ABSTRACT

There are many languages that co-exist in the ecosystem of your SAS® toolbox. This Hands-On Workshop teaches you how to use four SAS languages - Base SAS, PROC SQL, Perl language elements, and the SAS® Macro Language - to help you manipulate and investigate your data. Learn to leverage these powerful languages to check your data with simple, yet elegant techniques such as Boolean logic in PROC SQL, operators such as the SOUNDS-LIKE operator in the DATA step and PROC step, functions such as the SCAN function in the DATA step, efficient checking of your data with Perl regular expressions, and last but not least, the amazing marriage between PROC SQL and the SAS Macro Language to hold data you just found in a variable that you can use over and over again. This workshop focuses on coding techniques for data investigation and manipulation using Base SAS.

DATA USED IN THIS PRESENTATION

<table>
<thead>
<tr>
<th>TABLE NAME</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sashelp.demographics</td>
<td>The Sashelp.demographics data set provides the 2004 revision of data derived from world population prospects. The data set contains 197 observations.</td>
</tr>
<tr>
<td>Sashelp.mwelect</td>
<td>The Sashelp.mwelect data set provides midwest electrical supply monthly sales by product group. The data set contains 11,296 observations.</td>
</tr>
<tr>
<td>Pflugerville</td>
<td>Code to build the dataset is provided in the References section of this paper</td>
</tr>
</tbody>
</table>

Table 1. Details about the data sets used in this Hands-on workshop

1. INTRODUCTION

When the author set out to share the power of different languages in the SAS® toolkit, her initial targeted audience was the novice user. What she didn’t fully realize was the value of this topic to experienced users as well. For example, there is value to the user who came up to the author after her presentation to share that they were now able to view PROC SQL with a Boolean angle, and the advanced user also benefitted by learning about PERL regular
expressions in SAS. Clearly, this paper won’t be able to teach you every single nuance of these majestic languages in the short timeframe of a hands-on workshop. The purpose of this paper is to synthesize & distill each language to its best strengths. Whether you are a novice user or an experienced SAS coder, the hope is for you to get something new out of this paper. Comments and feedback are always appreciated.

The goal of this Hands-on workshop is to understand the shape of 4 SAS® languages. Four business scenarios have been developed in this Hands-on workshop to practice the four SAS® languages:

**Business Scenario 1** – Using the most misspelled city in Texas, this scenario will discuss the fundamental concepts of the SAS data step and how to filter data using the WHERE clause with the Sounds-like operator and the Contains Operator. It will also reveal where the sounds-like operator works well and where the contains operator may be a better fit.

**Business Scenario 2** – Using the SASHELP. Mwelect dataset, this scenario will discuss how to find a pattern using the language of Perl.

**Business Scenario 3** – Using the SASHELP. demographics dataset, this scenario will discuss how to create a macro variable to find the country with the highest population in 2004.

**Business Scenario 4** – Using the SASHELP. demographics dataset, this scenario will discuss how to use Boolean logic in PROC SQL to obtain population range counts by region.

**REVIEW OF SAS PROGRAMS**

A SAS program is a sequence of one or more steps.  
**DATA** steps typically build and manipulate SAS data sets. So, we can reference the DATA step as the **Builder**. Keeping the building capability in mind helps while writing data step code as the executable statements are, for the most part processed in sequence.

**PROC** steps typically process SAS data sets to generate reports and graphs, and to manage data. So, we can reference the PROC Step as the **Analyzer**. Keeping the analytic capability in mind helps while writing PROC steps as the order of statements is usually not important.

![Figure 1. The role of the DATA STEP vs the PROC STEP](image-url)
DATA EXTRACTION TOOL – LIBRARY TO READ SAS DATASETS

A SAS data library is a collection of one or more SAS files that are recognized by SAS and can be referenced and stored as a unit. A library is simply an alias, a pointer or a reference pointing to a physical location on your computer, e.g. a folder on your C drive.

Figure 2. The Libname Statement

Libname Code

```sas
libname PHSUG 'C:\HOW\Shankar';
```

2. SHAPE 1 - THE SAS DATA STEP – THE MANIPULATOR

BUSINESS SCENARIO 1 – FIND ALL PFLUGERVILLE RECORDS

You have been tasked to find all records for the city of Pflugerville in Texas. However, there’s a small problem. The city’s name is so misspelled. How can you filter your data?
Figure 3. Map of Texas with Pflugerville

USING THE DATA STEP TO CREATE A SAS DATASET

The Data Step is a powerful tool to create, clean, and prepare your data. These are some of the tasks it can perform:

- Filter rows and columns
- Compute new columns
- Conditionally process data

Figure 4. Data Step Code

DATA output-table;
SET input-table;
RUN;

FILTER DATA WITH THE WHERE CLAUSE

The WHERE expression defines the condition (or conditions) for selecting observations.

Figure 5. The Where Expression

THE SOUNDS LIKE OPERATOR

The sounds-like operator =* is very useful when fuzzy matching of character values is needed. It matches character strings based on their phonetic values. The sounds-like operator is based on the SOUNDEX algorithm for identifying words that sound alike.

Data step Code

data citytypo;
   set PHSUG.citysoundslike;
       where city=’Pflugerville’;
run;
Data step Results

<table>
<thead>
<tr>
<th>studentId</th>
<th>Name</th>
<th>city</th>
<th>state</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
<td>aaaa</td>
<td>ploogerville</td>
<td>TX</td>
</tr>
<tr>
<td>2222</td>
<td>bbbb</td>
<td>Phlurerville</td>
<td>TX</td>
</tr>
<tr>
<td>3333</td>
<td>cccc</td>
<td>plugerville</td>
<td>TX</td>
</tr>
<tr>
<td>4444</td>
<td>dddd</td>
<td>Phloogerville</td>
<td>TX</td>
</tr>
<tr>
<td>5555</td>
<td>eeee</td>
<td>Plugerville</td>
<td>Tx</td>
</tr>
</tbody>
</table>

However, the sounds like operator does not work in every instance. Observe what happens when we try to find all students named John in the SASHELP.CLASS data set.

Data Step Code

```sas
data PHSUG.john;
   set sashelp.class;
   where name =*"John";
run;
```

Data Step Results

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>F</td>
<td>12</td>
<td>59.8</td>
<td>84.5</td>
</tr>
<tr>
<td>John</td>
<td>M</td>
<td>12</td>
<td>59</td>
<td>99.5</td>
</tr>
</tbody>
</table>

THE SOUNDEX ALGORITHM

Why did our search for John return Jane as well? Consider the Soundex Algorithm. Soundex is an indexing system that translates a name into a 4-digit code. The advantage of Soundex is its ability to locate names by the way they sound, rather than by exact spelling.

<table>
<thead>
<tr>
<th>Code</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BFPV</td>
</tr>
<tr>
<td>2</td>
<td>CGJKQXZ</td>
</tr>
<tr>
<td>3</td>
<td>DT</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>MN</td>
</tr>
<tr>
<td>6</td>
<td>R</td>
</tr>
<tr>
<td>No code</td>
<td>AEHIOUYW</td>
</tr>
</tbody>
</table>
Figure 6. The Soundex Algorithm Chart

The steps used by SOUNDEX to derive the phonetic equivalent of a character string are as follows:

a) Retain the first letter of the character string.

b) Discard the letters A E H I O U W Y.

c) Assign a numeric value to the following consonants:
   1. B F P V
   2. C G J K Q S Z
   3. D T
   4. L
   5. M N
   6. R

d) Discard all duplicate classification values if they are adjacent. That is, DT results in a single value of 3, and NN results in a single value of 5).

Here is the answer to our puzzle as to why a search for John pulled up Jane as well.

<table>
<thead>
<tr>
<th>JOHN</th>
<th>Soundex</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>J</td>
</tr>
<tr>
<td>O</td>
<td>discarded</td>
</tr>
<tr>
<td>H</td>
<td>discarded</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>JANE</th>
<th>Soundex</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>J</td>
</tr>
<tr>
<td>A</td>
<td>discarded</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>discarded</td>
</tr>
</tbody>
</table>

Figure 7. John sounds like Jane

THE CONTAINS OPERATOR

The contains operator selects observations that include the specified substring.

- ? can be used instead of the mnemonic.
- The position of the substring within the variable’s values is not important.
- Comparisons made with the CONTAINS operator are case sensitive.

Equivalent Statements

where Job_Title contains 'Rep';
where Job_Title ? 'Rep';

Figure 8. The Contains Operator

Let’s see what happens when we use the contains operator.
DATA STEP CODE

data PHSUG.thisisJohn;
set sashelp.class;
where name contains "John";
run;

DATA STEP RESULTS

3. SHAPE 2 - PERL – MATCH A PATTERN

BUSINESS SCENARIO 2 - MATCH A PATTERN

We have been tasked to isolate all SKUs that match this pattern 'DDD ddddd '.

<table>
<thead>
<tr>
<th>SalesInUsd</th>
<th>SalesCost</th>
<th>QuantityInvo</th>
<th>SKU</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,121.42</td>
<td>1,589.61</td>
<td>2419</td>
<td>CPR 00108N 0800XR</td>
</tr>
<tr>
<td>2,495.77</td>
<td>2,099.13</td>
<td>1260</td>
<td>CPR 00108N 0800XR</td>
</tr>
<tr>
<td>2,942.77</td>
<td>1,882.82</td>
<td>1581</td>
<td>CPR 00108N 0800XR</td>
</tr>
<tr>
<td>2,412.63</td>
<td>1,171.20</td>
<td>1760</td>
<td>CPR 00108N 0800XR</td>
</tr>
<tr>
<td>2,006.53</td>
<td>1,506.36</td>
<td>1297</td>
<td>CPR 00108N 0800XR</td>
</tr>
<tr>
<td>1,911.10</td>
<td>1,988.19</td>
<td>1798</td>
<td>CPR 00200 0400XR</td>
</tr>
<tr>
<td>1,232.64</td>
<td>1,273.59</td>
<td>1864</td>
<td>CPR 00200 0400XR</td>
</tr>
<tr>
<td>1,839.40</td>
<td>1,997.69</td>
<td>1674</td>
<td>CPR 00200 0400XR</td>
</tr>
<tr>
<td>2,313.42</td>
<td>2,476.13</td>
<td>2039</td>
<td>CPR 00200 0400XR</td>
</tr>
</tbody>
</table>

Figure 9. Matching a pattern

USING PERL TO MATCH A PATTERN

Perl was designed specifically for text processing. The 1990s saw the growth of the World Wide Web. It also saw the rise of text-based information during that period. As one of the languages very capable of text manipulation and undergoing rapid development, Perl was suited to the task at hand. As a result, it became a very popular web programming language, even being referred to as the 'duct-tape of the Web'.
Perl is a very high-level language. That means that the code is quite dense. A Perl program might be around 30% to 70% as long as the corresponding program in C.

**PERL IN SAS**

Perl regular expressions were added to SAS in Version 9. SAS regular expressions (similar to Perl regular expressions but using a different syntax to indicate text patterns) have been around since version 6.12, but many SAS users are unfamiliar with either SAS or Perl regular expressions.

Because SAS already has such a powerful set of string functions, you might wonder why you need regular expressions. Many of the string processing tasks can be performed either with the traditional character functions or regular expressions. However, regular expressions can sometimes provide a much more compact solution to a complicated string manipulation task.

**MATCHING A PATTERN**

Since the backslash, forward slash, parentheses and several other characters have special meaning in a regular expression, you may wonder, how do you search a string for a \ character or a left or right parenthesis? You do this by preceding any of these special characters with a backslash character (in Perl jargon called an escape character). So, to match a \ in a string, you code two backslashes like this: \\\. To match an open parenthesis, you use \\.

/ delimiters
\ matches an open parenthesis
D matches a non-digit
d matches a digit
s matches a space
{n,m} Matches the previous subexpression n or more times, but no more than m
\) matches a closed parenthesis

**Perl Code**

```perl
title 'Midwest Electrical Supply Monthly Sales by product group';
title2 "SKUs that match this pattern only 'DDD dddd ";

proc print data=sashelp.mwelect;
    where prxmatch(("/\D{3}\s\d{5}\s/"), SKU) > 0;
run;
```
**Perl Results**

![Perl Results Table]

### 4. SHAPE 3 - MACRO – AUTOMATE FIND AND REPLACE

**BUSINESS SCENARIO 3 - USING MACRO VARIABLES TO AUTOMATE**

We have been asked to find the country with the highest population in 2004. Since we would like to feed this data to another report, we will store the country name and the population count in 2 macro variables that we can reuse over and over again.

![Figure 10. Using macro variables to automate results]

**CREATING AND REFERENCING MACRO VARIABLES**

The process of creating macro variables is simple. First, we create the macro variables and then submit code to create a report using the defined macro variables.

![Figure 11. Creating and referencing macro variables]
CREATING MACRO VARIABLES WITH PROC SQL

In PROC SQL, use an INTO clause to create macro variables and assign a value to them or to update existing macro variable values. The INTO clause must follow the SELECT clause.

**Figure 12. Creating macro variables with PROC SQL**

**CREATING MACRO VARIABLES: SYNTAX 1**

Syntax 1 places values from the first row returned by an SQL query into one or more macro variables. Data from additional rows returned by the query is ignored. The value from the first column in the SELECT clause is placed in the first macro variable listed in the INTO clause, and so on.

**Figure 13. Creating macro variables: Syntax 1**

**MACRO TO GRAB COUNTRY WITH THE HIGHEST POPULATION**

**Macro Code**

```sas
proc sql noprint;
   select pop format comma13., name
       into : Maxpop , : country
       from sashelp.demographics
       order by 1 descending;
   %put &=country;
   %put &=maxpop;
```

**Macro Results in the log**

```plaintext
45      %put &=country;
COUNTRY=CHINA
46      %put &=maxpop;
MAXPOP=1,323,344,591
```
5. SHAPE 4 – PROC SQL – SPEAK ELEGANT BOOLEAN

BUSINESS SCENARIO 4 - USING BOOLEAN LOGIC TO COUNT ROWS
We would like to obtain population range counts by region.

![Figure 14. World map with region names](image)

BOOLEAN LOGIC IN PROC SQL
Everything in the digital world can be broken down into 1 or 0, or rather Yes or No. We will take advantage of this Boolean capacity to get population counts by each region. First, it would be useful to understand the syntax order of PROC SQL.

PROC SQL SYNTAX ORDER
The specified order of the clauses below, within the SELECT statement is required.

```sql
PROC SQL;
SELECT object-item <, ...object-item>
   FROM from-list
   <WHERE sql-expression>
   <GROUP BY object-item <, ... object-item >>
   <HAVING sql-expression>
   <ORDER BY order-by-item <DESC> <, ...order-by-item>>;
QUIT;
```

![Figure 15. PROC SQL syntax order](image)
USING PROC SQL TO GET COUNTS

Proc Sql Code

title "population counts by country";
title2 "&country";
title3 "had the maximum population of &maxpop in 2005";
proc sql;
   select region,
      sum(pop <= 1000000) 'upto 1,000,000',
      sum(pop between 1000001 and 10000000) '1 - 10 million',
      sum(pop between 10000001 and 50000000) '10 - 50 million',
      sum(pop between 50000001 and 100000000) '50 - 100 million',
      sum(pop between 100000001 and 500000000) '100 - 500 million',
      sum(pop > 500000001 ) '500 million and above'
   from sashelp.demographics
      group by 1
;
quit;

Proc Sql Results

<table>
<thead>
<tr>
<th>Region</th>
<th>upto 1,000,000</th>
<th>1 - 10 million</th>
<th>10 - 50 million</th>
<th>50 - 100 million</th>
<th>100 - 500 million</th>
<th>500 million and above</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>5</td>
<td>20</td>
<td>18</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>AMR</td>
<td>11</td>
<td>12</td>
<td>9</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>EMR</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>EUR</td>
<td>7</td>
<td>26</td>
<td>13</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>SEAR</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WPR</td>
<td>14</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

population counts by country

CHINA

had the maximum population of 1,323,344,591 in 2005
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Shankar, Charu. April 2012. Go home on time with these 5 PROC SQL tips”. Blogs.sas.com website.
https://blogs.sas.com/content/sastraining/2012/04/24/go-home-on-time-with-these-5-proc-sql-tips/
**Code for building the Pflugerville dataset**

```sas
data PHSUG.misspelled;
  length studentId $4 Name $7 city $20 state $2;
  input studentid $ name $ city $ state $;
  datalines;
  1111 aaaa pllogervile TX
  2222 bbbb Pflugerville TX
  3333 cccc plugerrville TX
  4444 dddd Phloogerville TX
  5555 eeee Plugerville Tx
; run;
```

7. **ACKNOWLEDGMENTS**

The author is grateful to the many SAS users that have entered her life. Each User has either asked or answered a question. This in turn gave the author the impetus to research and study new ways to express the wonderful shape of SAS code. Sometimes a user appeared in the form of a teacher to show her the many ways in which to express the Shape of SAS code. The users are too many to thank individually so this is a thank you to every single user who has touched her life. This paper was originally an invited presentation at SAS global forum. Charu is grateful to the Pharmasug committee for inviting her to present this paper. She would also like to express her gratitude to her manager, Stephen Keelan without whose support and permission, this paper would not be possible.

8. **CONTACT INFORMATION**

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