Prediction of Mechanical Properties of Low-alloy Steels

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Background

Data set
"Mechanical properties of low alloy steels" from Kaggle contains alloy composition, temperature and mechanical properties. The data set was published at Kaggle, but today it isn't available. There are 915 instances of low alloy steels.

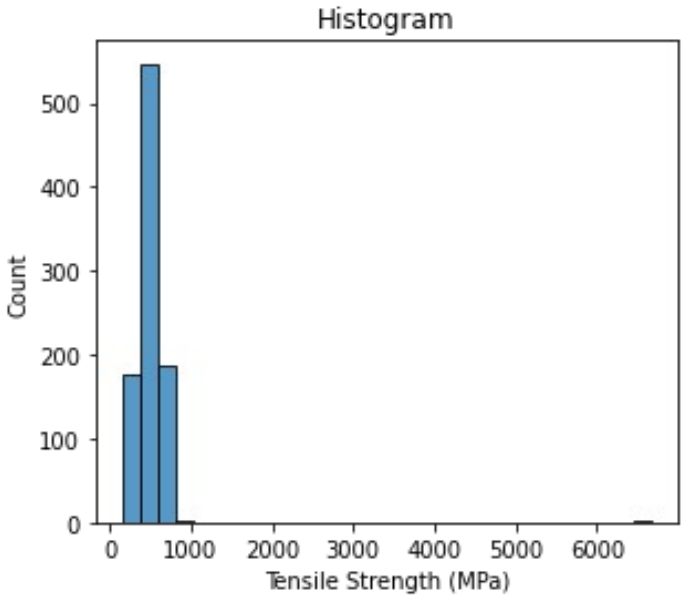
Context
Currently there are no precise theoretical methods to predict mechanical properties of steels. All the methods available are by backed by statistics and extensive physical testing of the materials.

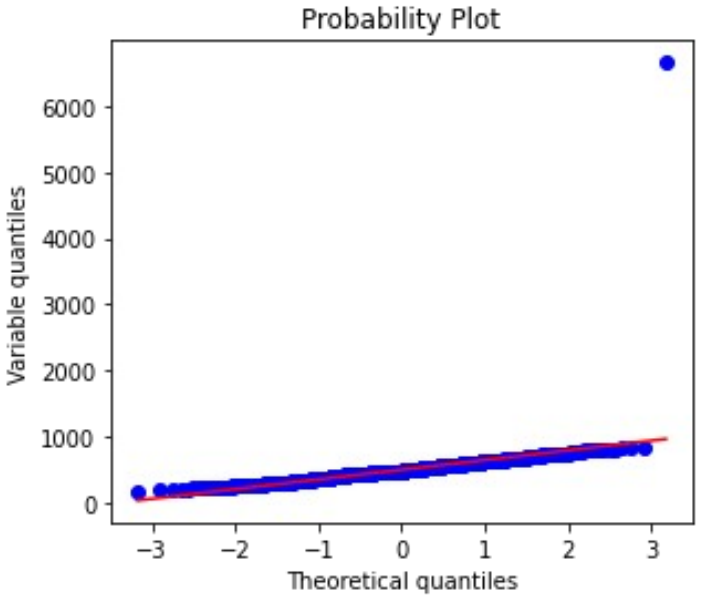
Introduction

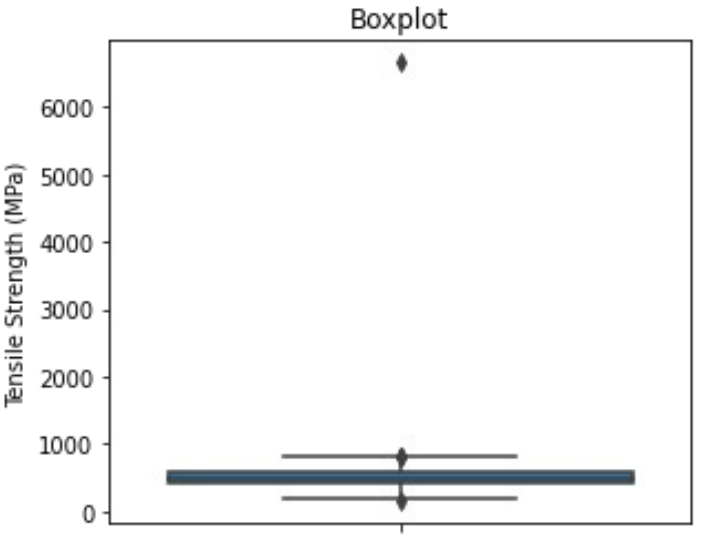
Content

This data set contains compositions by weight percentages of low-alloy steels along with the temperatures at which the steels were tested and the values mechanical properties observed during the tests. The alloy code is a string unique to each alloy. Weight percentages of alloying metals and impurities like Aluminum, copper, manganese, nitrogen, nickel, cobalt, carbon, etc are given in columns. The temperature in Celsius for each test is mentioned in a column. Lastly mechanical properties including tensile strength, yield strength, elongation and reduction in area are given in separate columns.

Exploratory Data Analysis

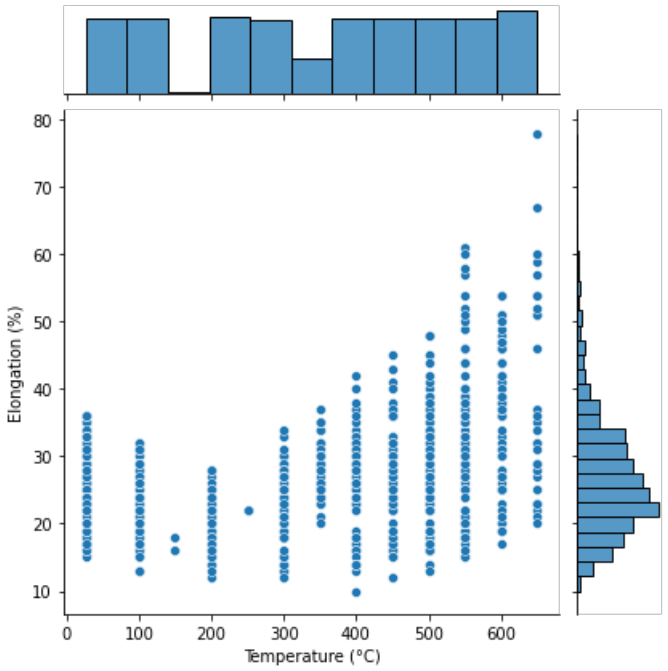


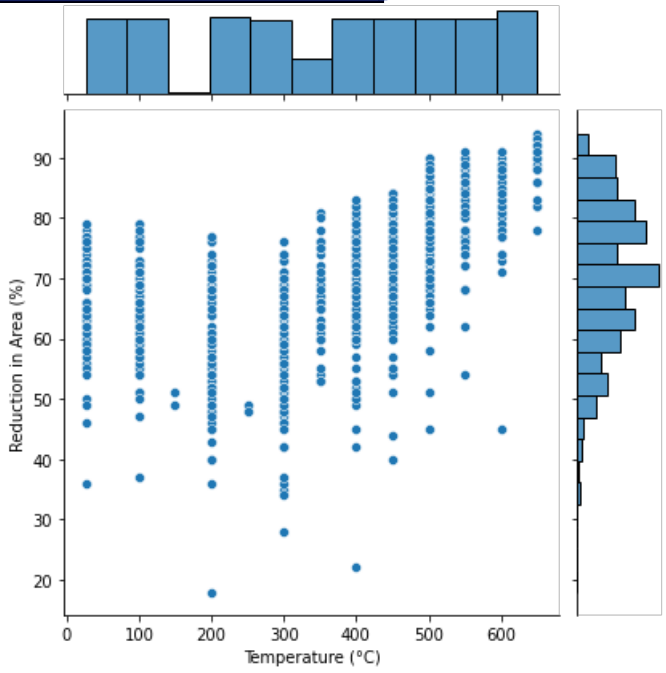




Distributions of numerical variables are reasonably close to normal. Tensile strength has one outlier, as shown above.

Exploratory Data Analysis





Target variables are highly dependent on carbon content and temperature and less dependent on other components.

Feature Engineering and Selection

Highly cardinal variable 'Alloy code' excluded

Outliers deleted

4 target variables defined:

Strength related:

- '0.2% Proof Stress (Mpa)'
- 'Tensile Strength (Mpa)'

Geometry related

- 'Elongation (%)'
- 'Reduction in Area (%)'

Results and Conclusions

Results of XGBoost regression modeling

Strength properties are easier to predict with R square above 0.96.
Geometrical properties are less predictable, R square above 0.86.

Summary table

Evaluation Criteria	0.2% Proof Stress (MPa)	Tensile Strength (MPa)	Elongation (%)	Reduction in Area (%)
RMSE train	488	474	5.91	13.68
RMSE test	352	614	9.93	18.49
R2 train	0.97	0.97	0.93	0.91
R2 test	0.98	0.96	0.86	0.86

The end

Thank you for your attention!