Predicting the strength of concrete

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1) Introduction

1.1 Overview :

Concrete is a complex composite material. The predictability of concrete properties is extremely low. Therefore, it is challenging to model the concrete properties according to the effect variables. The biggest challenge of experimental designs is a high number of effect variables affecting the response variables. Multiple effect variables increase the number of trials. The higher amount of uncontrollable variables makes it difficult to obtain the real response function.

Generally, the one-factor-at-a-time method is used in experimental designs to determine the concrete properties. The major disadvantage of this approach is that it does not consider the interaction between the factors (interaction terms). The higher the number of the controlled and uncontrolled effect variables that influence the concrete properties, the lesser the predicted accuracy. Despite this, a few experimental designs have been suggested by considering the controllable effect variables and interaction terms between them.

1.2 Purpose:

In recent years, the ML methods have become popular as they allow researchers to improve the prediction accuracy of concrete properties and are used for various engineering applications. The ML methods have been used to increase the prediction accuracy of concrete properties, and the data derived from the literature sources were used

Regression models tend to be used for the prediction of the compressive strength of high-strength concrete. These models also demonstrate how the concrete compressive strength depends on the mixing ratios.

Previous studies evaluated the amount of the concrete component materials and compared their results to the published data. In this study, the ML regression methods were compared to predict the compressive strength and slump values of the cube samples.. The study aimed to determine the most successful regression method by comparing the decision tree, random forest, Linear Regression.

2) Literature Survey

2.1 Existing Problem

This is generally determined by a standard crushing test on a concrete cylinder. This requires engineers to build small concrete cylinders with different combinations of raw materials and test these cylinders for strength variations with a change in each raw material. The recommended wait time for testing the cylinder is 28 days to ensure correct results. This consumes a lot of time and requires a lot of labour to prepare different prototypes and test them. Also, this method is prone to human error and one small mistake can cause the wait time to drastically increase.

2.2 Proposed Solution

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3) Theoretical Analysis

3.1 Hardware / Software designing

Python, Python Web Frameworks, Python for Data Analysis, Python For Data Visualization, Data Pre-processing Techniques, Machine Learning, Regression Algorithms

4) Experimental Analysis

The compressive strength data for the present work was obtained from the experiments. For generating a reliable data bank on concrete compressive strength, we had considered five parameters, namely, water-cementitious material ratio, cementitious content, water content, workability, and curing ages in the experimental program.

The casting and testing of specimens for generating the data bank were performed in controlled laboratory conditions.

Range of various parameters

Cement (component 1)(kg in a m^3 mixture) = 102 – 540

Blast Furnace Slag (component 2)(kg in a m^3 mixture) = 0 – 359.4

Fly Ash (component 3)(kg in a m^3 mixture) = 0 – 200.1

Water (component 4)(kg in a m^3 mixture) = 121.75 - 247

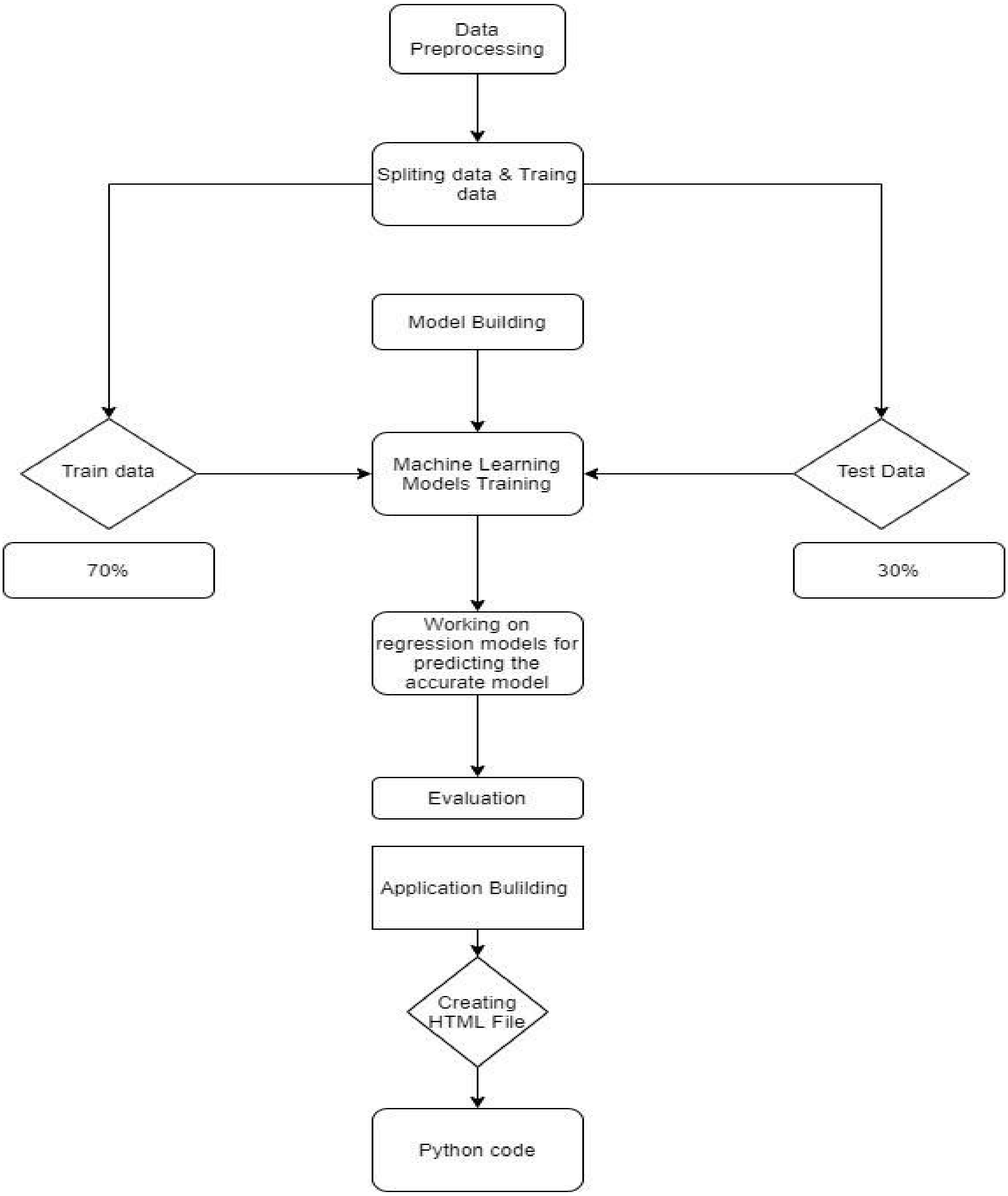
Superplasticizer (component 5)(kg in a m^3 mixture) = 0-32.2

Coarse Aggregate (component 6)(kg in a m^3 mixture) = 801- 1145

Fine Aggregate (component 7)(kg in a m^3 mixture) = 594 – 992.6

Age (day) = 1 - 365

5) Flowchart



Data Preprocessing
Spliting data & Traing data
Model Building
Train data
Machine Learning Models Training
Test Data
70%
30%
Working on regression models for predicting the accurate model
Evaluation
Application Bulilding
Creating HTML File
Python code

6) Result

We have analysed the Compressive Strength Data and used Machine Learning to Predict the Compressive Strength of Concrete. We have used Linear Regression and its variations, Lasso, Ridge and Random Forests to make predictions and compared their performance. Random Forest Regressor has the highest accuracy and is a good choice for this problem. Random Forest Regressor trains randomly initialized trees with random subsets of data sampled from the training data, this will make our model more robust

7) Advantages and Disadvantages

Advantages:

Using Machine learning to predict the strength of the concrete will be time and more accuracy in predicting the approximately close value can be done easily. It's more trustworthy and cost effective .It also reduces the manpower for doing the experiments to find the strength of the concrete in different unknown situations.

Disadvantages :

There is a 3 % chance that the outcome will not predict the approximate value in that situation it can be troublesome.

8) Applications:

- Can predict the strength of the concrete using the inputs provided.
- Implementable on the website

9) Conclusion

- Compared to all other Machine Learning Models Random Forest was best suitable for this data.
- Random Forest Regressor gave the maximum accuracy when tested using r2_score confusion matrix.
- Maximum accuracy received is 97.25 %.

10) Future Scope

This model can predict the outcome with many different inputs within seconds. The model will save a lot of time for the construction companies and the civil engineers. Experiment cost is also reduced which creates a bigger opportunity for construction companies in cost effectiveness work.

11) Appendix

Screenshots