



cleanR: Maid for Cleaning Datasets in R

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Abstract

Data cleaning and validation is the first step in any data analysis since the validity of the conclusions from the analysis hinged on the quality of the input data. Ideally, a human investigator should go through each variable in the dataset and look for potential errors — both in input values and coding.

We describe an R package which implements an extensive and customizable suite of checks to be applied to the variables in a dataset in order to identify potential problems in the corresponding variables. The typical output is a stand-alone document that summarizes the variables and lists potential errors. The results are typically presented in a stand-alone document that could be perused by an investigator with an understanding of the variables in the data and the experimental design.

The **cleanR** package is designed to be easily extended with custom user-created checks that are relevant in particular situations.

Keywords: data cleaning, quality control, R.

1. Introduction

Statisticians and data analysts spend a large portion of their time on data cleaning and on data wrangling. Packages such as **data.table**, and **plyr** have made data wrangling a lot easier in R, but there are only a few options available for automated data cleaning.

Data cleaning is a time consuming endeavour and it inherently requires human interaction since every dataset is different and the variables in the dataset can only be understood in the proper context of the experiment. While each dataset is different and requires unique attention there are often a number of similar tasks that are undertaken as part of the data cleaning and quality control process. This is especially true when data are received repeatedly from the same source as data providers tend to use a stable setup (and hence introduce the

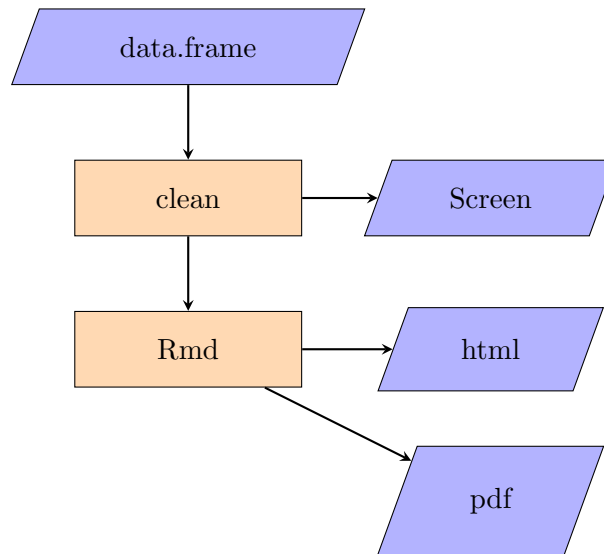


Figure 1: The process of cleaning data frames using the **cleanR** package. A series of check is applied to each variable in a `data.frame` and a summary of the result is either printed to the screen, or an R markdown file is produced which is subsequently rendered.

same set of potential mistakes that need to be identified and corrected).

In many situations these errors are discovered in the process of the data analysis (e.g., a categorical variable with numeric labels is wrongly classified as a numeric variable), but in other cases a human with knowledge about the data context area is needed to identify possible mistakes in the data (e.g., if there are 4 categories for a variable that should only have 3). It is necessary to summarize information — both numerically and graphically — about each variable in order for an investigator to detect possible errors, and help raise flags of warning to draw the attention of investigator for the situations where there *might* be a error.

The **cleanR** package supports the automated checking of errors in a dataset and produces an output document with detailed information about each variable that can be The process is illustrated in Figure 3. A dataset is cleaned and an R markdown file is produced and possibly rendered into html or pdf.

The manuscript is organized as follows. Section 2 presents a worked example and tutorial on how to use the **cleanR** package to create a summary of potential errors. Section 3 presents the steps that comprise the creation of the automated data cleaning that is part of the **clean** function, while the 4 Section explains how the set of checks and graphical visualisations that are part of the cleaning suite are extended by custom, used-written additions. Finally, plans for extending the package are described in Section ??.

2. Checking a dataset for errors

In **cleanR** the `clean` function is the primary workhorse and it should be the primary entry point for data cleaning.

First we

```
> library(cleanR)
> data(diamonds)
> head(diamonds)
```

	carat	cut	color	clarity	depth	table	price	x	y	z
1	0.23	Ideal	E	SI2	61.5	55	326	3.95	3.98	2.43
2	0.21	Premium	E	SI1	59.8	61	326	3.89	3.84	2.31
3	0.23	Good	E	VS1	56.9	65	327	4.05	4.07	2.31
4	0.29	Premium	I	VS2	62.4	58	334	4.20	4.23	2.63
5	0.31	Good	J	SI2	63.3	58	335	4.34	4.35	2.75
6	0.24	Very Good	J	VVS2	62.8	57	336	3.94	3.96	2.48

```
> data(testData)
> #head(testData)
```

To produce summary data-cleaning document

```
> clean(testData, replace=TRUE, openResult=FALSE)
```

By default, a ... is produced and the result is shown in Figure 2.

Arguments

3. The structure of cleanR

Bør vise DF -> prechecks -> for each variable do this ...

4. Extending cleanR by adding custom error checks

Lav en situation svarende til eksemplet

```
> characterFoo <- function(v) {
+   if (substr(substitute(v), 1, 1) == "_") {
+     out <- list(problem=TRUE, message="Note that the variable name begins with \\_")
+   } else out <- list(problem=FALSE, message="")
+   out
+ }
> class(characterFoo) <- "checkFunction"
> attr(characterFoo, "description") <- "I really hate underscores"
> #clean(testData, characterChecks=c(defaultCharacterChecks(), "characterFoo"))
>
```

Lav også et eksempel med rangecheck.

5. Customizing the cleanR output

Though the discussion in the above paints a picture of cleanR as a user-friendly package which requires practically no knowledge of R, one should not be mistaken to think that it is not

Data cleaning summary

The data frame examined has the following dimensions:

Feature	Result
Number of rows	15
Number of variables	14

Checks performed

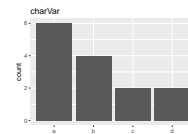
The following variable checks were performed, depending on the data type of each variable:

	character	factor	labelled	numeric	integer	logical
Identify miscoded missing values	×	×	×	×	×	
Identify prefixed and suffixed whitespace	×	×	×			
Identify levels with < 6 obs.	×	×				
Identify case issues	×	×				
Identify outliers				×	×	

Variable list

charVar

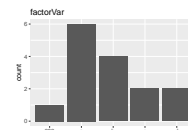
Feature	Result
Variable type	factor
Number of missing obs.	1 (6.67 %)
Number of unique values	4



- Note that the following levels have at most five observations: 'b', 'c', 'd'

factorVar

Feature	Result
Variable type	factor
Number of missing obs.	0 (0 %)
Number of unique values	5



- The following suspected missing value codes enter as regular values: '999'

Figure 2: Example output from running XXXX on the testData dataset. First a summary of the full dataset,

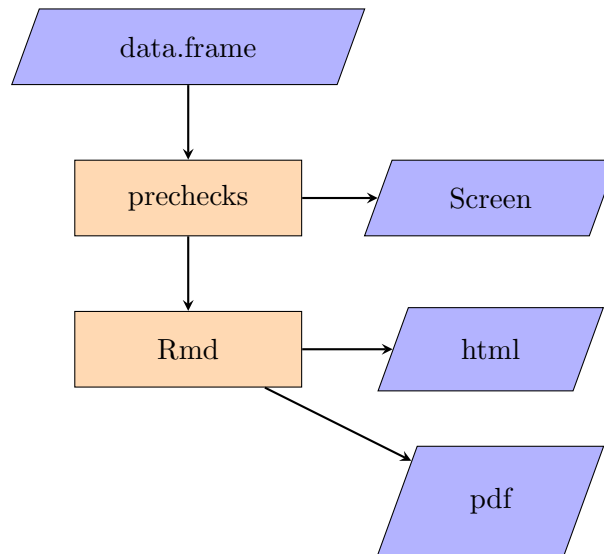


Figure 3: The process of cleaning data frames using the **cleanR** package. A series of check is applied to each variable in a `data.frame` and a summary of the result is either printed to the screen, or an R markdown file is produced which is subsequently rendered.

customizable. In fact, the main function of `cleanR`, `clean`, is mainly a tool for formatting the results from various checking-, summary- and visualization functions [as described... blabla](#). Thus, the actual work underlying a `cleanR` output file can be anything or nothing - depending on the arguments given to `clean`. This section consists of three parts. We commence this section with an overview of how contents are controlled in **cleanR** in terms of what cleaning steps are performed. Secondly, we turn to the possibilities of customizing what the final `cleanR` file looks like. Lastly, we go through an example of how to put all these customization options together in practice.

5.1. Controlling contents

By the *contents* of the `cleanR` output, we refer to every step that actually involves a function being called on variables from the dataset. There are three stages in which this occurs [\(with ref. to figure/flowchart?\)](#):

1. In the precheck functions
2. In the summarize/visualize/check (SVC) step
3. In the multivariate visualizations [Or whatever, in the stuff that we have not yet implemented. I'm pretending like this stage doesn't exist below.](#)

Each of these stages are controllable using appropriate function parameters in `clean`. In the above, we presented the default **cleanR** settings and how to tweak them into providing a slightly different data cleaning outputs. However, if for instance the dataset at hand requires completely different visualizations, more control is needed. **cleanR** uses three different types of functions for performing all stages in the above, namely `summaryFunctions`, `visualFunctions`

and `checkFunctions`. They each have distinct input-output structures and most instances of the functions are build as S3 generics with methods for different data classes. By understanding how to construct proper `summaryFunctions`, `visualFunctions` and `checkFunctions`, the entire contents of the **cleanR** output is at your hands. Therefore, this section is dedicated to introducing each in turn.

Something like a figure that gives an overview of all `summaryFunctions`, ... available in standard `cleanR`, including default settings and some kind of description of where they are called (in `precheck` or `SVC` step). Also something about what datatypes they can each be called on. Also, more text here about the relationship between the two (three) stages and the three function types.

Writing a summaryFunction

Though **cleanR** provides a special class for `summaryFunctions`, there really is nothing special about these functions: They are nothing but regular functions with a certain input/output-structure. Specifically, they all follow the template below:

```
mySummaryFunction <- function(v) {
  res <- [result of whatever summary we are doing]
  list(feature = "Feature name", result = res)
}
```

and we recommend furthermore adding them to the overview of all summary functions by converting them to proper `summaryFunction` objects:

```
mySummaryFunction <- summaryFunction(mySummaryFunction,
  description = "Some text describing what your summaryFunction does")
```

which adds the new function to the output of `allSummaryFunctions()`. Note that `v` is a vector and that `res` should be either a character string or something that will be printed as one. In other words, e.g. integers are allowed, but matrices are not. Though a lot of different things can go into the `summaryFunction` template, we recommend only using them for summarizing the features of a variable, and leaving tests and checks for the `checkFunctions` (presented below).

Writing a visualFunction

`visualFunctions` are the functions that produce the figures of a **cleanR** output document. Writing a visual function is slightly more complicated than writing a summary function. This follows from the fact that `visualFunctions` need to be able to output standalone code for plots in order for `clean` to build standalone `rmarkdown` files. We recommend using the following structure:

```
myVisualFunction <- function(v, vnam, doEval) {
  thisCall <- call("[the name of the function used to produce the plot]",
    v, [additional arguments to the plotting function])
  if (doEval) {
```

```

        return(eval(thisCall))
    } else return(deparse(thisCall))
}

```

```

myVisualFunction <- visualFunction(myVisualFunction,
    description = "Some text describing your visualFunction")

```

In this function, `v` is the variable to be visualized, `vnam` is its name (which should generally be passed to `title` or `main` arguments in plotting functions) and `doEval` controls whether the output is a plot (if `TRUE`) or a character string of standalone code for producing a plot (if `FALSE`). The latter `doEval` setting is not strictly necessary for its use in `clean`, but it makes it easier to assess what visualization options are available. In either case, it should be noted that all the parameters listed above, `v`, `vnam` and `doEval`, are mandatory, so they should be left as is (*as are?*), even if you do not want to use them. As with `summaryFunctions`, an overview of all available `visualFunctions` in the environment can be obtained by calling

```
allVisualFunctions()
```

and by calling

```
allVisual(v, vnam, output = "html")
```

an overview of all plotting options applied on `v` is produced and opened as a html document for easy comparison. *Should we mention the side effect of producing .rmd and .html files on disc?*

Writing a checkFunction

The last, but also most important, `cleanR` function type is the `checkFunction`. These are the functions that flag issues in the data and control the flow of the overall data cleaning process in the precheck stage. A `checkFunction` can be written using the following template:

```

myCheckFunction <- function(v) {
  [do your check]
  problem <- [is there a problem? TRUE/FALSE]
  problemValues <- [vector of values in v that are problematic]
  problemStatus <- list(problem = problem, problemValues = problemValues)

  problemMessage <- "[The message that should be printed prior to listing
    problem values in the cleanR output]"

  outMessage <- messageGenerator(list(problem = problem,
    problemValues = problemValues, message = problemMessage))

  list(problem = problem, message = message) #problem is TRUE/FALSE,
    # message is a text string
}
myCheckFunction <- checkFunction(myCheckFunction,
    description = "[A description of your checkFunction]")

```

Only the input parameter (`v`) and the output format strictly has to follow this structure. However, we recommend using `messageGenerator` for consistent styling of all `checkFunction` messages. This function simply pastes together the `problemMessage` and the `problemValues`, with the latter being quoted and sorted alphabetically. Note that printing quotes in `rmarkdown` requires an extensive amount of character escaping, so opting for `messageGenerator` really is the easiest solution.

While the descriptions of `summaryFunctions` and `visualFunctions` are only for internal use in the `allSummaryFunctions()` and `allVisualFunctions()` outputs, respectively, `checkFunction` descriptions are actually visible in the **cleanR** output document. These are the brief descriptions presented in Part 1 *eh? Is this clear? Whatever we call this section in the above* in the output document. If a `checkFunction` does not have a description (for instance, if it is just a regular function using the `checkFunction` input/output-structure), the function name will be printed instead of the description.

5.2. Controlling formatting

Something about how to control what is printed where. Should be much briefer than the stuff in the above. This section could maybe include the following points:

1. Controlling "part 1", i.e. the stuff that is printed before the loop is started.
2. The effect of prechecks.
3. A table containing other parameters that control formatting/stuff like this, e.g. `twoCol`, `checkDetails` (if we ever implement it), `listChecks`...

5.3. Controlling flow?

I feel like we maybe need yet another section about customization. We have not yet described the following (rather important(?)) features:

- The mode argument - controlling which SVC steps are performed
- `smartNum` - choosing whether or not numeric/integer variables with only a few levels are treated as factors
- `standAlone` - Describing how it is possible to produce `.Rmd` files that can be included in other `.Rmd` files using the `child` option and `standAlone = F` (removing the YAML preamble (and maybe also the `cleanR` commercial? Are we that nice?)).

5.4. A worked example

Maybe use the examples from the documentation to construct new `summaryFunction` etc. and add them to the default options.

6. To-dos in the code

... introduced by discrepancy between what I say we have done and what we have actually done:

- summaryFunction stuff:
 - Make constructor function
 - Make allSummaryFunctions()
 - Change class of all summary (and description) functions into summaryFunction (possibly letting description functions be a subclass?)
 - Maybe: Make clean check if summary functions are really summaryFunctions?
- visualFunction stuff:
 - Make constructor function
 - Make allVisualFunctions()
 - Change class of all visual functions into visualFunction
 - Maybe: Make clean check if visual functions are really visual functions?
- checkFunction stuff:
 - Make allCheckFunctions()
 - Work on messageGenerator() to make it better suited for being an exported function + export it
 - Make allVisual()

7. Using the online web-app

asd asd

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