Towards generic analyses of data validation functions

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Data validation

Informally

Determine whether a (subset) of data satisfies of violates a presumption that is based on domain knowledge.

Examples

- Do variables *revenue* and *cost* add up to *profit*?
- Is the average revenue within 10% of last year's?
- Is the most common educational level in this branch `high'?

Some characteristics

- univariate *vs* multivariate
- in-dataset *vs* cross-dataset
- in-record *vs* cross-record

Data validation

Observation: validation is a two-step process

1. Compute a `score'
2. Compare score with a valid region of scores

Examples

— Does *revenue* minus *cost*, minus *profit* equal 0?

— Is the average revenue within 10% of last year's?

— Is the most common educational level in this branch `high'?

Possible outcomes

— 1: Score is in valid region

— 0: Score not in valid region

— **NA**: Score can't be computed (because of missing values)

Data validation

Formally…

A validation function v is the composition of two functions:

$$v = i_V \circ s, \text{ where}$$

s : A score function
V : Set of valid score functions
i_V: Indicator function over V.

Explicitly

$$v(x) = i_V(s(x)) = \begin{cases} 1 \text{ if } s(x) \in V \\ 0 \text{ if } s(x) \notin V \\ \textbf{NA} \;\; \texttt{if} \;\; s(x) = \textbf{NA} \end{cases}$$

⇒ A validation function is fixed by determining s and V.

When x violates a presumption...

Severity

How much does the score differ from a valid score?

$$R(x) = \inf\{d(s(x), s') : s' \in V\}$$

$\Rightarrow d$ is a distance function on the codomain of s.

Impact

How much do I need to change x to obtain a valid score?

$$I(x) = \inf\{\tilde{d}(x, x') : s(x') \in V\}$$

$\Rightarrow \tilde{d}$ is a distance function on the set of possible data.

When x violates a presumption... (VALS)

Severity*

Indicates the significance of invalid records [...]
(user-specified record-wise indicator)

Discrepancy*

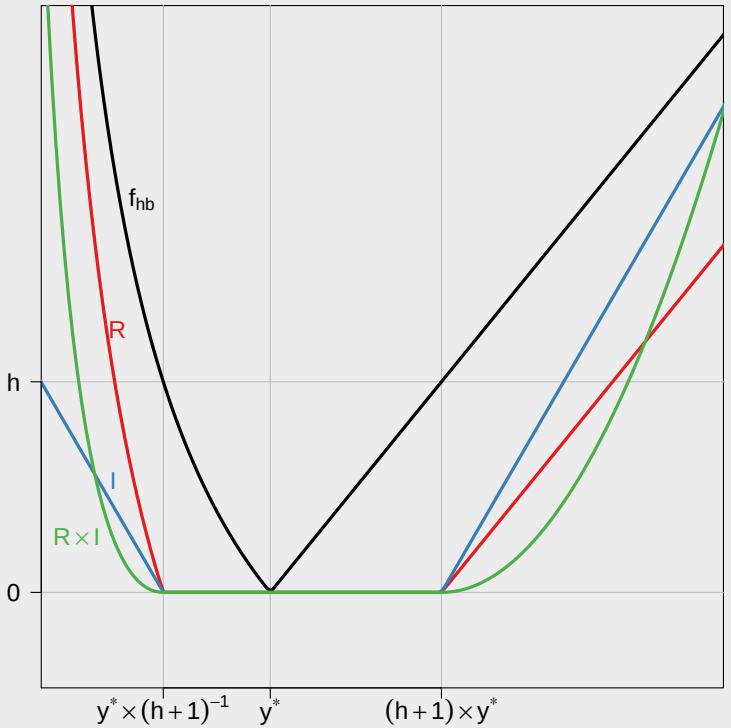
The discrepancy between the validated data and reference data [...]
(user-specified, rule-wise indicator)

* A. Simón(2013), Validation syntax:VALS version 0.1309

Example

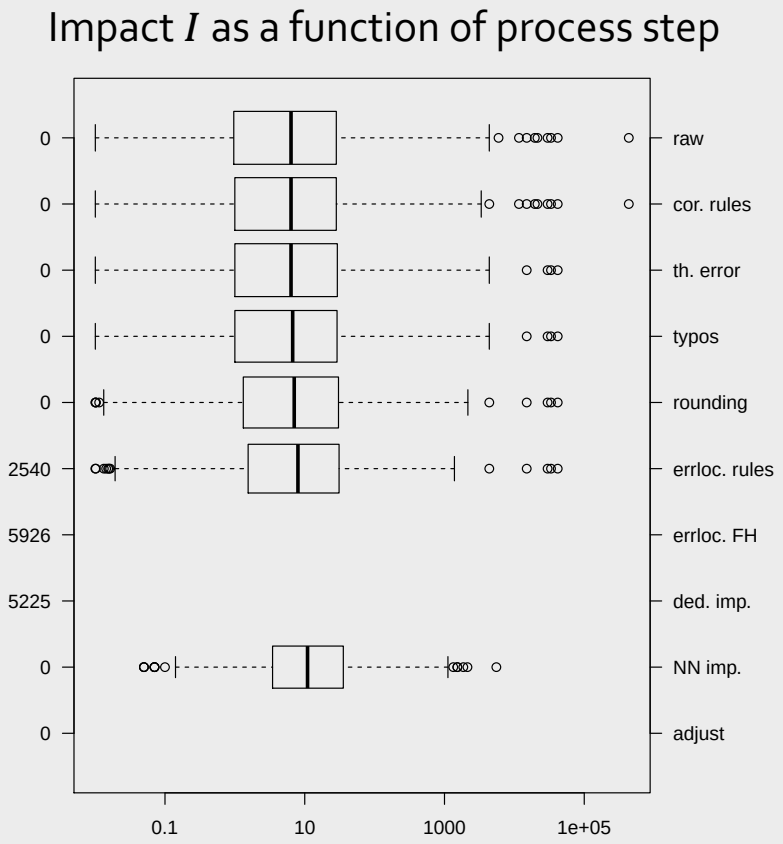
$$f_{hb}(x) = \max\left(\frac{y}{y^*}, \frac{y^*}{y}\right) - 1$$
$$(y > 0)$$

rule	$f_{hb}(y) < h$
score	$s(y) = f_{hb}(y)$
valid	$V = [0, h]$
distance	$d, \tilde{d} = \lvert x - x' \rvert$



Example

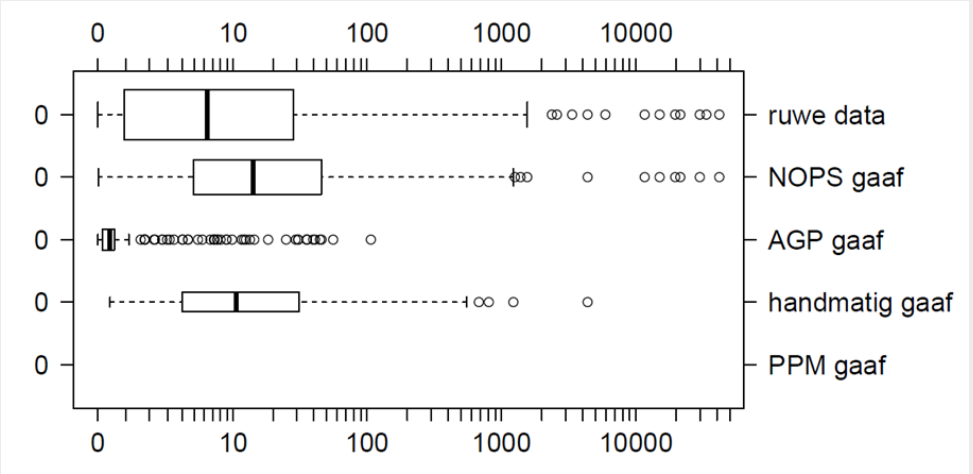
- 840×80 Linear (in)equality checks
- Euclidean distance.



Example

- 840×80 Linear (in)equality checks
- Euclidean distance.

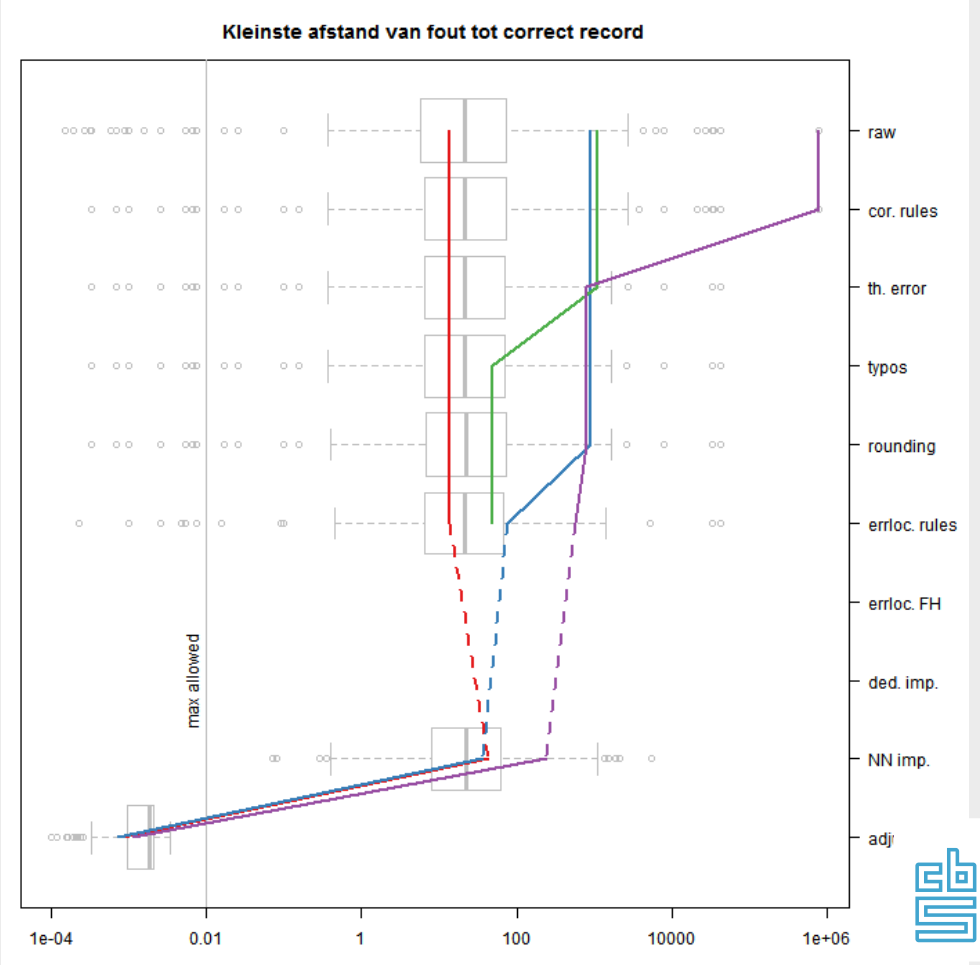
Impact I for different data editing systems



Example: impact function for all rules simultaneously

- 80 Linear (in)equality checks
- Euclidean distance.

Impact I accross data editing



Conclusions & outlook

Conclusions

— General approach to analysing validation results

— Applied to several types of data and rules

Outlook

— Derive R and I for other rule- and distance types

— General implemantation