Automating Preliminary Data Cleaning in SAS®
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ABSTRACT
Preliminary data cleaning or scrubbing tries to delete the following types of variables considered to be of little or no use: 1) variables with missing values or a uniform value across all records; 2) variables with very low coverages; 3) character variables for name, addresses and IPs. These variables are very commonly seen in big data. This paper introduces a SAS process that will automatically and efficiently detect these variables with a minimal manual handling from users. The output also helps users to identify those character variables that need to be converted to numeric values for downstream analytics.

INTRODUCTION
Variables of the following types are considered to be of little or no use in analytics:

- A numeric or character variable with missing values across all records
- A numeric or character variable with a uniform value across all records
- A numeric or character variable with a very low coverage (for example, < 0.5%)
- A character variable with too many categories. Name, address and email are common examples.

Cleaning the variables of the above types will reduce the file size, improve data quality and expedite downstream analyses. Users often manually run multiple procedures in SAS and review output summaries to find potential variables for deletion. When one works with large data with numerous variables or intends to build multiple models for different segments, this exercise can become quite repetitive and onerous. This paper introduces SAS process that will effectively save users from much of the burden in preliminary data cleaning or scrubbing.

THE LOGIC FOR PRELIMINARY CLEANING
Let’s strike a note of realism first. Preliminary data cleaning robotically examines the value expressions of all fields in the raw SAS file to detect possible variables of the aforementioned types that have little or no use. The machine does not – neither is it able to – interpret the business meanings of variables before making recommendations for deletion. Therefore, users still need to review the output list to decide which variables to exclude from further analyses.

For numeric variables, users can run the following PROC MEANS procedure and use the summary to detect variables of little or no use preliminarily:

```
proc means data=sasdataset MIN MAX N; run;
```

The following is how one can detect numeric or data-and-time-related variables of little or no use:

- N=0 suggests all records contain null (or missing) values.
- MIN=MAX suggests a uniform value across all records. Please bear in mind that this logic does not extend to a variable with missing values for some records and a non-missing uniform value for other records. For example, if a variable called “approved” has 45% of records showing missing values while 55% of other records showing a value of 1 for “approved”, it will not be recommended for deletion because the missing value could mean 0 for “unapproved”. The process introduced in the paper has also considered this case.
- When N/total_number_of records is extremely small, it suggests a very low coverage by the variable. Users can decide whether they would like to retain or drop these variables.

PROC MEANS does not apply to character variables, but one can manually run the following code and apply a similar set of logic for examining the data:

```
proc sql;
create table count_all_variables as
select count(X1) as X1_count, count(distinct X1) as distinct_X1_count,
```
count(X2) as X2_count, count(distinct X2) as distinct_X2_count,
......
count(Xn) as Xn_count, count(distinct Xn) as distinct_Xn_count
from sasdataset; quit;

For character variables, the following is how one can detect those of little or no use:

- When Xi_count=0, it suggests all observations contain null (or missing) values;
- When Xi_count=total_number_of_records and distinct_Xi_count=1, it means the variable has uniform value across all records. Also, bear in mind that this logic does not extend to a character variable with invalid values for some records and a valid uniform value for other records. For example, if a variable called having_score_or_not has 25% of records showing null values while 75% of other records showing a flag “YES”, it will not be recommended for deletion because the null value could mean “NO”. We have considered this case in designing the process.
- When Xi_count/total_number_of_records is extremely small, it suggests a very low coverage by the variable. Users can decide later whether they would like to retain or drop these variables.
- A very high distinct_Xi_count suggests numerous flags for a variable, such as name and address. Numeric values or date-and-time strings expressed in character should be retained and converted accordingly.

For a very limited number of variables, the above measures can be applied manually with a relative ease. When a data set contains hundreds or thousands of variables, one usually does not have time to screen through each variable. We would like to find a more efficient way rather than typing, copying and pasting these lines of codes.

THE SAS PROGRAM
In this paper, we introduce a SAS process that will automatically do the following in a sweep:

- Identify numeric variables and character variables with minimal manual handling from the user. Date-and-time-related variables are treated the same as numeric variables.
- Examine numeric and character variables by applying the aforementioned logic. The process is equally applicable to a data set containing numeric variables only or character variables only.
- At the end of the program, SAS generates a list of variables recommended for deletion, along with variable type (NUM, DATETIME or CHAR) and reason for recommendation for each variable.

Users only need to make minimal changes to several macro values at the beginning of the SAS program in order to use it.

```
libname my_lib "/opt/sas/Tablespace/alin/ARS/data"; /* your libname */
%let sasdata=subsamp; /* SAS data set */
%let cvthresh=0.005; /* threshold for defining a low coverage. */
%let dsthresh=0.3; /* for examining variables with too many flags. */
%let nodelete=csp_acct_id customer_id; /* merging keys and IDs to keep */
** no need to change any code below;
(See the rest of the program in the appendix.)
```

The following are explanations for some macro variables:

cvthresh: the threshold for defining a low coverage. For example, 0.005 means that variables with coverage less than 0.5% will be recommended for deleting. If one would like to retain all variables regardless of their coverages, set cvthresh=1.

dsthresh: number of distinct values or flags for a character variables. Typical examples are names, addresses, IP addresses, etc.

nodelete: variables you definitely would like to retain such as:

- Target variable (y) for analysis or for modeling
- record ID, account number and other merging keys
If you cannot determine which variables to retain, leave it blank as nodelete= now and decide later after reviewing the output.

The SAS program lists the following text strings as common expressions for invalid values:

' ', '#DIV/0!', '#DIV/0', "#N/A", "#NAME?", "#NULL!", "#NUM!", "#REF!", "#VALUE!", "NAN", "INF", "NULL", "NA", "N/A"

User can list more expressions for additional exclusions.

**THE SAS OUTPUT**
At the end of the program, a list of numeric and character variables will be assembled for review. The following is an example:

<table>
<thead>
<tr>
<th>Obs</th>
<th>variable</th>
<th>variable_type</th>
<th>reason_for_cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACQFICO201311</td>
<td>NUM</td>
<td>coverage too low (0.001319503)</td>
</tr>
<tr>
<td>2</td>
<td>AUTH_SEG</td>
<td>NUM</td>
<td>uniform value</td>
</tr>
<tr>
<td>3</td>
<td>BALANCE201311</td>
<td>NUM</td>
<td>coverage too low (0.001319503)</td>
</tr>
<tr>
<td>4</td>
<td>CRLINE201311</td>
<td>NUM</td>
<td>coverage too low (0.001319503)</td>
</tr>
<tr>
<td>5</td>
<td>ObsNum</td>
<td>NUM</td>
<td>uniform value</td>
</tr>
<tr>
<td>6</td>
<td>STMT_DT201311</td>
<td>DATETIME</td>
<td>all values null</td>
</tr>
<tr>
<td>7</td>
<td>approved</td>
<td>NUM</td>
<td>uniform value</td>
</tr>
<tr>
<td>8</td>
<td>extractdate</td>
<td>NUM</td>
<td>all values null</td>
</tr>
<tr>
<td>9</td>
<td>have_score</td>
<td>NUM</td>
<td>uniform value</td>
</tr>
<tr>
<td>10</td>
<td>sum_rstn_All_cnt_6mth</td>
<td>NUM</td>
<td>coverage too low (0.009877946)</td>
</tr>
<tr>
<td>11</td>
<td>CBNOHIT</td>
<td>CHAR</td>
<td>uniform value</td>
</tr>
<tr>
<td>12</td>
<td>ORG_ID201311</td>
<td>CHAR</td>
<td>coverage too low (0.001319503)</td>
</tr>
<tr>
<td>13</td>
<td>PAYHIST201311</td>
<td>CHAR</td>
<td>all values null</td>
</tr>
<tr>
<td>14</td>
<td>datasource</td>
<td>CHAR</td>
<td>uniform value</td>
</tr>
<tr>
<td>15</td>
<td>transaction_id</td>
<td>CHAR</td>
<td>too many flags (54566)</td>
</tr>
<tr>
<td>16</td>
<td>FICO_txt</td>
<td>CHAR</td>
<td>too many flags (213)</td>
</tr>
</tbody>
</table>

A fraction within brackets suggests the low percentage of coverage by a variable. An integer within brackets is the number of distinct flags or indicators a character variable has.

One should not rush to put the list of variables recommended for deletion into a DROP statement in a DATA step. SAS has identified these "suspects" merely based on their expressions rather than on their actual business meanings. I suggest the following practices for rescuing useful fields:

- Variables that are definitely worth retaining even though its expressions or values cannot be scaled or quantified. For example, transaction_id will be used for merging with other files and should be retained.
- Some character variables flagged as "too many flags" could be numeric values or date-and-time strings expressed in text. For example, the variable FICO_txt suggests 213 distinct values for FICO score across all records. This variable should be retained and converted to a numeric one.

After carefully reviewing all variables suggested by the summary list, one can apply a DROP statement in a DATA step to delete those unneeded ones. With a more compact-looking data set at hand, users can go on to apply various statistical methods to examine retained variables.

**CONCLUSION**
This paper introduces a process in SAS that can efficiently and effectively detect some variables of little or no use for preliminary data cleaning. We hope the suggested practice will expedite data examination for analysis and for modeling.

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APPENDIX

libname my_lib "/opt/sas/Tablespace/alin/ARS/data"; /* your libname */
%let sasdata=subsamp; /* SAS data set */
%let cvthresh=0.001; /* threshold for defining a low coverage. */
%let dsthresh=0.3; /* for examining variables with too many flags. */
%let nodelete=csp_acct_id customer_id; /* merging keys and IDs to keep */
** no need to change any code below;

PROC CONTENTS DATA=my_lib.&sasdata(drop=&nodelete) MEMTYPE=data OUT=varlist NOPRINT;
data subchar subnum;
length name $ 32.;
set varlist(keep=name type format);
if upcase(format)="DATETIME" then variable_type="DATETIME";
else variable_type="NUM";
if type=2 then output subchar;
else output subnum; run;

proc sql noprint; select count(type) into :subnumct from subnum; quit;
proc sql noprint; select count(type) into :subtxtct from subchar; quit;
%macro charnum;
%if &subnumct=0 %then %do;
proc delete data=subnum; run; %end;
%else %if &subtxtct=0 %then %do;
proc delete data=subchar; run; %end;
%mend;
%
%charnum;
%macro chknum;
%IF %SYSFUNC(EXIST(subnum))=1 %THEN %DO;
proc sql noprint; select count(*) into :totalcnt from my_lib.&sasdata; quit;
proc sort data=my_lib.&sasdata by name; run;
proc means data=my_lib.&sasdata min max n nway noprint;
output out=check_mean(drop=_type_ _freq_); run;
proc transpose data=check_mean out=trans_means; run;
data num_delete(keep=_name_ reason_for_cleaning);
length _name_ $ 32.;
length reason_for_cleaning $ 32.;
set trans_means;
if col1 in (0, .) then do; reason_for_cleaning="all values null"; clean=1; end;
else if col2=col3 and col1=&totalcnt then do; reason_for_cleaning="uniform value";
   clean=1; end;
else if col1/&totalcnt le &cvthresh then do; cvg=col1/&totalcnt;
   format cvg percent5.4;
   informat cvg percent5.4;
   reason_for_cleaning=("coverage too low ("||cvg||")"); clean=1; end;
if clean=1; run;
proc sort data=num_delete; by _name_; run;
proc sort data=subnum; by name; run;

data num_delete2(rename=(name=variable));
merge num_delete(in=t) subnum(rename=(name=name_));
by _name_; if t; run; %end;
%else %do; data num_delete; set _null_;
_name=''; reason_for_cleaning=''; %end;
%mend

%chknum

%macro chkchar;
%IF %SYSFUNC(EXIST(subchar))=1 %THEN %DO;
data subchar2; set subchar; seqnum+1; varid=compress("x"||seqnum); run;
proc sql noprint;
create table varcount as select count(*) as vcnt from subchar2; quit;
data _null_; set varcount; call symputx('varcount', vcnt); run;
proc sql; select name into :x1-:x&varcount from subchar; quit;
%macro countvar;
proc sql noprint; select count(*) into :totalcnt from my_lib.&sasdata; quit;
%do i=1 %to &varcount;
proc sql;
create table varcount&i as
select "&&x&i" as variable,
count(&&x&i) as obscnt,
count(&&x&i)/&totalcnt as obscntpct,
count(distinct &&x&i) as distinct_obscnt,
count(distinct &&x&i)/&totalcnt as distcntpct
from my_lib.&sasdata
where upcase(&&x&i) not in (' ', '#DIV/0!', "#DIV/0", "#N/A", "#NAME?", "#NULL!", "#NUM!", "#REF!", "#VALUE!", "NAN", "INF", "NULL", "NA", "N/A"); quit;
%mend;
%countvar

%chkchar;

data variables_to_clean;
retain variable variable_type reason_for_cleaning;
set num_delete2(in=s keep=variable variable_type reason_for_cleaning) char_delete(in=t keep=variable reason_for_cleaning);
if t then variable_type='CHAR';
if variable ne ' ' ; run;
proc print data=variables_to_clean; run;