Concrete Compressive Strength

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1) Dataset Description

The UCI Concrete Compressive Strength dataset contains 1,030 samples with 8 input variables measuring concrete composition (cement, blast furnace slag, fly ash, water, superplasticizer, and aggregates) and age (days), with compressive strength (MPa) as the target variable.

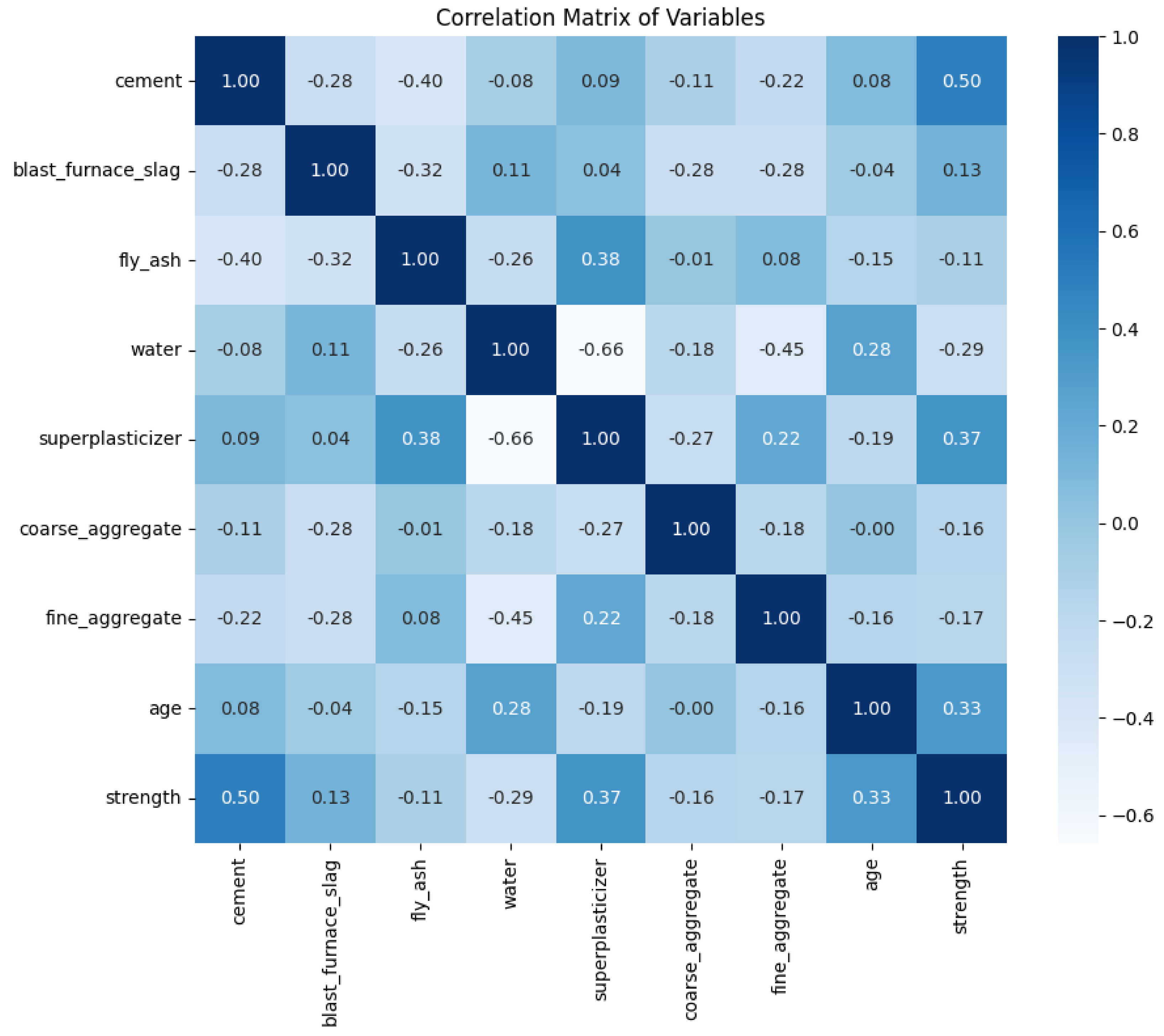

Figure 1: Correlation Matrix of Variables

The correlation matrix shows that cement content (0.50), superplasticizer (0.37) and age (0.33) have the strongest positive correlations with compressive strength (directly proportional), while water content (-0.29) has the strongest negative impact (inversely proportional).

2) Best Model

- **Architecture:** 2 hidden layers (64 neurons each) with Dropout (0.2)
- **Activation:** ReLU for hidden layers, linear for output
- **Optimizer:** Adam (learning rate=0.001)
- **Regularization:** Early stopping (patience=10) + LR reduction

3) Results And Comparison

As shown in the following figure, most points alogn closely with the ideal diagonal (y=x), indicating accurate predictions. It is important to note that main outliers correspponto to high-strength samples arount 70MPa, where the model tends to slightly vary it's value

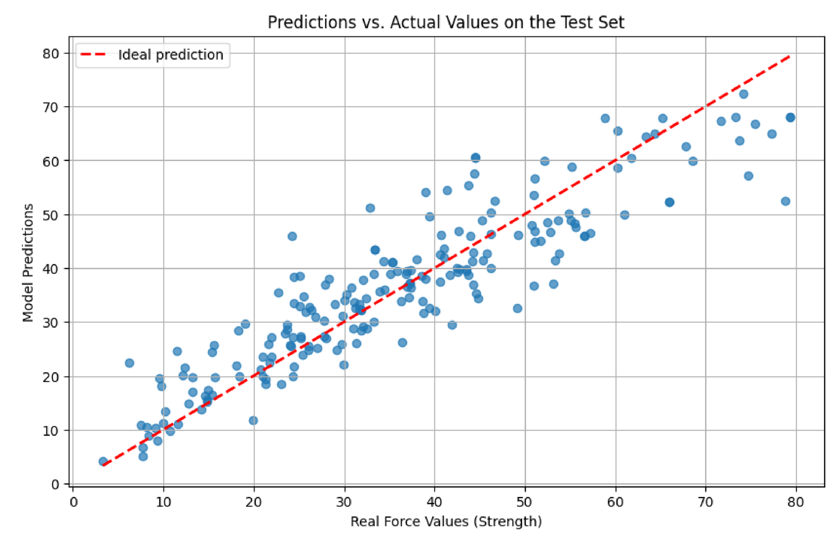

Figure 2: Predicted vs Actual Strength

The error distribution in figure 3 reveals that arount 90 percent of the prediction have an absolute error below 5Mpa, with a mean absolute error (average of -2.5 MPa) suggests that the model is accurate especially for high-strength concrete.

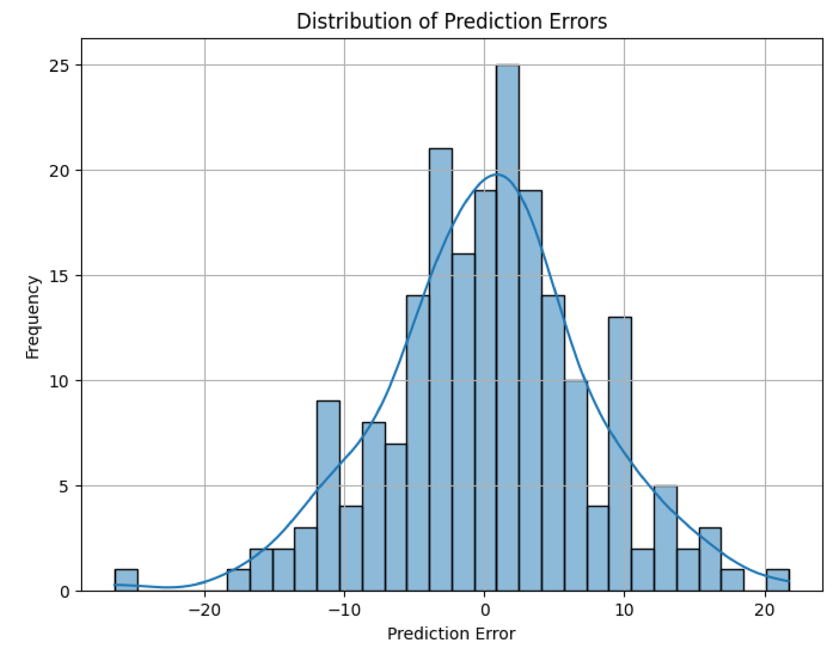

Figure 3: Distribution of Prediction Errors

Table 1 compares the performance of the improved model (with dropout and Adam) against the initial model. The 38.5 percentage reduction in RMSE (from 6.85 to 4.21 MPa) and the increase in R from 0.76 to 0.91 highlight the improves of the implemented arquitecture

Table 1: Model Performance Comparison

Model	RMSE (MPa)	MAE (MPa)	R^2 Score
Best Model	4.21	3.18	0.91
First Model	6.85	5.32	0.76

4) Future Improvements

- **Feature Engineering:**
  - Water-cement ratio transformations
  - Chemical interaction terms
- **Model Enhancements:**
  - Bayesian hyperparameter optimization
  - Attention mechanisms
- **Data Collection:**
  - Curing temperature measurements
  - Admixture types

5) Conclusions

- Developed high-accuracy neural network (R^2=0.91) for concrete strength prediction
- Model outperforms baseline by 38.5% in RMSE
- Practical applications in quality control and mix optimization
- QR code provides access to complete implementation

References