Detection of Correlation Reversal Manipulation using Benford's Law and Random Forest

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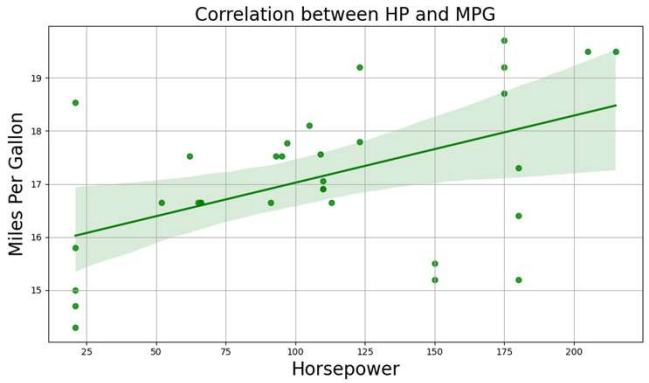
Q: Can we trust this data?



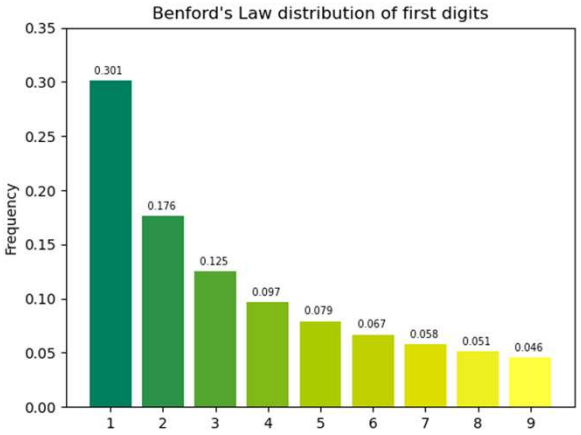
From a given data:

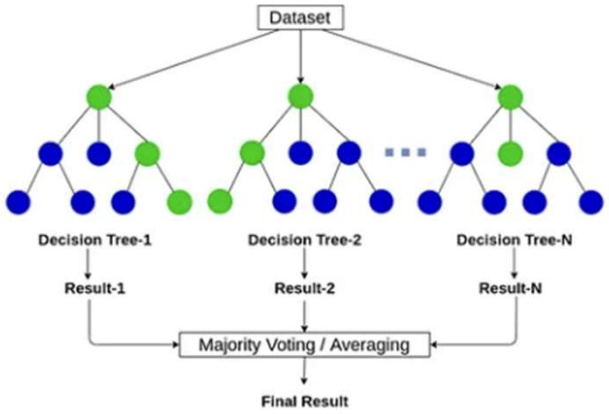
r = 0.5, p = 3.5e-03

"*The more horsepower we have, the more miles per gallon we get.*"

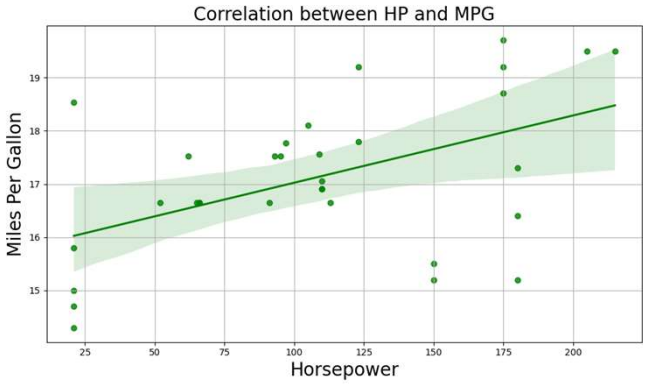
Benford's Law
(Statistical Analysis)

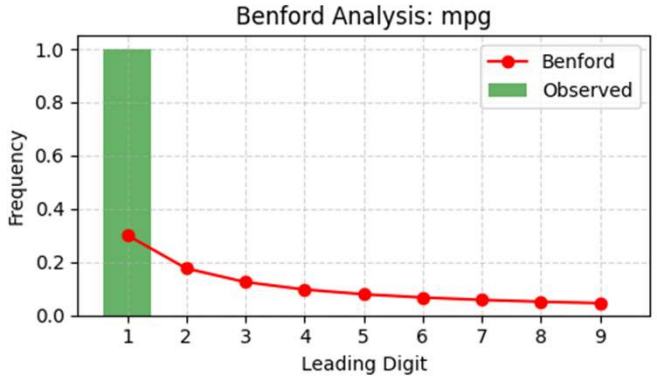
Random Forest
(Machine Learning)





Using Benford's Law to Detect Manipulation





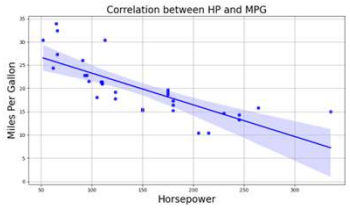
Chi-square = 74.3017, p-value = 0.0000000000006

Criteria: Chi-square > 30.58 and p < 0.0001

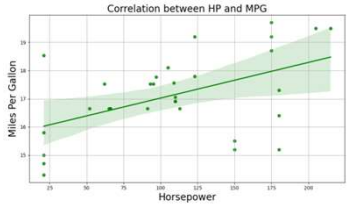
Classified as **manipulated** (anomaly and extreme)

Using Random Forest to Detect Manipulation

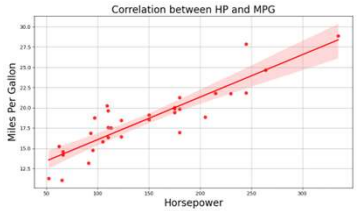
Original Data (Label=0)



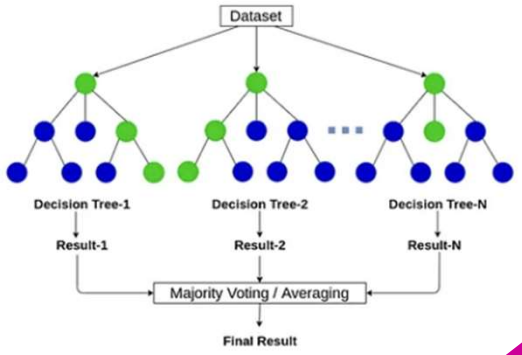
Manipulated Data (Label=1)



New Manipulated Data



Supervised Training



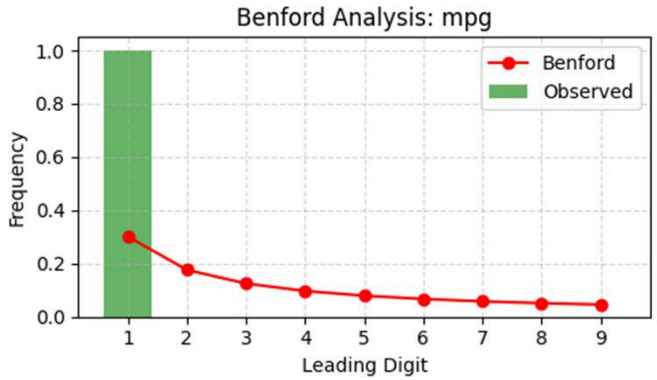
RF Model

Classifier

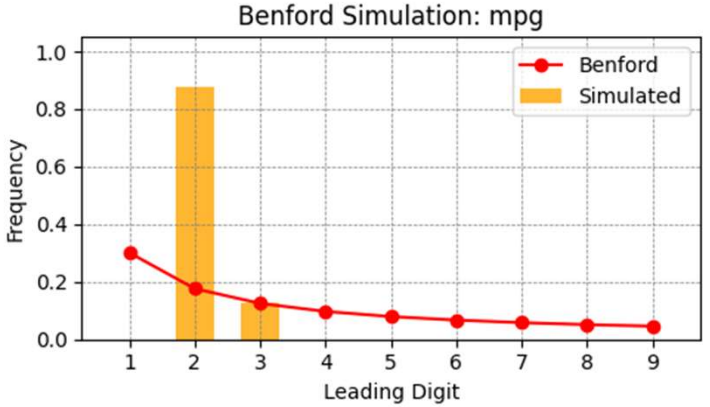
RF Model

Classified as **manipulated**

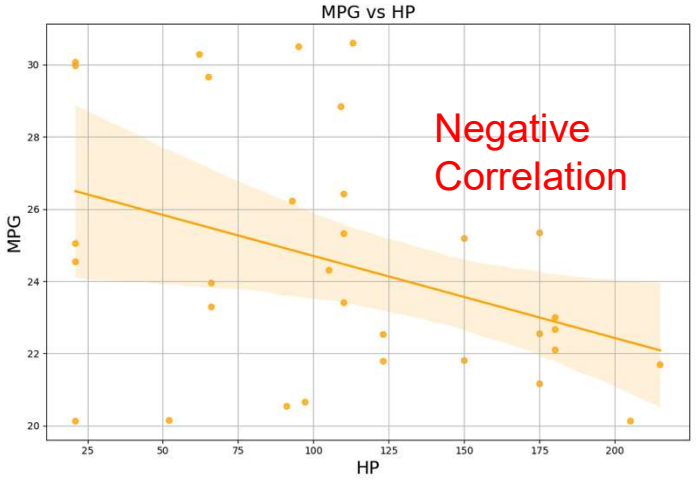
Using Benford's Law to Detect Correlation Reversal

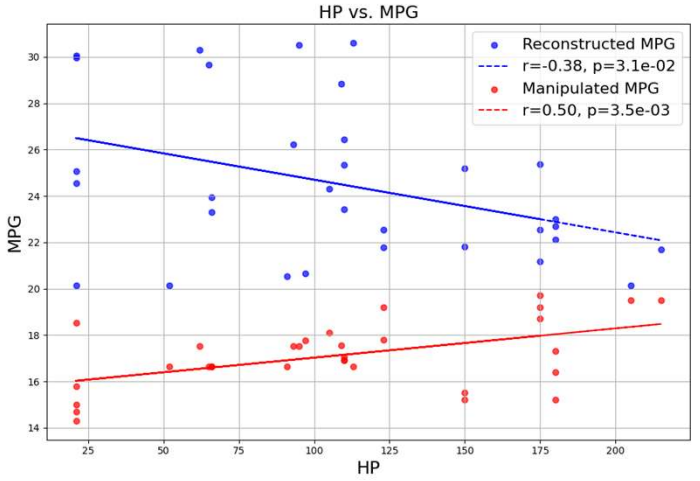


Stochastic Simulation



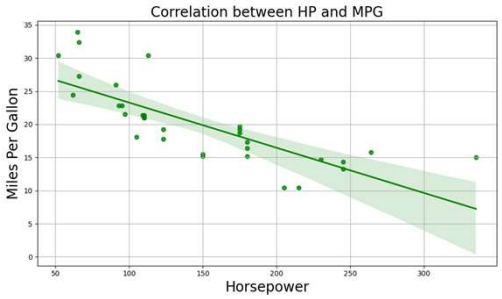
Reconstructed Data



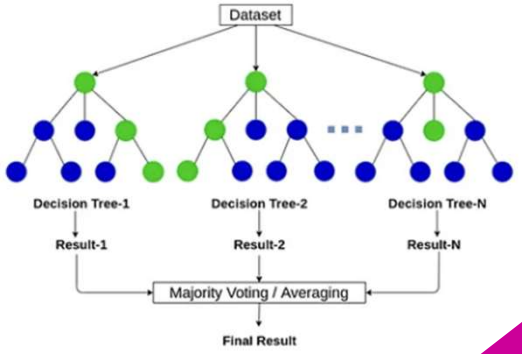


Using Random Forest to Detect Correlation Reversal

Original Data

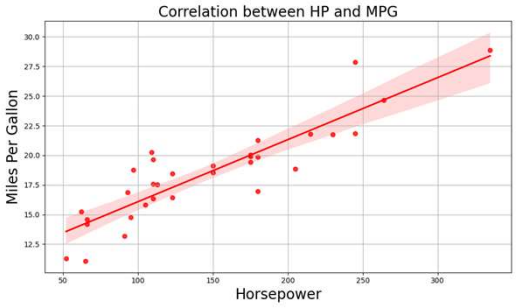


Training



RF Model

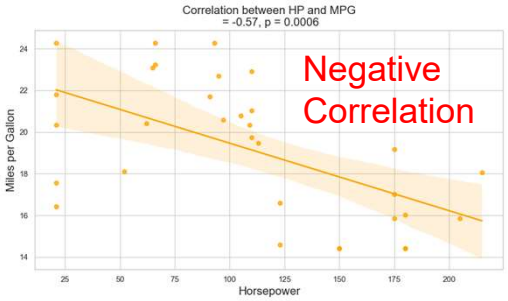
Manipulated Data

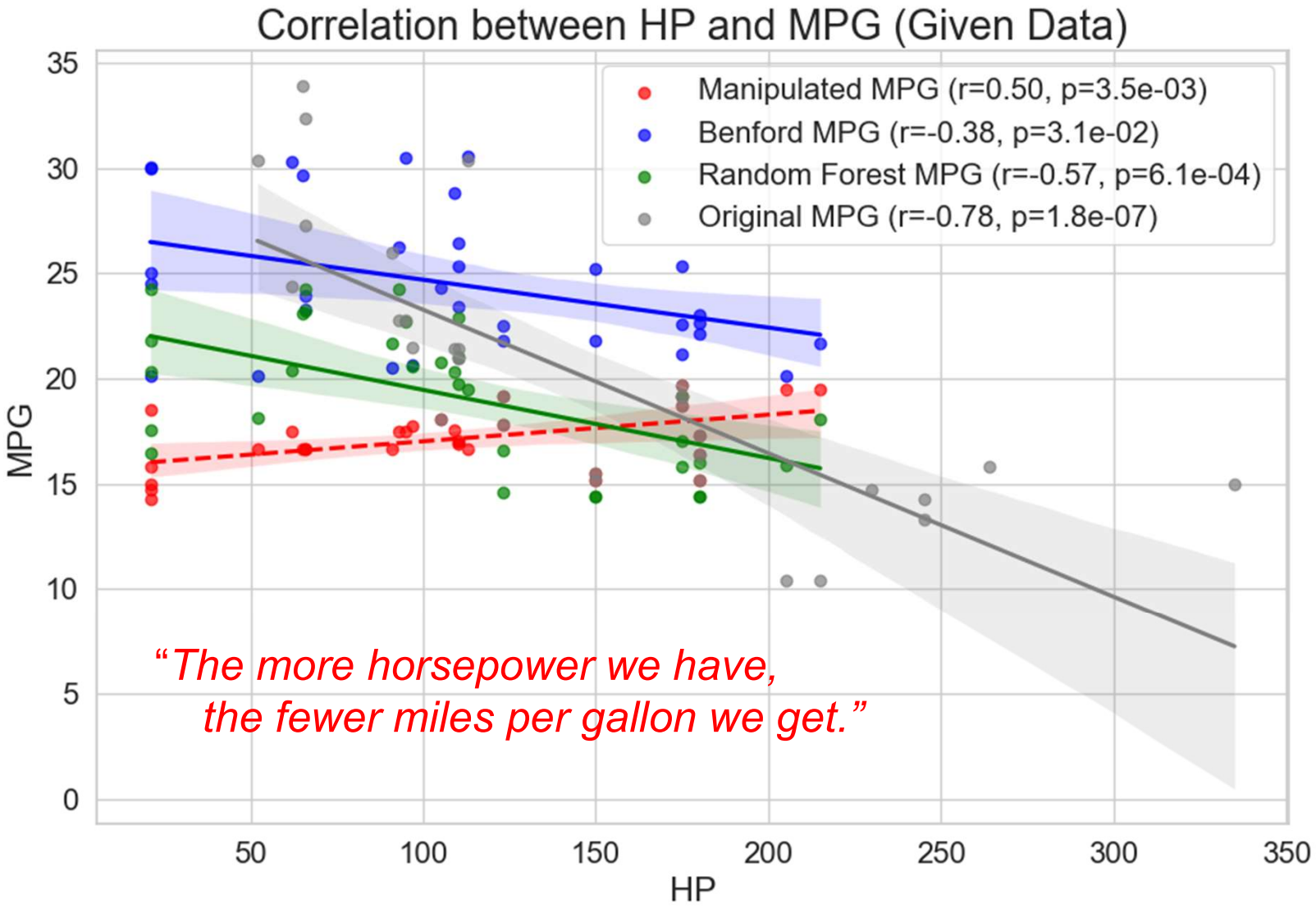


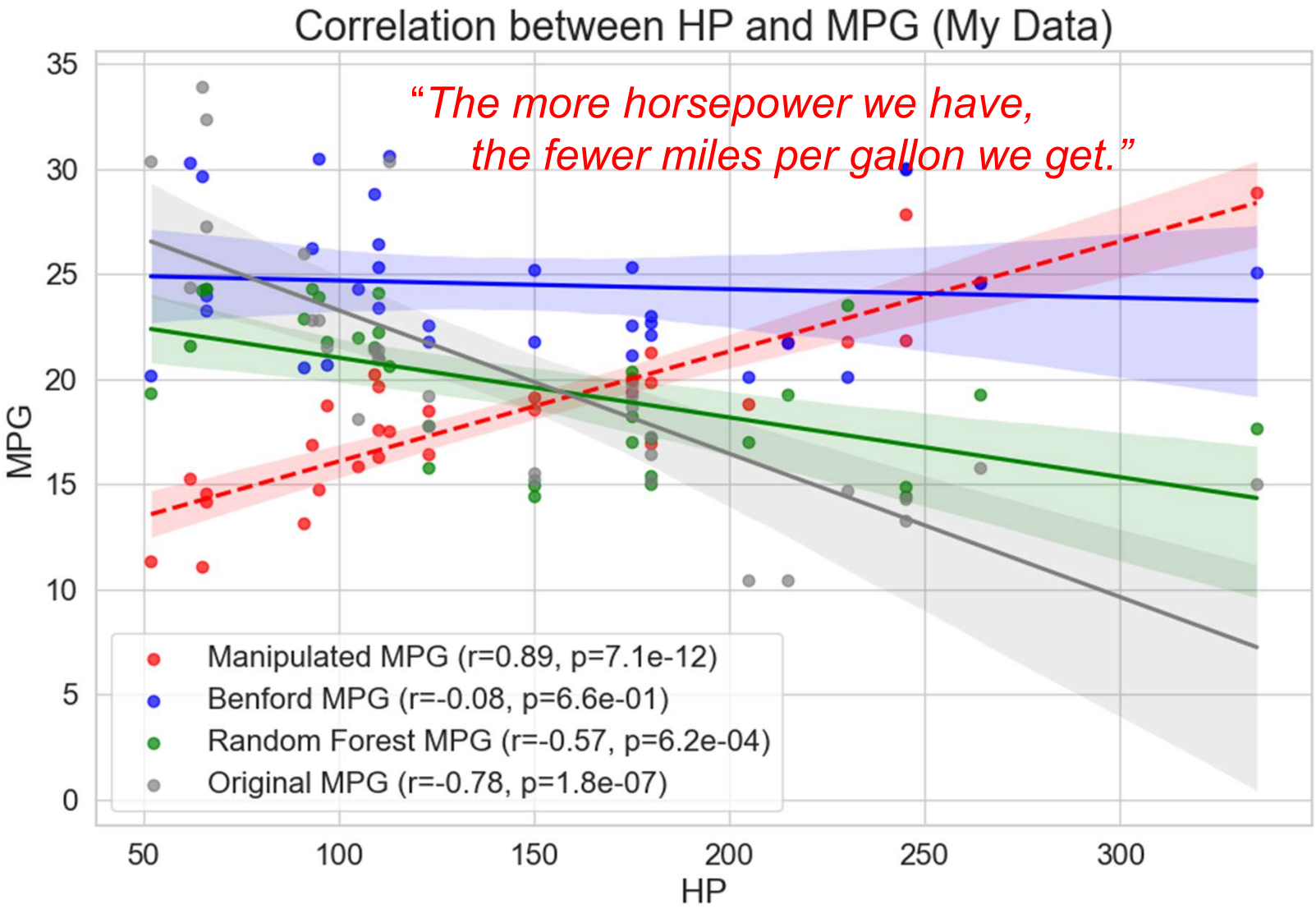
Regressor

RF Model

Reconstructed Data




Correlation between HP and MPG (Given Data)
Manipulated MPG (r=0.50, p=3.5e-03)
Benford MPG (r=-0.38, p=3.1e-02)
Random Forest MPG (r=-0.57, p=6.1e-04)
Original MPG (r=-0.78, p=1.8e-07)
MPG
HP
0
5
10
15
20
25
30
35
50
100
150
200
250
300
350
"The more horsepower we have,
the fewer miles per gallon we get."


Correlation between HP and MPG (My Data)
"The more horsepower we have,
the fewer miles per gallon we get."
MPG
HP
0
5
10
15
20
25
30
35
50
100
150
200
250
300
Manipulated MPG (r=0.89, p=7.1e-12)
Benford MPG (r=-0.08, p=6.6e-01)
Random Forest MPG (r=-0.57, p=6.2e-04)
Original MPG (r=-0.78, p=1.8e-07)

Evaluation of Random Forest Classifier and Regressor

```
=== Random Forest Classification Evaluation ===
              precision    recall  f1-score   support

           0       0.83      1.00      0.91         5
           1       1.00      0.88      0.93         8


=== Random Forest Regression Evaluation  ===
R² Score              : 0.6643
Mean Squared Error : 4.1079
Mean Absolute Error: 1.7576
```

Conclusion

1. Benford's law can detect data manipulation and correlation reversal.
2. Random Forest Algorithm can also detect data manipulation and correlation reversal.
3. Random Forest could approximate original data better than Benford's law (84% vs. 45%).
4. The original data was manipulated to show positive correlation between HP and MPG while still $p < 5\%$.