Causal inference of multivariate server performance logs

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Introduction

- Data monitoring and visualization
  - Datadog
- Causal Inference
  - Data Imputation
  - Stationary Transformation
  - Correlation Analysis
  - Causal and Inference

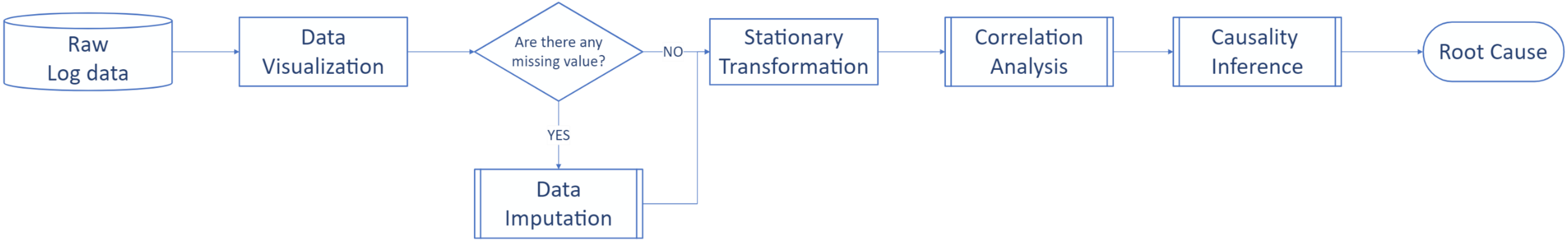
Data Monitoring and Visualization

Datadog

- Logs Dashboard | Datadog (datadoghq.com)

Causal Inference

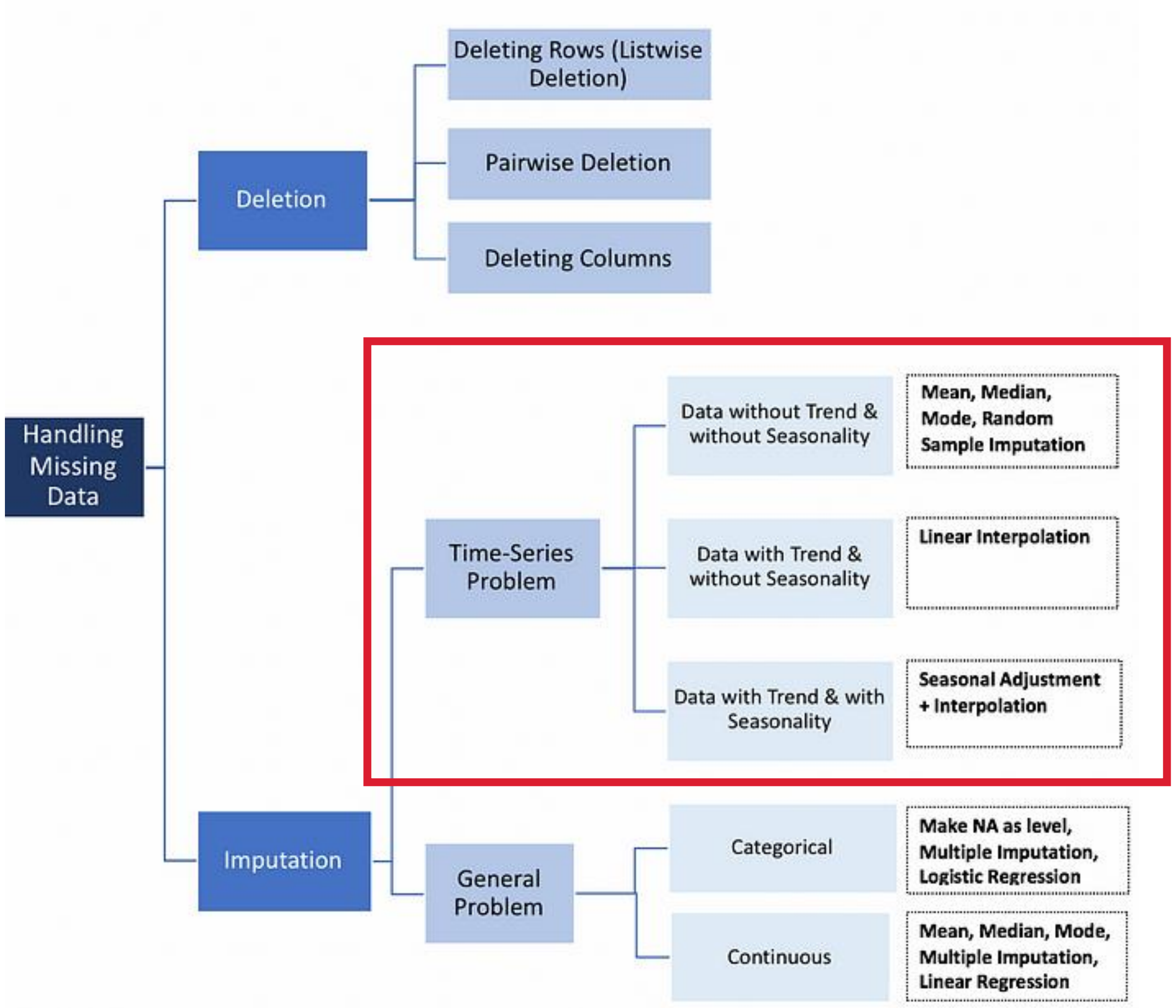
Establish whether and how changes in one variable cause changes in another



Example: Processor Time – Performance Counter (Instance: RapidResponse)

Data Imputation

Imputation for missing value to generate complete datasets


Handling Missing Data
Deletion
Deleting Rows (Listwise Deletion)
Pairwise Deletion
Deleting Columns
Imputation
Time-Series Problem
Data without Trend & without Seasonality
Mean, Median, Mode, Random Sample Imputation
Data with Trend & without Seasonality
Linear Interpolation
Data with Trend & with Seasonality
Seasonal Adjustment + Interpolation
General Problem
Categorical
Make NA as level, Multiple Imputation, Logistic Regression
Continuous
Mean, Median, Mode, Multiple Imputation, Linear Regression

INTERNAL USE

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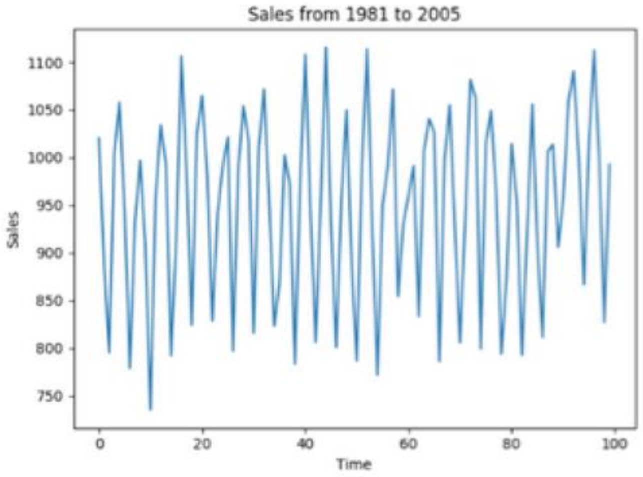
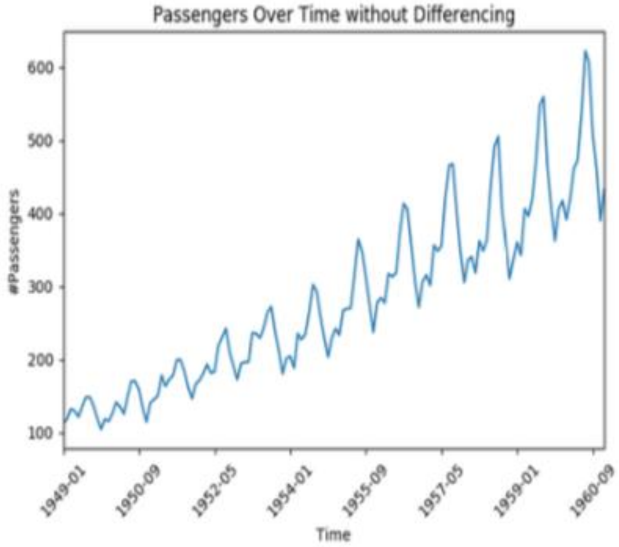
Stationary Transformation

Why stationary is important: most time series models assume that each point is independent of one another.

Stationary data: mean and variance do not vary across time



Stationary data



Non-stationary data

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Correlation Analysis

Evaluate strength and direction of the linear relationship between two variables

Question: We can only retain a month's worth of data, insufficient for any computation

Solution: Employ a variety of mathematical computations

Method:

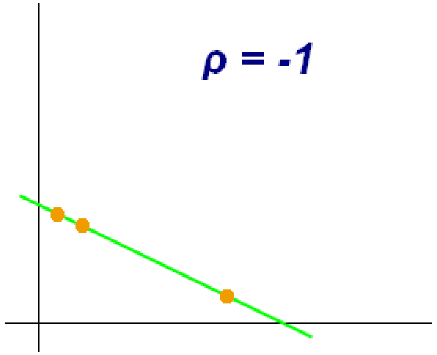
1. Pearson correlation coefficient
2. Spearman correlation coefficient
3. Kendall correlation coefficient

Correlation Analysis

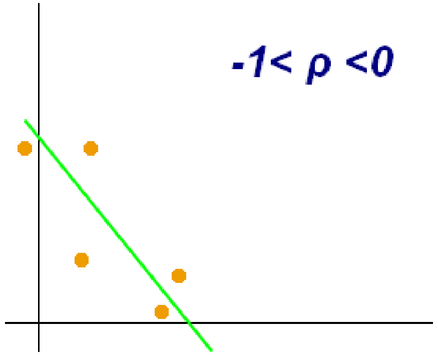
Pearson Correlation Coefficient: [-1,1]

Coefficient = 1 or -1: perfect linear relationship

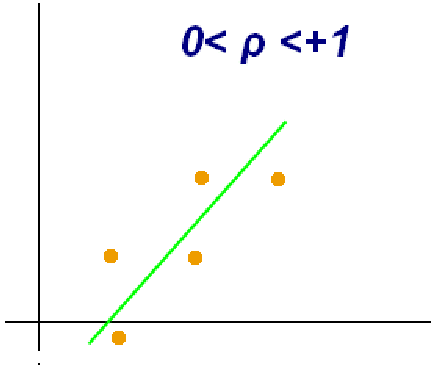
Coefficient = 0 : no linear relationship, could have a non-linear or more complex relationship



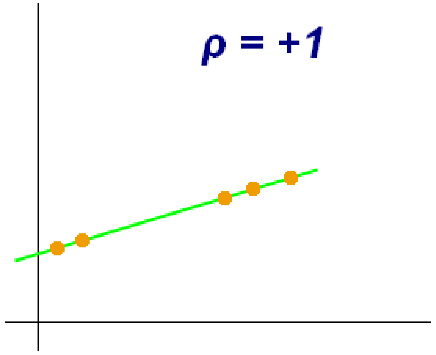
perfect negative correlation



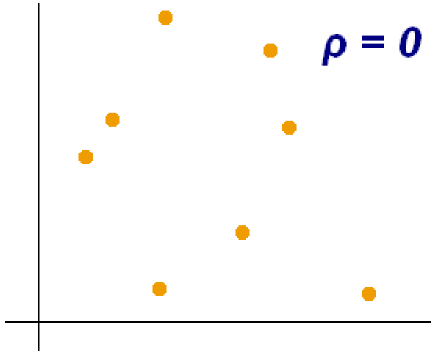
negative correlation



positive correlation

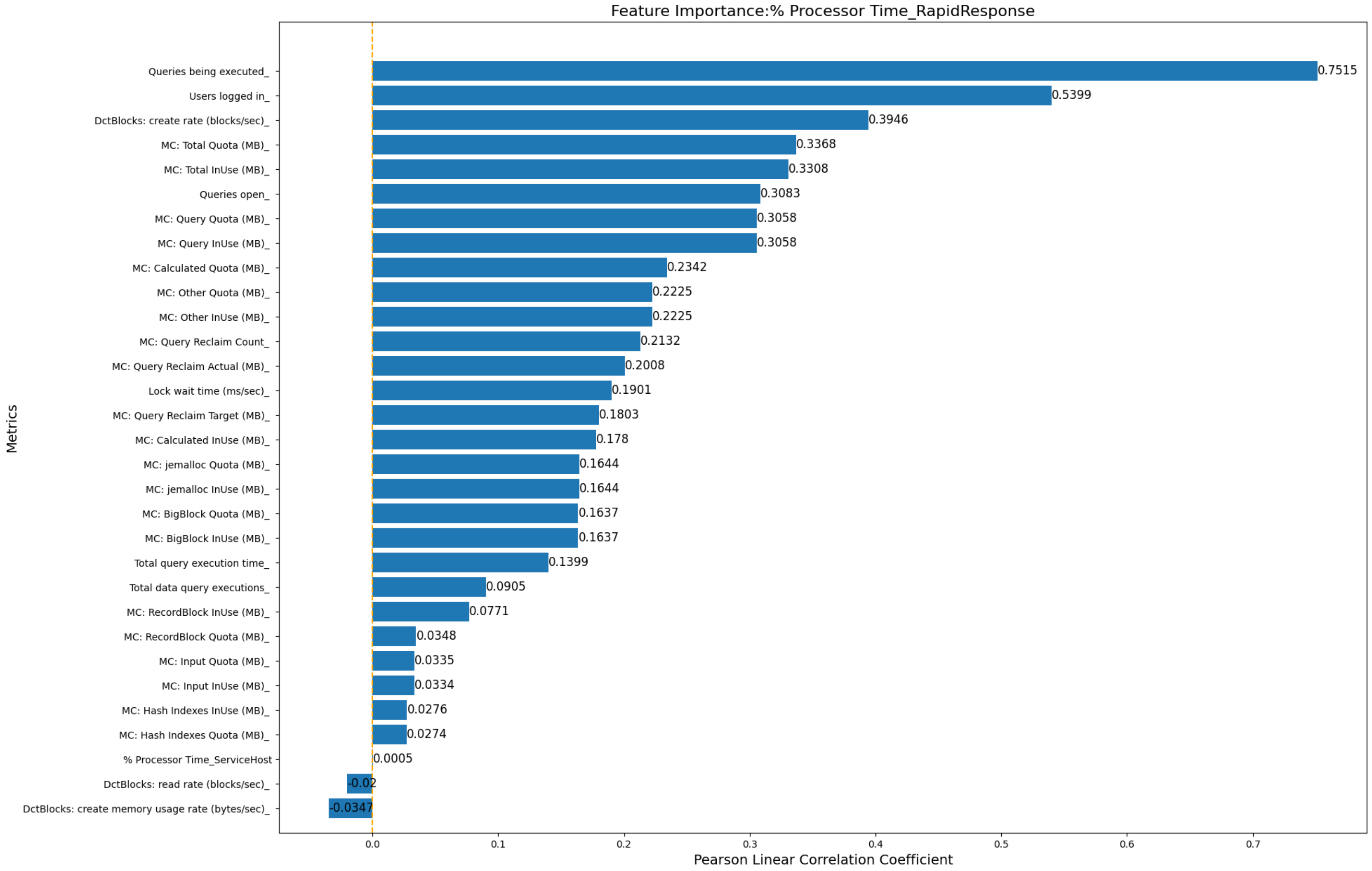


perfect positive correlation



no liner correlation

Pearson Correlation Coefficient

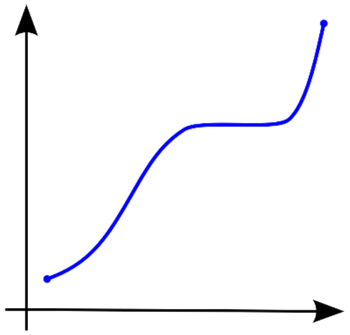


Correlation Analysis

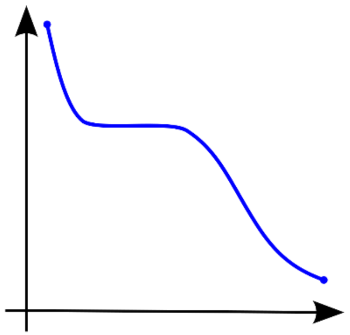
Spearman Correlation Coefficient

coefficient = 1/-1 : perfect positive/negative monotonic relationship

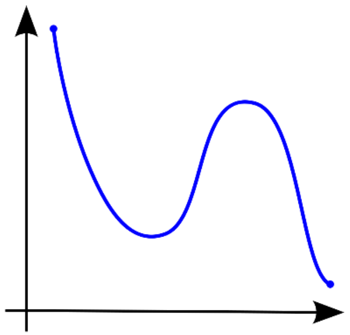
Coefficient = 0 : no monotonic relationship



Monotonic non-decreasing

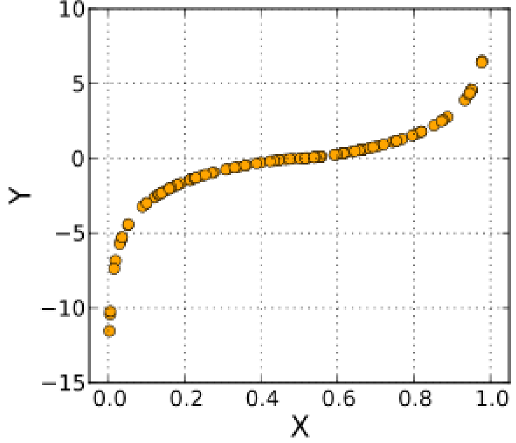


Monotonic non-increasing

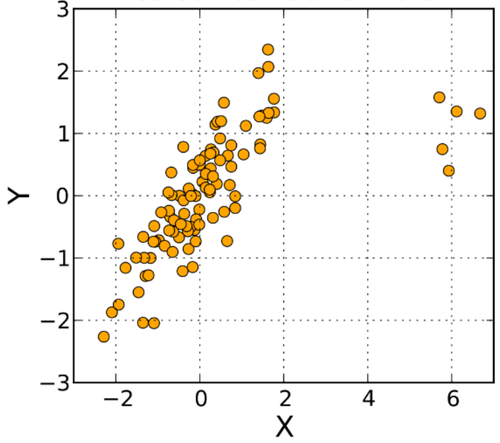


Not monotonic

Spearman correlation=1
Pearson correlation=0.88



Spearman correlation=0.84
Pearson correlation=0.67



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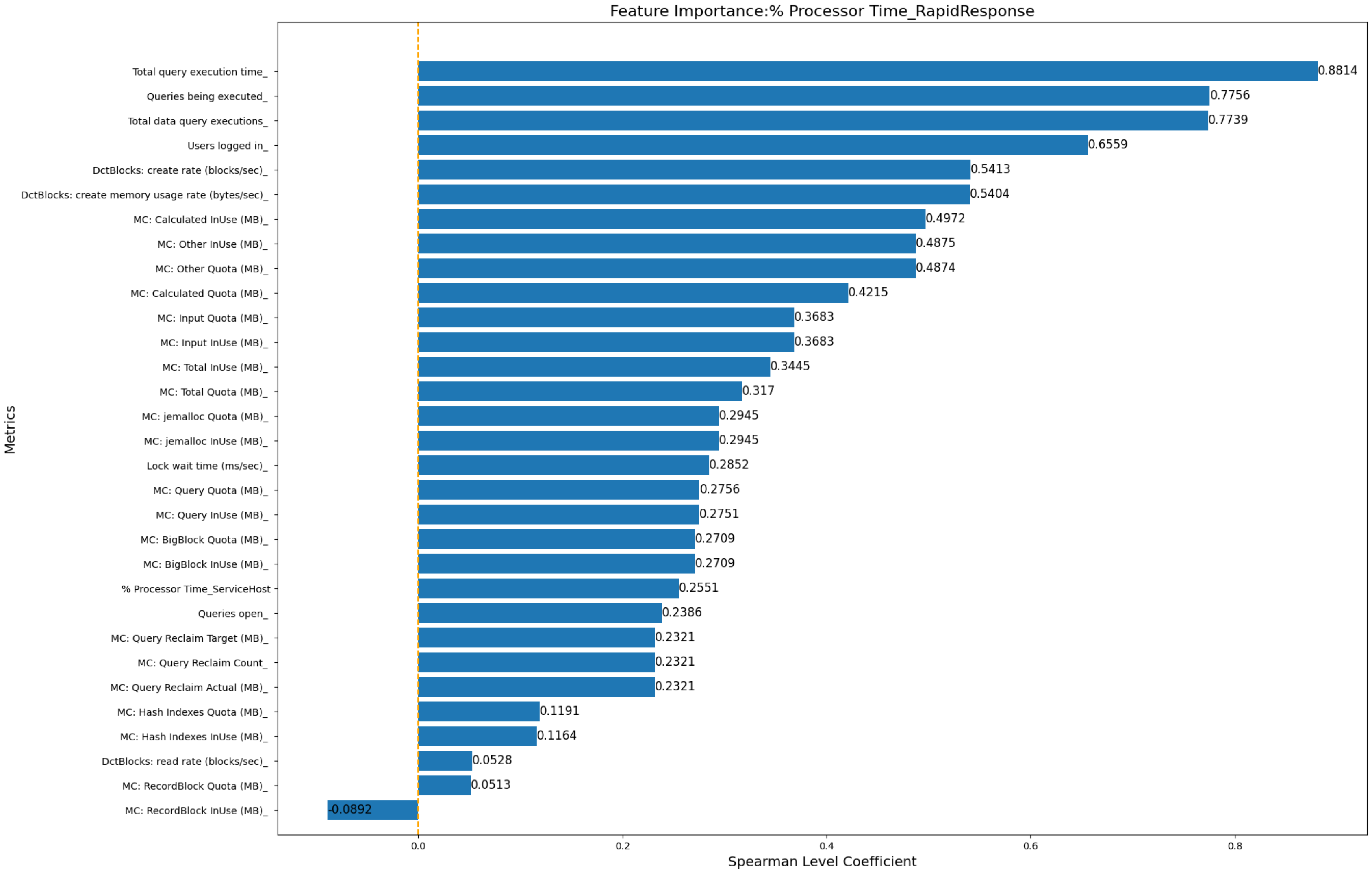
Spearman Correlation Coefficient



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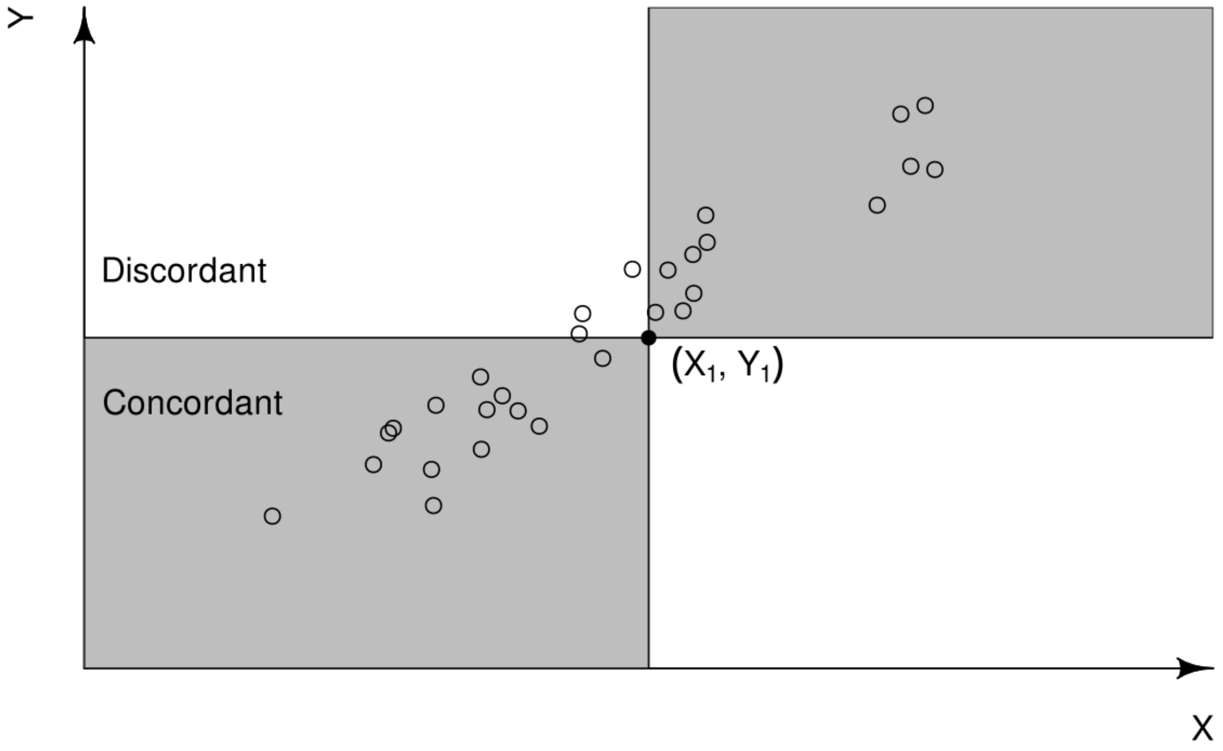
Kendall Correlation Coefficient

coefficient = 1/-1: ranks of corresponding values within each data sample always same

Coefficient = 0 : no association between the ranks of the values

Ex: (xi,yi), (xj,yj), i < j:

Either both xi > xj and yi > yj or xi < xj, yi < yj



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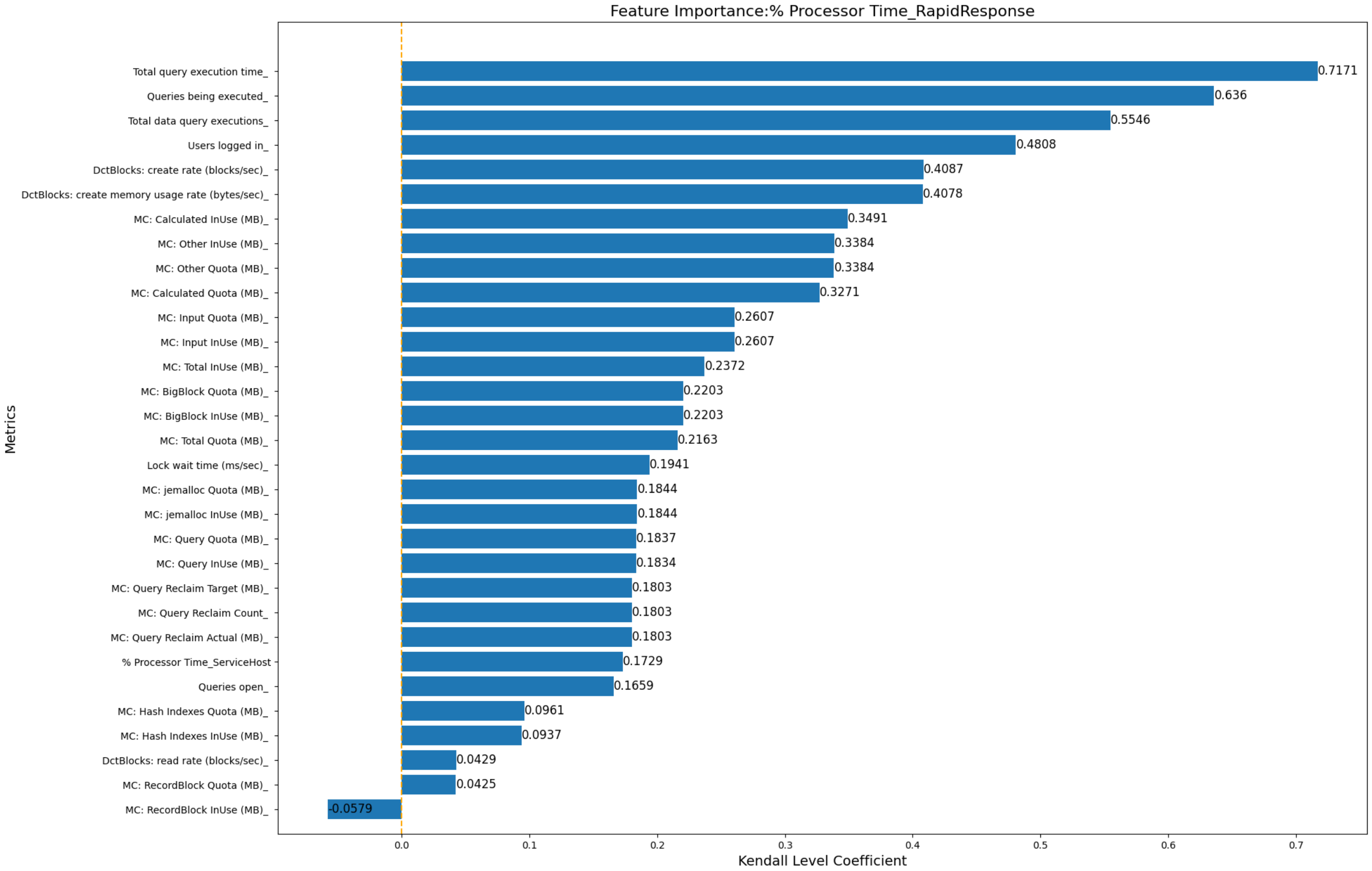
Kendall Correlation Coefficient

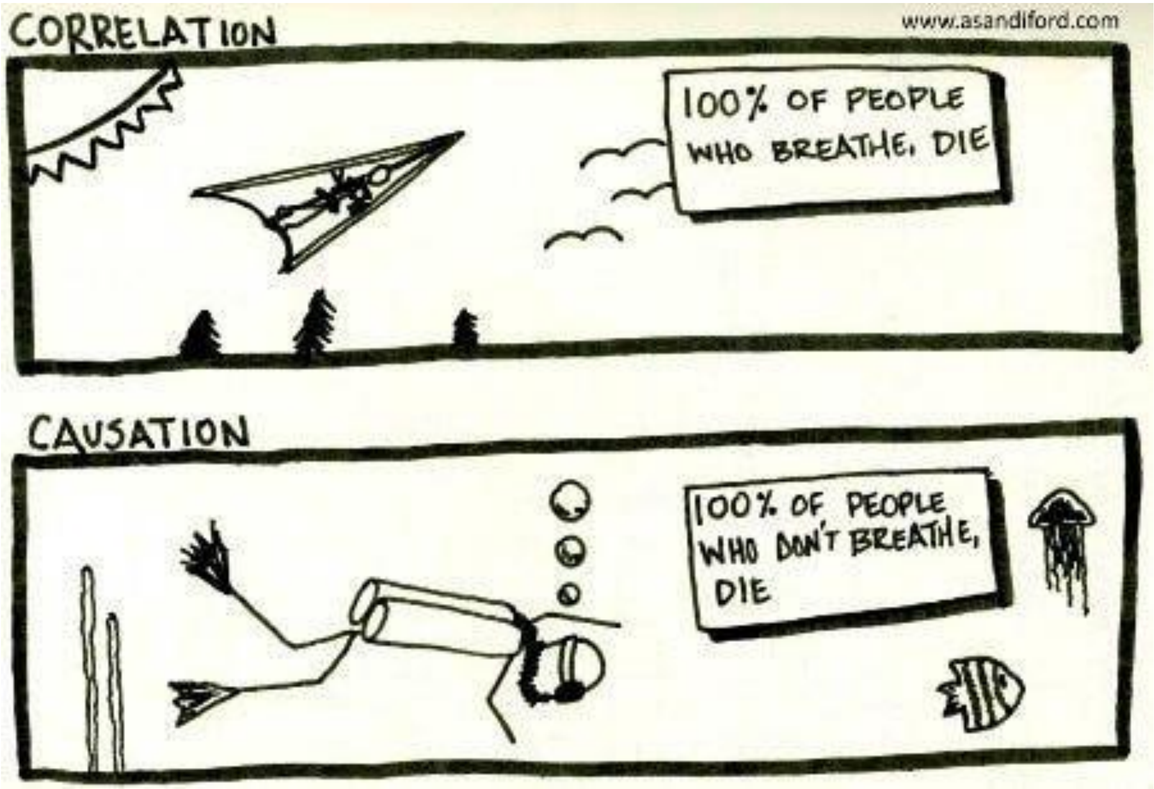


Correlation Coefficient

Top5 Results:

Pearson Correlation:	**Spearman Correlation:**	**Kendall Correlation:**
Queries being executed	Total query execution time	Total query execution time
Users logged in	Queries being executed	Queries being executed
DctBlocks: create rate (blocks/sec)	Total data query execution	Total data query execution
MC: Total Quota (MB)	Users logged in	Users logged in
MC: Total Inuse (MB)	DctBlocks: create rate (blocks/sec)	DctBlocks: create rate (blocks/sec)

Correlation VS Causation


CORRELATION
www.asandiford.com
100% OF PEOPLE WHO BREATHE, DIE
CAUSATION
100% OF PEOPLE WHO DON'T BREATHE, DIE

Transfer Entropy

Features of time series: max, min, mean, median, variance,…

Series A : 1, 2, 1, 2, 1, 2, 1, …

Series B : 1, 1, 2, 1, 2, 2, 1, …

Same mean, same variance, same median, different entropy

Larger the entropy, more chaotic the system

Transfer entropy: transfer of information

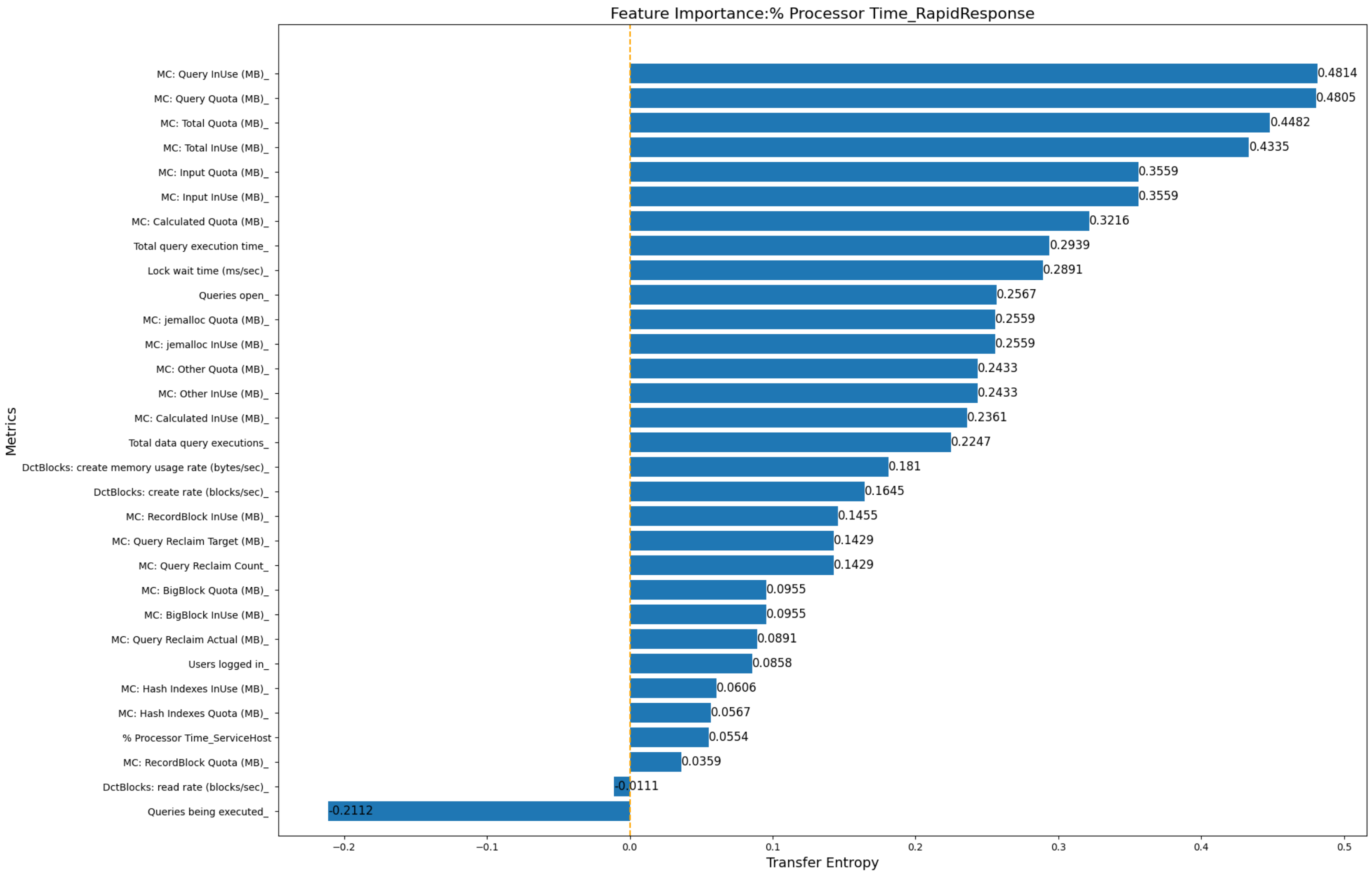
Causal Inference

Transfer Entropy

Symbol: direction of transfer

+:Y -> X

-: X -> Y



Causal Inference

Causal Inference

Neural Network: LSTM(Long-short term memory)

Step 1: Forecasting

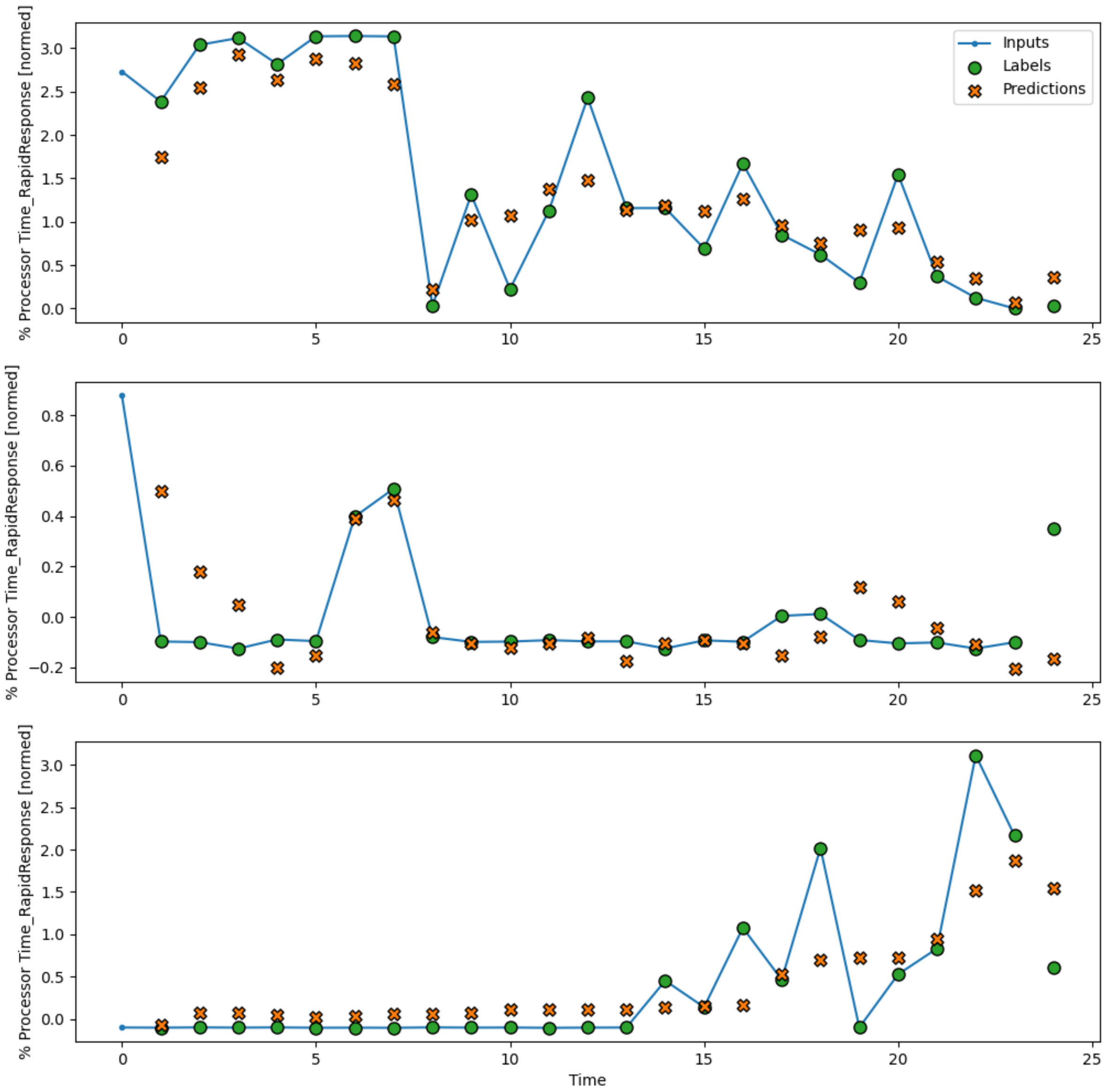
Step 2: Evaluating the prediction model

Step 3: Calculating feature Importance

Causal Inference

Step1: Forecasting

Selected 3 subsections from the entire dataset as examples



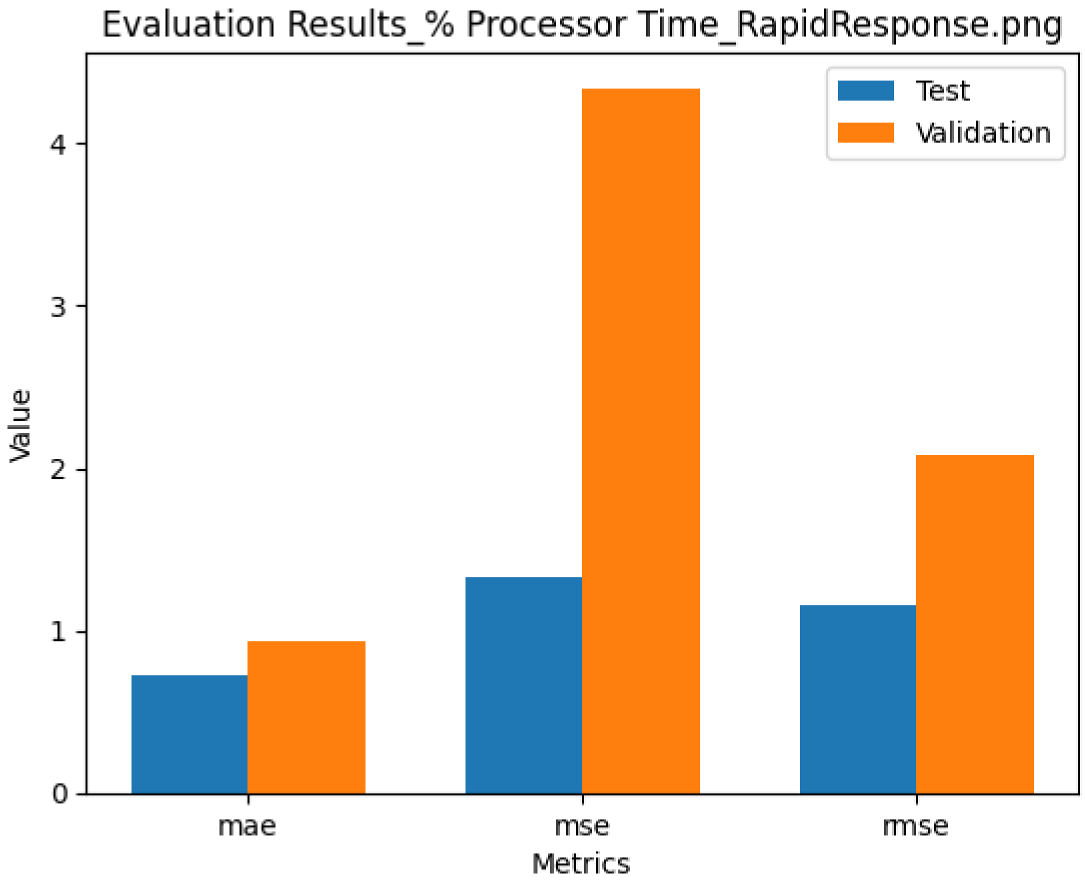
Causal Inference

Step 2: Evaluating the prediction model

MAE: mean absolute error

MSE: mean squared error

RMSE: root mean squared error



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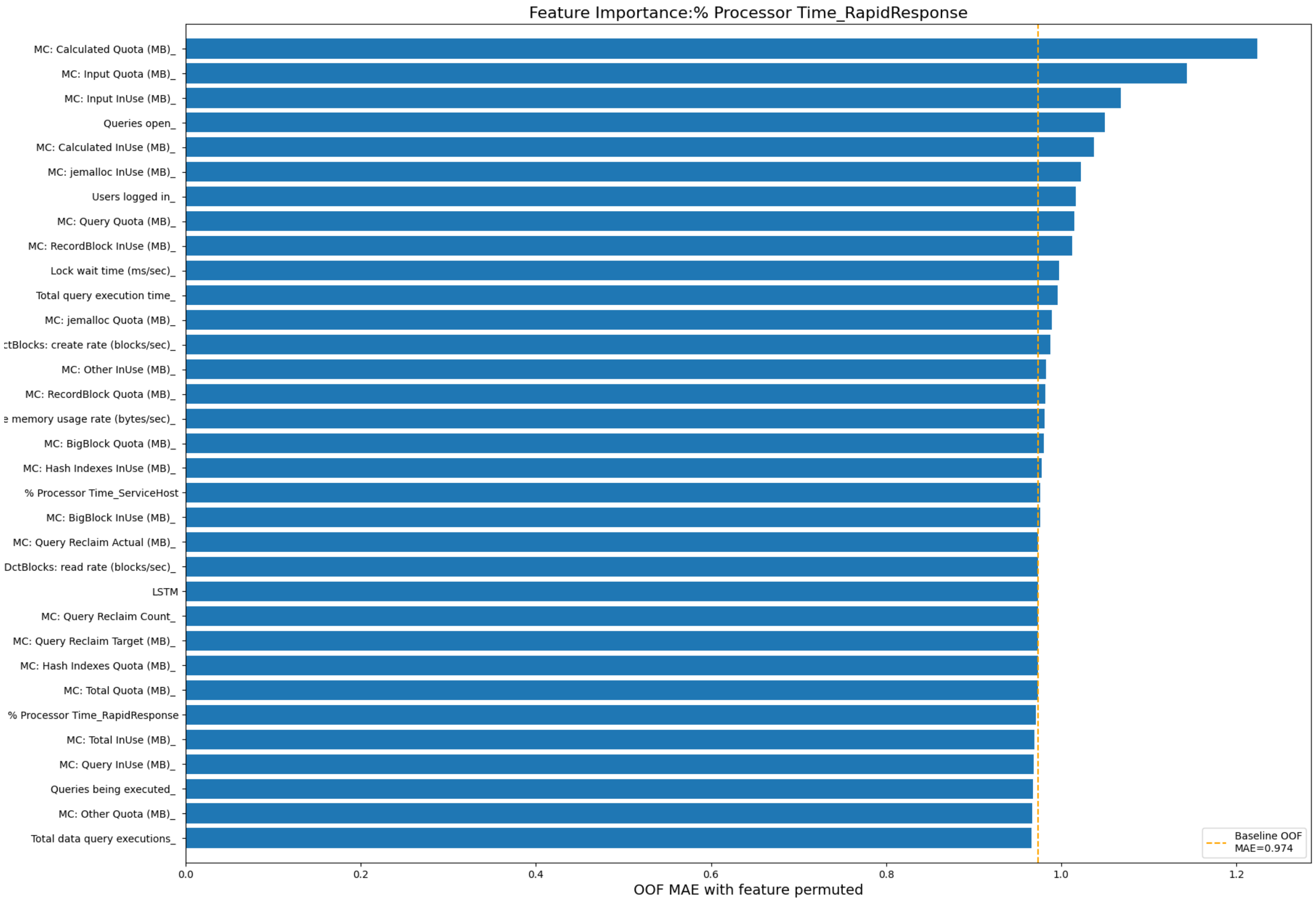
Causal Inference

Causal Inference

Step 3: Calculating feature Importance

OOF: Out-of-Fold, dividing a dataset into subsets, known as “folds.” Each fold is then used as a validation set once while the remaining folds are utilized for training.



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Conclusion

- Most Correlated metrics with Processor Time:
  - Total query execution time
  - Queries being executed
  - Total data query execution
  - users logged in
  - DctBlocks: create rate (blocks/sec)

- Metrics with the largest Transfer Entropy:
  - MC metrics
  - Total query execution time
  - Lock wait time
  - Queries open
  - Total data query execution

- Metrics with the biggest influence:
  - MC metrics
  - Queries open
  - Users logged in
  - Lock wait time
  - Total query execution time

Conclusion

Possible Reason of error:

- Insufficient data
- Inappropriate model selection
  - Not suitable
  - Overfitting, too complex
- Feature engineering issues
  - Incorrect stationary transformation