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cuallee: A python package for data quality checks across multiple DataFrame APIs

Herminio Vazquez [1*] **and Virginie Grosboillot** [2*]

1 Independent Researcher, Mexico **2** Swiss Federal Institute of Technology (ETH) * These authors contributed equally.

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Summary

In today's world, where vast amounts of data are generated and collected daily, and where data heavily influence business, political, and societal decisions, it's crucial to evaluate the quality of the data used for analysis, decision-making, and reporting. This involves understanding how reliable and trustworthy the data are. To address this need, we've created `cuallee`, a Python package for assessing data quality. `cuallee` is designed to be dataframe-agnostic, offering an intuitive and user-friendly API for describing checks across the most popular dataframe implementations such as PySpark, Pandas, Snowpark, Polars, DuckDB and BigQuery. Currently, `cuallee` offers over 50 checks to help users evaluate the quality of their data.

Statement of need

For data engineers and data scientists, maintaining a consistent workflow involves operating in hybrid environments, where they develop locally before transitioning data pipelines and analysis to cloud-based environments. Whilst working in local environments typically allows them to fit data sets in memory, moving workloads to cloud environments involve operating with full scale data that requires a different computing framework (Schelter et al., 2018), i.e. distributed computing, parallelization, and horizontal scaling.

This shift in computing frameworks requires the adoption of testing strategies that can accommodate testing activities in both local and remote environments, without the need to rewrite test scenarios or employ different testing approaches for assessing various quality dimensions of the data (Fadlallah et al., 2023b).

An additional argument is related to the rapid evolution of the data ecosystem (Fadlallah et al., 2023a). Organizations and data teams are constantly seeking ways to improve, whether through cost-effective solutions or by integrating new capabilities into their data operations. However, this pursuit presents new challenges when migrating workloads from one technology to another. As information technology and data strategies become more resilient against vendor lock-ins, they turn to technologies that enable seamless operation across platforms, avoiding the chaos of fully re-implementing data products. In essence, no data testing strategy needs to be rewritten or reformulated due to platform changes.

One last argument in favor of using a quality tool is the need to integrate quality procedures into the early stages of data product development. Whether in industry or academia, there's often a tendency to prioritize functional aspects over quality, leading to less time being dedicated to quality activities. By providing a clear, easy-to-use, and adaptable programming interface for data quality, teams can incorporate quality into their development process, promoting a proactive approach of building quality in rather than relying solely on testing to ensure quality.

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Methods

cuallee employs a heuristic-based approach to define quality rules for each dataset. This prevents the inadvertent duplication of quality predicates, thus reducing the likelihood of human error in defining rules with identical predicates. Several studies have been conducted on the efficiency of these rules, including auto-validation (Tu et al., 2023) and auto-definition using profilers.

Checks

Check	Description	DataType
`is_complete`	Zero `nulls`	*agnostic*
`is_unique`	Zero `duplicates`	*agnostic*
`is_primary_key`	Zero `duplicates`	*agnostic*
`are_complete`	Zero `nulls` on group of columns	*agnostic*
`are_unique`	Composite primary key check	*agnostic*
`is_composite_key`	Zero duplicates on multiple columns	*agnostic*
`is_greater_than`	`col > x`	*numeric*
`is_positive`	`col > 0`	*numeric*
`is_negative`	`col < 0`	*numeric*
`is_greater_or_equal_than`	`col >= x`	*numeric*
`is_less_than`	`col < x`	*numeric*
`is_less_or_equal_than`	`col <= x`	*numeric*
`is_equal_than`	`col == x`	*numeric*
`is_contained_in`	`col in [a, b, c, ...]`	*agnostic*
`is_in`	Alias of `is_contained_in`	*agnostic*
`not_contained_in`	`col not in [a, b, c, ...]`	*agnostic*
`not_in`	Alias of `not_contained_in`	*agnostic*
`is_between`	`a <= col <= b`	*numeric, date*
`has_pattern`	Matching a pattern defined as a `regex`	*string*
`is_legit`	String not null & not empty `^\S$`	*string*
`has_min`	`min(col) == x`	*numeric*
`has_max`	`max(col) == x`	*numeric*
`has_std`	`σ(col) == x`	*numeric*
`has_mean`	`μ(col) == x`	*numeric*
`has_sum`	`Σ(col) == x`	*numeric*
`has_percentile`	`%(col) == x`	*numeric*
`has_cardinality`	`count(distinct(col)) == x`	*agnostic*
`has_max_by`	A utilitary predicate for `max(col_a) == x for max(col_b)`	*agnostic*
`has_min_by`	A utilitary predicate for `min(col_a) == x for min(col_b)`	*agnostic*
`has_correlation`	Finds correlation between `0..1` on `corr(col_a, col_b)`	*numeric*
`has_entropy`	Calculates the entropy of a column `entropy(col) == x` for classification problems	*numeric*
`is_inside_iqr`	Verifies column values reside inside limits of interquartile range `Q1 <= col <= Q3` used on anomalies.	*numeric*
`is_in_millions`	`col >= 1e6`	*numeric*
`is_in_billions`	`col >= 1e9`	*numeric*
`is_t_minus_1`	For date fields confirms 1 day ago `t-1`	*date*

Check	Description	DataType
`is_t_minus_2`	For date fields confirms 2 days ago `t-2`	*date*
`is_t_minus_3`	For date fields confirms 3 days ago `t-3`	*date*
`is_t_minus_n`	For date fields confirms n days ago `t-n`	*date*
`is_today`	For date fields confirms day is current date `t-0`	*date*
`is_yesterday`	For date fields confirms 1 day ago `t-1`	*date*
`is_on_weekday`	For date fields confirms day is between `Mon-Fri`	*date*
`is_on_weekend`	For date fields confirms day is between `Sat-Sun`	*date*
`is_on_monday`	For date fields confirms day is `Mon`	*date*
`is_on_tuesday`	For date fields confirms day is `Tue`	*date*
`is_on_wednesday`	For date fields confirms day is `Wed`	*date*
`is_on_thursday`	For date fields confirms day is `Thu`	*date*
`is_on_friday`	For date fields confirms day is `Fri`	*date*
`is_on_saturday`	For date fields confirms day is `Sat`	*date*
`is_on_sunday`	For date fields confirms day is `Sun`	*date*
`is_on_schedule`	For date fields confirms time windows i.e. `9:00 - 17:00`	*timestamp*
`is_daily`	Can verify daily continuity on date fields by default. `[2,3,4,5,6]` which represents `Mon-Fri` in PySpark. However new schedules can be used for custom date continuity	*date*
`has_workflow`	Adjacency matrix validation on `3-column` graph, based on `group`, `event`, `order` columns.	*agnostic*
`satisfies`	An open `SQL expression` builder to construct custom checks	*agnostic*
`validate`	The ultimate transformation of a check with a `dataframe` input for validation	*agnostic*

Controls

This are the controls

Check	Description	DataType
`completeness`	Zero `nulls`	*agnostic*
`percentage_fill`	`%` rows not empty	*agnostic*
`percentage_empty`	`%` rows empty	*agnostic*

References

Fadlallah, H., Kilany, R., Dhayne, H., El Haddad, R., Haque, R., Taher, Y., & Jaber, A. (2023a). BIGQA: Declarative big data quality assessment. *Journal of Data and Information Quality*, *15*. https://doi.org/10.1145/3603706

Fadlallah, H., Kilany, R., Dhayne, H., El Haddad, R., Haque, R., Taher, Y., & Jaber, A. (2023b). Context-aware big data quality assessment: A scoping review. *Journal of Data and Information Quality*, *15*. https://doi.org/10.1145/3603707

Schelter, S., Lange, D., Schmidt, P., Celikel, M., Biessmann, F., & Grafberger, A. (2018). Automating large-scale data quality verification. *Proc. VLDB Endow.*, *11*(12), 1781–1794. https://doi.org/10.14778/3229863.3229867

Tu, D., He, Y., Cui, W., Ge, S., Zhang, H., Han, S., Zhang, D., & Chaudhuri, S. (2023). Auto-validate by-history: Auto-program data quality constraints to validate recurring data pipelines. *Proceedings of the 29th ACM SIGKDD Conference on Knowledge Discovery and Data Mining*, 4991–5003. https://doi.org/10.1145/3580305.3599776