Data Visualization

Lecture 5
Mathamatics Visualization

Phuc Loi Luu, PhD
p.luu@garvan.org.au
luu.p.loi@googlemail.com

Content

Plot a mathmatics graph

- Calculus and Gradient Descent
- Linear Algebra
- Statistics

Defining a Function in R (1)

- Example 1: define a function fahrenheit_to_celsius that converts temperatures from Fahrenheit to Celsius:

```
fahrenheit_to_celsius <- function(temp_F) {
  temp_C <- (temp_F - 32) * 5 / 9
  return(temp_C)
}
fahrenheit_to_celsius(32)
fahrenheit_to_celsius(212)
```

```
> fahrenheit_to_celsius <- function(temp_F) {
  temp_C <- (temp_F - 32) * 5 / 9
  return(temp_C)
}
> fahrenheit_to_celsius(32)
[1] 0
> fahrenheit_to_celsius(212)
[1] 100
```

https://swcarpentry.github.io/r-novice-inflammation/02-func-R/

Defining a Function in R (2)

- Example 2: define a function SumNum that add all the digits of a number, i.e SumNum(3)=1+2+3=6:

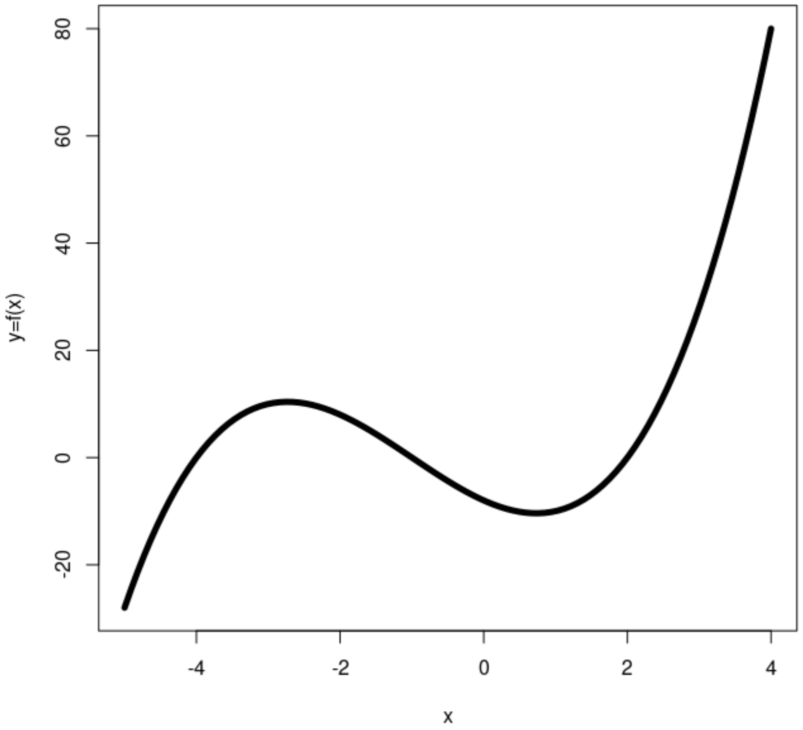
```
SumNum(num) {
  }
SumNum(10)
```

Calculus (1)

- Plot the polynomial function

$$y = f(x) = x^3 + 3x^2 - 6x - 8$$

```
# Define a function
f <- function(x) (x^3 + 3 * x^2 - 6 * x - 8)
# plot the curve
curve(f, from=-5, to=4, ylab = "y=f(x)", lwd=5)
```



https://rpubs.com/wkmor1/simple-derivatives-in-r

Calculus (2)

- Plot the polynomial function

$$y = f(x) = x^3 + 3x^2 - 6x - 8$$

```
# Define a function
f <- function(x) (x^3 + 3 * x^2 - 6 * x - 8)
# plot the curve
curve(f, from=-50, to=40, ylab = "y=f(x)", lwd=5)
```

https://rpubs.com/wkmor1/simple-derivatives-in-r

Calculus (3)

Differentiate a function

$$y = f(x) = x^3 + 3x^2 - 6x - 8$$

The first derivative of y

$$y' = 3x^2 + 6x - 6$$

 # Differentiate a function
 # define function g which is the derivative of f(x)
g <- function(x) {}
body(g) <- D(body(f), 'x')
 # The derivative of f(x) is: body(g)

```
> g
function (x)
3 * x^2 + 3 * (2 * x) - 6
> body(g)
3 * x^2 + 3 * (2 * x) - 6
```

https://rpubs.com/wkmor1/simple-derivatives-in-r

Calculus (4)

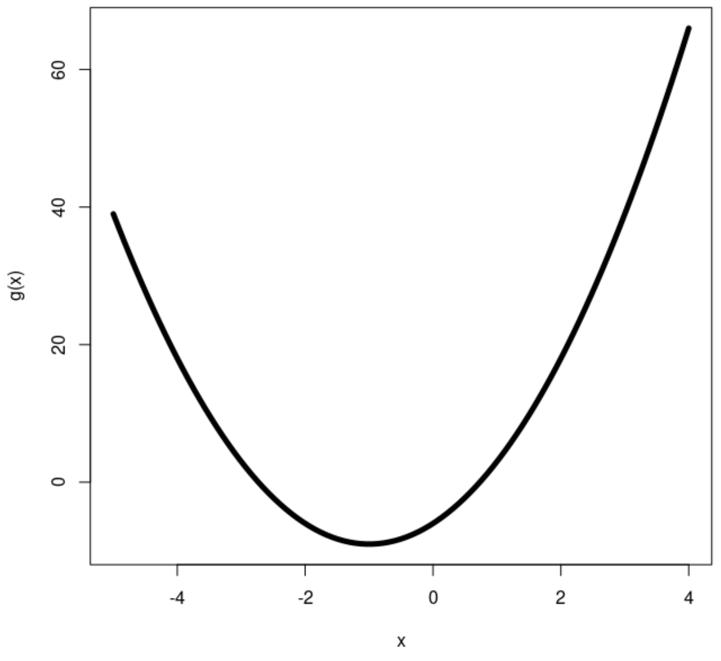
Differentiate a function

$$y = f(x) = x^3 + 3x^2 - 6x - 8$$

The first derivative of y

$$y' = 3x^2 + 6x - 6$$

Plot *y'*




```
# Differentiate a function
# define function g which is the derivative of f(x)
g <- function(x) {}
body(g) <- D(body(f), 'x')
# Plot the derivative.
curve(g, -5, 4, ylab = "g(x)", lwd=5)
```

https://rpubs.com/wkmor1/simple-derivatives-in-r

Calculus (5)

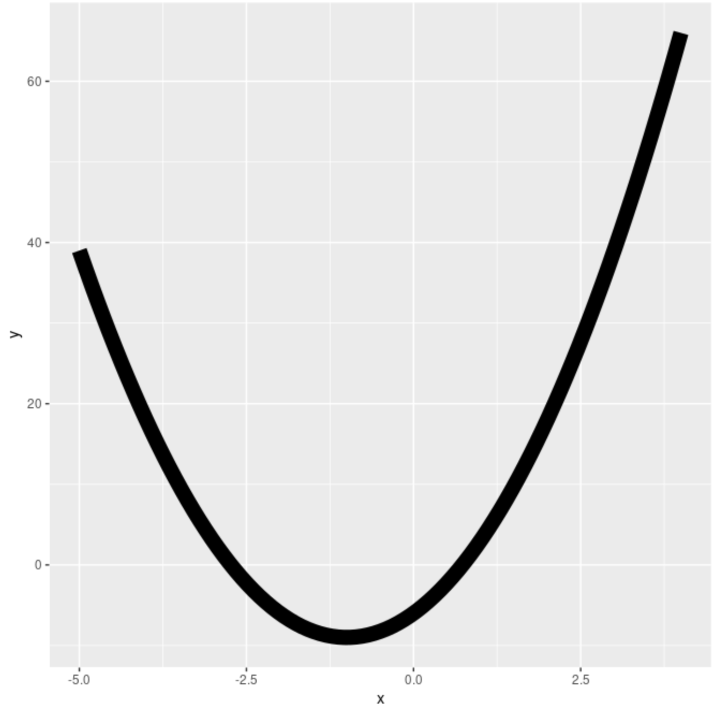
Differentiate a function

$$y = f(x) = x^3 + 3x^2 - 6x - 8$$

The first derivative of y

$$y' = 3x^2 + 6x - 6$$

Plot *y'* in ggplot



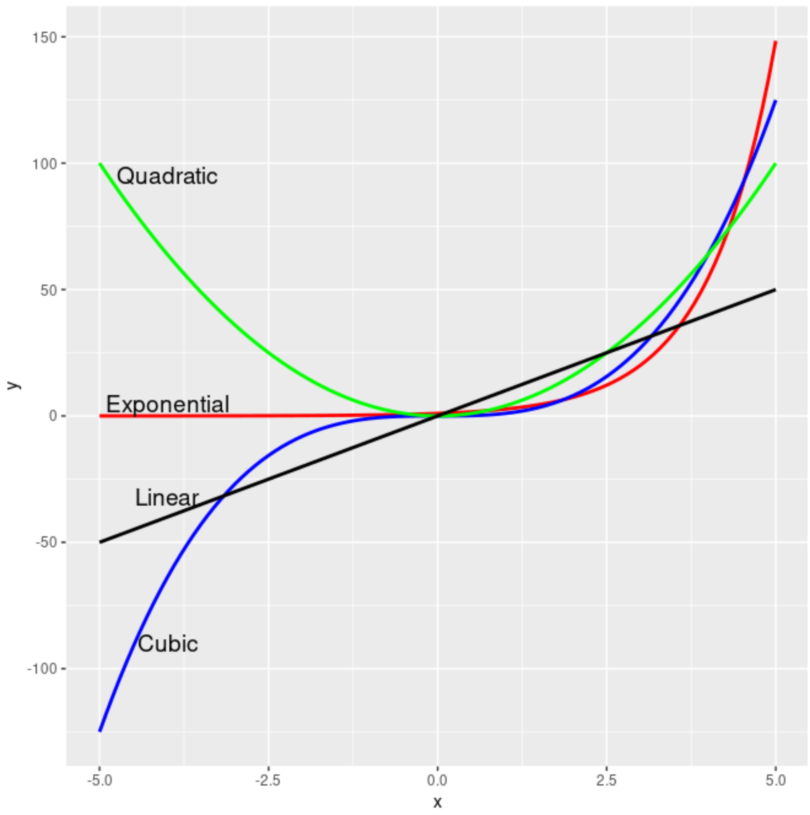

```
library(ggplot2)
# Plot the derivative.
ggplot(data.frame(x = c(-5, 4)), aes(x = x)) +
        stat_function(fun = g, lwd=5)
```

https://rpubs.com/wkmor1/simple-derivatives-in-r

Calculus (6)

Differentiate a function

$$y = e^x$$
$$y = x^3$$
$$y = 4x^2$$
$$y = 10x$$




```
# Draw multiple functions function in one plot
four_curves <- ggplot(data.frame(x = c(-5, 5)), aes(x = x)) +
        stat_function(fun = exp, color="red", lwd = 1) +
        stat_function(fun = function(x){x^3}, color="blue", lwd = 1) +
        stat_function(fun = function(x){4*x^2}, color="green", lwd = 1) +
        stat_function(fun = function(x){10*x}, color="black", lwd = 1) +
        annotate(geom="text", label = "Exponential", x = -4, y = 5, size =5) +
        annotate(geom="text", label = "Quadratic", x = -4, y = 95, size =5) +
        annotate(geom="text", label = "Cubic", x = -4, y = -90, size =5) +
        annotate(geom="text", label = "Linear", x = -4, y = -32, size =5)

four_curves
```

https://www.youtube.com/watch?v=x7OXp3KvynU&t=31s

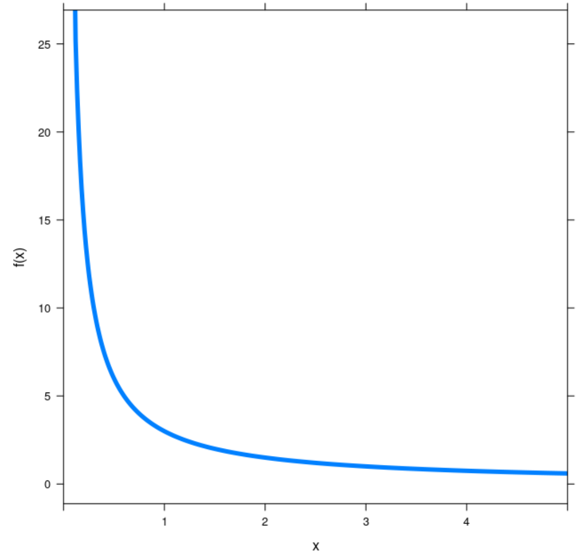
Calculus plot with mosaicCalc

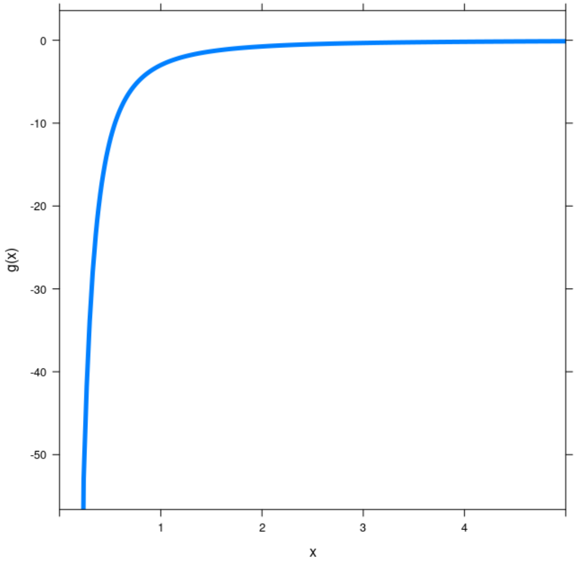
Plot the function y and its first derivative

$$y = \frac{3}{x}$$

```
library(mosaic)
library(mosaicCalc)

# plot derivative function of y = 3/x
# define function
f <- makeFun(a / x ~ x, a = 3)
# plot f
plotFun(f, xlim=c(0,5), lwd=5)
# cal derivative of f
g <- D(a / x ~ x, a = 3)
# plot g
plotFun(g, xlim=c(0,5), lwd=5)
```





https://cran.r-project.org/web/packages/mosaicCalc/vignettes/Calculus_with_R.html

Calculus: parabola, tangent and secant

Plot the parabola p: $y = x^2$

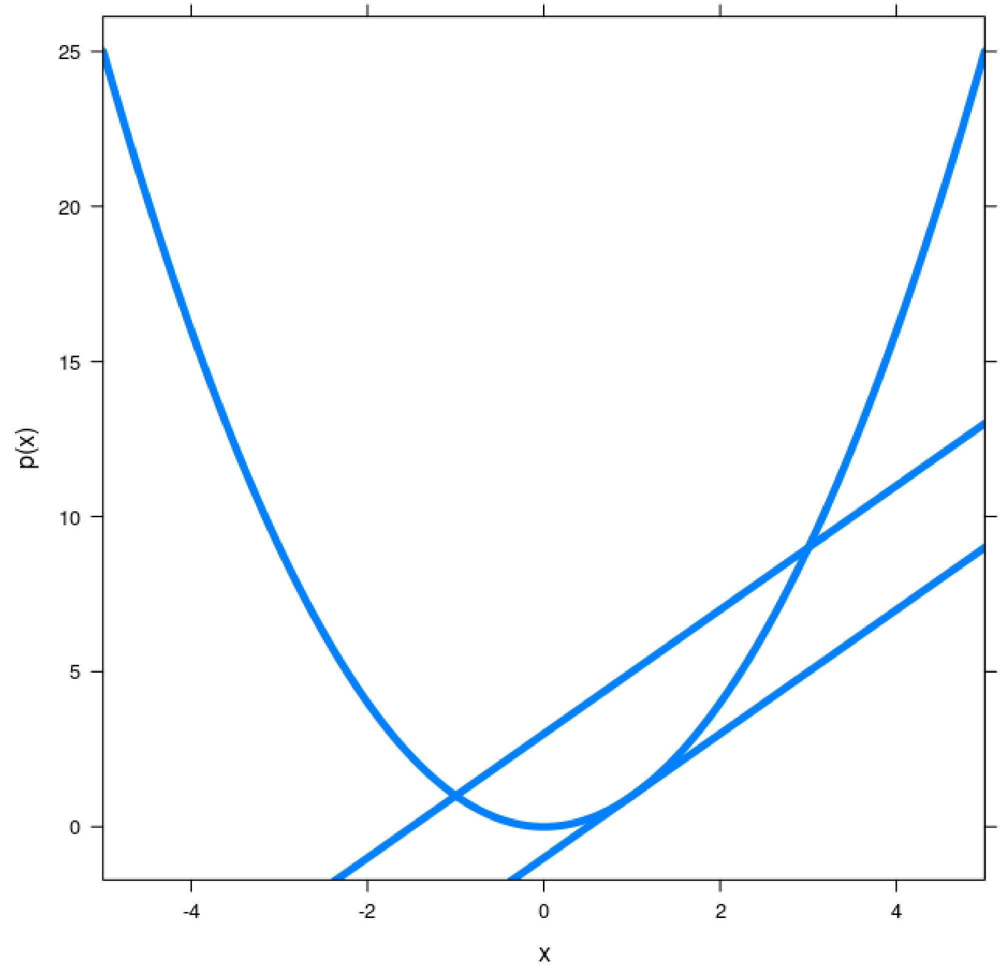
Plot the line d1: $y = 2x - 1$

Plot the line d2: $y = 2x + 3$

```
library(mosaic)
library(mosaicCalc)

# define function
p <- makeFun(x^2 + a ~ x, a = 0)
d1 <- makeFun(2*x + a ~ x, a = -1)
d2 <- makeFun(2*x + a ~ x, a = 3)

# plot p and d
plotFun(p, xlim=c(-5,5), lwd=5)
plotFun(d1, xlim=c(-5,5), lwd=5, add=T)
plotFun(d2, xlim=c(-5,5), lwd=5, add=T)
```



Calculus: min and max

Plot the parabola p: $y = x^2 - 2x + 2$

Calculate the first derivative of y

Plot y' in the same plot with p

```
library(mosaic)
library(mosaicCalc)

# define function
p <- makeFun(x^2 + a ~ x, a = 0)
d1 <- makeFun(2*x + a ~ x, a = -1)

# plot p and d
plotFun(p, xlim=c(-5,5), lwd=5)
plotFun(d1, xlim=c(-5,5), lwd=5, add=T)
```

Calculus: Gradient Descent

$$\hat{f}(x) = \min_{x} x^2 - 2x + 2$$

1) Take the derivative of the function
2) Study the derivative at the point we guessed (x=3)

$$x_{i+1} = x_i - \alpha f'(x_i)$$

3) Update n times (n=10) step 2)