Data Visualization and Graphics in R

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December 6th, 2016

Outline

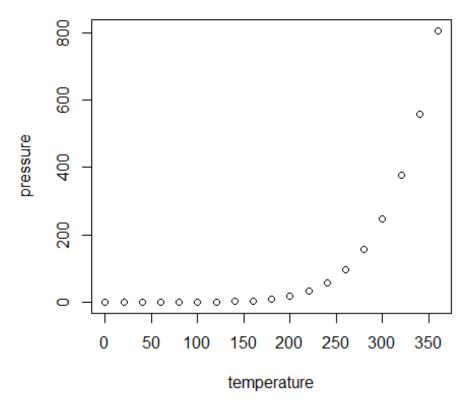
- Plotting using build in graphics tools in R
- Plotting with graphic packages in R (ggplot2)
- Visualizing data by different types of graphs in R (scatter plot, line graph, bar graph, histogram, boxplot, pie chart, heat map, Venn diagram, correlation plot)
- Generate and output polished graphs for publication and presentation

Why using R for plotting

- 1. When the large sample size exceed the capacity for excel, prism or other graphic tools
- 2. Fast and simple
- 3. Super easy with any modification
- Reproduce the figures and keep exact same format for new figures on new data
- 5. Bundle with complicated statistical analysis
- Many add-on packages for various needs beyond build in graphics tools

Basic Plot Example

data ()
str (pressure)
plot (pressure)



Labels and Axes

Default: R uses the variable names for axes labels and computes range for axes.

Manual change by:

axes labels: xlab, ylabsize of labels: cex.labaxes range: xlim, ylim

Titles

main: sets plot title (above plot)

• sub: sets subtitle (beneath plot)

Symbols, colors and lines

• type: "p" for points, "I" for lines, "b" for both, "h" for histogram-like

pch: point symbol

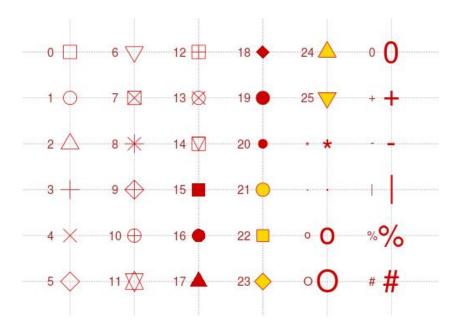
· col: color

cex: size factor

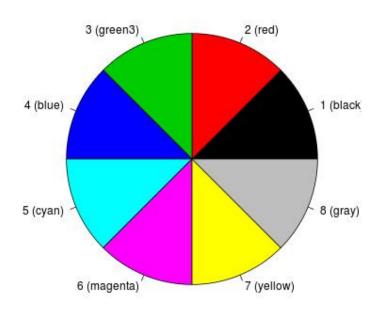
• Ity: line type

• lwd: line width

Plot symbols



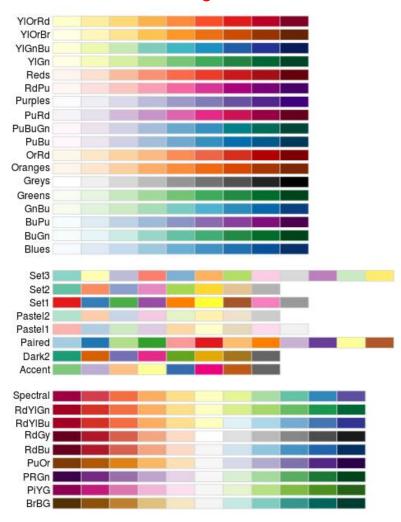
The default color palette in R:



R Color Palette other options

- rainbow(n)
- heat.colors(n)
- terrain.colors(n)
- topo.colors(n)
- cm.colors(n)

RcolorBrewer Package Palette



R color cheat sheet

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plot(pressure, col="#0000FF")
plot(pressure, col="blue")

Line Types

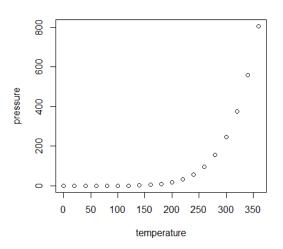
Line Types: Ity=

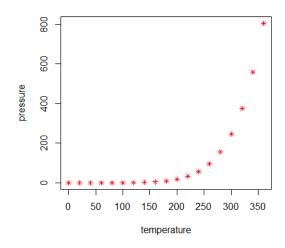


Plot example 1 plot points with formatting

plot (pressure, type="p")

plot (pressure, type="p", pch = 8, cex =0.8, col="red")

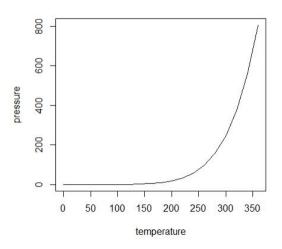


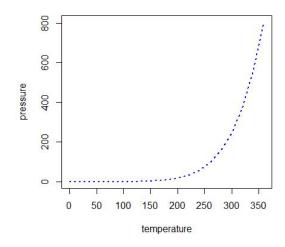


Plot example 2 line graph with formatting

plot (pressure, type="I")

plot (pressure, type="l", lty = 3, lwd =2, col="blue")

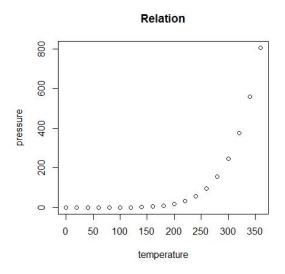


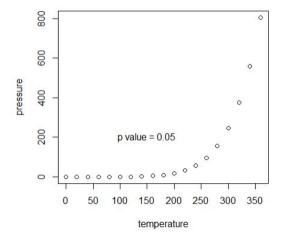


Plot example 3 add title and text

plot (pressure, main="Relation")

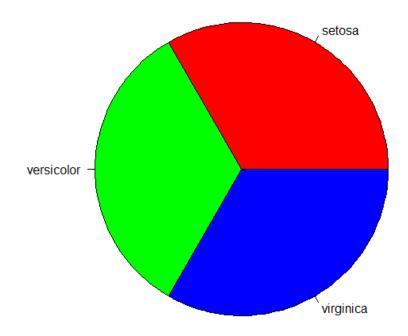
plot (pressure) text (150,200, label = "p value = 0.05")





Pie chart

Pie chart is used to visualize the composition of the data groups

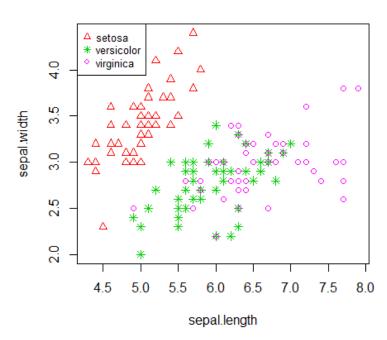


pie(table(iris\$Species), col=rainbow(3))

Plot for multiple group

```
data(iris) # load iris data
pch.vec <- c(2,8,21)[iris$Species]
col.vec <- c(2,3,6)[iris$Species]
plot(iris$Sepal.Length, iris$Sepal.Width, col = col.vec, pch=pch.vec, xlab="sepal.length", ylab="sepal.width",main="iris")
legend ("topleft", pch=c(2,8,21),col=c(2,3,6),legend = unique(iris$Species), cex=0.8)
```





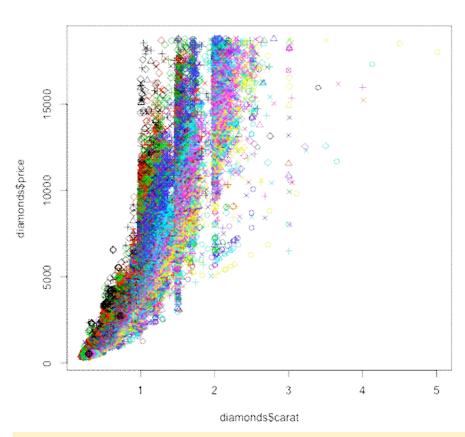
Beyond simple graphs: ggplot2

- Hadley Wickham's ggplot2 package provides a unified interface and simple set of options.
- Once you learn how ggplot2 works for one type of plot, you can easily apply the knowledge for any other types of plots
- It provides beautiful, publication ready results.
- Easy to plot for data with multiple groups and build legend automatically

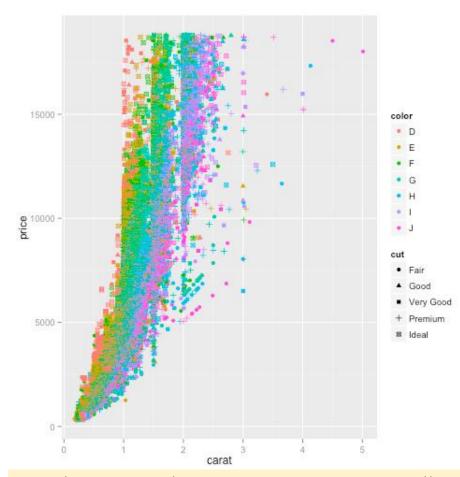
"R Graphics Cookbook by Winston Chang (O'Reilly). Copyright 2013 Winston Chang, 978-1-449-31695-2."

http://www.cookbook-r.com/Graphs/

Build-in R Plotting VS ggplot2



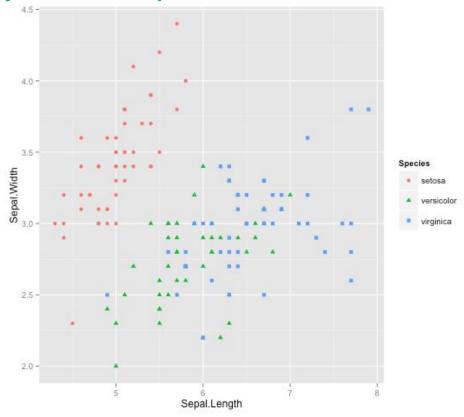
plot(diamonds\$carat, diamonds\$price, col = diamonds\$color,
 pch = as.numeric(diamonds\$cut))



ggplot(diamonds, aes(carat, price, col = color, shape = cut)) +
geom_point()

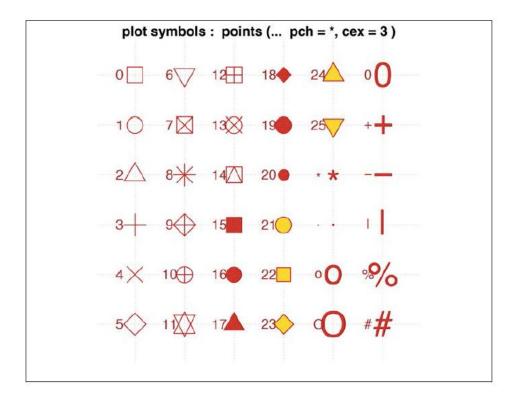
Scatter plot

display the relationship between two continuous variables



ggplot(iris, aes(x=Sepal.Length, y=Sepal.Width, shape=Species, colour=Species)) +
 geom_point()

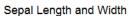
scale_shape_manual

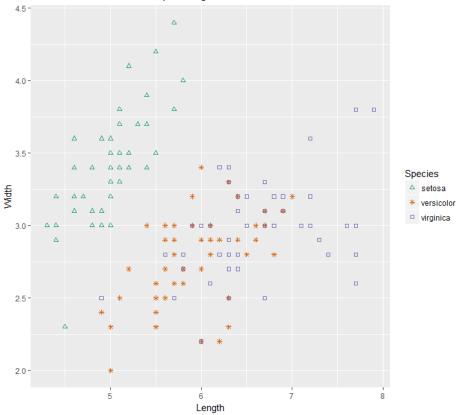


scale_colour_brewer



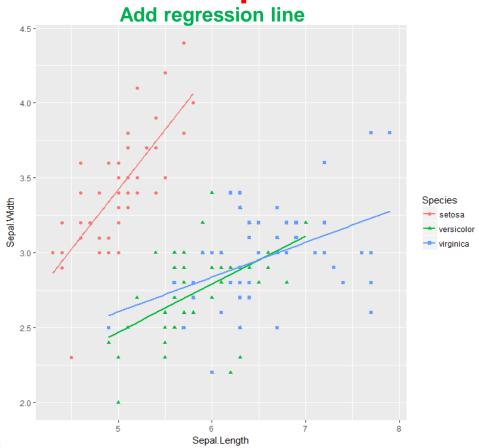
Scatter plot Change the points shape and color





```
ggplot(iris, aes(x=Sepal.Length, y=Sepal.Width, shape=Species, colour=Species)) + geom_point() +
scale_colour_brewer(palette="Dark2")+
scale_shape_manual(values=c(2,8,0))+
labs(x="Length",y="Width",title="Sepal Length and Width")+
theme(plot.title = element_text(hjust = 0.5))
```

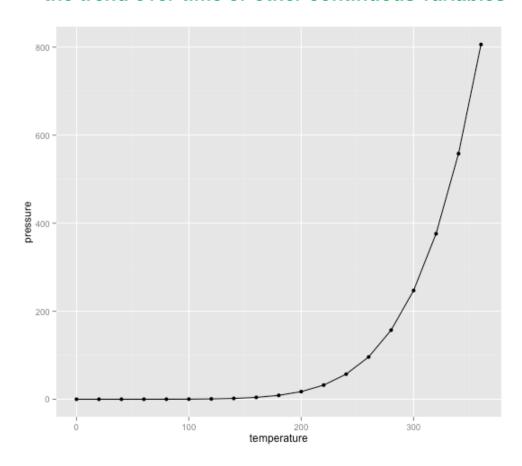
Scatter plot



ggplot(iris, aes(x=Sepal.Length, y=Sepal.Width, shape=Species, colour=Species)) +
 geom_point() +
 geom_smooth(method=lm, se=FALSE)

Line Graph

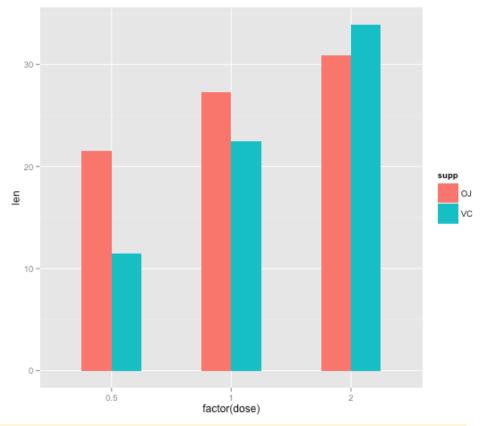
the trend over time or other continuous variables

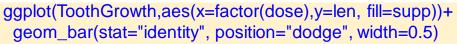


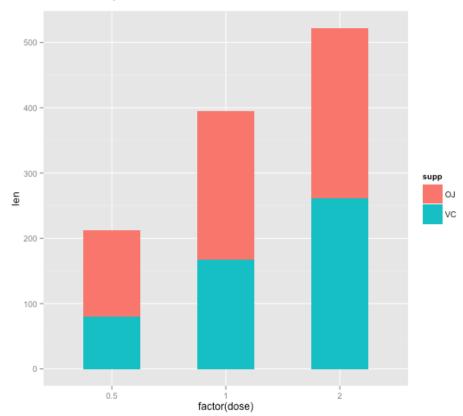
ggplot(pressure, aes(x=temperature, y=pressure)) + geom_line() + geom_point()

display numeric values (y-axis) for different categories (x-axis)

1. Bar graph for exact value for y

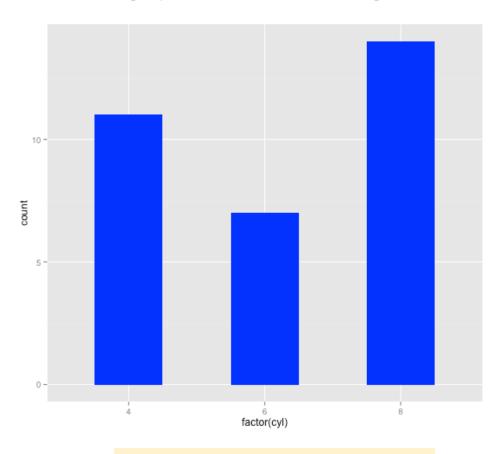






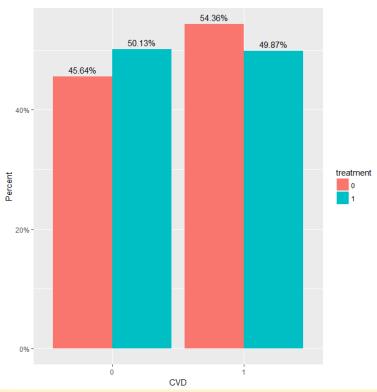
ggplot(ToothGrowth,aes(x=factor(dose),y=len, fill=supp))+
geom_bar(stat="identity", width=0.5)

2. bar graph for counts of a categorical variable



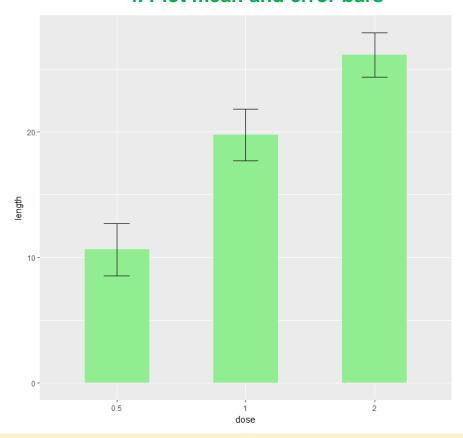
ggplot(mtcars, aes(x=factor(cyl))) +
geom_bar(fill="blue",width=0.5)

3. bar graph for percentage of a categorical variable



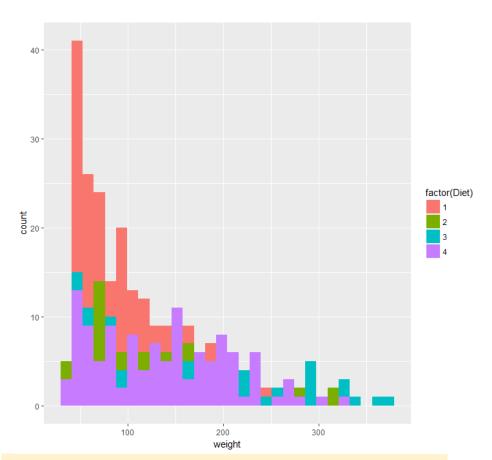
```
ggplot(dig, aes(x= factor(CVD), group=factor(TRTMT))) +
  geom_bar(aes(y = ..prop.., fill = factor(TRTMT)), stat="count", position="dodge")+
  geom_text(aes(label = scales::percent(..prop..), y= ..prop..),
      stat= "count",position=position_dodge(0.9), vjust = -.5) +
  labs(x="CVD",y = "Percent", fill="treatment") +
  scale_y_continuous(labels=scales::percent)
```

4. Plot mean and error bars

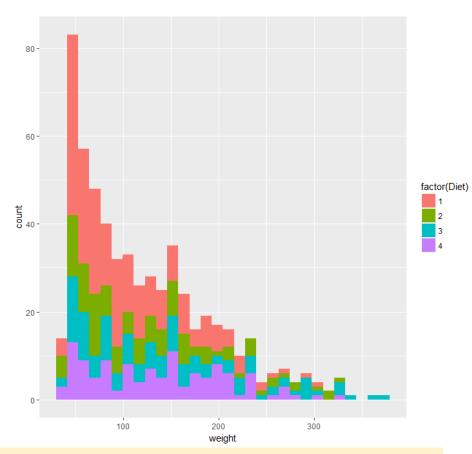


ggplot(ToothGrowth, aes(factor(dose), len)) +
 stat_summary(fun.y = mean, geom = "bar", width=0.5, fill="lightgreen") +
 stat_summary(fun.data = mean_cl_normal, geom = "errorbar", width=0.2)+
 labs(x="dose", y="length")

Visualize the distribution of data: I. histogram

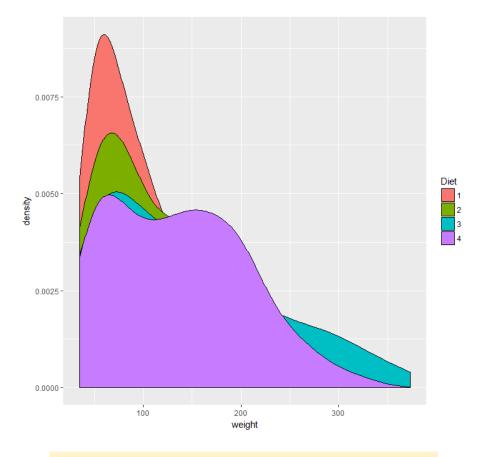


ggplot(ChickWeight, aes(x=weight, fill=factor(Diet))) +
geom_histogram(position="identity")



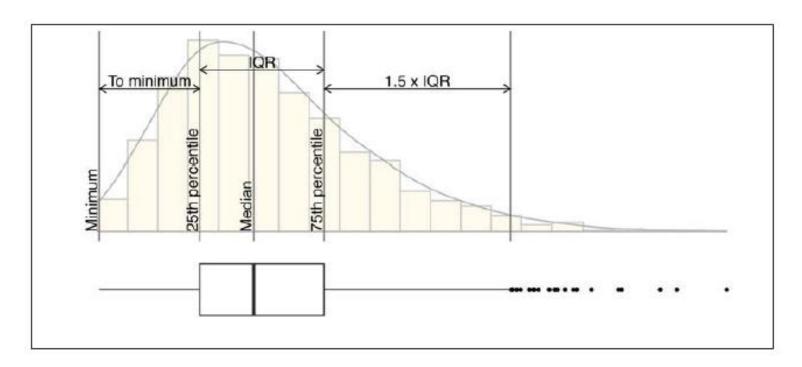
ggplot(ChickWeight, aes(x=weight, fill=factor(Diet))) +
geom_histogram()

Visualize the distribution of data: II. Density Curve

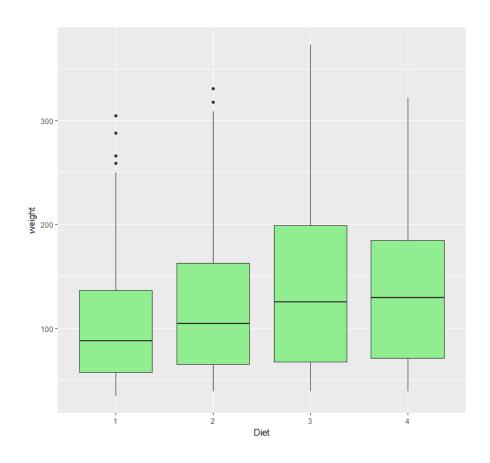


ggplot(ChickWeight, aes(x=weight, fill=Diet)) +
geom_density()

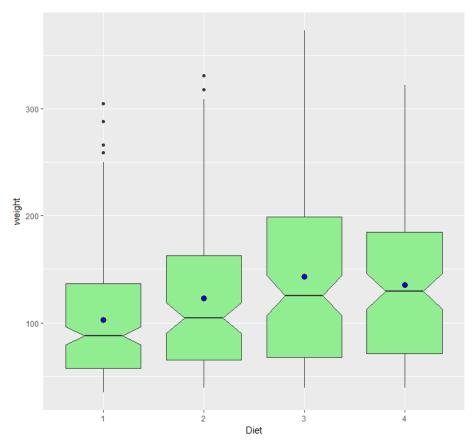
Transformation among histogram, density curve and boxplot



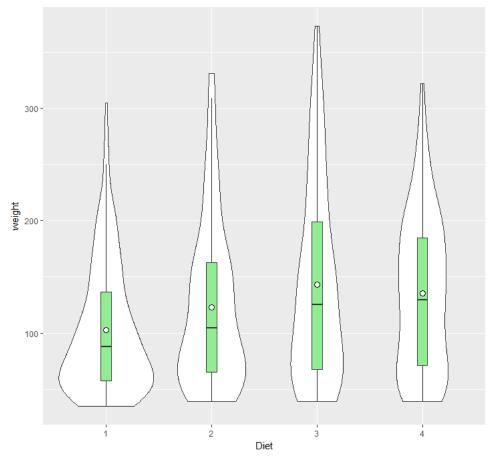
[&]quot;R Graphics Cookbook by Winston Chang (O'Reilly). Copyright 2013 Winston Chang, 978-1-449-31695-2."



ggplot(ChickWeight, aes(x=Diet, y=weight)) +
geom_boxplot(fill="lightgreen")

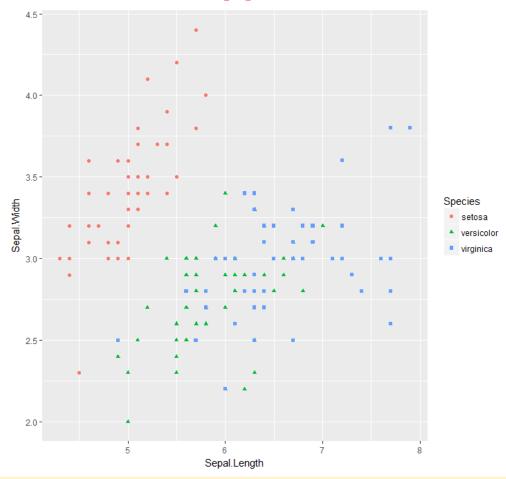


```
ggplot(ChickWeight, aes(x=Diet, y=weight)) +
geom_boxplot(fill="lightgreen",notch=TRUE)+
stat_summary(fun.y="mean",geom="point", fill="blue", shape=21, size=3)
```

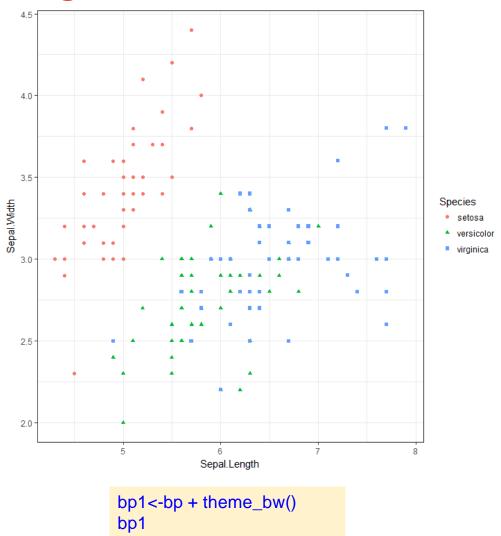


```
ggplot(ChickWeight, aes(x=Diet, y=weight)) +
geom_boxplot(notch=TRUE)+
stat_summary(fun.y="mean",geom="point", fill="blue", shape=21, size=3)
```

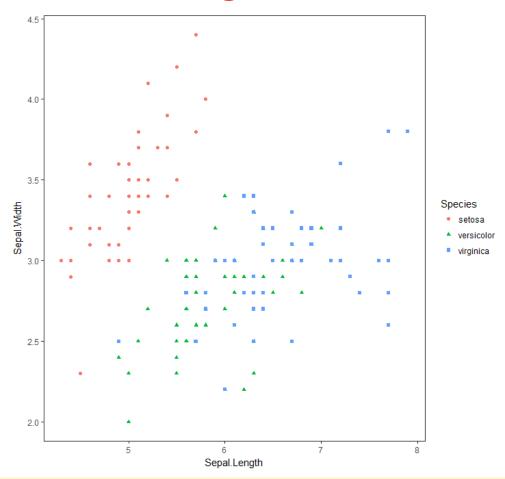
Change the overall appearance of the graph



Set background to be black and white

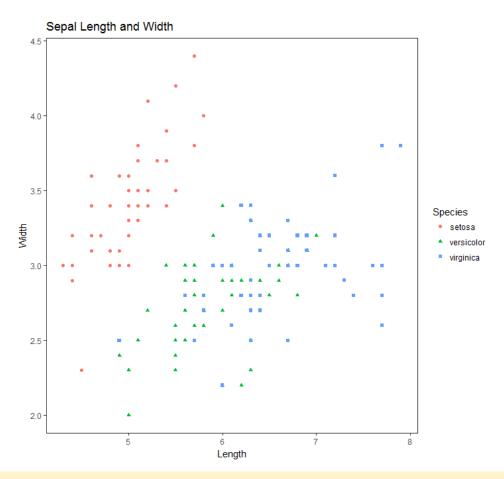


Remove grid lines



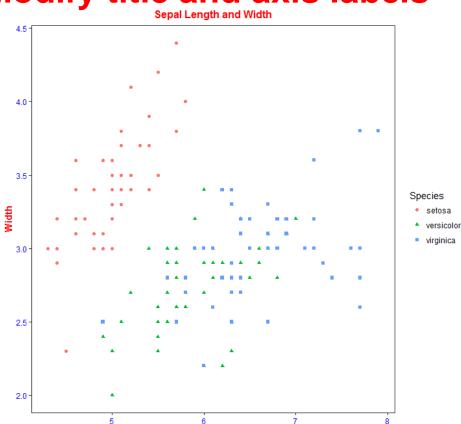
bp2<-bp1 + theme(panel.grid.major = element_blank(),panel.grid.minor = element_blank()) bp2

Add Labels



bp3<- bp2+labs(x="Length",y="Width",title="Sepal Length and Width") bp3

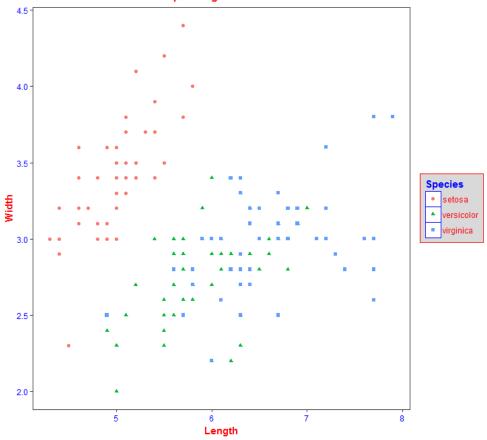
Modify title and axis labels



Length

Modify legend





bp4 +
theme(legend.background = element_rect(fill="grey85", colour="red", size=0.2),
legend.title = element_text(colour="blue", face="bold", size=11),
legend.text = element_text(colour="red"),
legend.key = element_rect(colour="blue", size=0.2))

Simplified code (plotting for single group)

Default tools in R	Scatter plot	ggplot
plot (x, y, type="p")		ggplot(data, aes(x= , y=,)) + geom_point()
	Line graph	
plot (x, y, type="l")		ggplot(data, aes(x= , y=,)) + geom_line()
	Bar graph	
barplot(x=table(x))		<pre>ggplot(data, aes(x=factor())) + geom_bar()</pre>
	Histogram	
hist(x)		ggplot(data, aes(x=)) + geom_histogram()
	Boxplot	
boxplot(data=data, y~x)		<pre>ggplot(data, aes(x=factor(),y=)) + geom_boxplot()</pre>

Simplified code (plotting for multiple groups)

Scatter plot

```
ggplot(data, aes(x= , y=, shape=factor(group), colour=factor(group))) +
  geom_point()
```

Bar graph

```
ggplot(data, aes(x=factor(), fill=factor(group))) +
  geom_bar(postion="dodge")
```

Histogram

```
ggplot(data, aes(x=,fill=factor(group))) +
  geom_histogram(position ="identity")
```

Density Curve

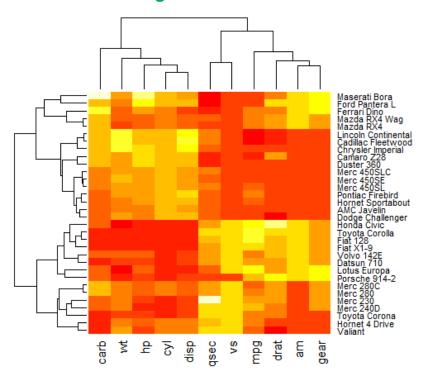
```
ggplot(data, aes(x=,fill=factor(group))) +
  geom_density()
```

Boxplot

```
ggplot(data, aes(x=factor(),y=, fill=factor(group))) +
  geom_boxplot()
```

Heatmap

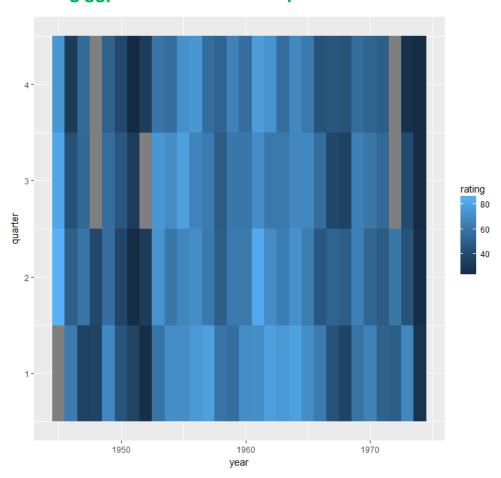
Heat maps are used to visualize the level of signal of one variable across different time point or other groups



scale data to mean=0, sd=1 and convert to matrix
mtscaled <- as.matrix(scale(mtcars))
create heatmap and don't reorder columns
heatmap(mtscaled, Colv=F, scale='none')</pre>

Heatmap

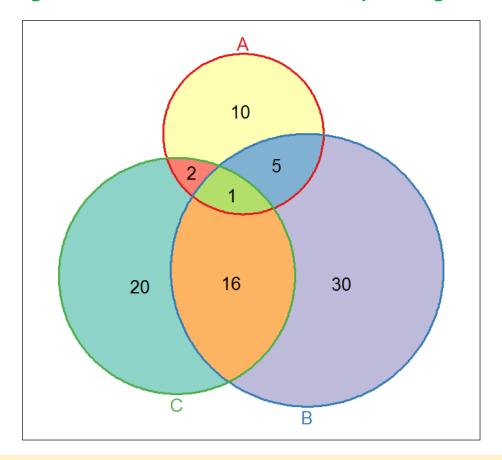
Using ggplot2 to draw heat map on time series data



ggplot(pres_rating, aes(x=year, y=quarter, fill=rating))+geom_tile()

Venn Diagram

Venn diagrams are used to check the overlap among different groups

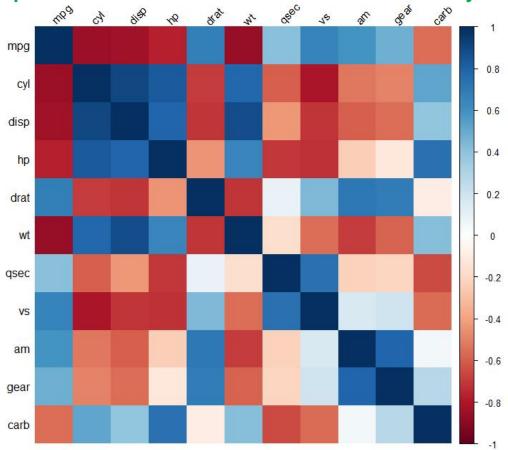


library(Vennerable)

V <- Venn(SetNames=c('A','B','C'),Weight=c(0,10,30,5,20,2,16,1)) plot(V, doWeights=TRUE,type='circles')

Correlation Plot

Correlation plot is used to check the association or similarity among variables



mcor<-cor(mtcars)
library(corrplot)
corrplot(mcor, method="shade", shade.col=NA, tl.col="black", tl.srt=45)

Output for publication or presentation

Output to PNG: png("myplot-%d.png", width=400, height=400)
plot(mtcars\$wt, mtcars\$mpg)
ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point()
dev.off()

Output to TIFF: tiff("myplot-%d.tiff", width=400, height=400)
plot(mtcars\$wt, mtcars\$mpg)
ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point()
dev.off()

Output to PDF: pdf("myplot.pdf", width=4, height=4)
plot(mtcars\$wt, mtcars\$mpg)
ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point()
dev.off()

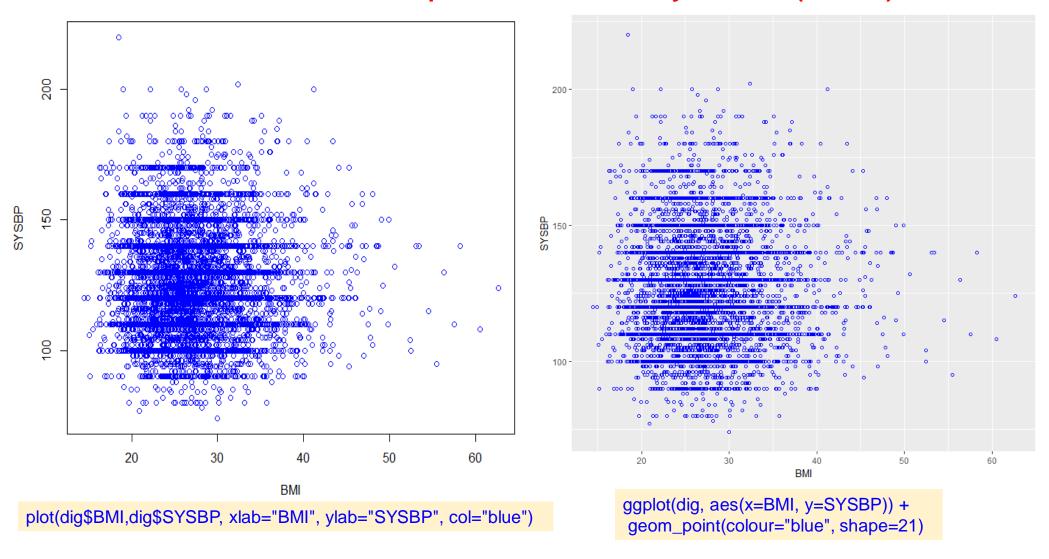
Output to postscript: postscript("myplot.eps", width=4, height=4)
plot(mtcars\$wt, mtcars\$mpg)
ggplot(mtcars, aes(x=wt, y=mpg)) + geom_point()
dev.off()

Note: dev .off () is to let R know you're finished with plotting commands and it can output the file.

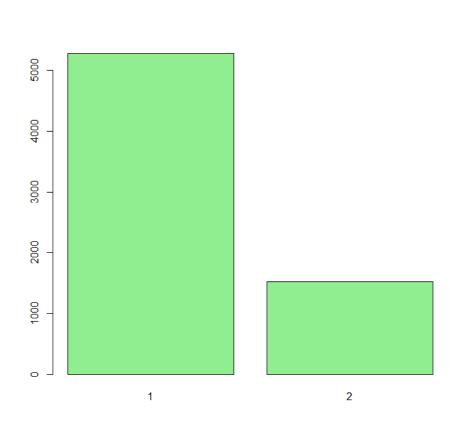
Practice Session

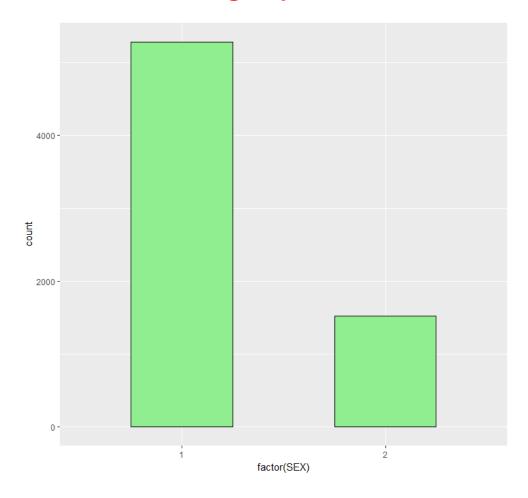
- 1. An R script that includes all the code covered in this presentation is provided with detailed step-wise annotation and you will go over all the plots during the first half of the practice session.
- 2. You will try to answer a list of five questions and draw plots to visualize the practicing clinical trial DIG NHLBT Teaching data set

Q1: Check the relationship between BMI and Systolic BP (SYSBP)



Q2: Plot the number of patients for different SEX groups

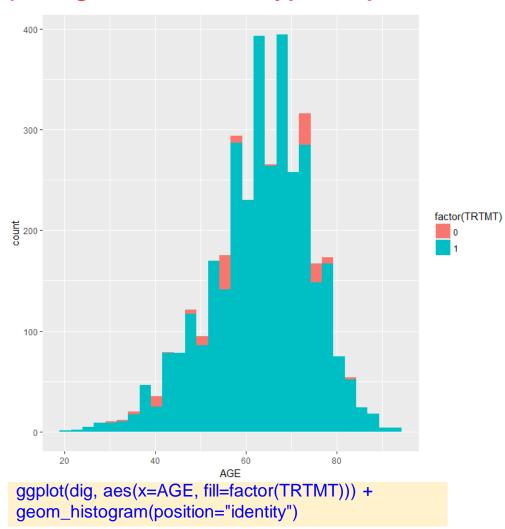




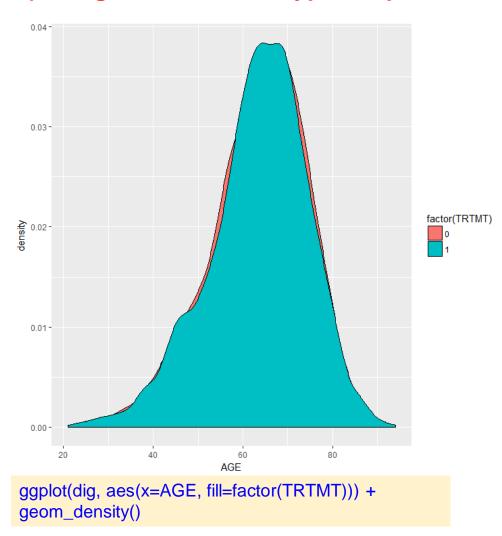
barplot(table(dig\$SEX), col="lightgreen")

ggplot(dig, aes(x=factor(SEX))) +
geom_bar(colour="black", fill="lightgreen", width=0.5)

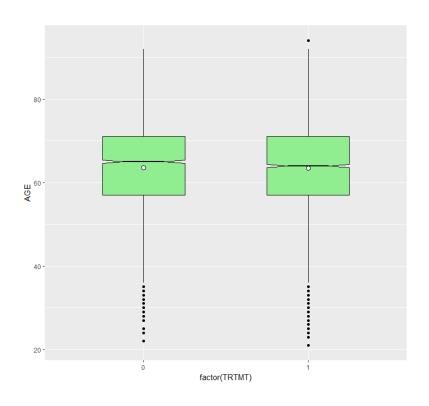
Q3: Use ggplot to check the distribution of AGE in different treatment groups (TRTMT) using three different types of plots - histogram

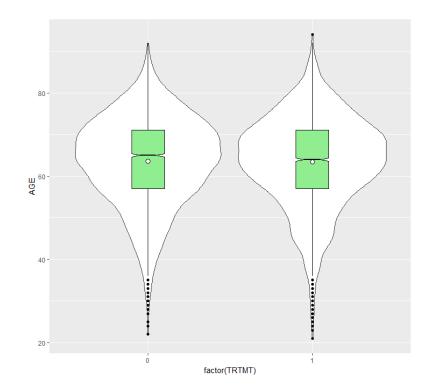


Q3: use ggplot to check the distribution of AGE in different treatment groups (TRTMT) using three different types of plots – density curve



Q3: use ggplot to check the distribution of AGE in different treatment groups (TRTMT) using three different types of plots – boxplot

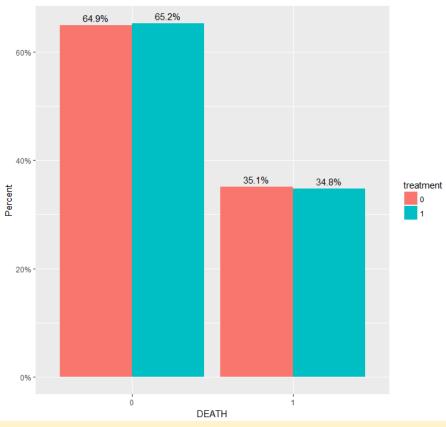




ggplot(dig, aes(x=factor(TRTMT), y=AGE)) +
geom_boxplot(notch=TRUE, width=0.5, colour="black", fill="lightgreen") +
stat_summary(fun.y="mean",geom="point", fill="white", shape=21, size=3)

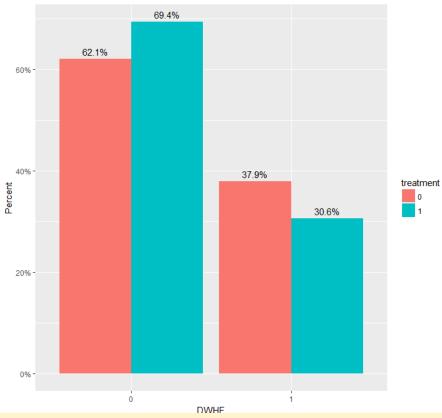
ggplot(dig, aes(x=factor(TRTMT), y=AGE)) + geom_violin() +
geom_boxplot(notch=TRUE, width=0.2, colour="black", fill="lightgreen")+
stat_summary(fun.y="mean",geom="point", fill="white", shape=21, size=3)

Q4. A. plot the percentage of DEATH in different treatment groups (TRTMT)



```
ggplot(dig, aes(x= factor(DEATH), group=factor(TRTMT))) +
  geom_bar(aes(y = ..prop.., fill = factor(TRTMT)), stat="count", position="dodge")+
  geom_text(aes( label = scales::percent(..prop..), y= ..prop.. ), stat= "count",position=position_dodge(0.9),
  vjust = -.5) +
  labs(x="DEATH",y = "Percent", fill="treatment") +
  scale_y_continuous(labels=scales::percent)
```

Q4. B. plot the percentage of death attributed to worsening heart failure (DWHF) in different treatment groups (TRTMT)



```
ggplot(dig, aes(x= factor(DWHF), group=factor(TRTMT))) +
  geom_bar(aes(y = ..prop.., fill = factor(TRTMT)), stat="count", position="dodge")+
  geom_text(aes( label = scales::percent(..prop..), y= ..prop.. ), stat= "count",position=position_dodge(0.9),
  vjust = -.5) +
  labs(x="DWHF",y = "Percent", fill="treatment") +
  scale_y_continuous(labels=scales::percent)
```

Q5 take plot from Q4b, try to polish the graph

```
Q4B<-ggplot(dig, aes(x= factor(DWHF), group=factor(TRTMT))) +
geom_bar(aes(y = ..prop.., fill = factor(TRTMT)), stat="count", position="dodge")+
geom_text(aes( label = scales::percent(..prop..), y= ..prop.. ), stat=
"count",position=position_dodge(0.9), vjust = -.5) +
labs(x="DWHF",y = "Percent", fill="treatment") +
scale_y_continuous(labels=scales::percent)
Q4B+
theme bw()+
theme(panel.grid.major = element blank(),panel.grid.minor = element blank())+
labs(x="DWHF", y="Percentage", title="Percentage of DWHF in Different Treatment
Group") +
theme(axis.title.x = element_text(colour="red", size=11,face="bold"),
    axis.text.x = element_text(colour="blue"),
    axis.title.y = element_text(colour="red", size=11,face="bold", angle = 90),
    axis.text.y = element_text(colour="blue"),
    plot.title = element text(colour="red", size=12, face="bold", hjust=0.5)) +
theme(legend.background = element rect(fill="grey85", colour="red", size=0.2),
    legend.title = element_text(colour="blue", face="bold", size=11),
    legend.text = element_text(colour="red"))
```

Percentage of DWHF in Different Treatment Group

