Machine Learning Model Tracking Document

1. Dataset Information

Dataset Name:	Well 160
Number of Samples:	160
Number of Features:	4 (Tf, Rs, Gg, Api)
Target Variable:	Bob
Outlier Handling:	None
Feature Engineering Applied:	None
Scaling/Normalization Applied:	Only for Neural Networks
Encoding Applied:	None

2. Preprocessing Steps

Step	Description
Train-Test Split	70% - 30%
Shuffling	Yes, using random_state=42
Handling Missing Data	None
Feature Scaling	Only for Neural Networks
Feature Selection	None

3. Models Used & Hyperparameters

Model	Hyperparameters	Training Time
XGBoost	n_estimators=200, learning_rate=0.05, max_depth=4	0.0553
CatBoost	iterations=1000, learning_rate=0.05, depth=4, l2_leaf_reg=5	0.1069
Neural Network	[128, 64], epochs=100, batch_size=16	2.5446
Stacking Ensemble	Default base models + CatBoost final estimator	0.4885
Extra Trees	n_estimators=200	0.0532
Deep Neural Network	[256, 128, 64], epochs=150, batch_size=32	2.3703

4. Evaluation Metrics

Model	MSE	RMSE	MAE	R^2 Score	Adjusted R^2
XGBoost	0.0006	0.0251	0.0159	0.9851	0.9838
CatBoost	0.0003	0.0181	0.0123	0.9922	0.9915
Neural Network	0.0022	0.0473	0.0373	0.9472	0.9423
Stacking Ensemble	0.0002	0.0147	0.0120	0.9949	0.9944
Extra Trees	0.0002	0.0138	0.0110	0.9955	0.9951
Deep Neural Network	0.0027	0.0517	0.0418	0.9369	0.9311

5. Cross-Validation Summary (5-Fold)

Model	RMSE Mean	RMSE Std	MAE Mean	MAE Std	R^2 Mean	R^2 Std
Stacking Ensemble	0.0159	0.0036	0.0110	0.0015	0.9937	0.0019
Extra Trees Regressor	0.0162	0.0017	0.0120	0.0010	0.9932	0.0022
XGBoost	0.0201	0.0033	0.0138	0.0012	0.9894	0.0039
CatBoost	0.0237	0.0106	0.0138	0.0032	0.9842	0.0145
Neural Network	0.1867	0.0467	0.1444	0.0334	0.0315	0.5853
Deep Neural Network	0.2188	0.0545	0.1770	0.0433	-0.3119	0.6285

6. Visualizations

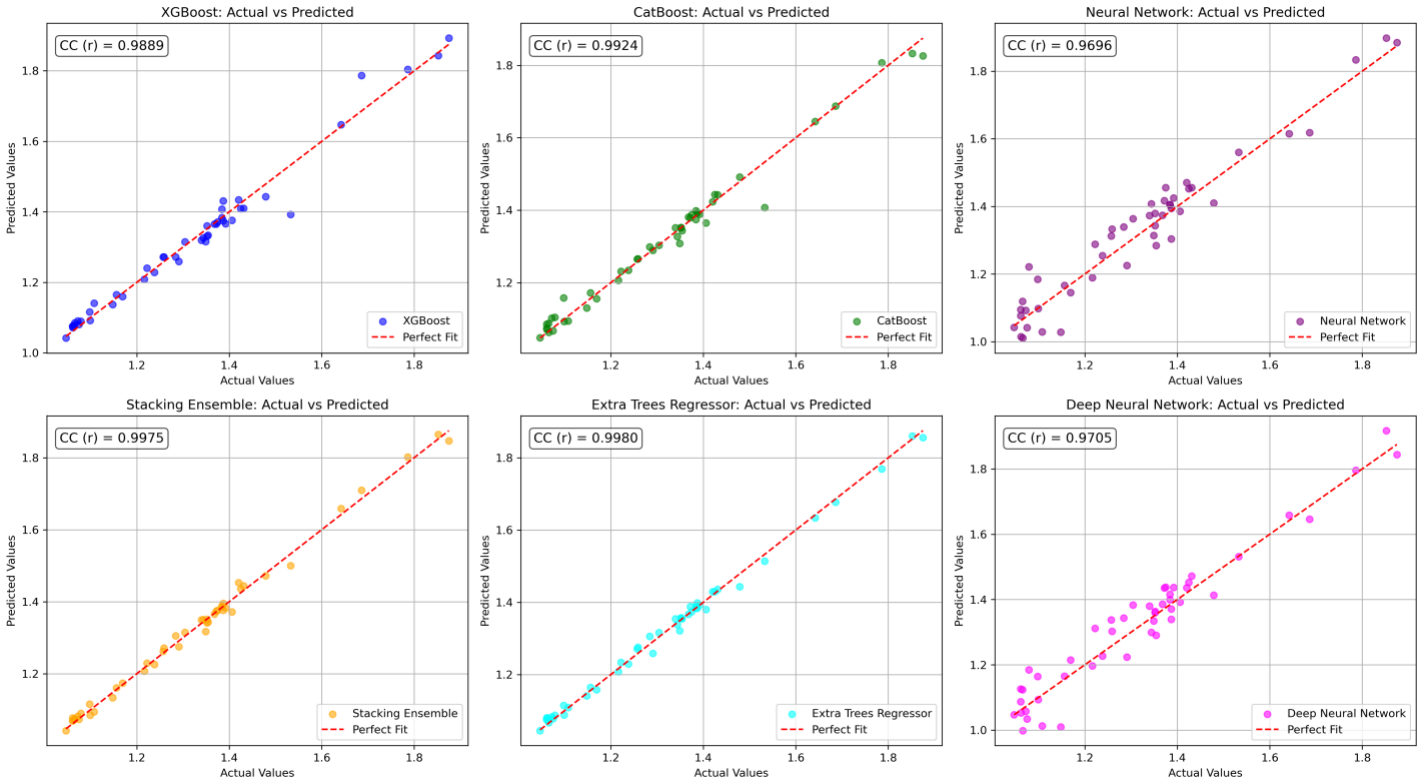

Figure 1: Actual vs. Predicted Values for Bob (Well 160)

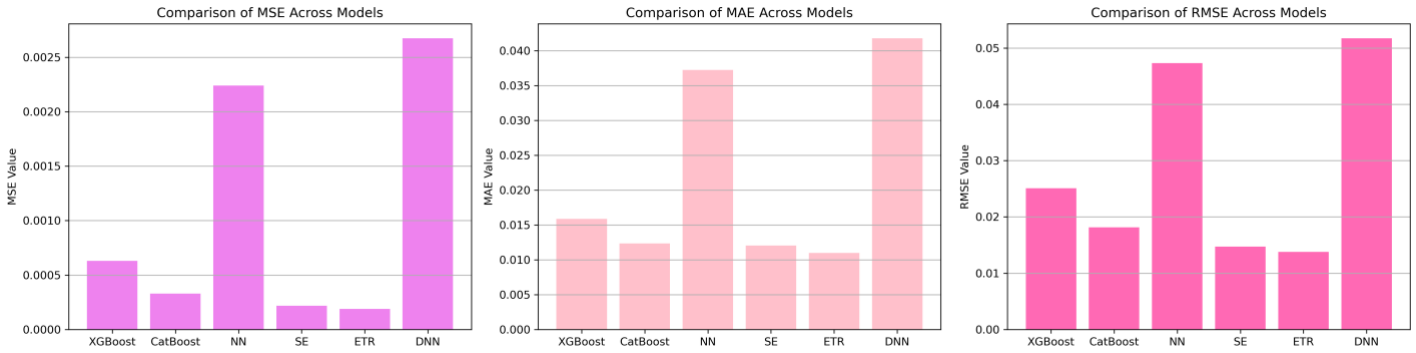

Figure 2: Bar Charts of MSE, RMSE, MAE for Bob (Well 160)

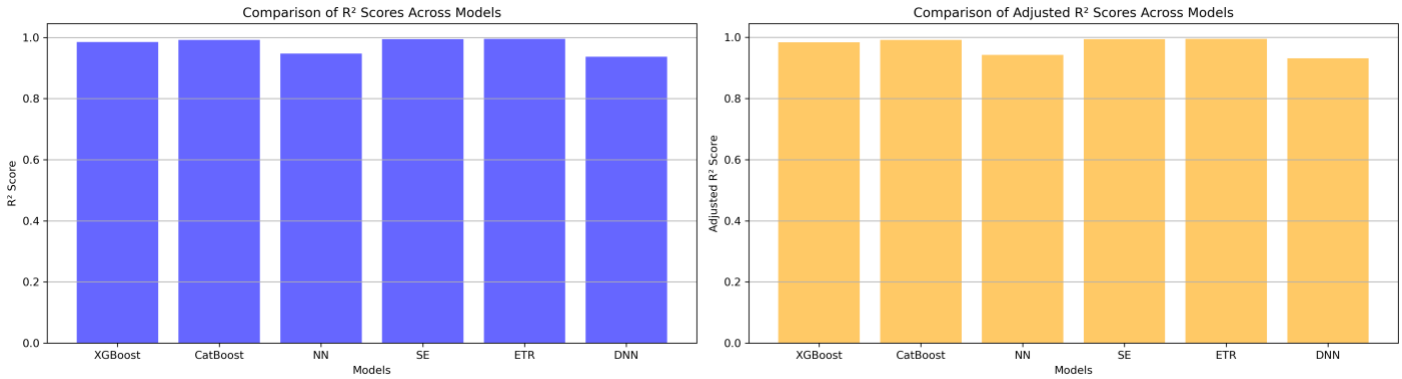

Figure 3: Bar Charts of R^2 and Adjusted R^2 for Bob (Well 160)

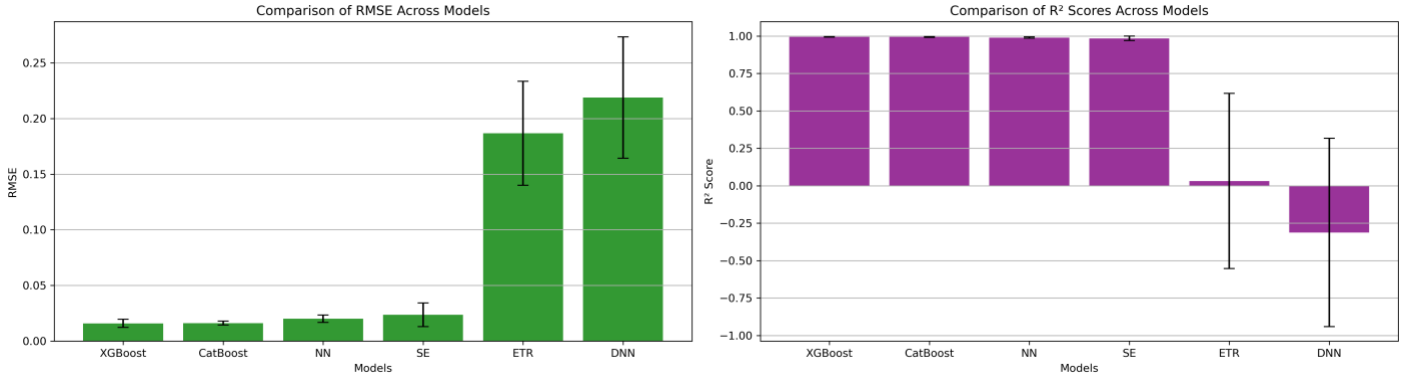

Figure 4: Error Bars for RMSE and R^2 from CV for Bob (Well 160)

7. Observations & Next Steps

- **Best Performing Model: Extra Trees Regressor** (RMSE: 0.0138, R^2: 0.9955)
  - Stacking Ensemble was very close, with RMSE 0.0147 and R^2 0.9949.
  - CatBoost and XGBoost also performed well but slightly behind ensemble methods.
  - Neural-based models (NN and DNN) performed poorly compared to tree-based models.
    - Deep Neural Network had a negative mean R^2 during cross-validation (-0.3119).
    - Indicating generalization problems on small datasets.

8. Code Access

The complete source code for data preprocessing, model training, evaluation, and visualization is available here. The repository includes organized Jupyter notebooks for each phase, dataset, and target, as well as requirements for reproducibility.