Smarter Solutions with Hybrid Rule-ML Systems

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Shameless Self-Promotion

- PhD in Computational Sciences
- 12+ years of Python and Data Science experience
- Worked for small/medium/large enterprise companies, startups, etc
- Lead Data Scientist at Hyke
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Roadmap

- Rule-Based Systems
- ML-Based Systems
- Practical Cases
- Personal Experience
- Q&A

Rule-based systems

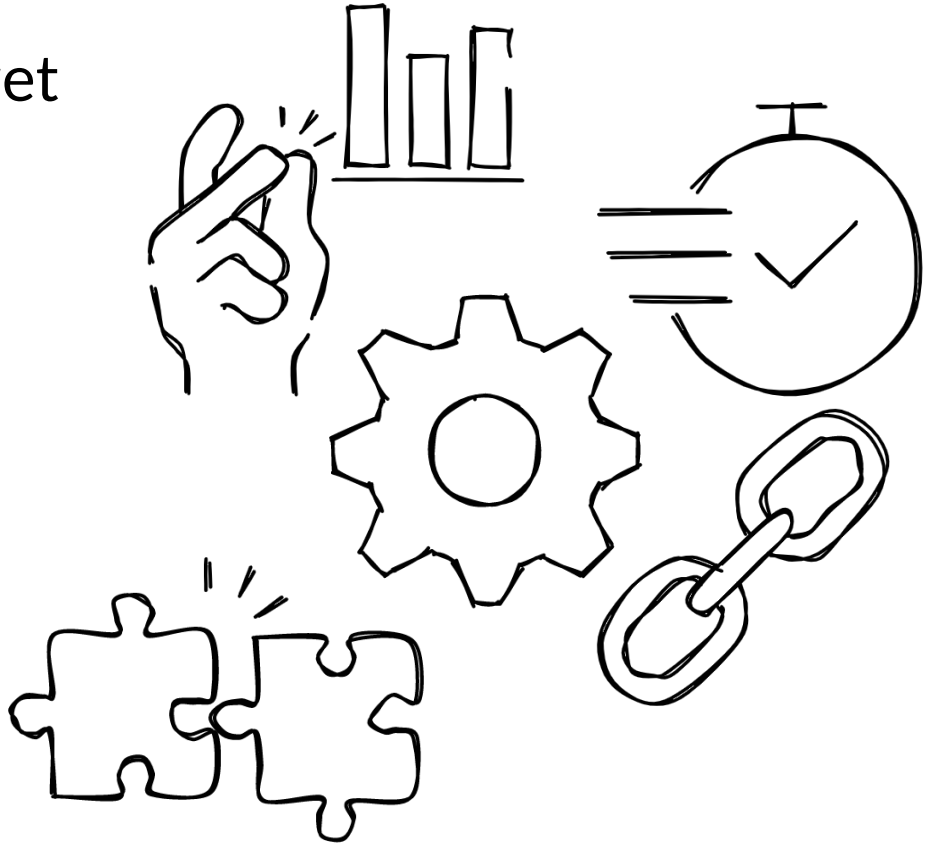
Set of if-then statements, also known as rules, to make decisions or perform specific tasks

Key: domain knowledge

Examples:
Finance: identify fraud by some common transaction patterns
Healthcare: assign doctors, based on medical history and analysis
Supply Chain: demand forecasting for new product introduction (NPI)

Rule-based systems: Advantages

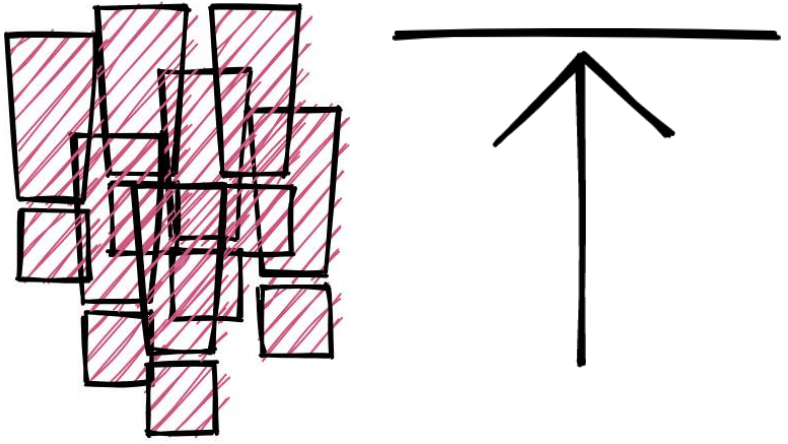
+ Simple to comprehend and interpret
+ Fast to implement
+ Easy to modify
+ Robust
+ Compatible with ML



Rule-based systems: Disadvantages

- Issues involving a vast number of variables
- Problems with numerous constraints
- Limited to existing rules

_id	f1	f2	f3	f4	...	fn-1	fn
1	1.3	2.1	0.99	1.1	...	8.7	11.2
2	24.5	4.1	3.5	2.3	...	9.5	3.1
3	2.2	45.1	NaN	0.2	...	11.7	NaN
4	0.31	2.9	4.4	1.4	...	0	23.1



ML-based systems

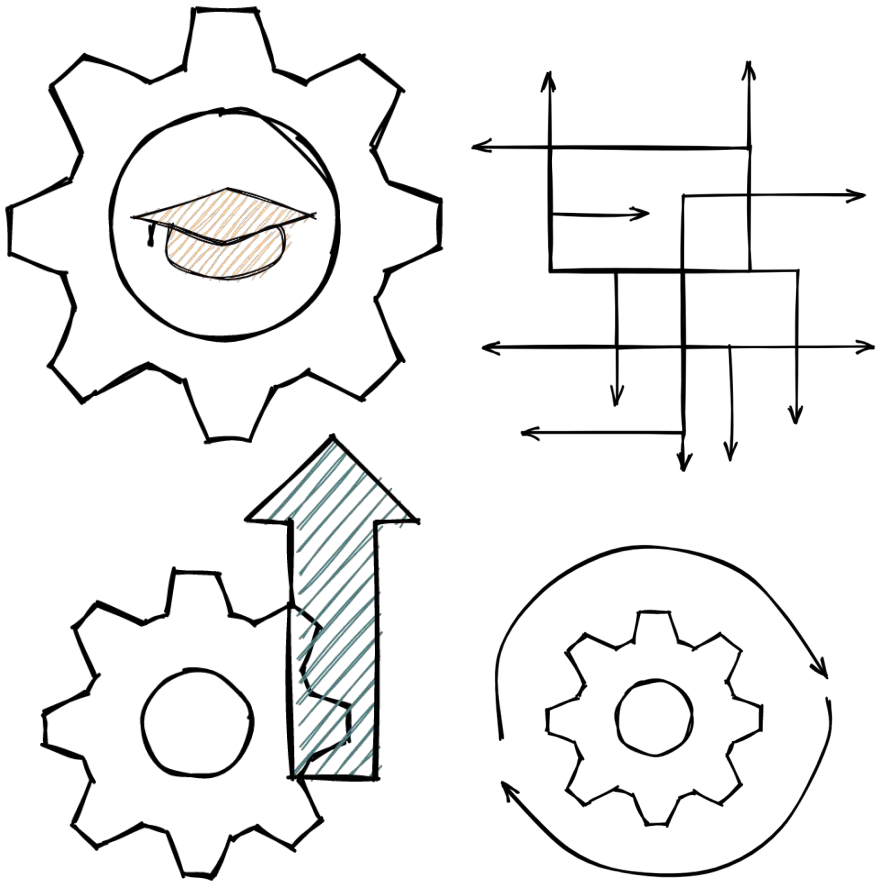
Set of algorithms to learn from data and make predictions or take actions without being explicitly programmed to do so

Key: patterns from historical data

Examples:
Finance: analyze large amounts of financial data to detect outlier fraudulent transactions
Healthcare: analyze patient data and predict the likelihood of a patient developing a certain disease
Supply Chain: demand forecasting based on historical sales

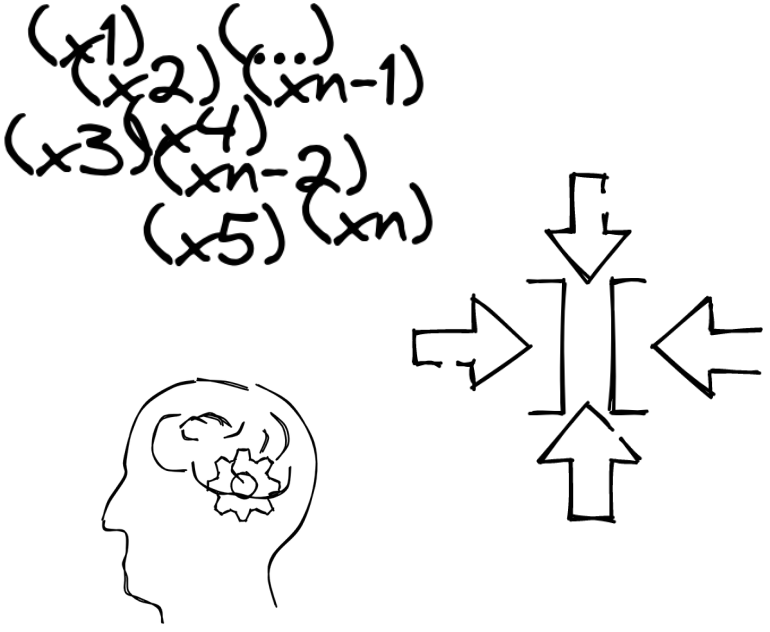
ML-based systems: Advantages

+ Autonomous learning systems
+ Ability to tackle more intricate problems
+ Higher efficiency with reduced human intervention compared to rule-based systems
+ Flexibility to adapt to changes in data and environment over time through continuous learning



ML-based systems: Disadvantages

- Requires data. Sometimes a lot
- Limited to the data ML seen before
- Limited cognitive ability



Rule vs ML-based systems

What shall I choose?

Rule vs ML-based systems

Rule-Based:

- Danger of error
- Fast delivery
- Not enough data

ML-Based:

- Complex problem
- Self-learning
- More flexible
- Better results

Hybrid rule-ML systems

A hybrid rule-ML system is a combination of the two approaches, which aims to leverage the strengths of both to achieve better results.

Sometimes even better than either system can on its own.

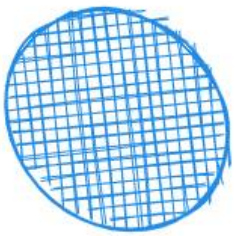
Hybrid-based systems

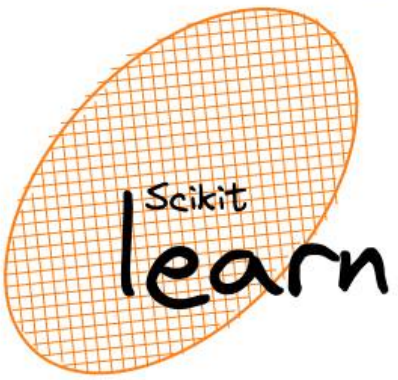
_id	n_bedrooms	area	price	...	sold_7	price_drop
1	1	800	1.1	...	0	0
2	1	750	0.9	...	1	0
3	2	1100	1.6	...	0	1
4	0	600	0.7	...	1	1
n	1	900	1.2	...	0.7	0.45

1. **Rule**(X_i) → **ML**(X_i): Feature engineering
2. **ML**(Y_i) → **Rule**(Y_i): Post processing
3. **ML**(Y_i) → **Rule**(Z_i): Use ml predictions for other decisions. For example, should we place a bid for a flat.
4. **ML**(Yi) + **Rule**(Yi) → aggregated forecast


Jupyter


pandas

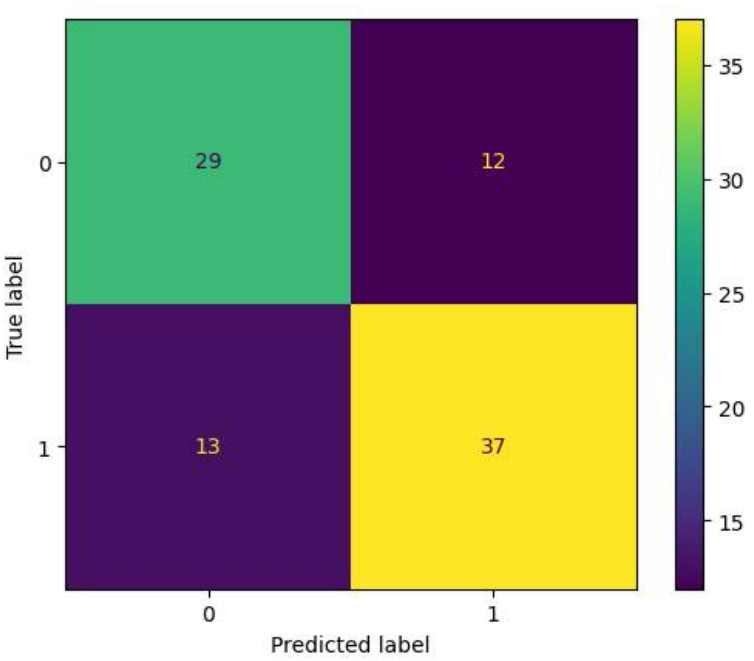



Scikit
learn


Tensor Flow

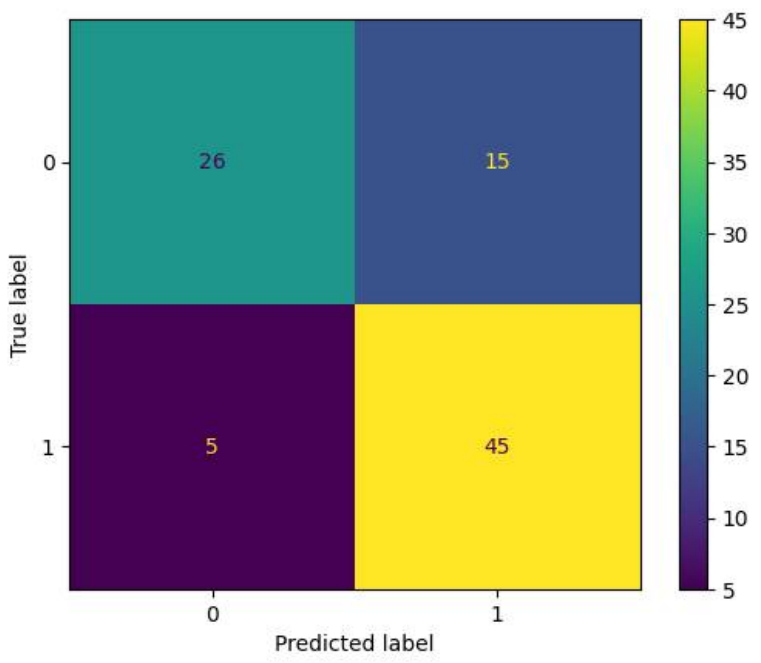
Hybrid Systems: Missed Feature

Pure ML (Random Forest)



F1 = 0.747

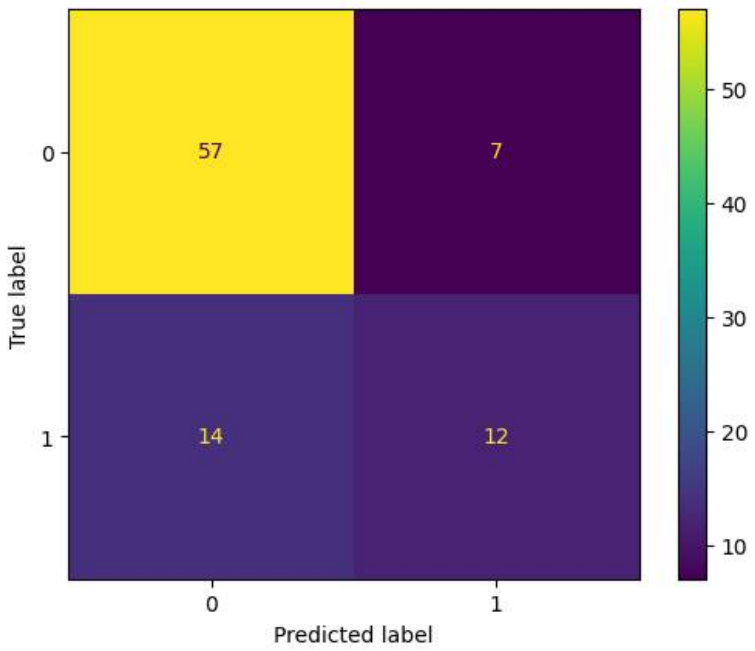
Hybrid Based



F1 = 0.818

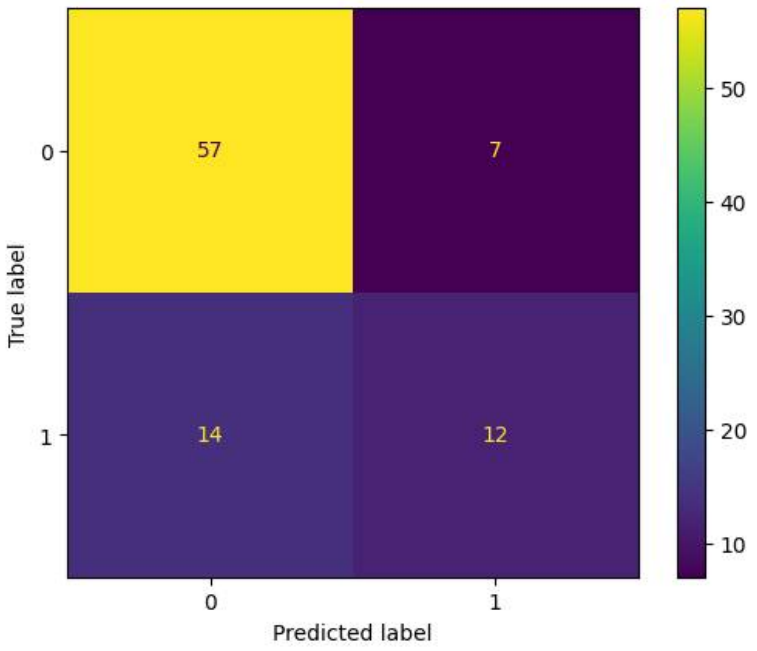
Hybrid Systems: All Feature Caught

Pure ML (Random Forest)



F1 = 0.533

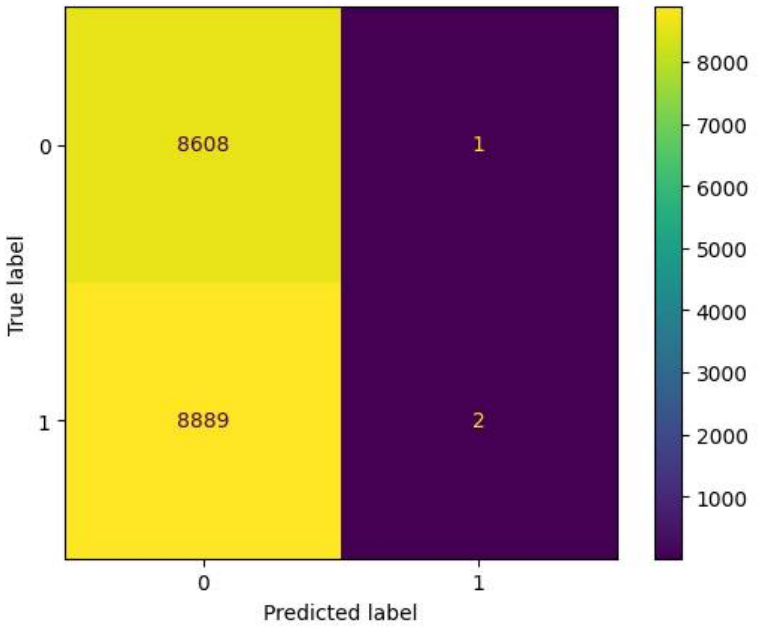
Hybrid Based



F1 = 0.533

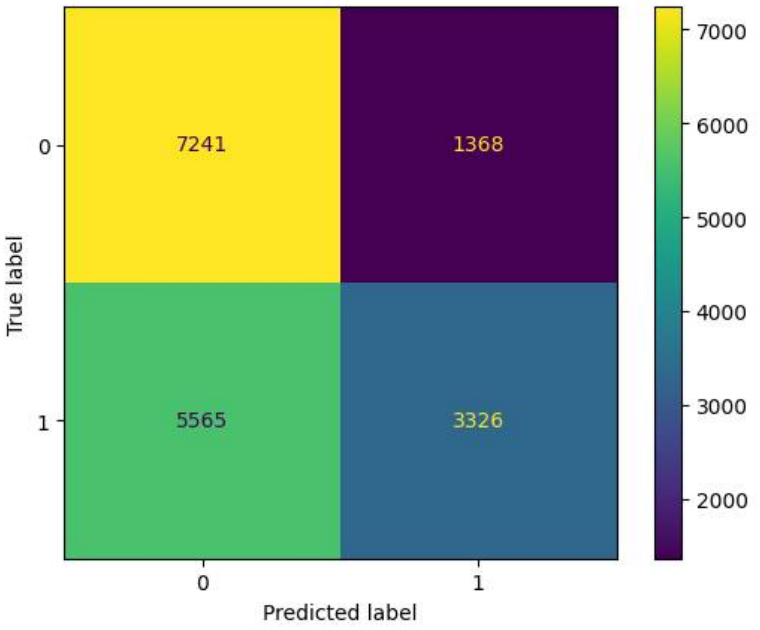
Hybrid Systems: Neural Network

Pure ML (NN)



F1 = 0.0004

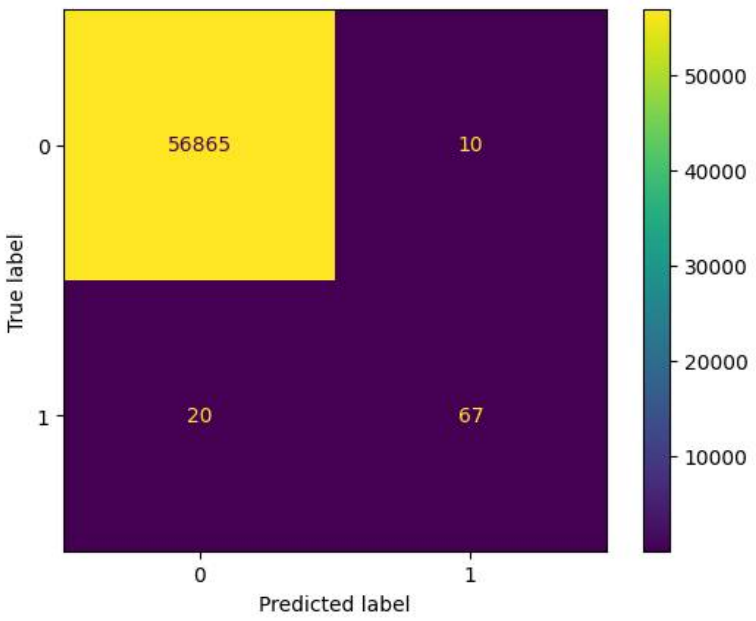
Hybrid Based



F1 = 0.489

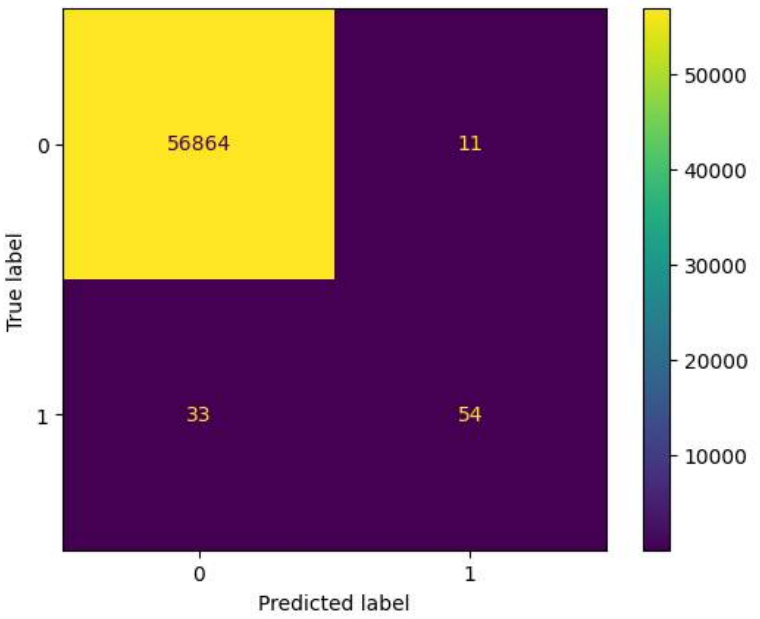
Hybrid Systems: Unbalanced Dataset

Pure ML (kNN)



F1 = 0.817

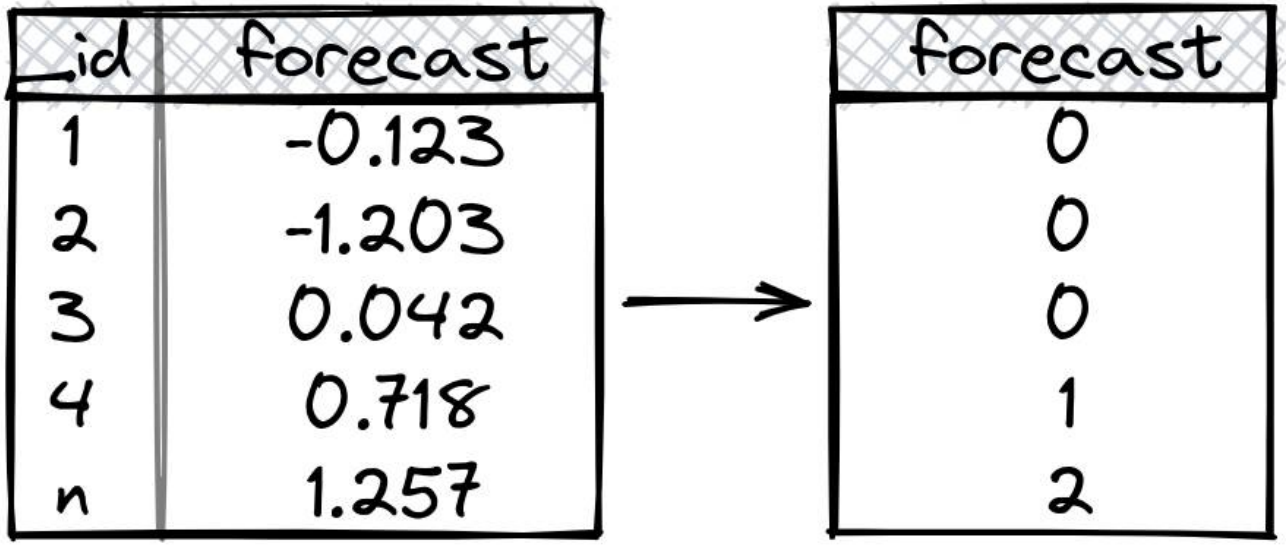
Hybrid Based



F1 = 0.711

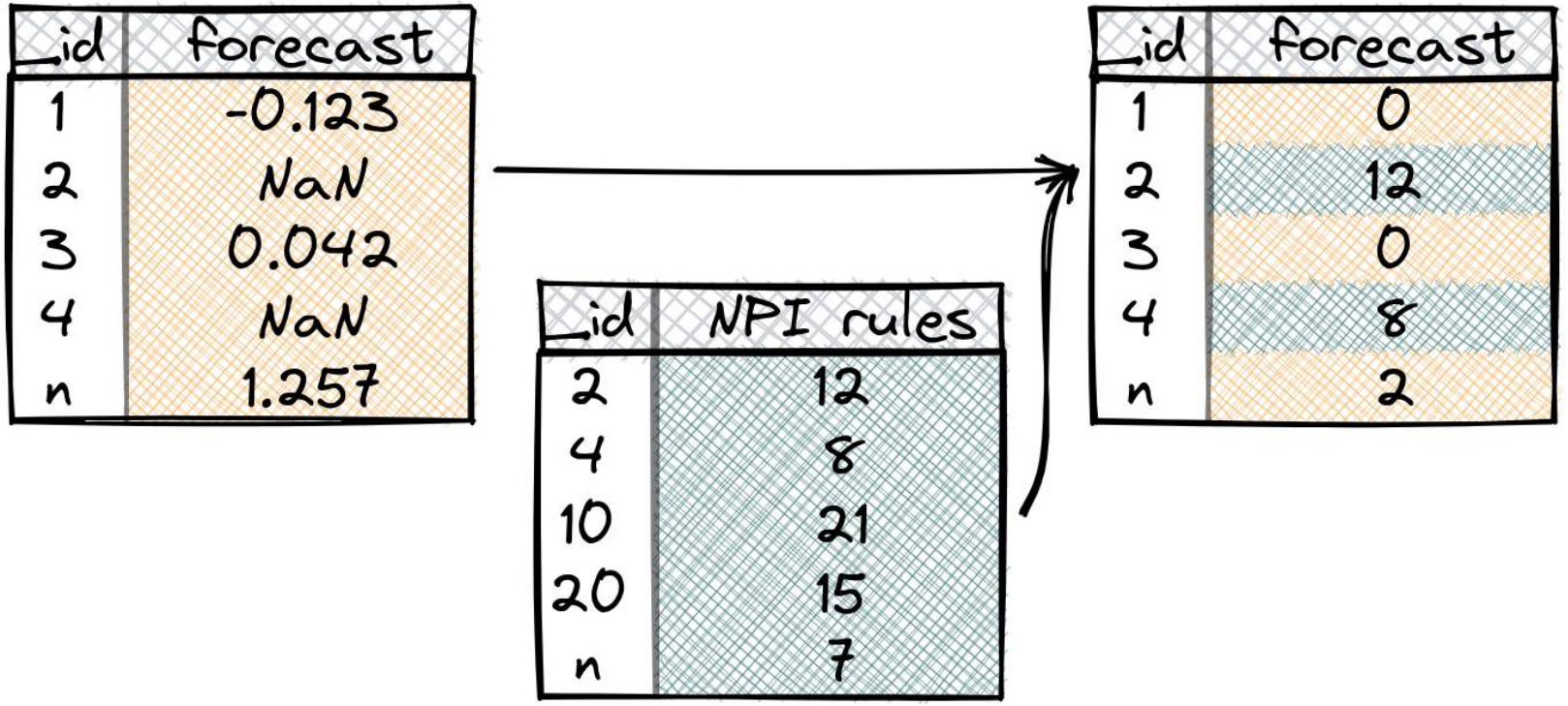
Hybrid Systems: Demand Forecasting

1. Format Outputs (without Data Filtering)



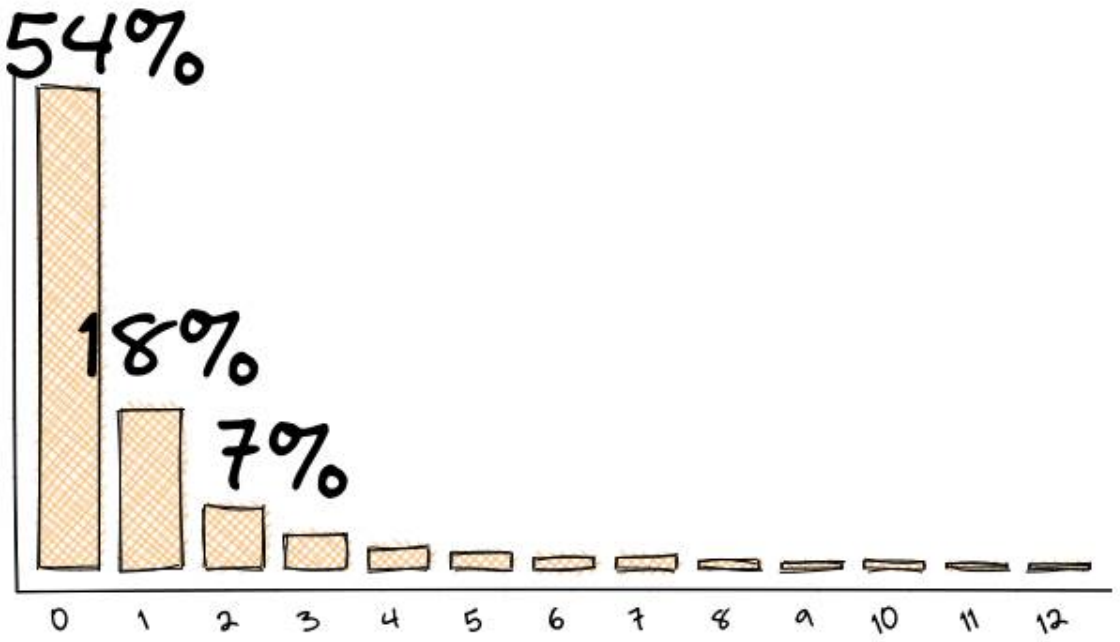
Hybrid Systems: Demand Forecasting

2. Format NPI Outputs (without Data Filtering)



Hybrid Systems: Demand Forecasting

3. Select Threads (with Data Filtering) for Time Series



Conclusions

Hybrid rule-ML systems offer practical benefits such as fast implementation, robustness to outliers, and increased transparency.

They are handy when combining business logic with machine learning. For instance, hybrid rule-ML systems in healthcare can diagnose diseases by combining clinical rules and machine learning algorithms that analyze patient data.

As business and data science continue to incorporate, hybrid systems can be crucial in smoother integration.

Time for Questions

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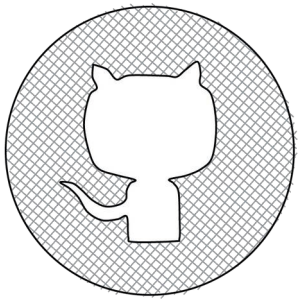

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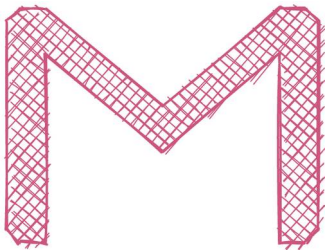

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