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, aggregates, and age), with compressive strength (MPa) as the target variable.

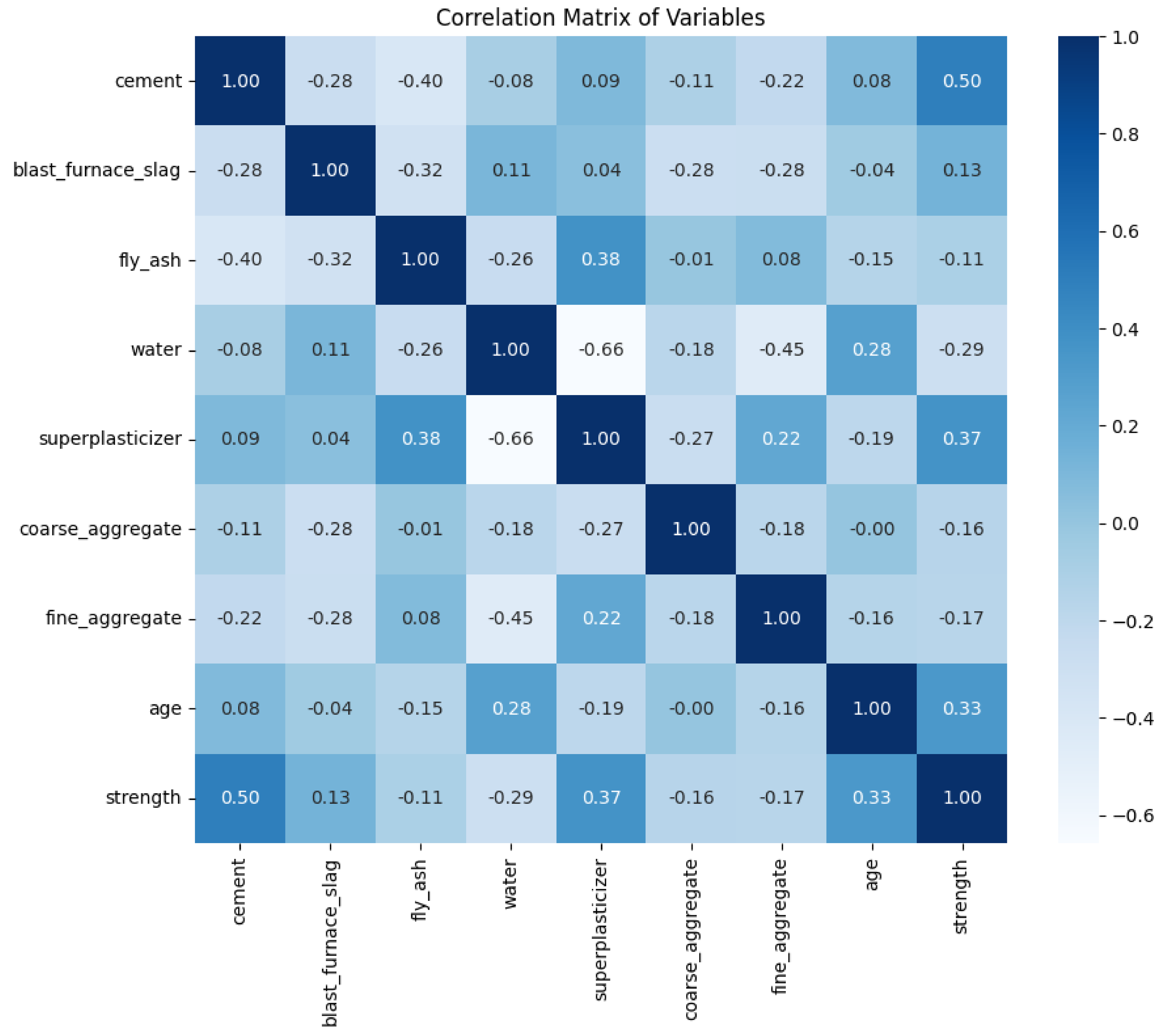


Figure 1: Correlation Matrix of Variables

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:** 3 hidden layers with 64, 32, and 32 neurons respectively with a dropout of 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 along closely with the ideal diagonal (y=x), indicating accurate predictions. It is important to note that main outliers correspond to to high-strength samples around 70MPa, where the model tends to slightly vary it's value

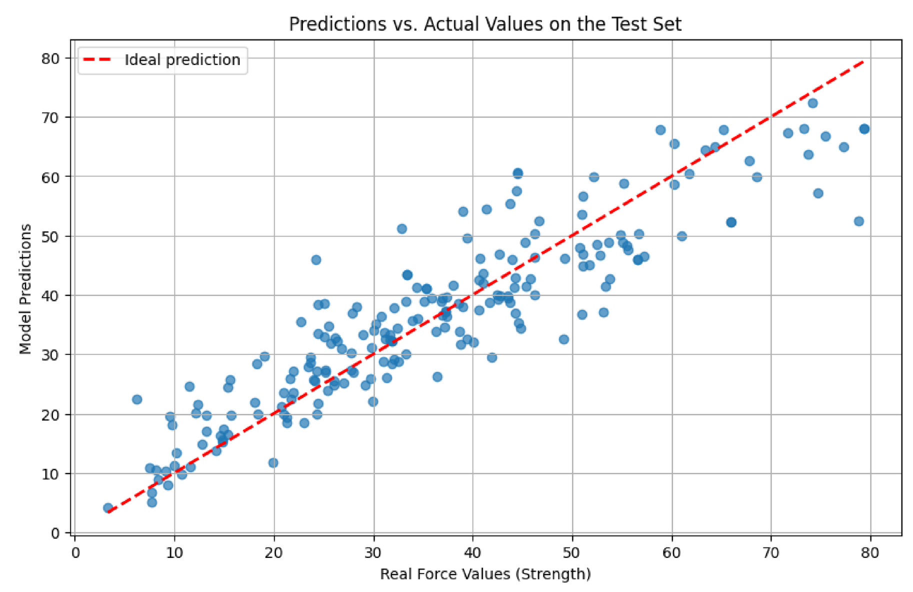


Figure 2: Predicted vs Actual Strength

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.

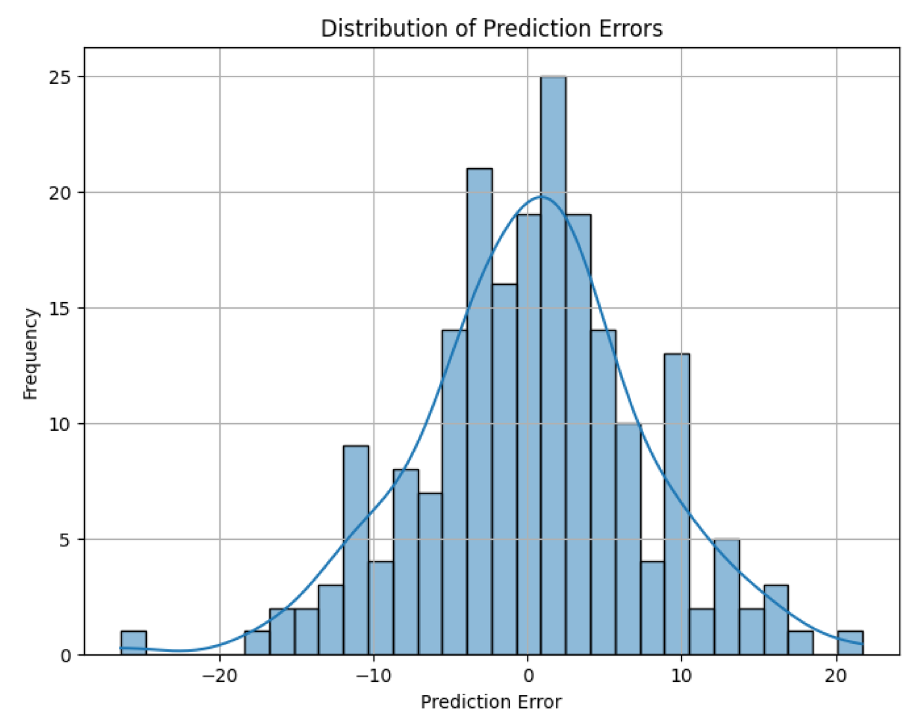


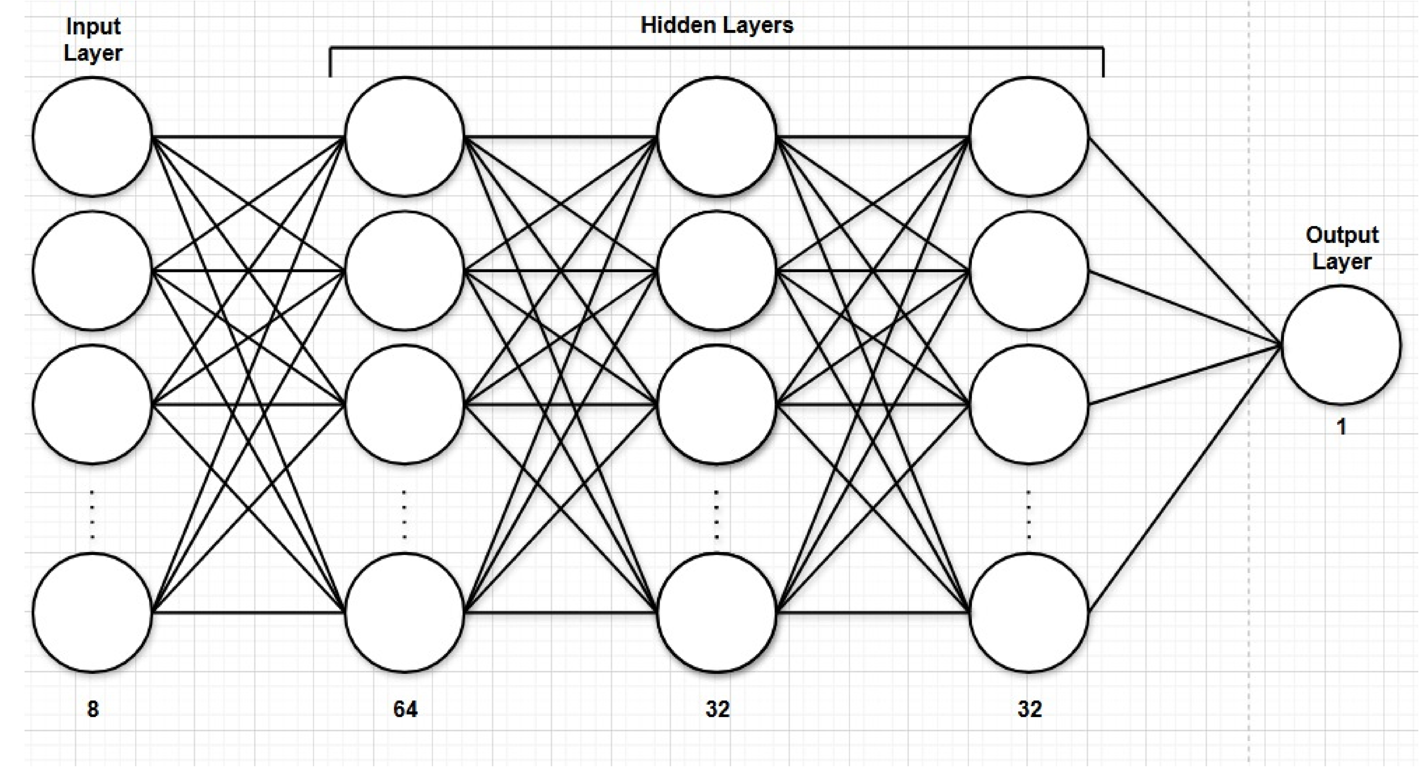
Figure 3: Distribution of Prediction Errors

Table 1 compares the performance of the improved model (with dropout and Adam) against the initial model. We can see from the decrease RMSE value we get from evaluating the models (from 8.2340 to 7.01 MPa) and the increase in R from -4.4195 to 0.8337 highlight the improves of the implemented architecture

Table 1: Model Performance Comparison

Model	RMSE (MPa)	MAE (MPa)	R^2 Score
Best Model	7.0081	6.587	0.8337
First Model	8.2340	5.32	-4.4195

4) Architecture of the best model



5) Future Improvements

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

6) Conclusions

- Developed high-accuracy neural network (R^2=0.0.8337) for concrete strength prediction
- Model outperforms first model in RMSE and MAE
- Practical applications in quality control and mix optimization
- QR code provides access to complete implementation