Formal Description of Validity Criteria for Data and Automated Cloud-Based Validity Checking to Generate a Validated Data Set

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15.02.2022 – 12.08.2022

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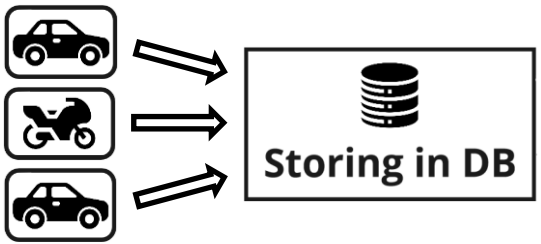

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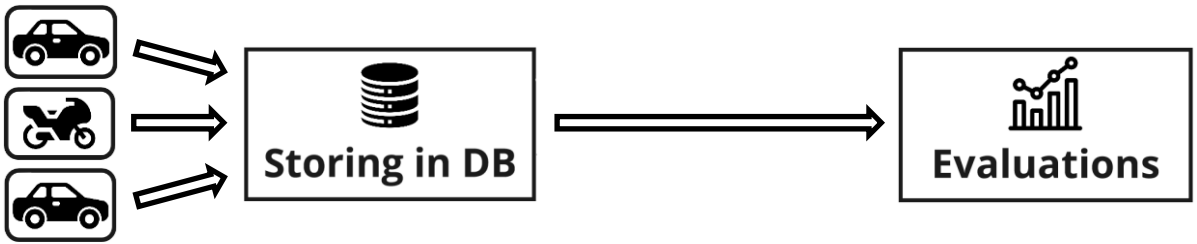

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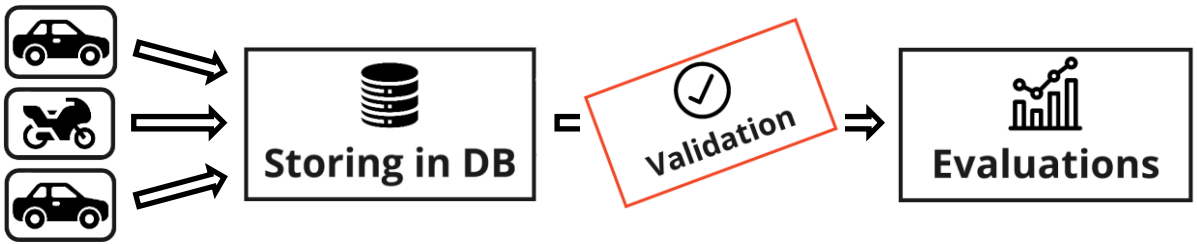
  => **FASTA** data
- Every day there are approximately 100,000 new vehicle readouts which are stored but **not validated**
- Based on FASTA data, evaluations are made for a wide variety of areas
- Due to measurement errors, sensor failures or faulty software these can be **incorrect**



Outline

- ~~Motivation~~
- Problem Statement
- Data Validation Requirements
- Pandera (Data Validation Library)
- Conditional Language
- Validation of Multidimensional Values
- Evaluation
- Conclusion

Problem Statement

- Formal validation of FASTA data:

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  - Individual columns (primitive data types)

VNR	Power	Km_Per_Day	Series_Production
MK41480	141	49.9507389	1
SR57464	190	30.7980456	0

Example individual columns

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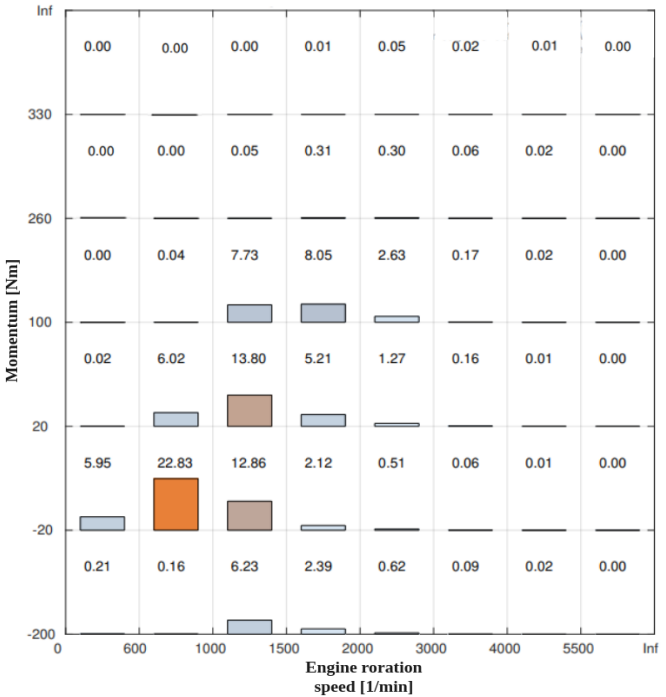
  - Individual columns (primitive data types)
  - Multidimensional values (e.g. Histograms)



Example: KF-PROZ multidimensional values

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Example: Conditional rules and combination of individual attributes

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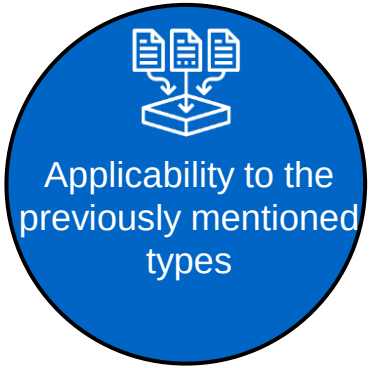

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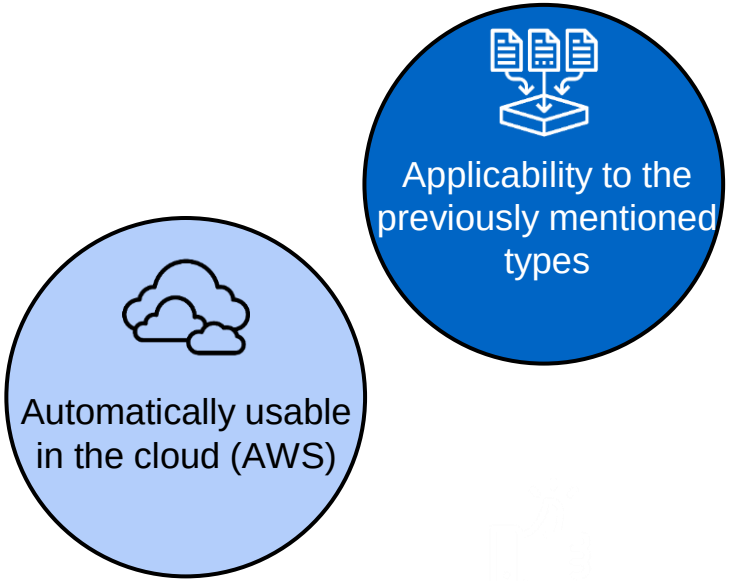

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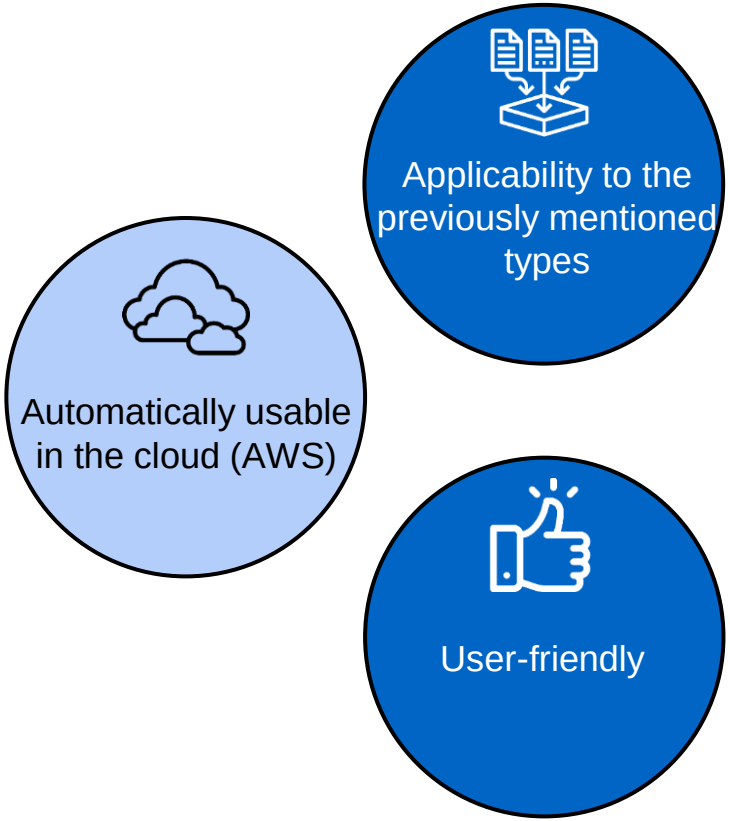

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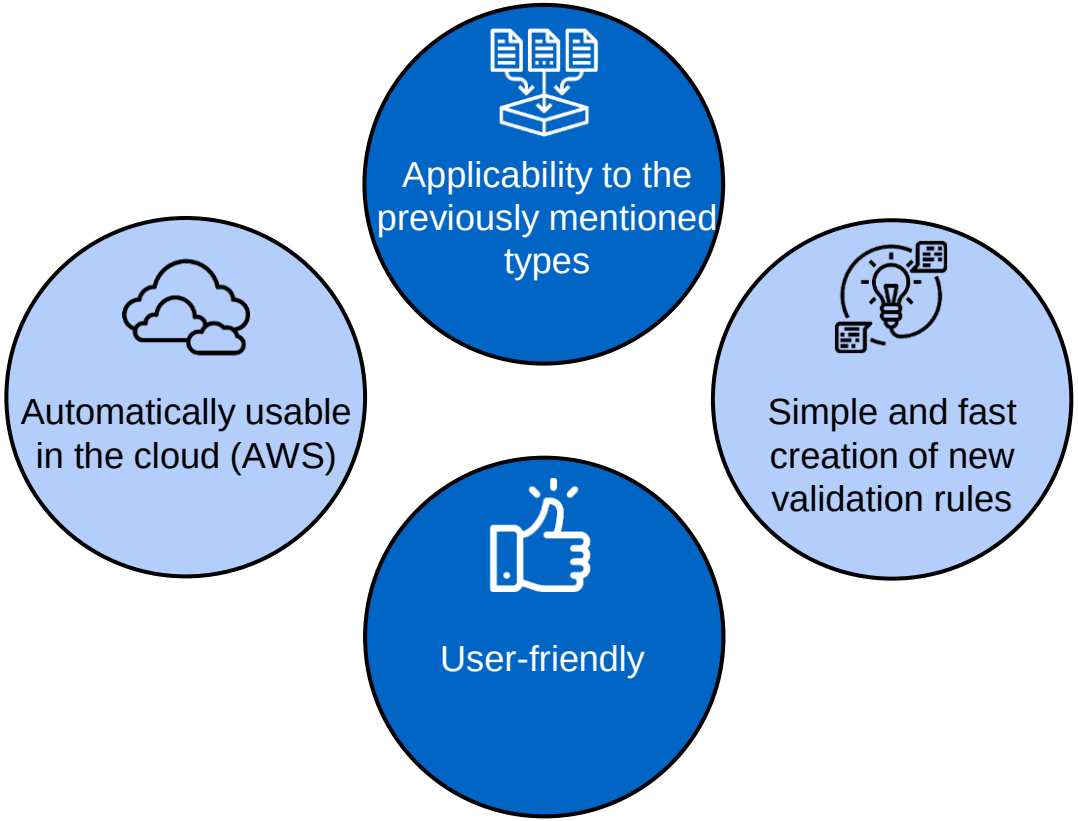

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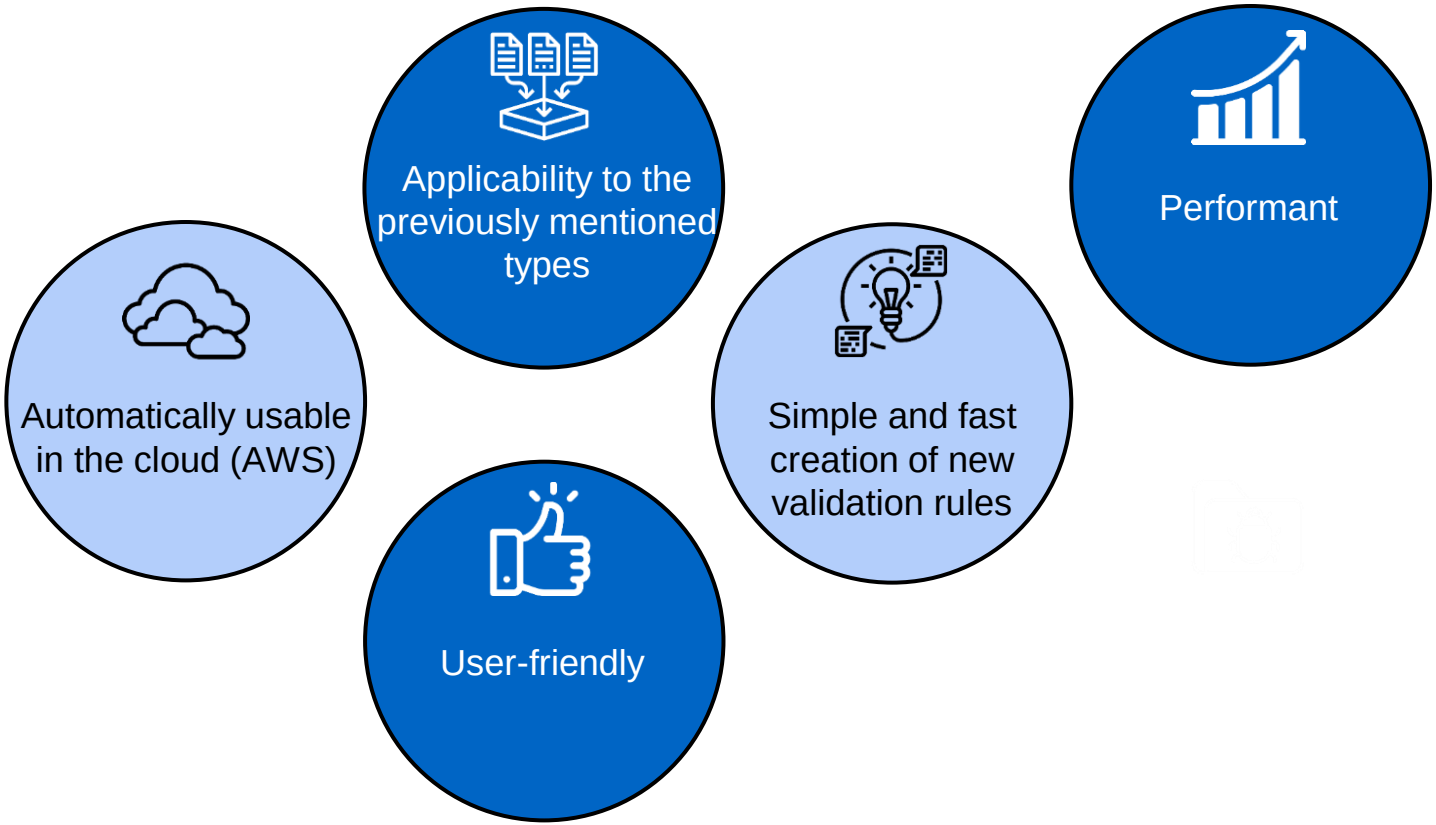

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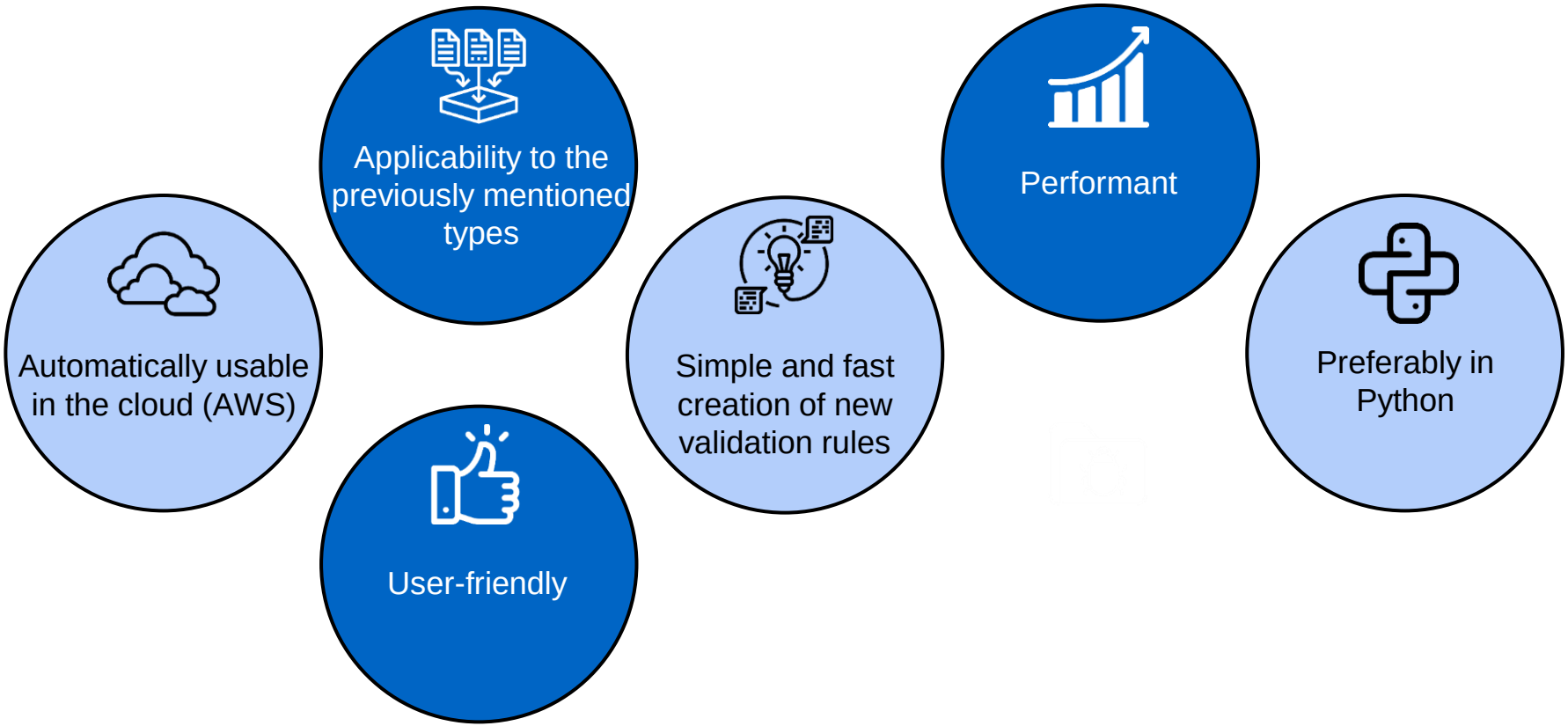

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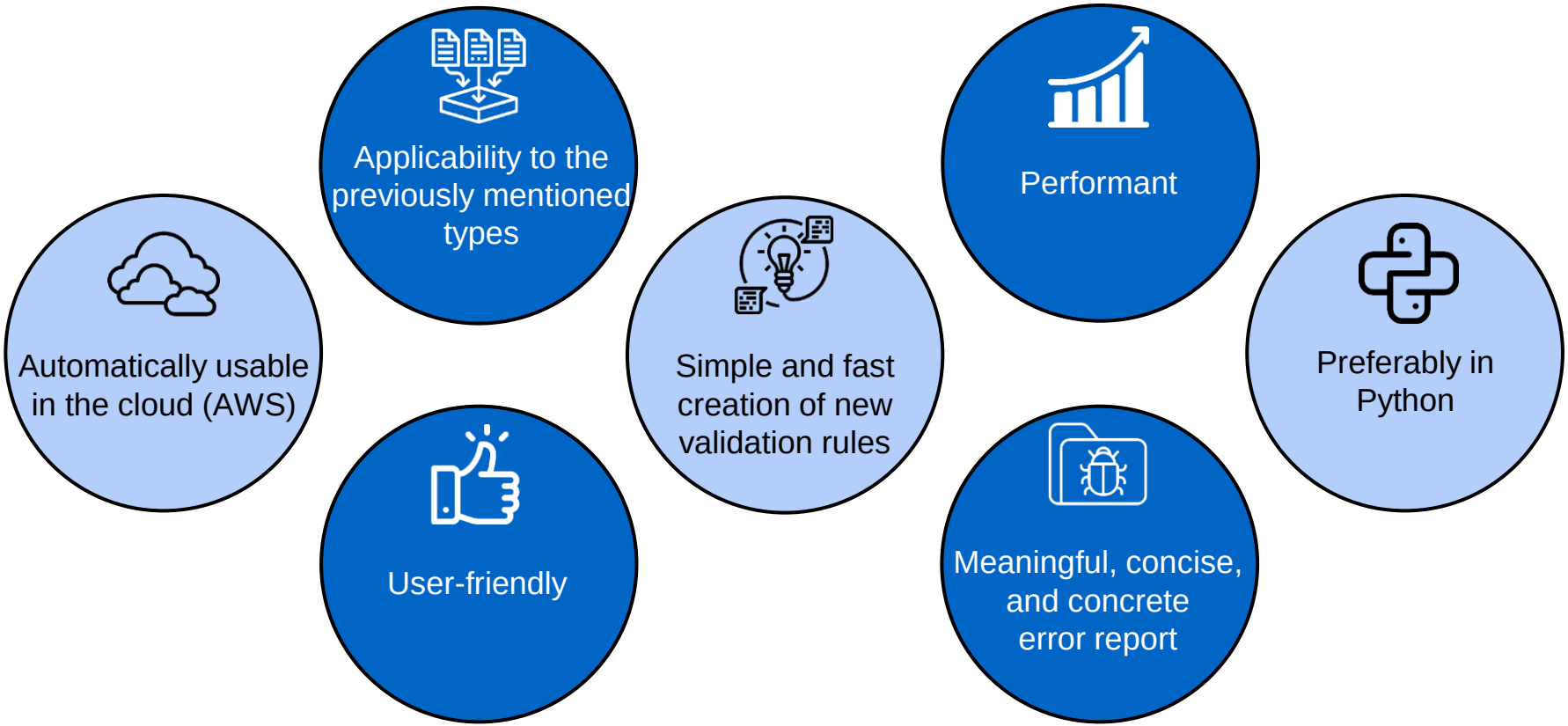

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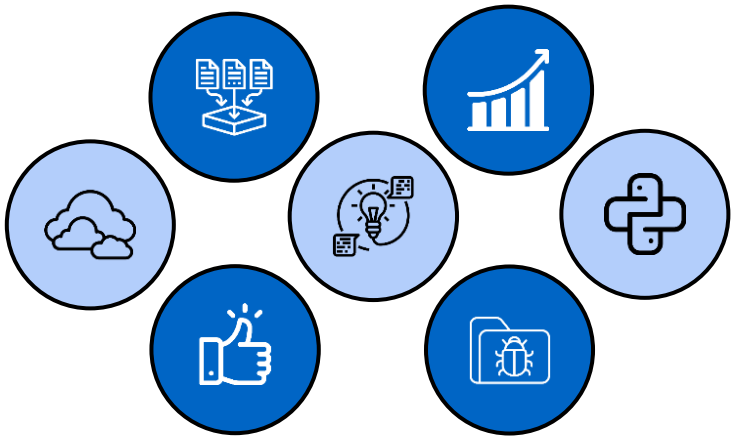
Pandera [1]

- Definition of a Schema
- At runtime data validation on DataFrame (Excel table)
- Adding own (more complex) validation rules by an annotation
- Error report as DataFrame (Excel tables)



index	check	column	schema_context	check_number	failure_case
0	OperatingDays_validation	---	DataFrameSchema	---	---
	TMOT_temp_order	TMOT	Column	2	[63.2755 28.75814 0 0 0]
	sum_up_to_100	TMOT	Column	1	[63.2755 28.75814 0 0 0]
21	not_nullable	AvgTripLen	Column		
48	date_before_current_date	ReadoutDate	Column	1	738293
1050	in_range(0, 1000)	AvgTripLen	Column	0	1601,285714
1582	greater_than_or_equal_to(0)	OperatingDays	Column	0	-17

[1] https://pandera.readthedocs.io/en/stable/

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Example: Conditional rules and combination of individual attributes

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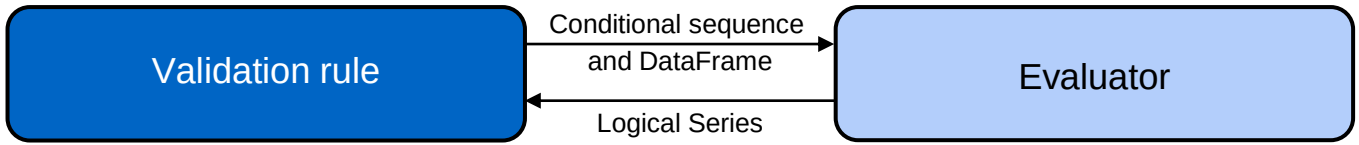

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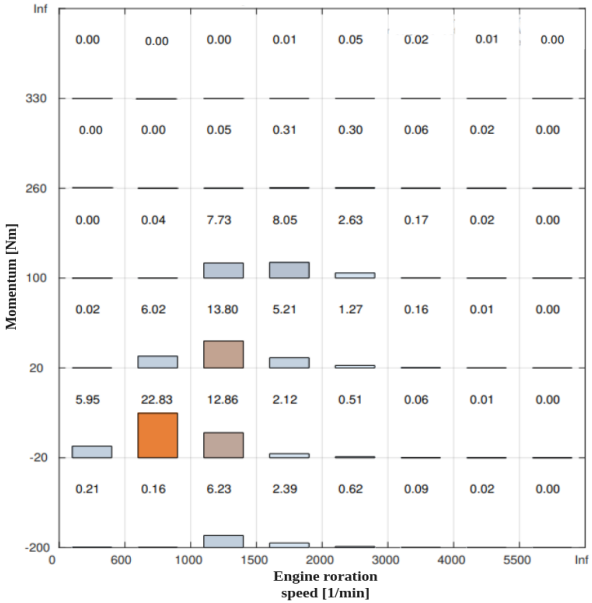
Validation of Multidimensional Values – KF-PROZ

- A Total of 48 values per vehicle evaluation



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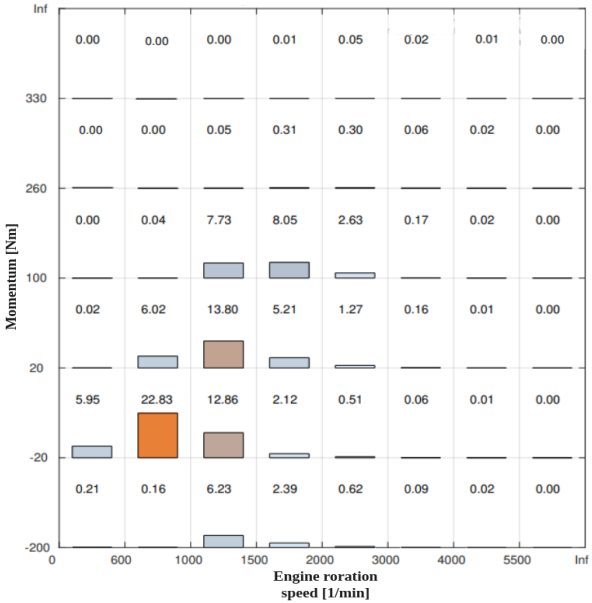

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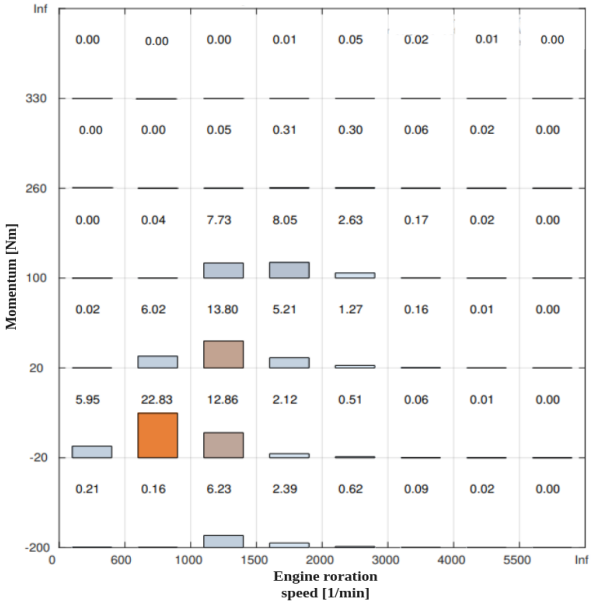

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Machine Learning Model (Black Box)

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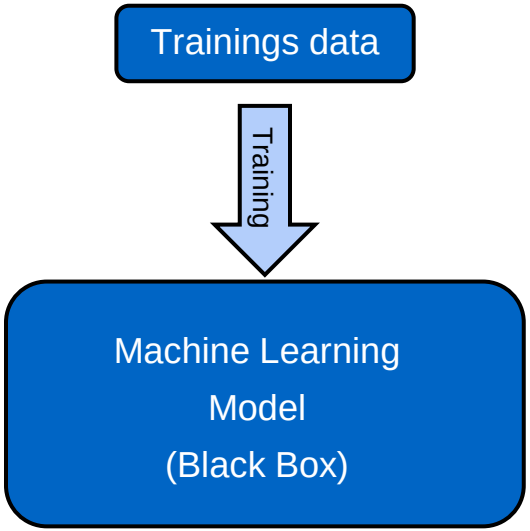

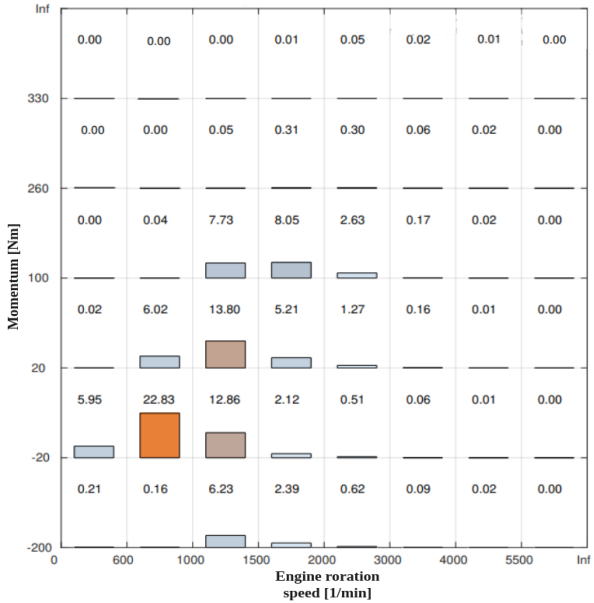

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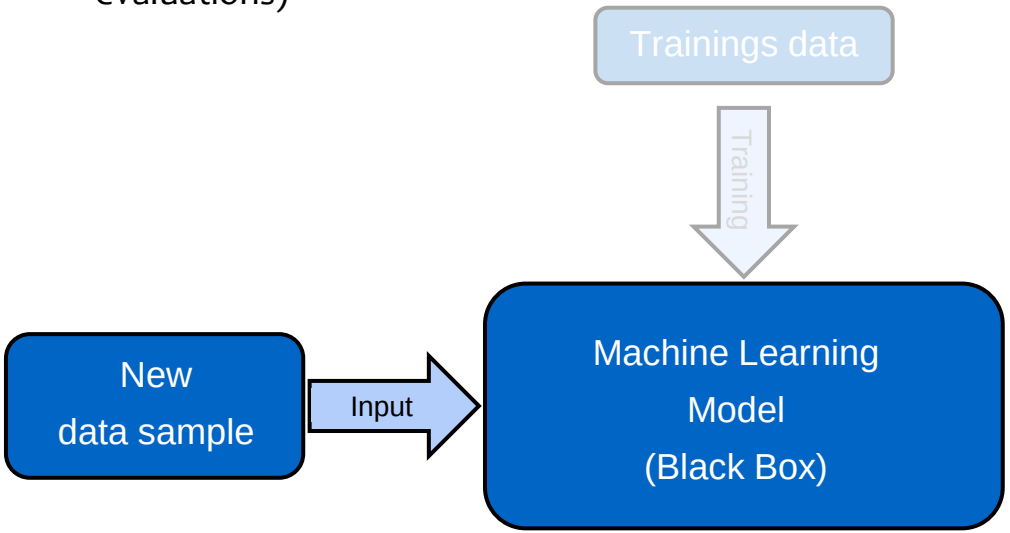

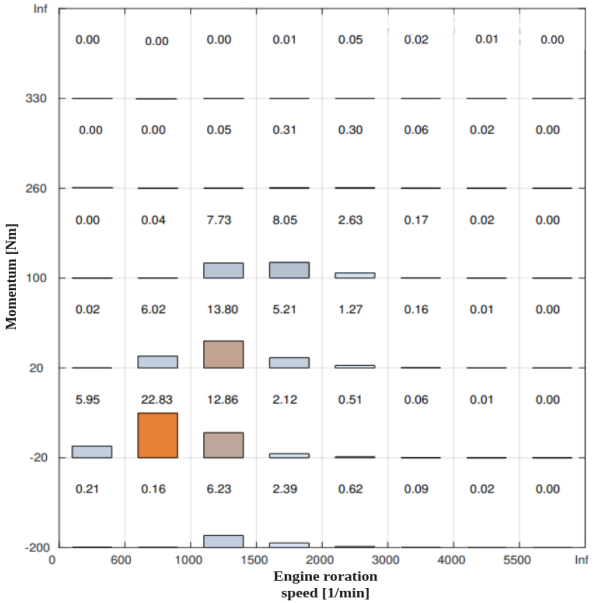

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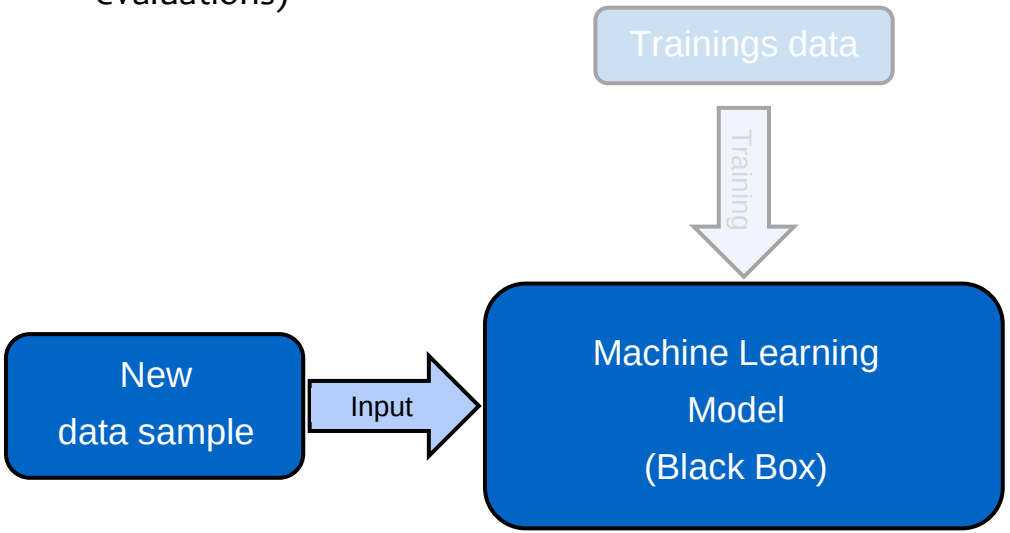

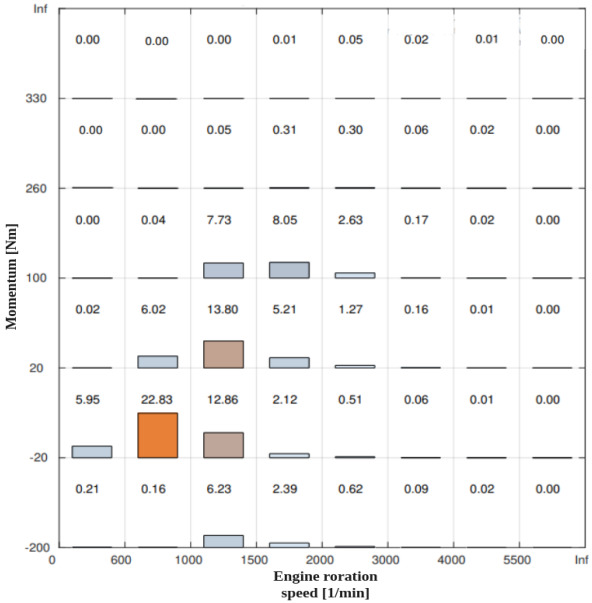

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Motorvariante A

Motorvariante B

Motorvariante C

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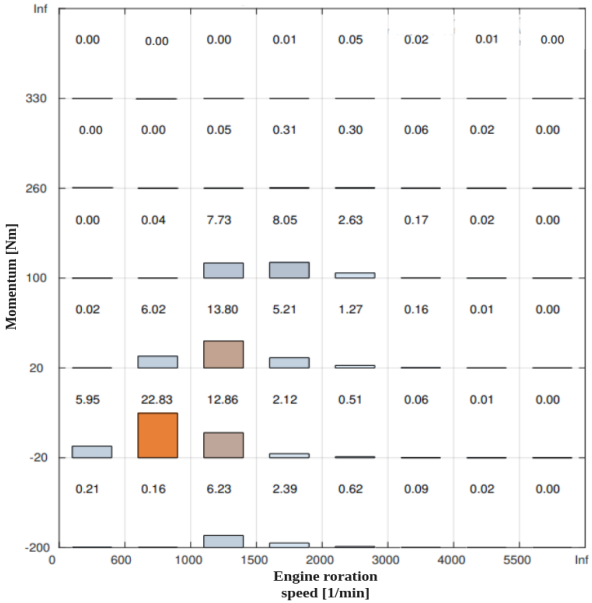

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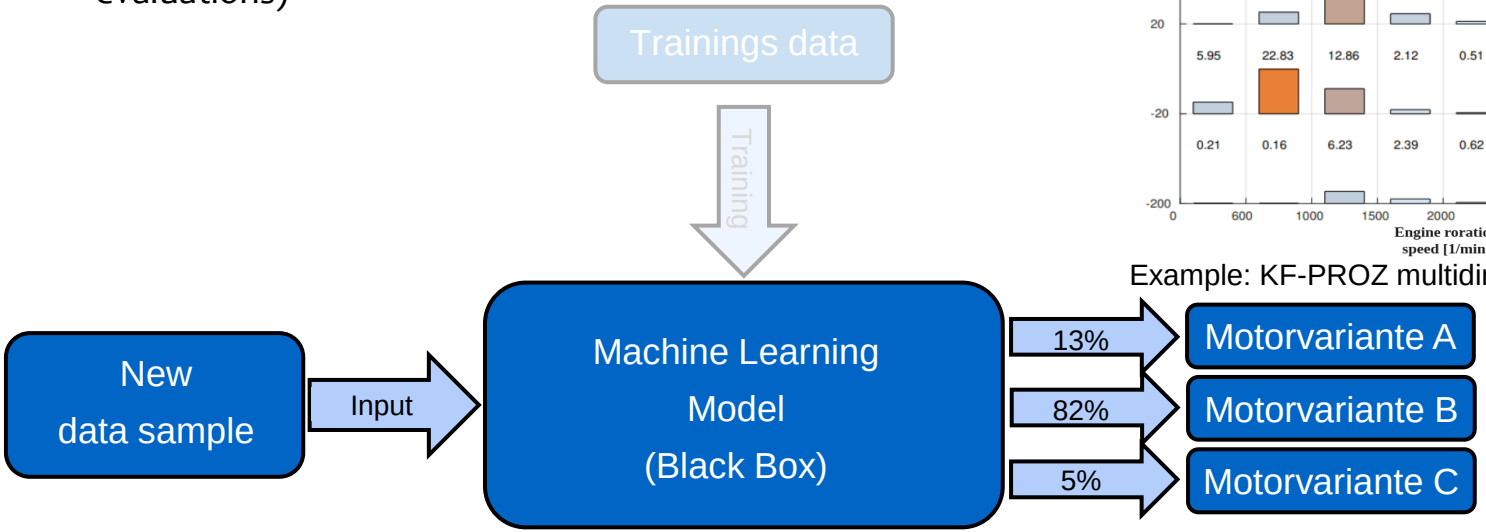

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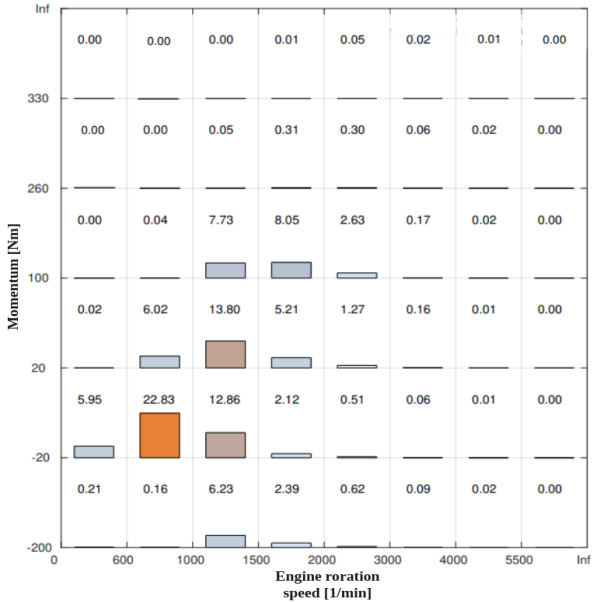

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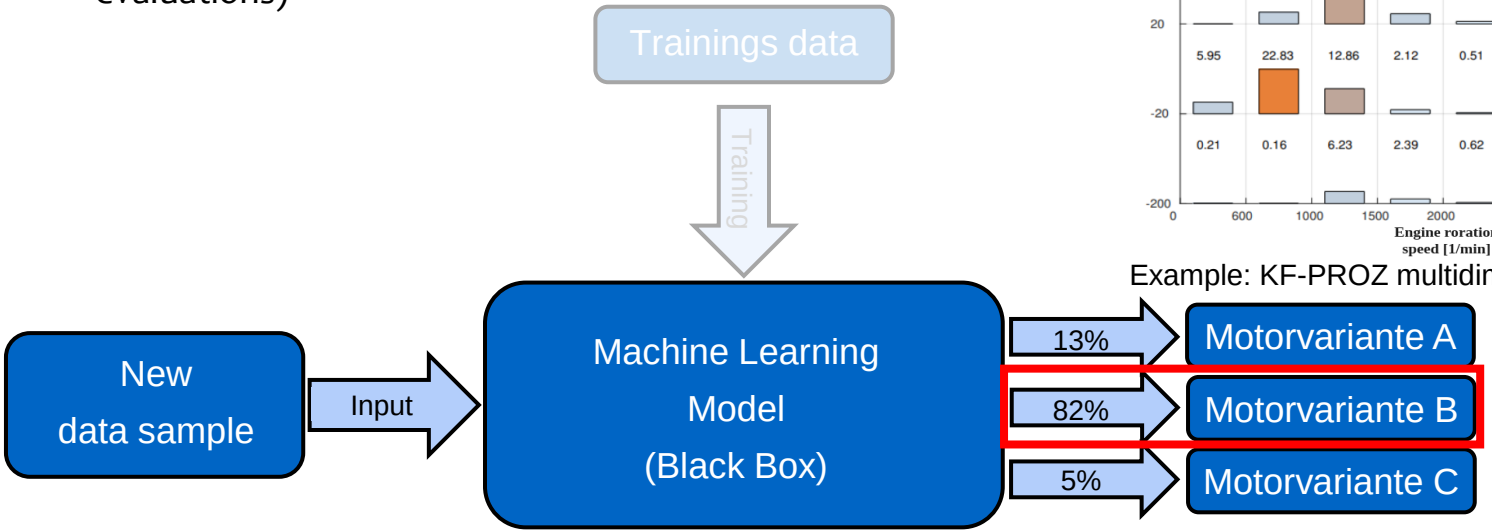

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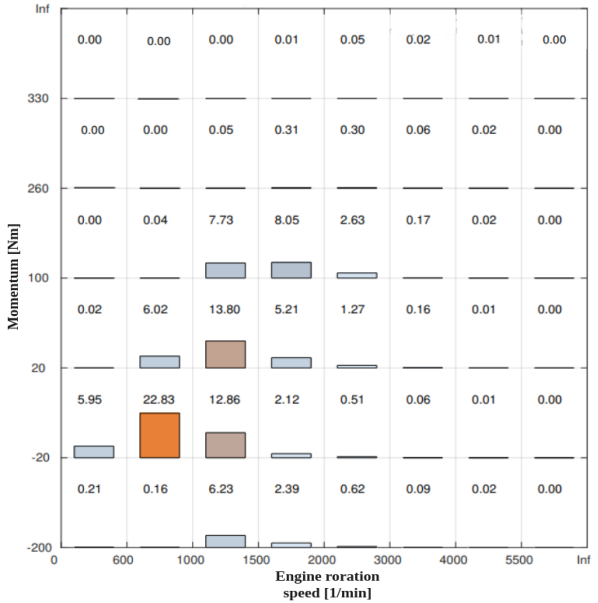

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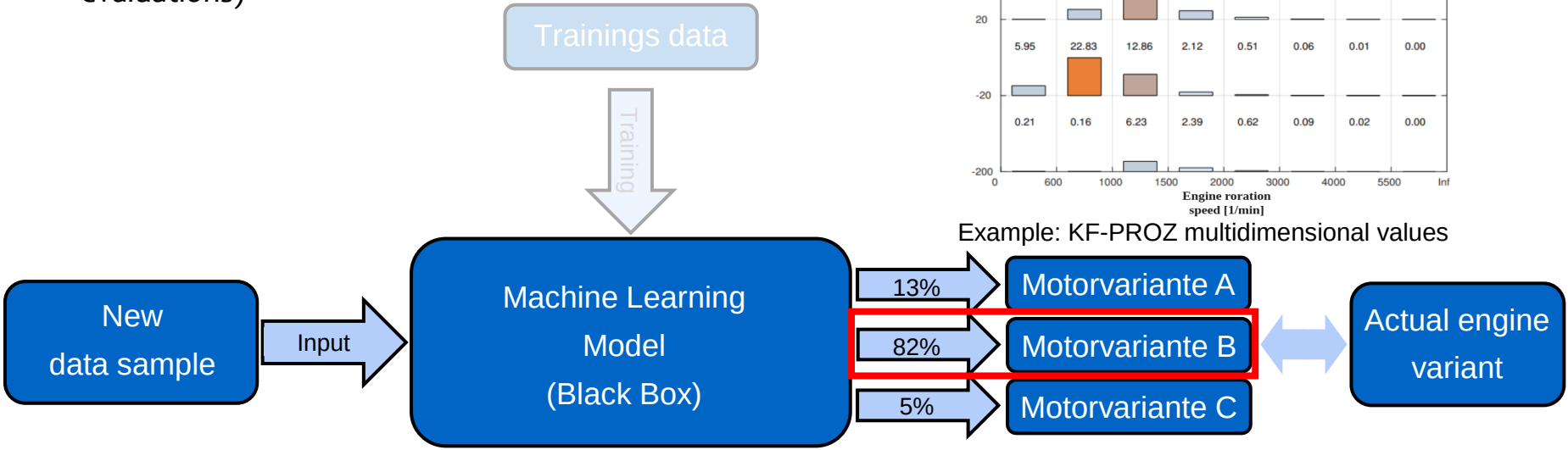

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  - Taking the average of multiple benchmarks
- **ML Model - Multidimensional Values:**
  - ~ 97% accuracy
- **Conditional Language** vs. **Direct implementation:**

Implementation	10,000 Records	50,000 Records	100,000 Records	1,000,000 Records
Direct	206.7 ms	975.6 ms	1954.6 ms	19179.3 ms
Conditional Language	225.3 ms	996.6 ms	1992.2 ms	19313.8 ms
Difference Δ of *Direct* and Conditional Language Implementation	18.6 ms	21.0 ms	37.6 ms	134.5 ms

Evaluation (2) – Pandera Validation

- **Pandera validation:**
  - In total 86 Validation rules
  - Combination of rules:
    - directly implemented and
    - formulated with the conditional language

Function	10,000 Records	50,000 Records	100,000 Records	1,000,000 Records
Schema validation	2.441 sec	9.296 sec	17.500 sec	173.362 sec

- Out of 10,000 random FASTA records 5.5% had at least one validation rule violation

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Conclusion

- FASTA data validation improves the overall data quality with a short runtime
- Multidimensional values validation rules are realizable by classification ML Models
- The created Conditional Language is universally applicable on logic tasks
- All processes can be ported to the Amazon Web Services (AWS) Cloud

Sources

- N. Bantilan, „Pandera: Statistical Data Validation of Pandas Dataframes“, in Proceedings of the 19th Python in Science Conference, M. Agarwal and C. Calloway and D. Niederhut and D. Shupe, 2020, pp. 116 – 124
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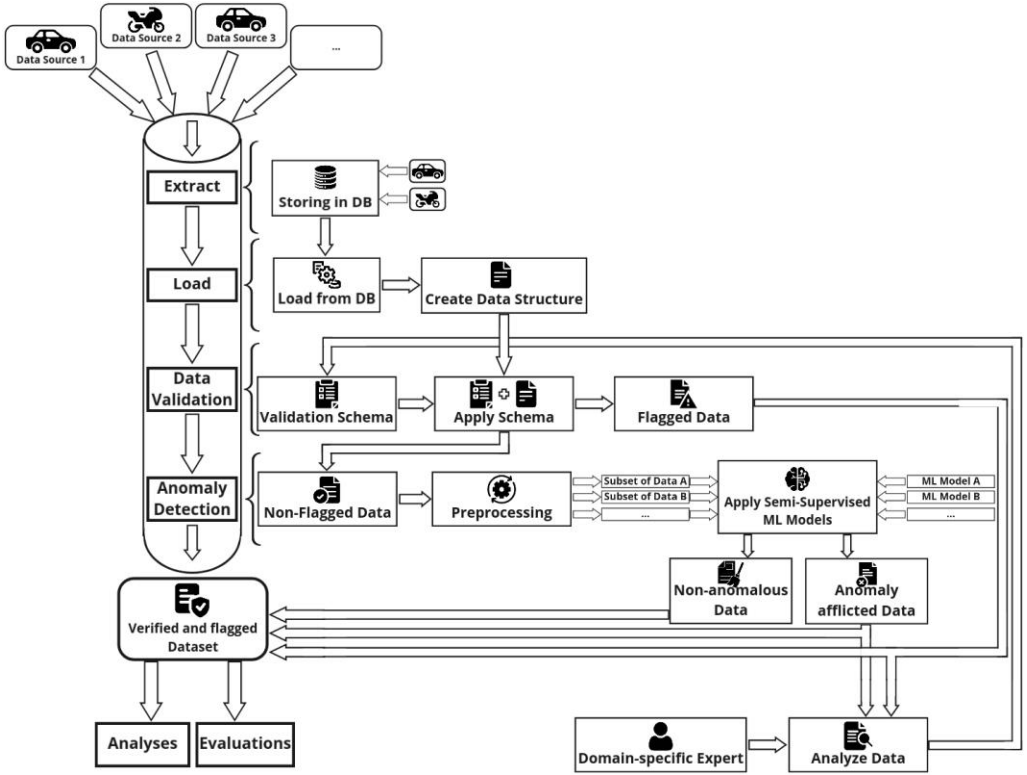
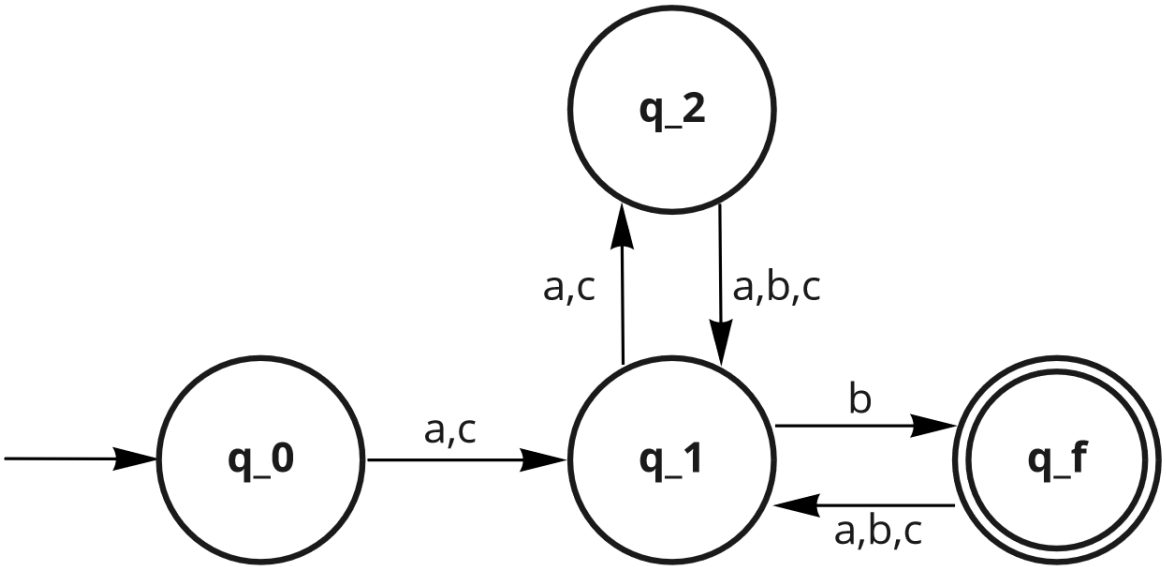
- Icons from Flaticon.com. Artists: Becris, Freepik, Kiranshastry, Payungkead, Pause08, ultimatearm

Backup

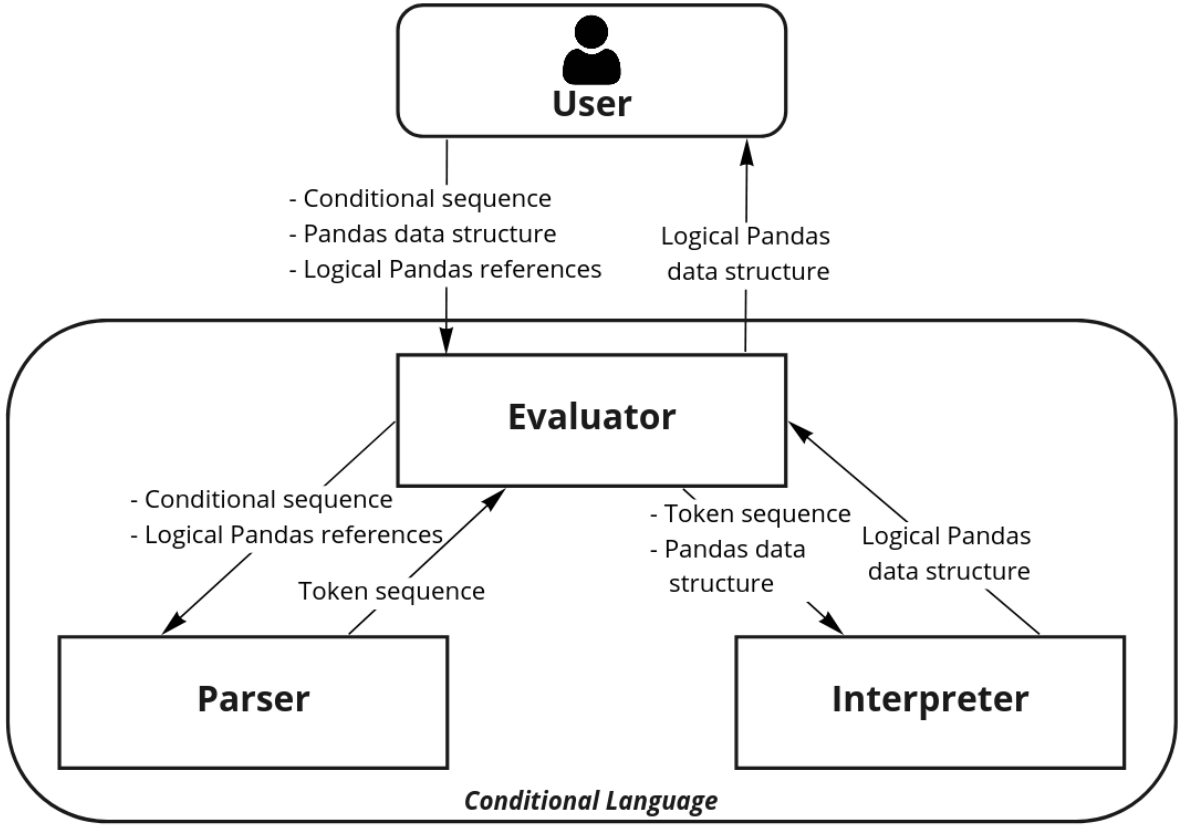
Backup – Overview



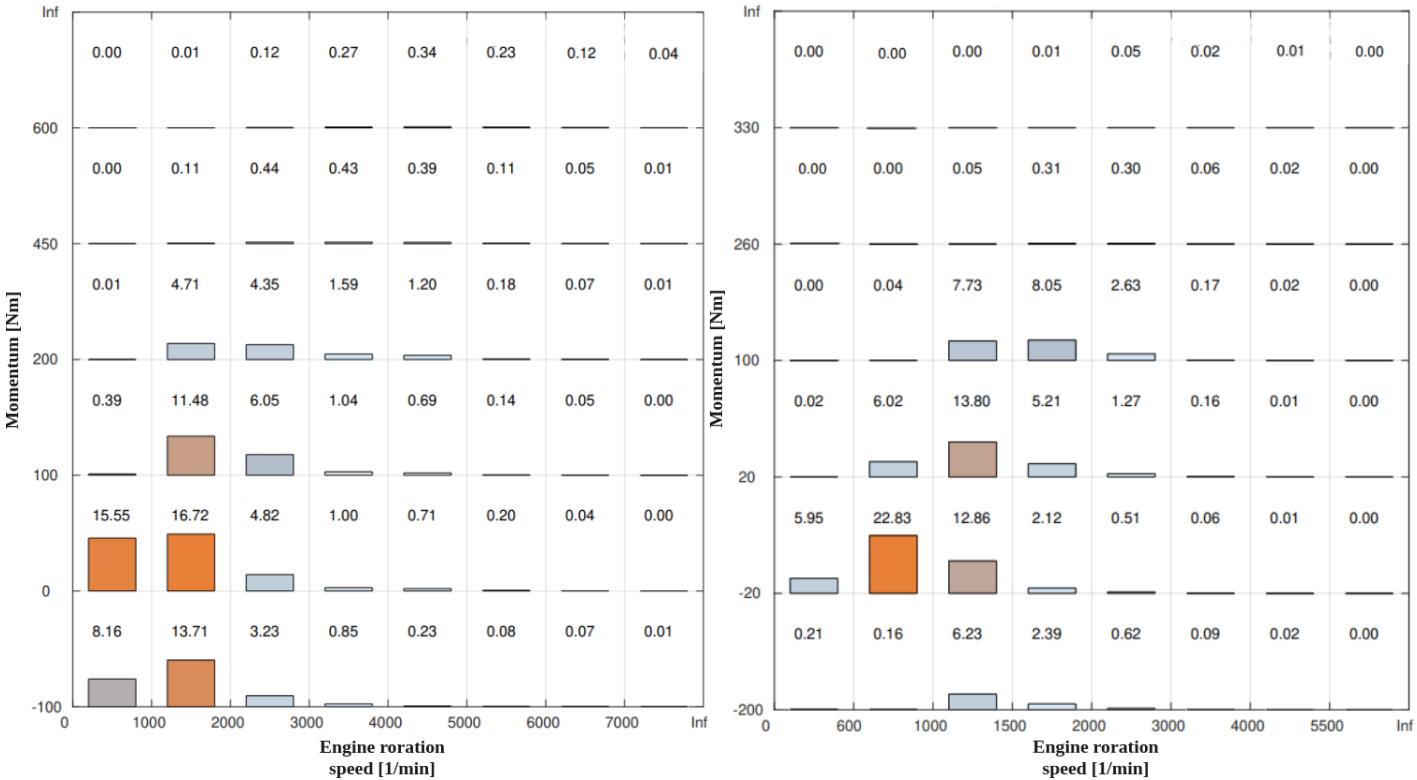
Backup – DSL Automata explained



Backup – DSL Explanation of the Evaluator Abstraction



Backup – Multidimensional Values KF-Proz Comparison



Backup – Evaluation(s)

- Multidimensional (trained) classification ML Model:
  - (Input) – 200 – ReLu – 200 – ReLu – (Output)

- Found violations of validation rules of 10,000 random FASTA data records:
  - ~ 85 % NULLs
  - ~ 5 % not summed to 100
  - ~ 3 % Incorrect engine variant distribution (KF-Proz)
  - ~ 2 % each :
    - Presented OperatingDays conditional validation rule
    - Date before current year
    - Not in specified range
    - Pattern match violation
  - ~ 1 % smaller than 0