

1) Baseline XGBoost

Data: 80% Training 20% Validation

colsample_bytree=0.3,

learning_rate=0.1,

max_depth=5,

n_estimators=100

Baseline XGBoost MSE (Train): 0.623058598718014

Baseline XGBoost MSE (Test): 0.6420943976217208

XGB HHO (Harris Hawks Optimization),

max_iters=100

population_size=30

Best Parameters from HHO: [0.15904768 3.15382353 52.56399205]

HHO Optimized MSE (Train/Test): 0.6736009438931361 0.611900698210180

XGB PSO (Particle Swarm Optimization)

PSO Optimization of hyperparameters is done using the pyswarm library

bounds = ([0.01, 3, 50], [0.2, 10, 200])

swarmsize=50,

maxiter=100

PSO Optimized MSE (Train/Test): 0.6736009306703107 0.611900692378837

XGB GA (Genetic Algorithm)

max_num_iteration': 200,

'population_size': 50,

'mutation_probability': 0.1,

'elit_ratio': 0.01,

'crossover_probability': 0.5,

'parents_portion': 0.3,

'crossover_type': 'uniform',

'max_iteration_without_improv': 50

Best Parameters from GA: [0.15902394 3.74492169 52.67433708]

Best MSE from GA: 0.6119021163371854

GA Optimized MSE (Train/Test): 0.6736057906273277 0.6119021163371854

XGB BBO (Biogeography-Based Optimization

n_estimators", 50, 200

max_depth", 3, 10

Best Parameters from BBO (Optuna): 'learning_rate': 0.12054631325814388, 'max_depth': 3,

'n_estimators': 64}

Best MSE from BBO (Optuna): 0.617080042477531

BBO (Optuna) Optimized MSE (Train/Test): 0.6779396558659353 0.617080042477531

2) Extreme Learning Machine (ELM)

Data: 80% Training 20% Validation

ELM MSE (Train): 0.8880013376796757

ELM MSE (Test): 0.7826613626311693

```
n_hidden = 30
input_weights = None
biases = None
output_weights = None
def sigmoid = 1 / (1 + np.exp(-x))
```

ELM HHO (Harris Hawks Optimization),

```
dimension=1, lower=10, upper=100
max_evals=100
population_size=30
HHO Optimized ELM MSE (Train): 0.8952705039205147
HHO Optimized ELM MSE (Test): 0.7888287446207194
```

ELM PSO (Particle Swarm Optimization)

```
lb = [10]
ub = [100]
Best n_hidden from PSO: 41
Best MSE from PSO: 0.6032802430193484
PSO Optimized ELM MSE (Train): 0.8679245729209053
PSO Optimized ELM MSE (Test): 0.8629605522987526
```

ELM GA (Genetic Algorithm)

```
Best n_hidden from GA: 40
Best MSE from GA: 0.6024373828780031
GA Optimized ELM MSE (Train): 0.8138031763512372
GA Optimized ELM MSE (Test): 0.914098731729617
```

ELM BBO (Biogeography-Based Optimization)

```
vn_hidden", 10, 100
n_trials=100
Best n_hidden from BBO (Optuna): 34
Best MSE from BBO (Optuna): 0.641367240173688
```

3) Random Forest (RF)

```
Data: 80% Training 20% Validation
MSE: 35702235.74418667, R2: -6.043527755178625
```

RF HHO (Harris Hawks Optimization),

```
max_iters=100
population_size=30
Optimized Parameters (HHO): n_estimators = 99, max_depth = 3
Best MSE achieved: 0.58787776732519
```

RF PSO (Particle Swarm Optimization)

```
lb = [10, 1] # Lower bounds for n_estimators and max_depth
ub = [100, 20] # Upper bounds for n_estimators and max_depth
swarmsize=10, maxiter=10
Best Optimized Parameters (PSO): [41.70629072 3.85779957]
```

Best Optimized Mean Squared Error (PSO): 0.5905351801080733
Optimized RF Model (PSO) - Mean Squared Error: 0.5926641543108092
Optimized RF Model (PSO) - R² Score: 0.37844445135111004

RF GA (Genetic Algorithm)

Optimized Parameters (GA): [0, 4]
GA optimized parameters: [0.1781056152379834, 4.250662476314364, 226.21730517442415]
Optimized RF Model (GA) - Mean Squared Error: 0.5920059751706191
Optimized RF Model (GA) - R² Score: 0.37913471563251544

RF BBO (Biogeography-Based Optimization)

'n_estimators', 10, 100
max_depth = trial.suggest_int('max_depth', 1, 20
Optimized Parameters (Optuna): {'n_estimators': 100, 'max_depth': 3

4) LSTM Baseline Model

Data: 80% Training 20% Validation
LSTM(units=50, return_sequences=False)
Dropout(0.2)
Dense(1))
LSTM()
Dropout()
Epoch : 20
train loss: 0.7021 -
val_loss: 0.6184

LSTM HHO (Harris Hawks Optimization),

max_evals=100
population_size=20
Optimized Parameters (HHO): lstm_units = 47, dropout_rate = 0.1

LSTM PSO (Particle Swarm Optimization)

Optimized Parameters (PSO): lstm_units = 100, dropout_rate = 0.1, learning_rate = 0.009061625299078394, batch_size = 52
Best MSE achieved: 0.594499901737335
Train loss: 0.6931

LSTM GA (Genetic Algorithm Optimization)

max_num_iteration': 100,
'population_size': 50
Optimized Parameters (GA): lstm_units = 76, dropout_rate = 0.25290333922644315, learning_rate = 0.005376892691117486, batch_size = 20
Train loss: 0.6898

LSTM BBO (Biogeography-Based Optimization)

Trial 29 finished with value: 0.6183785246981112 and parameters: {'units': 25, 'dropout_rate': 0.10033135848157035}. Best is trial 25 with value: 0.6120825705376208.