;4;12;110;14]
Predicted Values: [-20.8788424277758;-0.944222140056124;18.8806238336383;10.8456008537165;80.3840085987497;7.38447423893336]

Data Point 4
Input Values: [39.7445631662175;-1.27783701261293;50.7949589136699]
True Values: [-20;4;-12;-20;78;0]
Predicted Values: [-17.8533675558886;-10.2672283900903;6.882018192998864;4.20478969607274;78.0895110293273;4.1655570701803]

Data Point 5
Input Values: [14.6188545526042;-13.0424019855474;23.1645019235109]
True Values: [-20;-4;4;12;102;7]
Predicted Values: [-16.7677450087295;6.51304408017571;9.2244546211016;6.31266190471527;94.7889413647902;6.6847083410332]

Generalized Model



True and Predicted Values for the First 5 Data Points:
Data Point 1
Input Values: [17.6501758086464;9.19801248678441;0.476756596580092]
True Values: [-20;4;20;-20;110;14]
Predicted Values: [-20;-4;20;-12;110;14]

Data Point 2
Input Values: [14.4174431646692;-7.64438021477108;42.4531881636444]
True Values: [-20;20;4;-12;78;7]
Predicted Values: [-20;-12;4;12;78;7]

Data Point 3
Input Values: [11.6946376726245;-27.5534670338399;14.2285297134609]
True Values: [-20;20;4;12;110;14]
Predicted Values: [-20;12;4;20;110;14]

Data Point 4
Input Values: [39.7445631662175;-1.27783701261293;50.7949589136699]
True Values: [-20;4;-12;-20;78;0]
Predicted Values: [-12;-20;-12;-4;78;0]

Data Point 5
Input Values: [14.6188545526042;-13.0424019855474;23.1645019235109]
True Values: [-20;-4;4;12;102;7]
Predicted Values: [-20;20;4;-4;102;7]

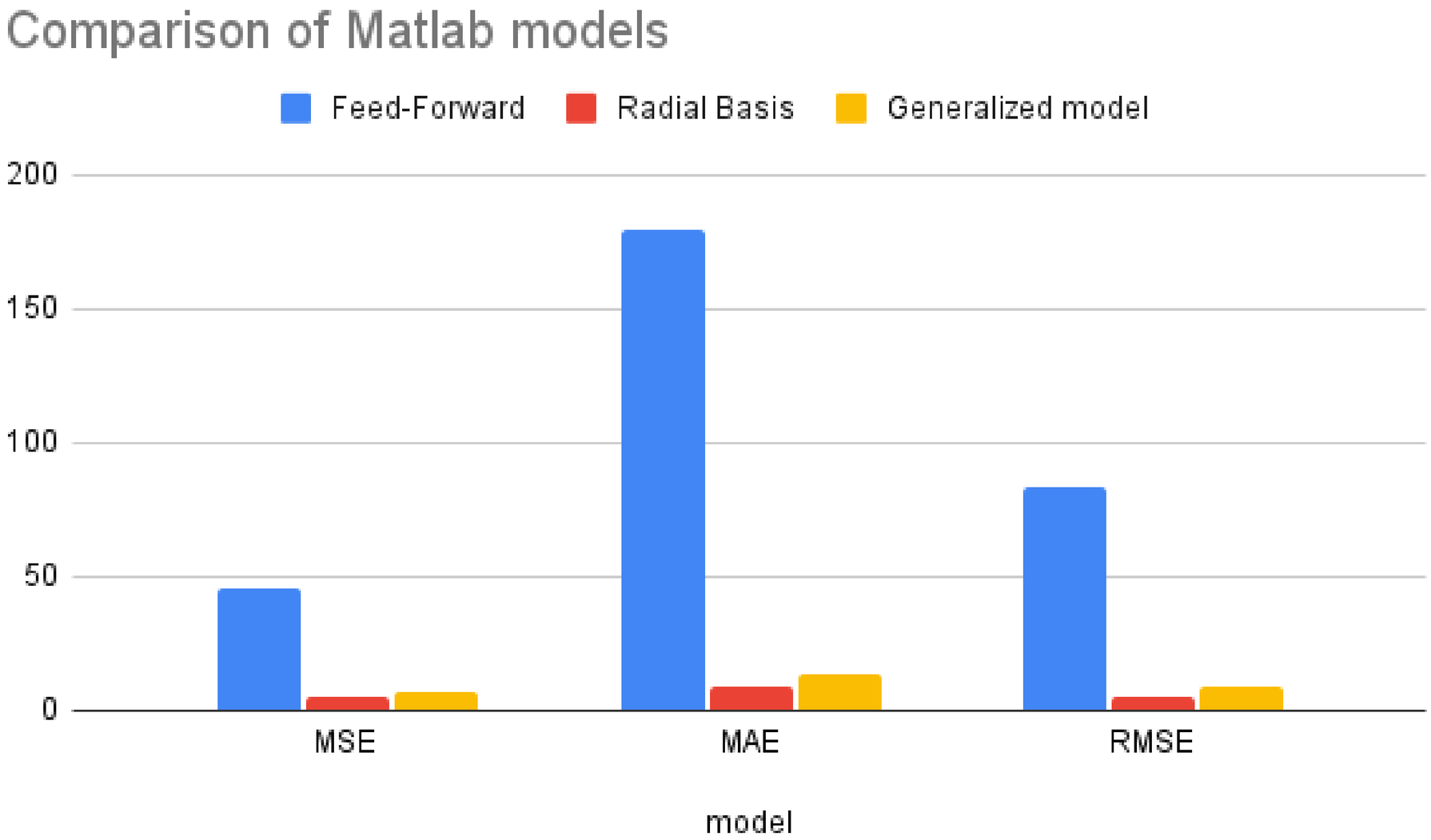
Compare

model	speed	accuracy	light weight
ff	✓	✓	✓
rb	✓	✓	
grnn	✓✓	✓	✓✓

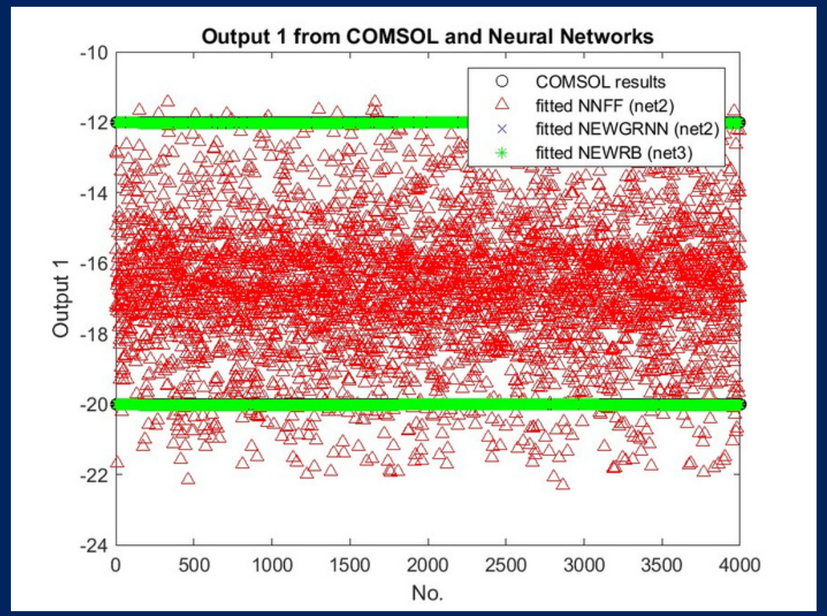
Scores

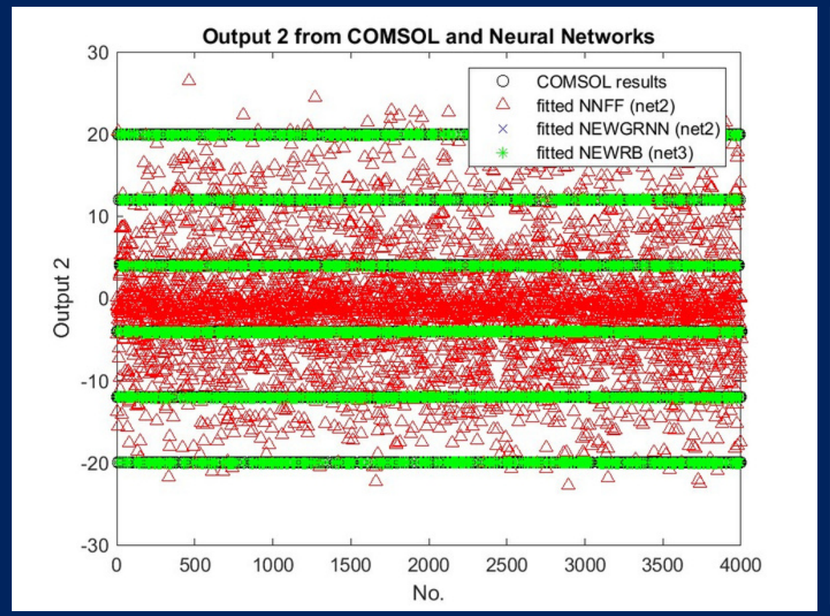
model	MSE	MAE	RMSE
Feed-Forward	45.3604	5.1431	6.7350
Radial Basis	179.3797	8.8829	13.3933
Generalized model	83.8090	5.5267	9.1547

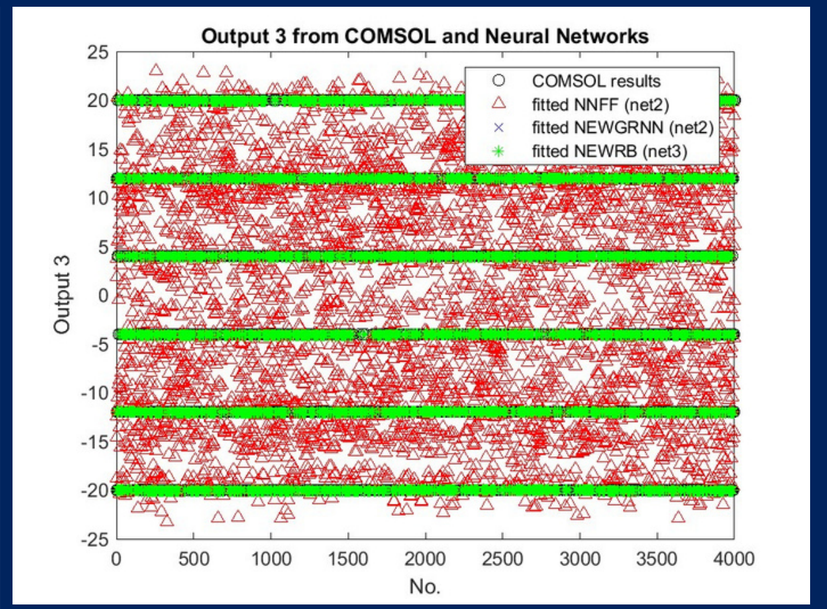
Comparison of Matlab models

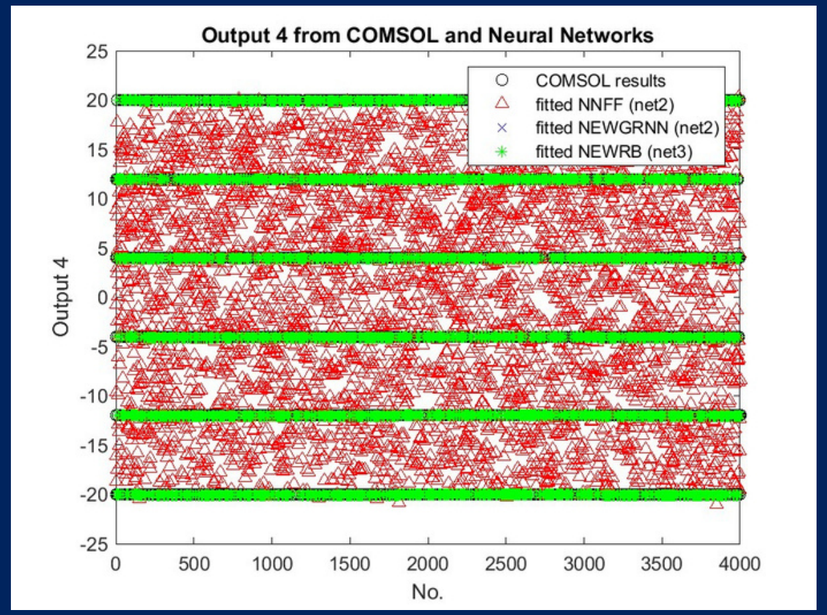


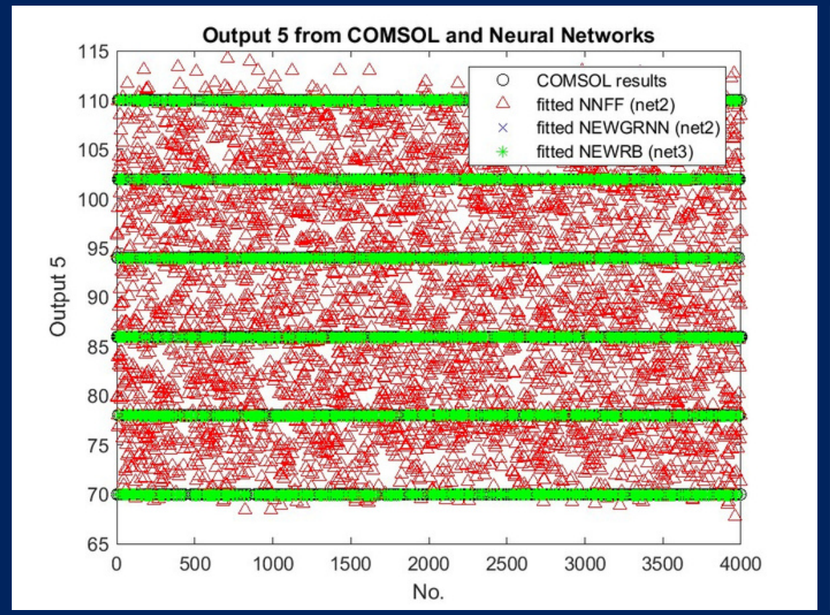
Train

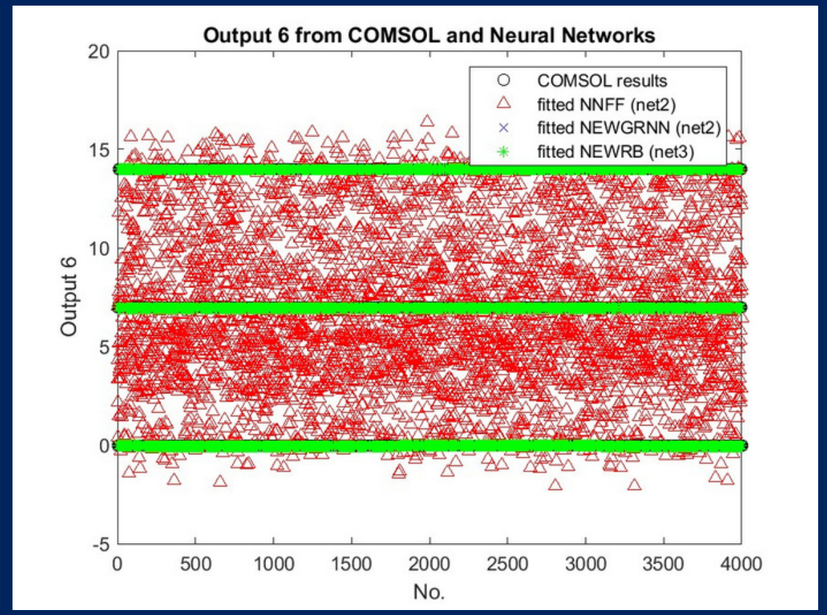

Output 1 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 1
No.


Output 2 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 2
No.

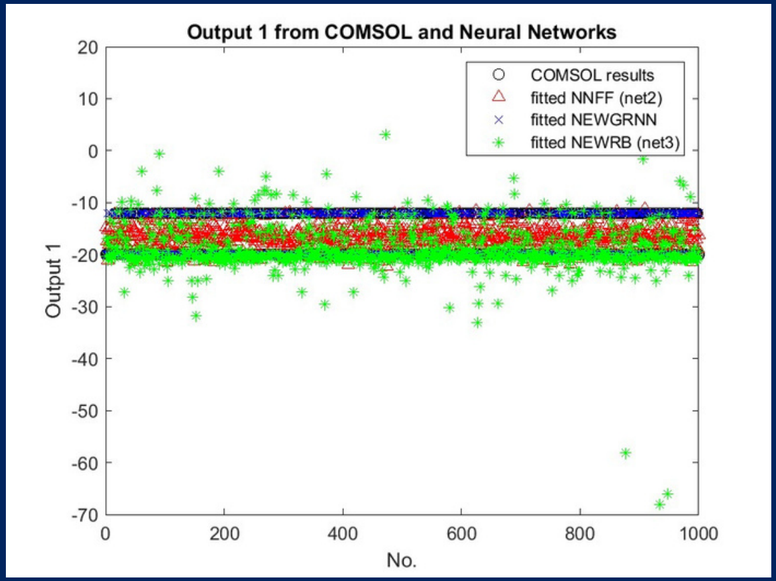

Output 3 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 3
No.

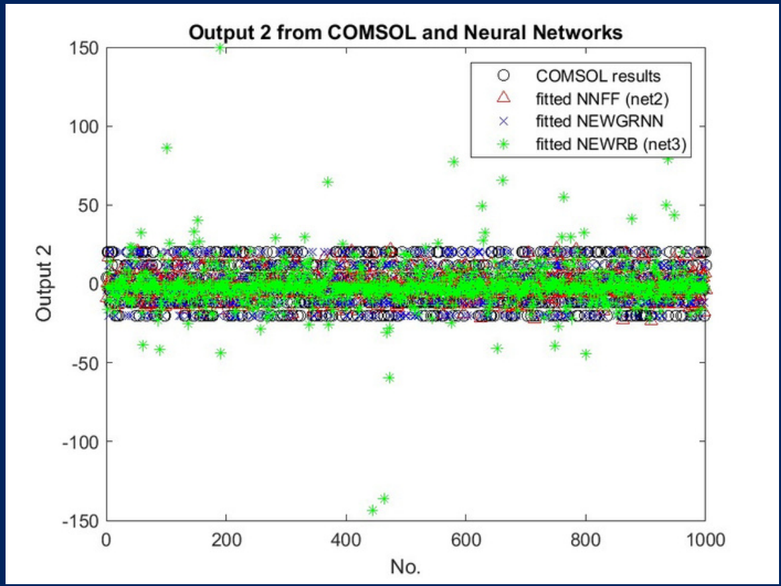

Output 4 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 4
No.

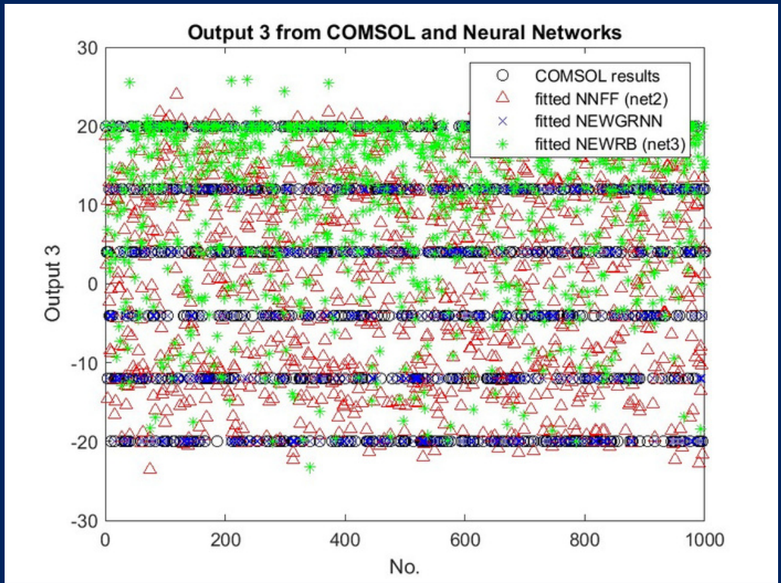

Output 5 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 5
No.

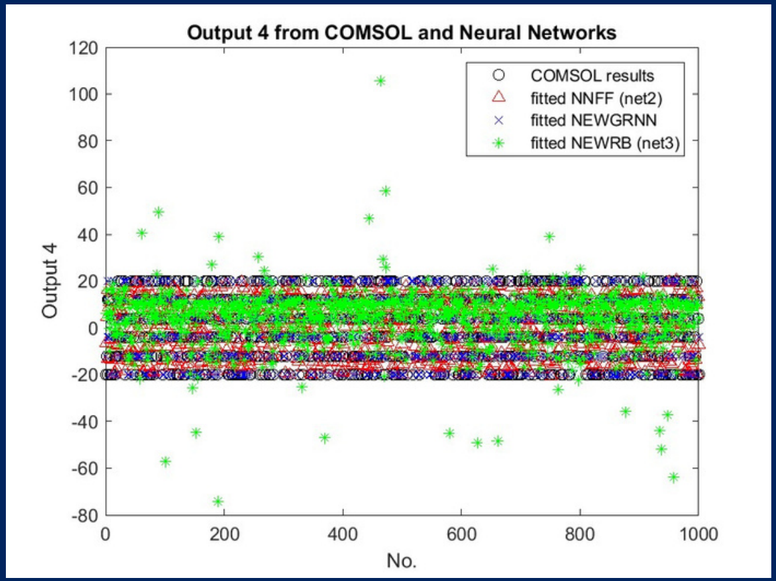

Output 6 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN (net2)
fitted NEWRB (net3)
Output 6
No.

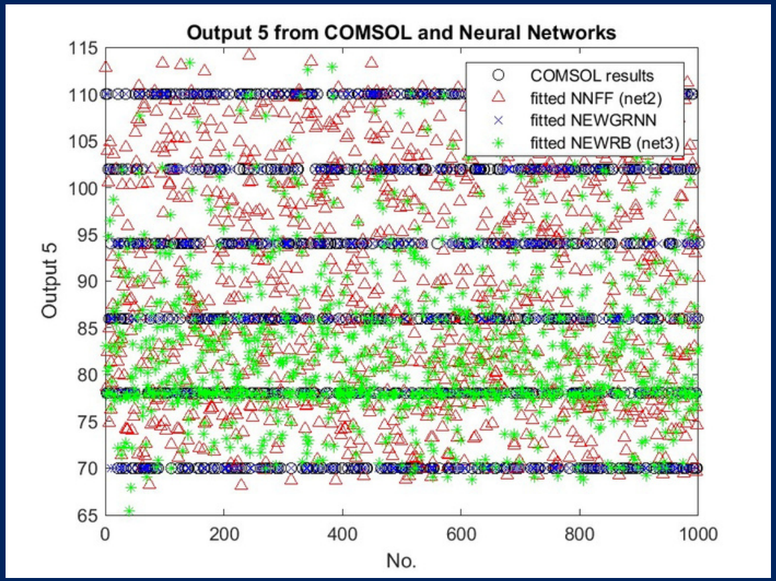
Test

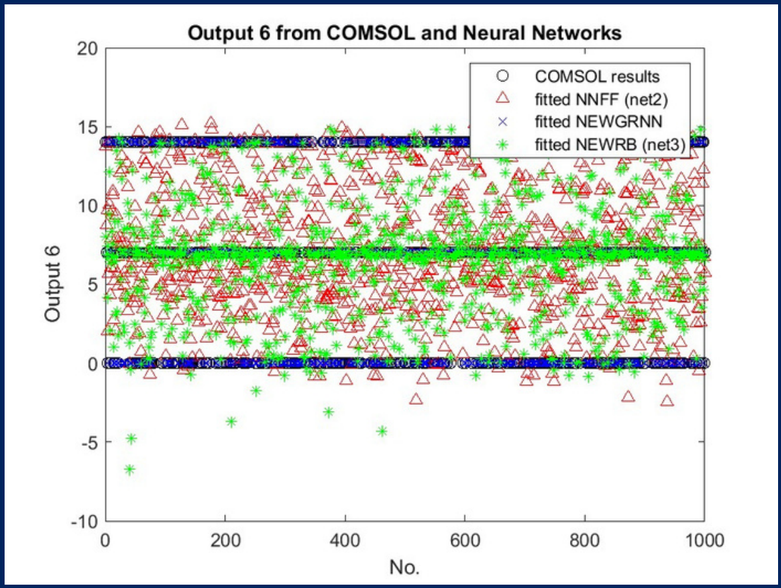

Output 1 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 1
No.


Output 2 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 2
No.

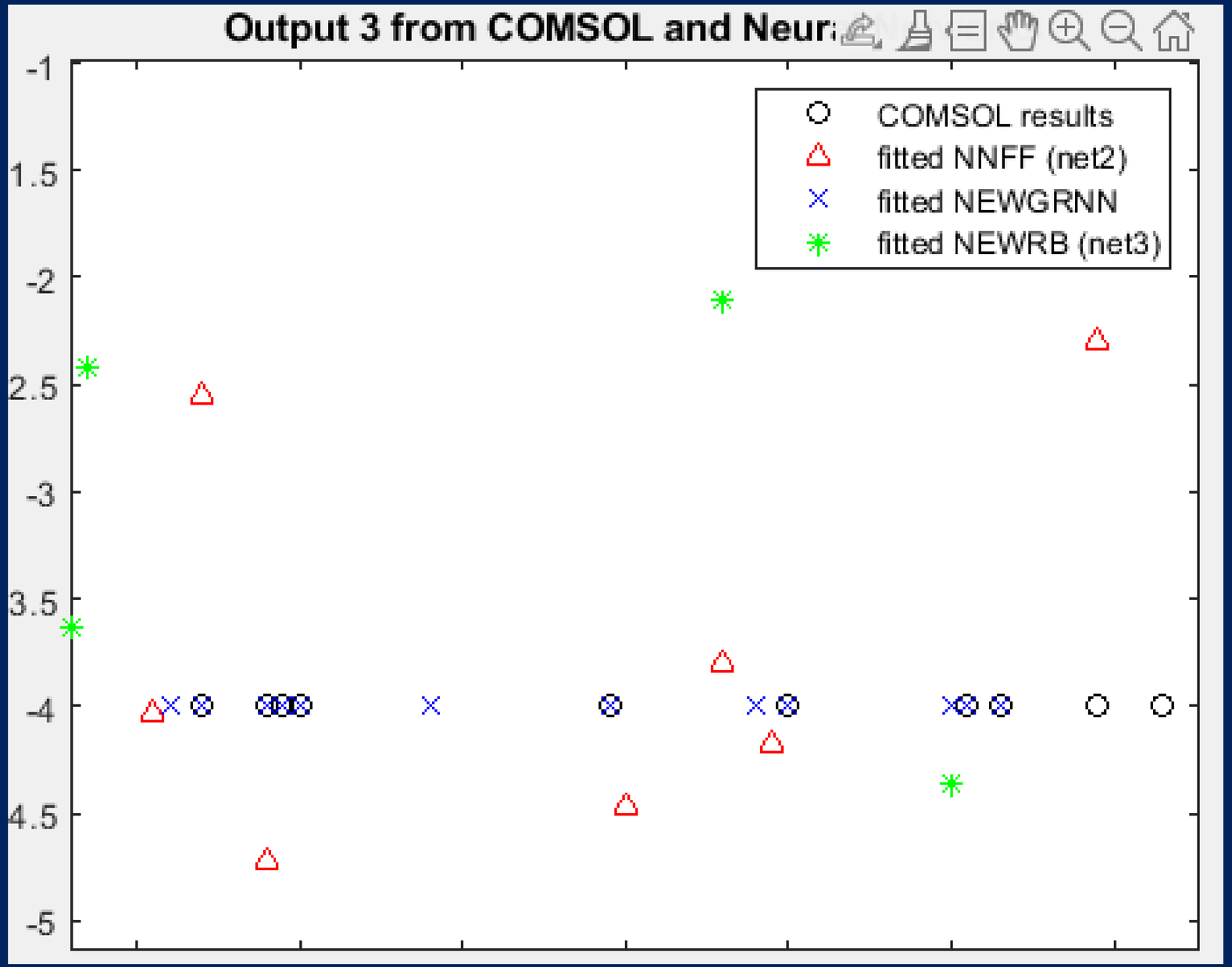

Output 3 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 3
No.


Output 4 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 4
No.


Output 5 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 5
No.


Output 6 from COMSOL and Neural Networks
COMSOL results
fitted NNFF (net2)
fitted NEWGRNN
fitted NEWRB (net3)
Output 6
No.

Zoom in on output 3 of the test data to see which model is the best.



road map of building model

01

read Data

02

Split into train and test sets

03

select input and output

04

run different models

05

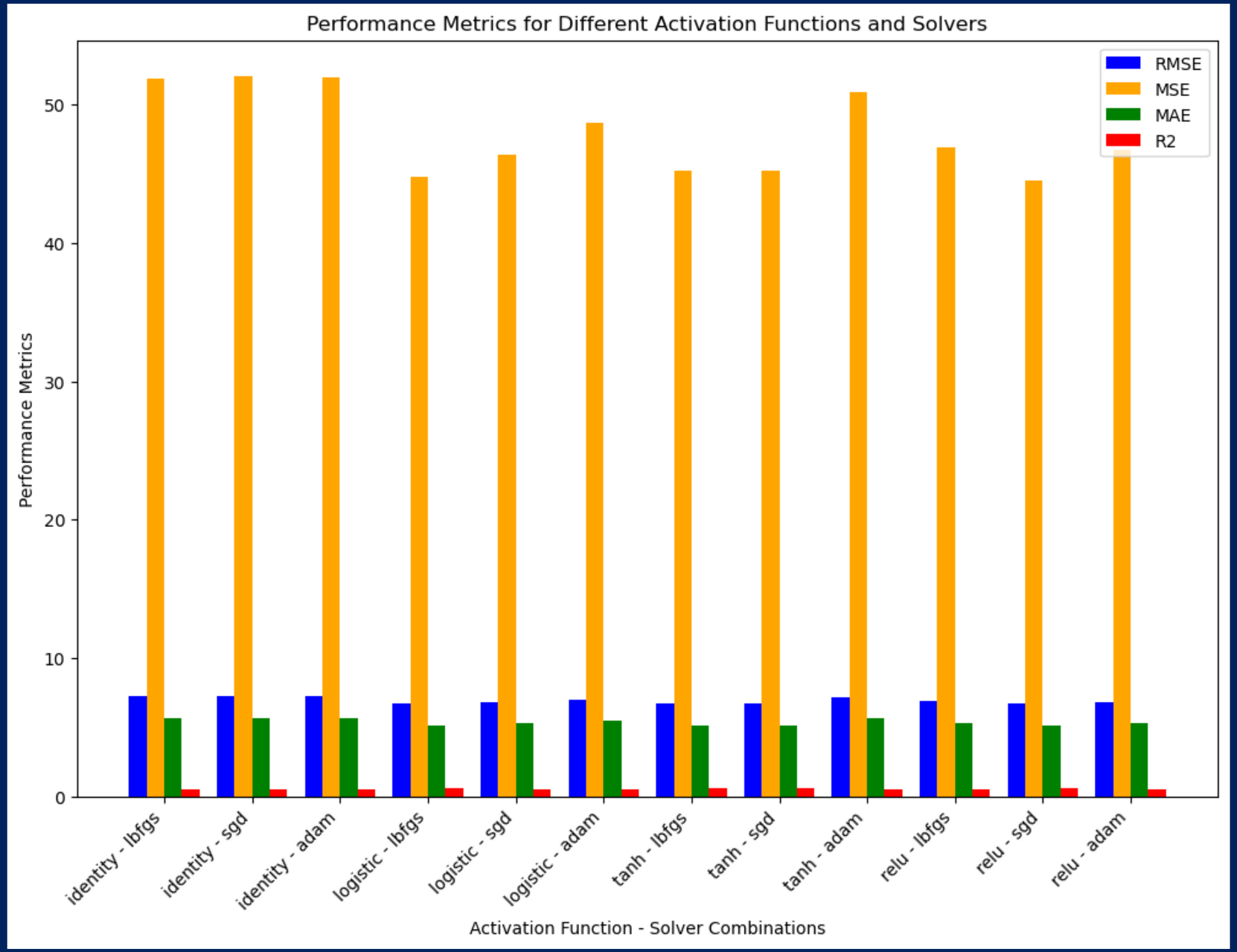
test each model by test data

06

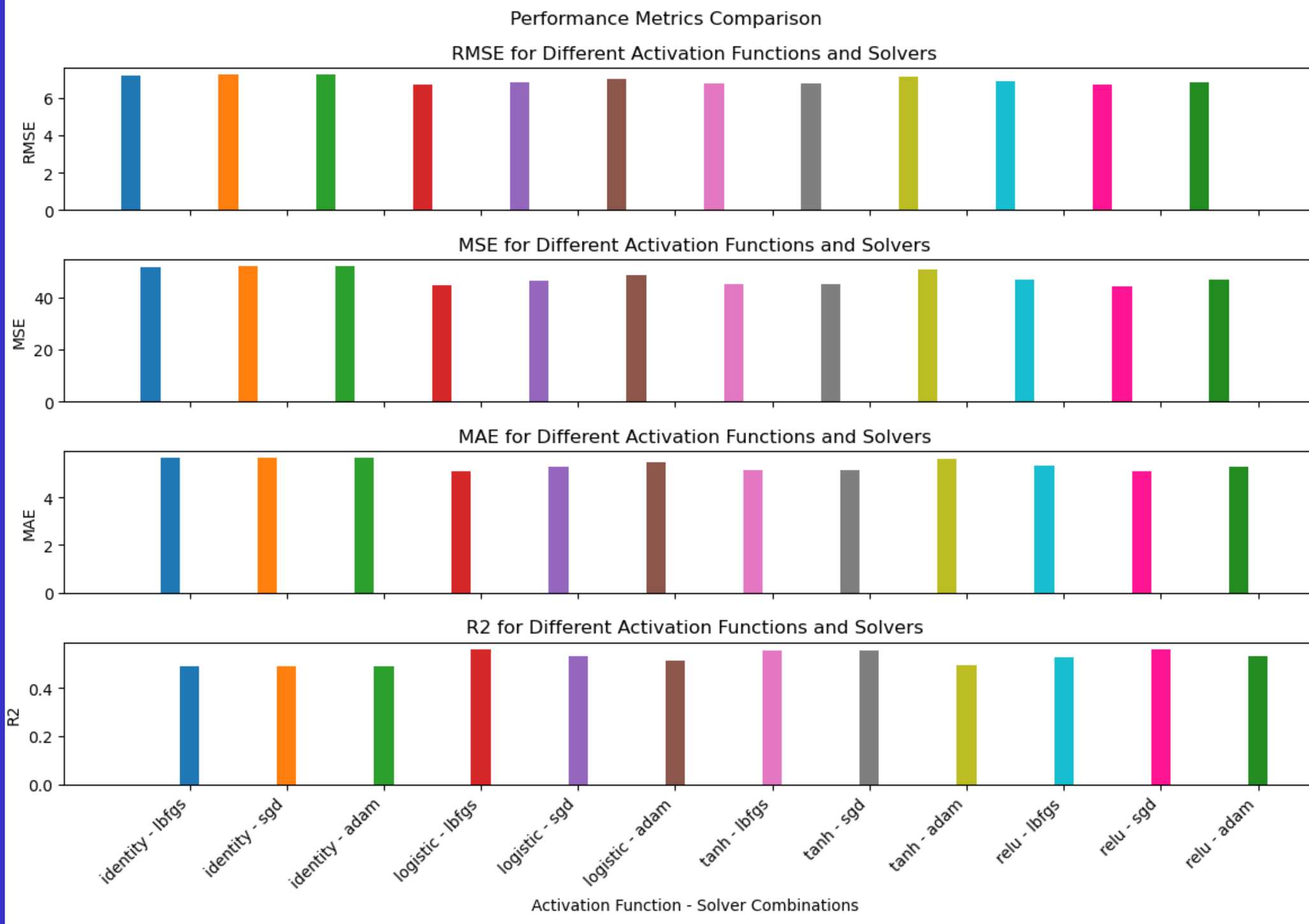
save weights for best model

python

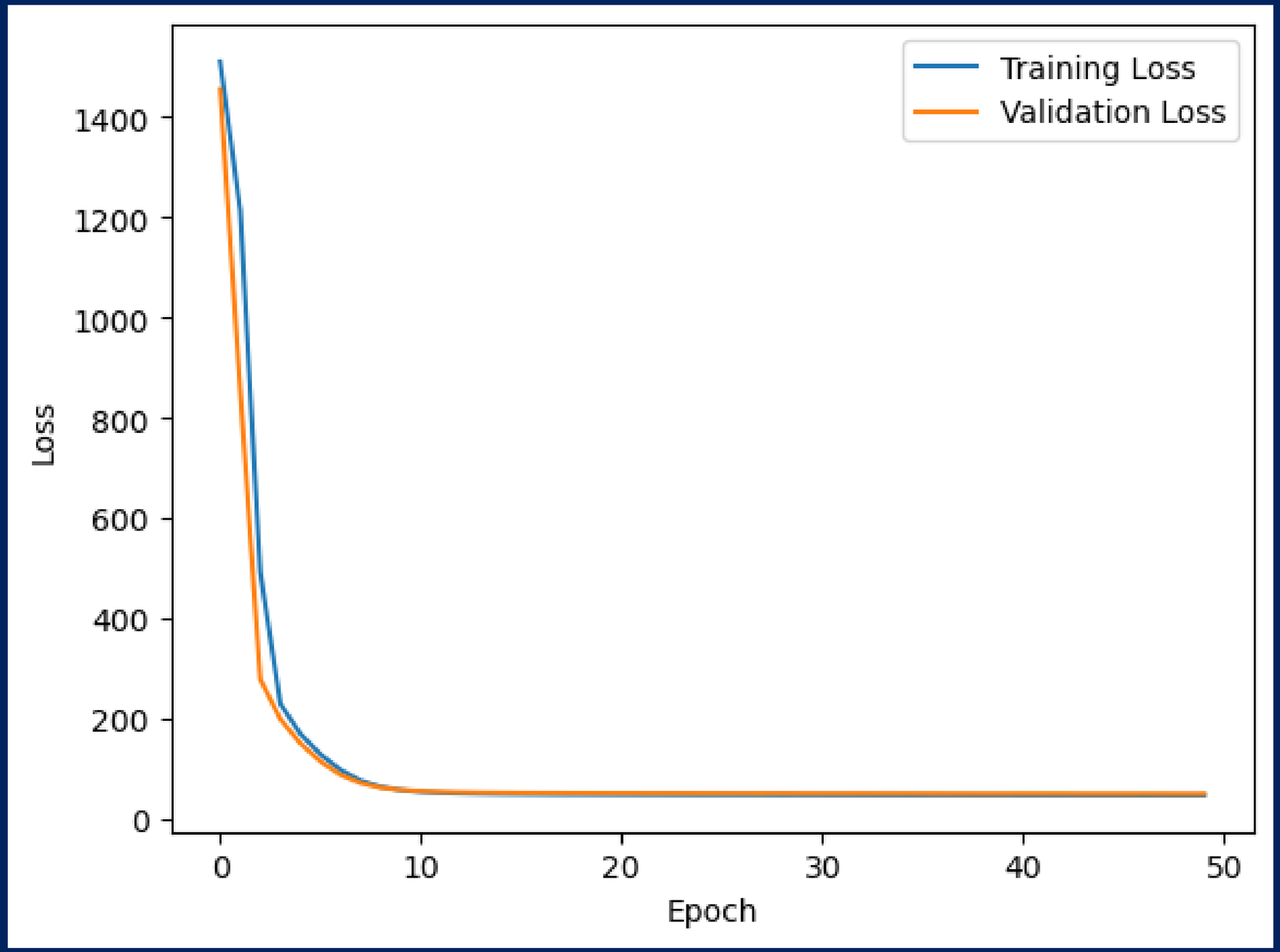
compare between different Activation and Solver of neural network



compare between different Activation and Solver of neural network



Training and Validation Loss of neural network



compare between different Machine Learning algorithms

	Model	MAE	MSE	RMSE	R2	RMSLE	MAPE	TT (Sec)
dt	Decision Tree Regressor	0.0053	0.0025	0.0421	1.0000	0.0017	0.0002	0.0190
xgboost	Extreme Gradient Boosting	0.0581	0.0078	0.0878	1.0000	0.0047	0.0034	0.1280
et	Extra Trees Regressor	0.0176	0.0012	0.0346	1.0000	0.0035	0.0017	0.1460
catboost	CatBoost Regressor	0.0269	0.0014	0.0375	1.0000	0.0048	0.0025	0.9170
lightgbm	Light Gradient Boosting Machine	0.0554	0.0058	0.0762	1.0000	0.0051	0.0034	0.2480
rf	Random Forest Regressor	0.0312	0.0034	0.0579	1.0000	0.0051	0.0024	0.2160
gbr	Gradient Boosting Regressor	0.2836	0.1298	0.3598	0.9994	0.0279	0.0198	0.1390
knn	K Neighbors Regressor	1.4344	3.5574	1.8822	0.9841	0.1412	0.1587	0.0190
lar	Least Angle Regression	1.5888	4.2791	2.0673	0.9808	0.1641	0.1824	0.0200
br	Bayesian Ridge	1.5902	4.2782	2.0671	0.9808	0.1650	0.1844	0.0170
ridge	Ridge Regression	1.5903	4.2783	2.0671	0.9808	0.1650	0.1843	0.0210
lr	Linear Regression	1.5903	4.2783	2.0671	0.9808	0.1650	0.1843	0.3820
en	Elastic Net	1.5981	4.3322	2.0799	0.9806	0.1724	0.2065	0.0200
lasso	Lasso Regression	1.5988	4.3375	2.0812	0.9805	0.1725	0.2073	0.0190
llar	Lasso Least Angle Regression	1.5988	4.3375	2.0812	0.9805	0.1725	0.2073	0.0180
ada	AdaBoost Regressor	2.5186	9.4889	3.0778	0.9573	0.2023	0.2875	0.0960
huber	Huber Regressor	2.3193	10.5027	2.9854	0.9527	0.2080	0.2614	0.0360
omp	Orthogonal Matching Pursuit	9.2363	113.4098	10.6474	0.4912	0.4639	0.9708	0.0160
par	Passive Aggressive Regressor	9.5901	164.0681	11.9523	0.2574	0.5321	1.4346	0.0170
dummy	Dummy Regressor	12.1430	223.6785	14.9510	-0.0019	0.5987	1.6116	0.0270

Prediction of best model Decision Tree

The best hyperparameters for decision Tree

	Parameters
ccp_alpha	0.0
criterion	squared_error
max_depth	None
max_features	None
max_leaf_nodes	None
min_impurity_decrease	0.0
min_samples_leaf	1
min_samples_split	2
min_weight_fraction_leaf	0.0
random_state	4666
splitter	best

New Data:

	theta_1	theta_2	theta_3	theta_4	theta_5	theta_6	target_1	target_2	target_3
2987	-12	-20	-20	20	94	0	34.621690	-17.360548	43.903854
3629	-12	-12	-20	20	78	0	39.882357	-20.842538	53.963809

	Model	MAE	MSE	RMSE	R2	RMSLE	MAPE
0	Decision Tree Regressor	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000

Predictions:

	theta_1	theta_2	theta_3	theta_4	theta_5	theta_6	target_1	target_2	target_3	prediction_label
2987	-12	-20	-20	20	94	0	34.621689	-17.360548	43.903854	43.903854
3629	-12	-12	-20	20	78	0	39.882359	-20.842537	53.963810	53.963810