# Predicting Aerodynamic Noise from Airfoil Geometry using Machine Learning

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Date: July 10, 2025

Tools Used: Python, Scikit-learn, XGBoost, Pandas, Matplotlib, Seaborn

GitHub Repo: [Neelayjain02/airfoil-noise-ml]

## 1. Objective

This project aims to predict aerodynamic noise (in dB) generated by airfoils using machine learning. We use physical parameters such as frequency, angle of attack, chord length, velocity, and displacement thickness to train multiple regression models. The goal is to evaluate these models and interpret which parameters most influence sound pressure levels.

## 2. Dataset Summary

Source: UCI Airfoil Self-Noise Dataset

Rows: 1503

Features:

- Frequency (Hz)
- Angle of attack (deg)
- Chord length (m)
- Free-stream velocity (m/s)
- Suction side displacement thickness (m)

Target:
- Sound pressure level (dB)

## 3. EDA & Visualization

Noise tends to decrease with increasing frequency. A non-linear relation exists between angle of attack and noise. Displacement thickness has a strong positive correlation with noise. Visualizations used include correlation heatmap, scatter plots, pairplots, and target distribution.

## 4. Model Training & Evaluation

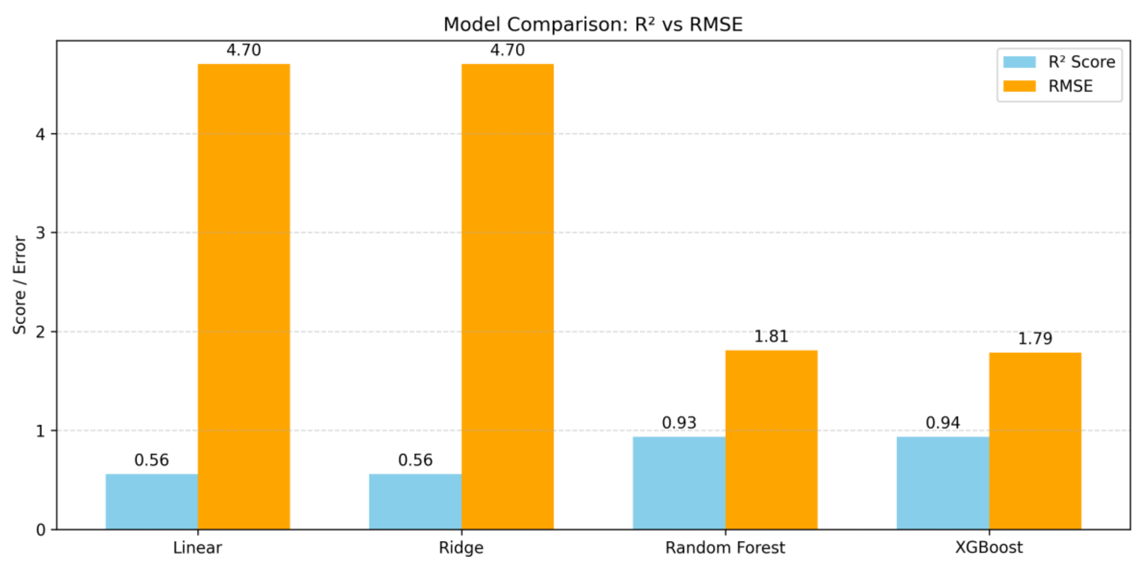
Models Tested:

- Linear Regression
- Ridge Regression
- Random Forest
- XGBoost

Evaluation:

- Linear: $R^2$ 0.5583, RMSE 4.70
- Ridge: $R^2$ 0.5581, RMSE 4.70
- Random Forest: $R^2$ 0.9346, RMSE 1.81
- XGBoost: $R^2$ 0.9364, RMSE 1.79

**Winner:** XGBoost showed the best performance.

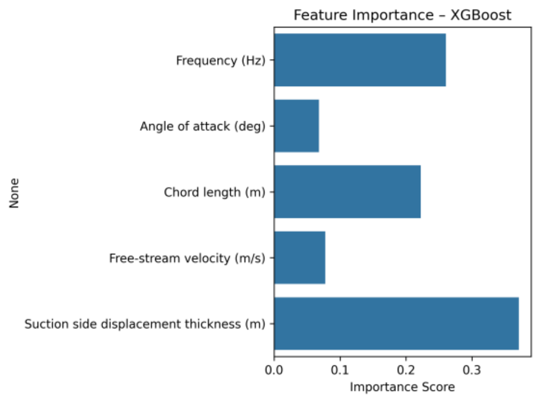


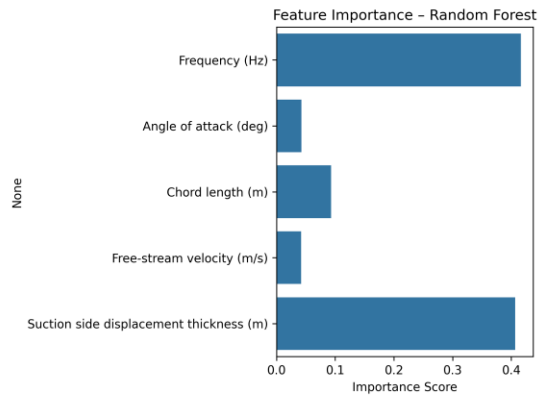
## 5. Feature Importance

Top features influencing noise:

- Suction side displacement thickness (~40%)
- Frequency (~40%)
- Others (Chord, AoA, Velocity) had minor influence

These results match theoretical aerodynamic expectations.




## 6. Conclusion & Learnings

- Built an ML-based system to predict airfoil self-noise with high accuracy
- Learned how to apply regression models to a real-world mechanical engineering dataset
- Gained insights into how physical parameters drive noise
- Skills used: Python, EDA, regression, evaluation, and feature interpretation

## 7. GitHub & LinkedIn

GitHub: [Neelayjain02/airfoil-noise-ml]

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