Module 8

Data Cleaning

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Instructor

Data

- We will be using multiple data sets in this lecture:
  - Salary, Monument, Circulator, and Restaurant from OpenBaltimore: https://data.baltimorecity.gov/browse?limitTo=datasets
  - Gap Minder - very interesting way of viewing longitudinal data
    - Data is here - http://www.gapminder.org/data/
  - http://spreadsheets.google.com/pub?key=rMsQHawTObBb6_U2ESjKXYw&output=xls

Data Cleaning

In general, data cleaning is a process of investigating your data for inaccuracies, or recoding it in a way that makes it more manageable.

MOST IMPORTANT RULE - LOOK AT YOUR DATA!

Again - `table`, `summarize`, `is.na`, `any`, `all` are useful.

Data Cleaning

```
> table(c(0, 1, 2, 3, NA, 3, 3, 2,2, 3), useNA="ifany")
```

```
   0    1    2    3 <NA> 
   1    1    3    4    1 
```

```
> table(c(0, 1, 2, 3, 2, 3, 3, 2,2, 3), useNA="always")
```

```
   0    1    2    3 <NA> 
   1    1    4    4    0 
```

```
> tab <- table(c(0, 1, 2, 3, 2, 3, 3, 2,2, 3), c(0, 1, 2, 3, 2, 3, 3, 4, 4, 3),
+               useNA="always")
> margin.table(tab, 2)
```

```
   0    1    2    3    4 <NA> 
   1    1    2    4    2    0 
```

```
> prop.table(tab)
```

```

       0   1   2   3   4 <NA>
0    0.1 0.0 0.0 0.0 0.0  0.0
1    0.0 0.1 0.0 0.0 0.0  0.0
2    0.0 0.0 0.2 0.0 0.2  0.0
3    0.0 0.0 0.0 0.4 0.0  0.0
<NA> 0.0 0.0 0.0 0.0 0.0  0.0
```

```
> prop.table(tab,1)
```

```

       0   1   2   3   4 <NA>
0    1.0 0.0 0.0 0.0 0.0  0.0
1    0.0 1.0 0.0 0.0 0.0  0.0
2    0.0 0.0 0.5 0.0 0.5  0.0
3    0.0 0.0 0.0 1.0 0.0  0.0
<NA>
```

Download Salary FY2012 Data

https://data.baltimorecity.gov/Financial/Baltimore-City-Employee-Salaries-FY2012/7ymi-bvp3

Download as a CSV and then read it into R as the variable `Sal`

Download Salary FY2012 Data

https://data.baltimorecity.gov/Financial/Baltimore-City-Employee-Salaries-FY2012/7ymi-bvp3

Download as a CSV and then read it into R as the variable `Sal`

```
> Sal = read.csv("data/Baltimore_City_Employee_Salaries_FY2012.csv",as.is=TRUE)
> colnames(Sal)[1] = "Name" # make uppercase
```

Data Cleaning

- `any()` - checks if there are any TRUES
- `all()` - checks if ALL are true

```
> Sal[1:4,]
```

```
                 Name                      JobTitle AgencyID
1   Aaron,Patricia G Facilities/Office Services II   A03031
2      Aaron,Petra L    ASSISTANT STATE'S ATTORNEY   A29005
3 Abaineh,Yohannes T                EPIDEMIOLOGIST   A65026
4 Abdal-Rahim,Naim A               EMT FIREFIGHTER   A64215
                 Agency   HireDate AnnualSalary  GrossPay
1      OED-Employment Dev 10/24/1979    $51862.00 $52247.39
2 States Attorneys Office 09/25/2006    $64000.00 $59026.81
3  HLTH-Health Department 07/23/2009    $57900.00 $57129.79
4         Fire Department 03/30/2011    $34146.00 $35537.88
```

```
> any(is.na(Sal$Name))
```

```
[1] FALSE
```

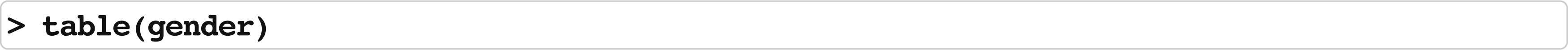
Example of Cleaning:

For example, let's say gender was coded as Male, M, m, Female, F, f. Using Excel to find all of these would be a matter of filtering and changing all by hand or using if statements.

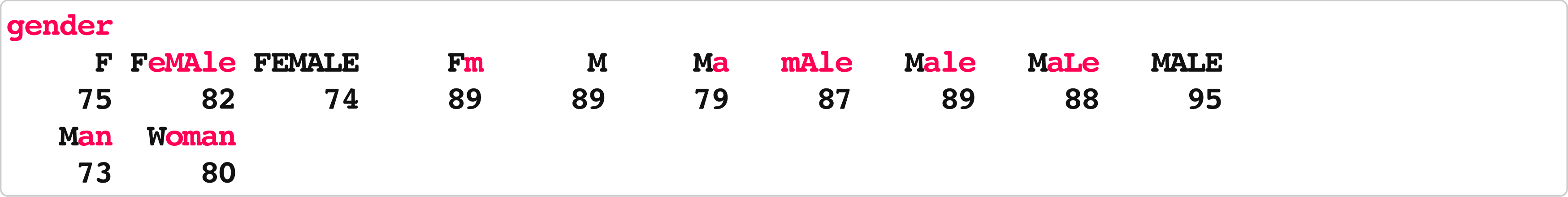
In R, you can simply do something like:

```
data$gender[data$gender %in% c("Male", "M", "m")] <- "Male"
```

Sometimes though, it's not so simple. That's where functions that find patterns come in very useful.



```
> table(gender)
```



```
gender
     F FeMAle FEMALE     Fm      M     Ma   mAle   Male   MaLe   MALE
    75     82     74     89     89     79     87     89     88     95
   Man  Woman
    73     80
```

Find/Replace and Regular Expressions

- R can do much more than find exact matches for a whole string
- Like Perl and other languages, it can use regular expressions.
- What are regular expressions?
- Ways to search for specific strings
- Can be very complicated or simple
- Highly Useful

'Find' functions

grep: grep, grepl, regexpr and gregexpr search for matches to argument pattern within each element of a character vector: they differ in the format of and amount of detail in the results.

`grep(pattern, x, fixed=FALSE)`, where:

- pattern = character string containing a regular expression to be matched in the given character vector.
- x = a character vector where matches are sought, or an object which can be coerced by as.character to a character vector.
- If fixed=TRUE, it will do exact matching for the phrase anywhere in the vector (regular find)

```
> grep("Rawlings",Sal$Name) # These are the indices/elements where the pattern match occurs
```

```
[1] 11755 11756 11757 11758
```

`grep()` returns something similar to which() on a logical statement

```
> grep("Rawlings",Sal$Name)
```

```
[1] 11755 11756 11757 11758
```

```
> grep("Rawlings",Sal$Name,value=TRUE)
```

```
[1] "Rawlings Jr,Anthony H" "Rawlings,Kellye A"     "Rawlings,Paula M"
[4] "Rawlings,Stephanie C"
```

```
> Sal[grep("Rawlings",Sal$Name),]
```

```
                       Name             JobTitle AgencyID
11755 Rawlings Jr,Anthony H       AIDE BLUE CHIP   W02712
11756     Rawlings,Kellye A EMERGENCY DISPATCHER   A99372
11757      Rawlings,Paula M       COMMUNITY AIDE   A04015
11758  Rawlings,Stephanie C                MAYOR   A01001
                  Agency   HireDate AnnualSalary   GrossPay
11755      Youth Summer  06/07/2011    $1   $1
11756 Police Department  01/06/2003    $4  $5
11757    R&P-Recreation  12/10/2007    $1   $9
11758     Mayors Office  12/07/1995   $1 $1
```

Grep Options

```
> head(grep("Tajhgh",Sal$Name, value=TRUE))
```

```
[1] "Reynold,Tajhgh J"
```

```
> grep("Jaffe",Sal$Name)
```

```
integer(0)
```

```
> length(grep("Jaffe",Sal$Name))
```

```
[1] 0
```

A bit on Regular Expressions

- http://www.regular-expressions.info/reference.html
- They can use to match a large number of strings in one statement
- `.` matches any single character
- `*` means repeat as many (even if 0) more times the last character
- `?` makes the last thing optional

Using Regular Expressions

- Look for any name that starts with:
  - Payne at the beginning,
  - Leonard and then an S
  - Spence then a capital C

```
> grep("Payne.*", x=Sal$Name, value=TRUE)
```

```
 [1] "Payne,Brittany N"          "Payne-Cooke,Shelley F"
 [3] "Payne,Denise I"            "Payne El,Jackie"
 [5] "Payne,Gary W"              "Payne,James D"
 [7] "Payne,James R"             "Payne,Jasman T"
 [9] "Payne Johnson,Nickole A"  "Payne,Jordan A"
[11] "Payne,Karen V"             "Payne,Leonard S"
[13] "Payne,Mary A"              "Payne,Micah W"
[15] "Payne,Michael N"           "Payne,Walter"
[17] "Ray Payne,Marion J"
```

```
> grep("Leonard.?S", x=Sal$Name, value=TRUE)
```

```
[1] "Payne,Leonard S"      "Szumlanski,Leonard S"
```

```
> grep("Spence.*C.*", x=Sal$Name, value=TRUE)
```

```
[1] "Spence Jr,Leonard C" "Spencer,Charles A"   "Spencer,Clarence W"
[4] "Spencer,Michael C"
```

Replace

Let's say we wanted to sort the data set by Annual Salary:

```
> class(Sal$AnnualSalary)
```

```
[1] "character"
```

```
> sort(c("1", "2", "10")) #  not sort correctly (order simply ranks the data)
```

```
[1] "1"  "10" "2"
```

```
> order(c("1", "2", "10"))
```

```
[1] 1 3 2
```

Replace

So we must change the annual pay into a numeric:

```
> head(as.numeric(Sal$AnnualSalary), 4)
```

```
[1] NA NA NA NA
```

R didn't like the $ so it thought turned them all to `NA`.

`sub()` and `gsub()` can do the replacing part.

Replacing and subbing

Now we can replace the `$` with nothing (used fixed=TRUE because $ means something in regular expressions):

```
> Sal$AnnualSalary <- as.numeric(gsub(pattern="$", replacement="",
+                                     Sal$AnnualSalary, fixed=TRUE))
> Sal <- Sal[order(Sal$AnnualSalary,decreasing=TRUE), ] # use negative to sort descending
> Sal[1:5, c("Name", "AnnualSalary", "JobTitle")]
```

```
                           Name AnnualSalary             JobTitle
1012          Bernstein,Gregg L       238772    STATE'S ATTORNEY
844    Bealefeld III,Frederick H       197700 EXECUTIVE LEVEL III
1120               Black,Harry E       180000 EXECUTIVE LEVEL III
12510        Sanchez,Alexander M       175000 EXECUTIVE LEVEL III
677                Barbot,Oxiris       170000 EXECUTIVE LEVEL III
```

Useful String Functions

Useful String functions

- `toupper()`, `tolower()` - uppercase or lowercase your data:
- `str_trim()` (in the `stringr` package) - will trim whitespace
- `nchar` - get the number of characters in a string
- `substr(x, start, stop)` - substrings from position start to position stop
- `strsplit(x, split)` - splits strings up - returns list!
- `paste()` - paste strings together - look at `?paste`

Paste

Paste can be very useful for joining vectors together:

```
> paste("Visit", 1:5, sep="_")
```

```
[1] "Visit_1" "Visit_2" "Visit_3" "Visit_4" "Visit_5"
```

```
> paste("Visit", 1:5, sep="_", collapse=" ")
```

```
[1] "Visit_1 Visit_2 Visit_3 Visit_4 Visit_5"
```

```
> paste("To", "is going be the ", "we go to the store!", sep="day ")
```

```
[1] "Today is going be the day we go to the store!"
```

```
> # and paste0 can be even simpler see ?paste0
> paste0("Visit",1:5)
```

```
[1] "Visit1" "Visit2" "Visit3" "Visit4" "Visit5"
```

```
> paste(1:5, letters[1:5], sep="_")
```

```
[1] "1_a" "2_b" "3_c" "4_d" "5_e"
```

```
> paste(6:10, 11:15, 2000:2005, sep="/")
```

```
[1] "6/11/2000"  "7/12/2001"  "8/13/2002"  "9/14/2003"  "10/15/2004"
[6] "6/11/2005"
```

```
> paste(paste("x",1:5,sep=""),collapse="+")
```

```
[1] "x1+x2+x3+x4+x5"
```

Strsplit

```
> x <- c("I really", "like writing", "R code")
> y <- strsplit(x, split=" ")
> y[[2]]
```

```
[1] "like"    "writing"
```

```
> sapply(y, "[", 1) # on the fly
```

```
[1] "I"    "like" "R"
```

```
> sapply(y, "[", 2) # on the fly
```

```
[1] "really"  "writing" "code"
```

Data Merging/Append

- Merging - joining data sets together - usually on key variables, usually "id"
- `merge()` is the most common way to do this with data sets
- `rbind`/`cbind` - row/column bind, respectively
  - `rbind` is the equivalent of "appending" in Stata or "setting" in SAS
  - `cbind` allows you to add columns in addition to the previous ways
- `reshape2` package also has a lot of information about different ways to reshape data (wide to long, etc) - but has a different (and sometimes more intuitive syntax)
- `t()` is a function that will transpose the data

Merging

```
> base <- data.frame(id=1:10, Age= seq(55,60, length=10))
> base[1:2,]
```

```
  id   Age
1  1 55.00
2  2 55.56
```

```
> visits <- data.frame(id=rep(1:8, 3), visit= rep(1:3, 8), Outcome= seq(10,50, length=24))
> visits[1:2,]
```

```
  id visit Outcome
1  1     1   10.00
2  2     2   11.74
```

```
> merged.data <- merge(base, visits, by="id")
> merged.data[1:5,]
```

```
  id   Age visit Outcome
1  1 55.00     1   10.00
2  1 55.00     3   23.91
3  1 55.00     2   37.83
4  2 55.56     2   11.74
5  2 55.56     1   25.65
```

```
> dim(merged.data)
```

```
[1] 24  4
```

```
> all.data <- merge(base, visits, by="id", all=TRUE)
> tail(all.data)
```

```
   id   Age visit Outcome
21  7 58.33     2   48.26
22  8 58.89     2   22.17
23  8 58.89     1   36.09
24  8 58.89     3   50.00
25  9 59.44    NA      NA
26 10 60.00    NA      NA
```

```
> dim(all.data)
```

```
[1] 26  4
```

Aside: Dates

You can convert date-like strings in the Date class (http://www.statmethods.net/input/dates.html for more info)

```
> circ = read.csv("data/Charm_City_Circulator_Ridership.csv",as.is=TRUE)
> head(sort(circ$date))
```

```
[1] "01/01/2011" "01/01/2012" "01/01/2013" "01/02/2011" "01/02/2012"
[6] "01/02/2013"
```

```
> circ$date <- as.Date(circ$date, "%m/%d/%Y") # creating a date for sorting
> head(circ$date)
```

```
[1] "2010-01-11" "2010-01-12" "2010-01-13" "2010-01-14" "2010-01-15"
[6] "2010-01-16"
```

```
> head(sort(circ$date))
```

```
[1] "2010-01-11" "2010-01-12" "2010-01-13" "2010-01-14" "2010-01-15"
[6] "2010-01-16"
```

Data Reshaping

Disclaimer: the `reshape` command in R is not remarkably intuitive.

- Wide - multiple measurements are variables / columns so that the data gets wider with more measurements
- Long - multiple measurements are rows so data gets longer with more measurements
- One example would be many ids with multiple visits

Example of Long/Wide

```
> head(wide)
```

```
  id visit1 visit2 visit3
1  1   Good   Good    Bad
```

```
> head(long)
```

```
  id visit Outcome
1  1     1    Good
2  1     2    Good
3  1     3     Bad
```

Data Reshaping

- Good resource: http://www.ats.ucla.edu/stat/r/faq/reshape.htm

```
> head(Indometh) # this is long
```

```
  Subject time conc
1       1 0.25 1.50
2       1 0.50 0.94
3       1 0.75 0.78
4       1 1.00 0.48
5       1 1.25 0.37
6       1 2.00 0.19
```

Data Reshaping

```
> wide <- reshape(Indometh, v.names = "conc", idvar = "Subject",
+                 timevar = "time", direction = "wide")
> head(wide)
```

```
   Subject conc.0.25 conc.0.5 conc.0.75 conc.1 conc.1.25 conc.2 conc.3
1        1      1.50     0.94      0.78   0.48      0.37   0.19   0.12
12       2      2.03     1.63      0.71   0.70      0.64   0.36   0.32
23       3      2.72     1.49      1.16   0.80      0.80   0.39   0.22
34       4      1.85     1.39      1.02   0.89      0.59   0.40   0.16
45       5      2.05     1.04      0.81   0.39      0.30   0.23   0.13
56       6      2.31     1.44      1.03   0.84      0.64   0.42   0.24
   conc.4 conc.5 conc.6 conc.8
1    0.11   0.08   0.07   0.05
12   0.20   0.25   0.12   0.08
23   0.12   0.11   0.08   0.08
34   0.11   0.10   0.07   0.07
45   0.11   0.08   0.10   0.06
56   0.17   0.13   0.10   0.09
```

Data Reshaping

```
> dim(Indometh)
```

```
[1] 66  3
```

```
> wide
```

```
   Subject conc.0.25 conc.0.5 conc.0.75 conc.1 conc.1.25 conc.2 conc.3
1        1      1.50     0.94      0.78   0.48      0.37   0.19   0.12
12       2      2.03     1.63      0.71   0.70      0.64   0.36   0.32
23       3      2.72     1.49      1.16   0.80      0.80   0.39   0.22
34       4      1.85     1.39      1.02   0.89      0.59   0.40   0.16
45       5      2.05     1.04      0.81   0.39      0.30   0.23   0.13
56       6      2.31     1.44      1.03   0.84      0.64   0.42   0.24
   conc.4 conc.5 conc.6 conc.8
1    0.11   0.08   0.07   0.05
12   0.20   0.25   0.12   0.08
23   0.12   0.11   0.08   0.08
34   0.11   0.10   0.07   0.07
45   0.11   0.08   0.10   0.06
56   0.17   0.13   0.10   0.09
```

Data Reshaping

- If you've reshaped a data set - to get it back, just reshape it again

```
> reshape(wide, direction = "long")[1:10,]
```

```
       Subject time conc
1.0.25       1 0.25 1.50
2.0.25       2 0.25 2.03
3.0.25       3 0.25 2.72
4.0.25       4 0.25 1.85
5.0.25       5 0.25 2.05
6.0.25       6 0.25 2.31
1.0.5        1 0.50 0.94
2.0.5        2 0.50 1.63
3.0.5        3 0.50 1.49
4.0.5        4 0.50 1.39
```

Note the row name change

Data Reshaping - A Better Example

```
> TB <- read.xlsx(file="data/indicator_estimatedincidencealltbper100000.xlsx",
+                 sheetName="Data")
> head(TB, 1)
```

```
  TB.incidence..all.forms..per.population.per.year. X1990 X1991
1                                               Afghanistan   168   168
  X1992 X1993 X1994 X1995 X1996 X1997 X1998 X1999 X2000 X2001 X2002 X2003
1   168   168   168   168   168   168   168   168   168   168   168   168
  X2004 X2005 X2006 X2007 NA.
1   168   168   168   168  NA
```

```
> TB$NA. <- NULL
> head(TB, 1)
```

```
  TB.incidence..all.forms..per.population.per.year. X1990 X1991
1                                               Afghanistan   168   168
  X1992 X1993 X1994 X1995 X1996 X1997 X1998 X1999 X2000 X2001 X2002 X2003
1   168   168   168   168   168   168   168   168   168   168   168   168
  X2004 X2005 X2006 X2007
1   168   168   168   168
```

Data Reshaping - A Better Example

```
> colnames(TB) <- c("Country", paste("Year", 1990:2007, sep="."))
> head(TB,1)
```

```
      Country Year.1990 Year.1991 Year.1992 Year.1993 Year.1994 Year.1995
1 Afghanistan       168       168       168       168       168       168
  Year.1996 Year.1997 Year.1998 Year.1999 Year.2000 Year.2001 Year.2002
1       168       168       168       168       168       168       168
  Year.2003 Year.2004 Year.2005 Year.2006 Year.2007
1       168       168       168       168       168
```

Data Reshaping - More is better!

```
> TB.long <- reshape(TB, idvar="Country", v.names="Cases", times=1990:2007,
+                    direction="long", timevar="Year",
+                    varying = paste("Year", 1990:2007, sep="."))
>
> head(TB.long, 4)
```

```
                           Country Year Cases
Afghanistan.1990       Afghanistan 1990   168
Albania.1990               Albania 1990    25
Algeria.1990               Algeria 1990    38
American Samoa.1990 American Samoa 1990    21
```

```
> rownames(TB.long) <- NULL
> head(TB.long, 4)
```

```
         Country Year Cases
1    Afghanistan 1990   168
2        Albania 1990    25
3        Algeria 1990    38
4 American Samoa 1990    21
```