Exploratory Statistical Data Analysis With R Software (ESDAR)

Swayam Prabha

Lecture 6

Operations with Matrices in R

Shalabh

Department of Mathematics and Statistics

Indian Institute of Technology Kanpur

Slides can be downloaded from

http://home.iitk.ac.in/~shalab/sp

Matrix

A matrix is a rectangular array with *p* rows and *n* columns.

An element in the *i*-th row and *j*-th column is denoted by X_{ij} (book version) or *X*[*i*, *j*] ("program version"), *i* = 1,2,...,*n*, *j* = 1,2,...,*p*.

We consider only numerical matrices, whose elements are generally real numbers.

Matrix

In R, a 4 × 2-matrix *X* can be created with a following command:

```
> x = matrix( nrow=4, ncol=2, data=c(11,12,13,
14,15,16,17,18) )
> x
     [,1] [,2]
[1,]   11   15
[2,]   12   16
[3,]   13   17
[4,]   14   18
```

Matrix

We see:

- **The parameter `nrow` defines the row number of a matrix.**

- **The parameter `ncol` defines the column number of a matrix.**

- **The parameter `data` assigns specified values to the matrix elements.**

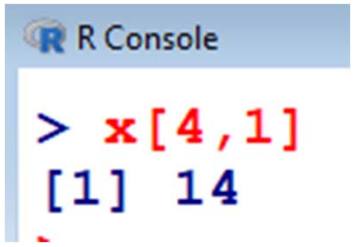
- **The values from the parameters are written column-wise in matrix.**

Matrix

```
> x
     [,1] [,2]
[1,]   11   15
[2,]   12   16
[3,]   13   17
[4,]   14   18
```

One can access a single element of a matrix with `x[i,j]`:

```
> x[4,1]
[1] 14
```

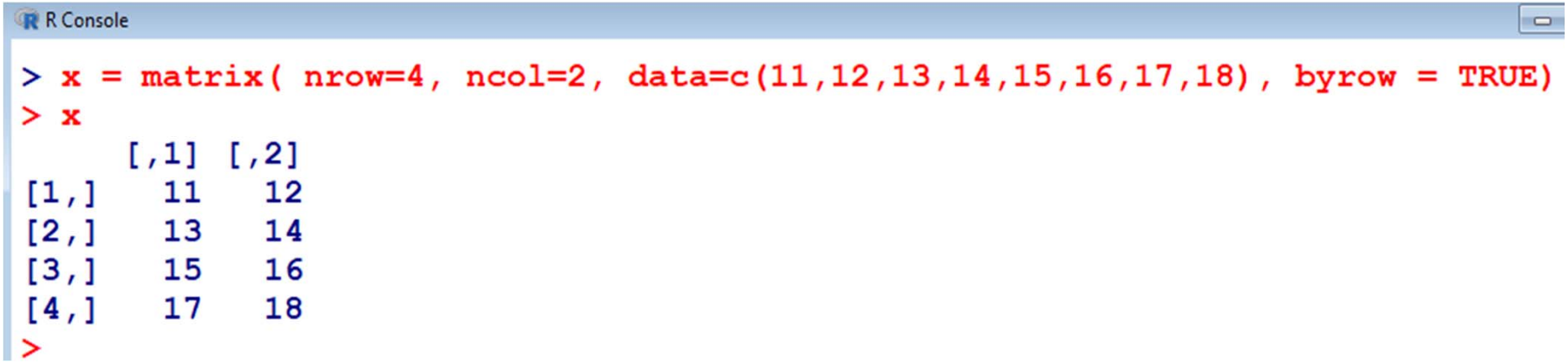


Matrix

In case, the data has to be entered row wise, then a 4 × 2-matrix *X* can be created with

```
> x = matrix( nrow=4, ncol=2,
data=c(11,12,13,14,15,16,17,18), byrow = TRUE)
> x
     [,1]  [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
>
```

Matrix


R Console
> x = matrix(nrow=4, ncol=2, data=c(11,12,13,14,15,16,17,18), byrow = TRUE)
> x
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
>

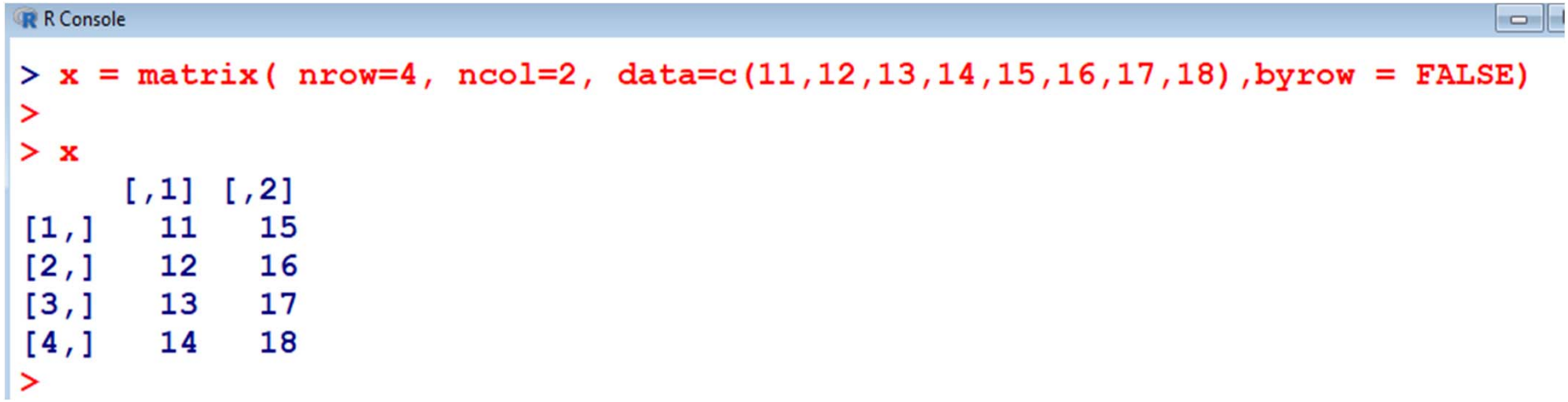
Matrix

In case, the data has to be entered column wise, then a 4 × 2-matrix

***X* can be created with**

```
x = matrix( nrow=4, ncol=2,
data=c(11,12,13,14,15,16,17,18),byrow = FALSE)
> x
     [,1]  [,2]
[1,]   11   15
[2,]   12   16
[3,]   13   17
[4,]   14   18
```

Matrix


R Console
> x = matrix(nrow=4, ncol=2, data=c(11,12,13,14,15,16,17,18),byrow = FALSE)
>
> x
     [,1] [,2]
[1,]   11   15
[2,]   12   16
[3,]   13   17
[4,]   14   18
>

Matrix

Transpose of a matrix *X*: *X'*

Consider the matrix

$$x = \begin{pmatrix} 11 & 15 \\ 12 & 16 \\ 13 & 17 \\ 14 & 18 \end{pmatrix}$$

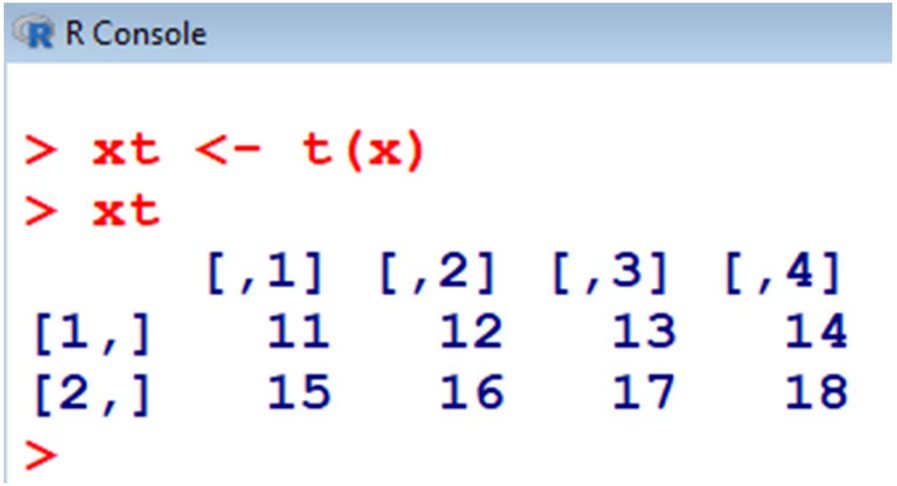
```
> x = matrix( nrow=4, ncol=2, data=c(11,12,13,14,
15,16,17,18), byrow = FALSE)

> x
     [,1]  [,2]
[1,]   11   15
[2,]   12   16
[3,]   13   17
[4,]   14   18
```

Matrix

Transpose of a matrix *X*: *X'*

```
> xt <- t(x)
> xt
     [,1]   [,2]   [,3]   [,4]
[1,]   11     12     13     14
[2,]   15     16     17     18
```

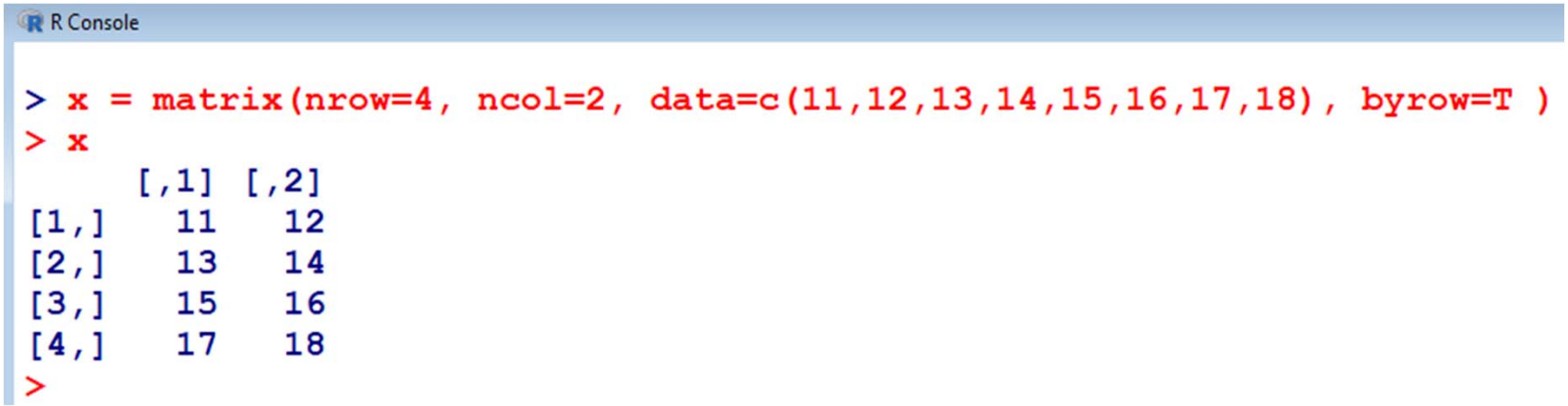


Matrix

Multiplication of a matrix with a constant

```
> x = matrix(nrow=4, ncol=2,
data=c(11,12,13,14,15,16,17,18), byrow=T )

> x
     [,1]  [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
```



Matrix

Multiplication of a matrix with a constant

```
> x = matrix(nrow=4, ncol=2,
data=c(11,12,13,14,15,16,17,18), byrow=T )
> x
     [,1]   [,2]
[1,]   11     12
[2,]   13     14
[3,]   15     16
[4,]   17     18
> 4*x
     [,1] [,2]
[1,]   44   48
[2,]   52   56
[3,]   60   64
[4,]   68   72
```

Matrix

Multiplication of a matrix with a constant

R Console

```
> x = matrix(nrow=4, ncol=2, data=c(11,12,13,14,15,16,17,18), byrow=T )
> x
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
>
> 4*x
     [,1] [,2]
[1,]   44   48
[2,]   52   56
[3,]   60   64
[4,]   68   72
>
```

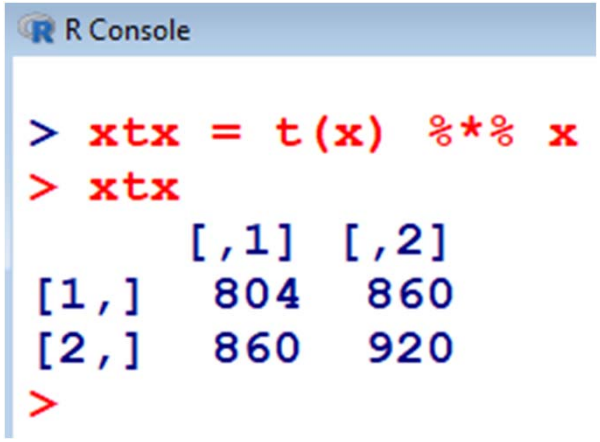
Matrix

Matrix multiplication: operator %*%

Consider the multiplication of *X*' with *X*

```
> xtx = t(x) %*% x

> xtx
      [,1]  [,2]
[1,]  804   860
[2,]  860   920
```



Matrix

Matrix multiplication: operator %*%

```
> y = matrix(nrow=2, ncol=2,
data=c(11,12,13,14), byrow=T )

> z = matrix(nrow=2, ncol=2, data=c(21,22,23,
24), byrow=T )
```

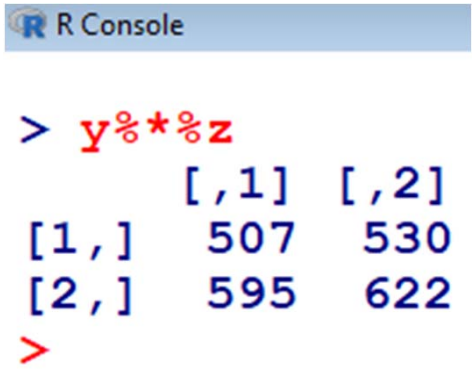
```
> y
     [,1] [,2]
[1,]   11   12
[2,]   13   14
```

```
> z
     [,1] [,2]
[1,]   21   22
[2,]   23   24
```

Matrix

Matrix multiplication: operator %*%

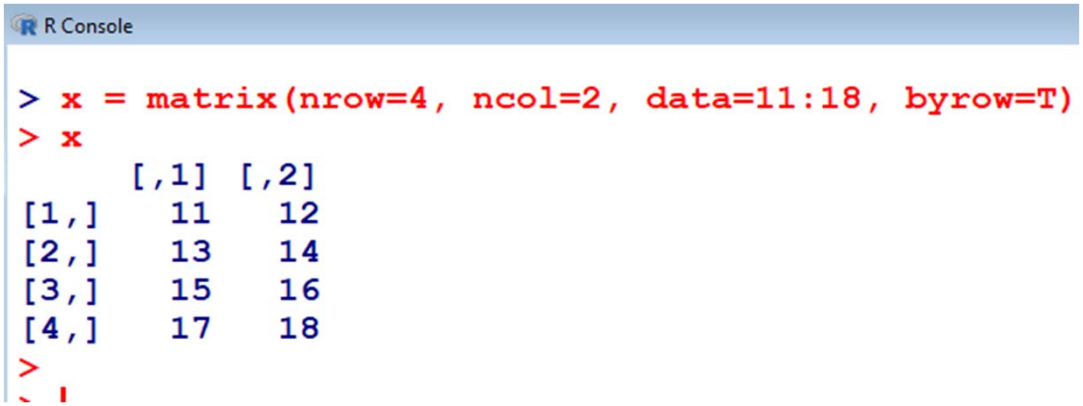
```
> y%*%z
     [,1] [,2]
[1,]  507  530
[2,]  595  622
```



Matrix

Addition and subtraction of matrices (of same dimensions) can be executed with the usual operators + and -

```
> x = matrix(nrow=4, ncol=2, data=11:18,
  byrow=T)
> x
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
```

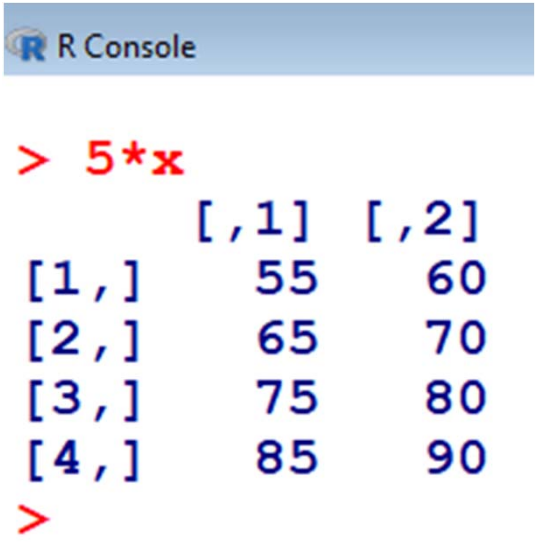


Matrix

Addition and subtraction of matrices (of same dimensions!) can be executed with the usual operators + and -

Create another matrix.

```
> 5*x
     [,1] [,2]
[1,]   55   60
[2,]   65   70
[3,]   75   80
[4,]   85   90
```

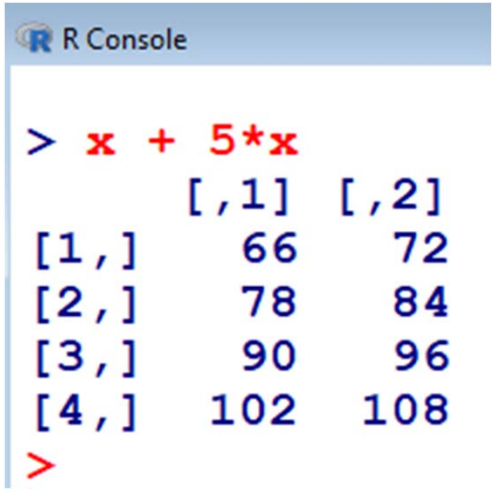


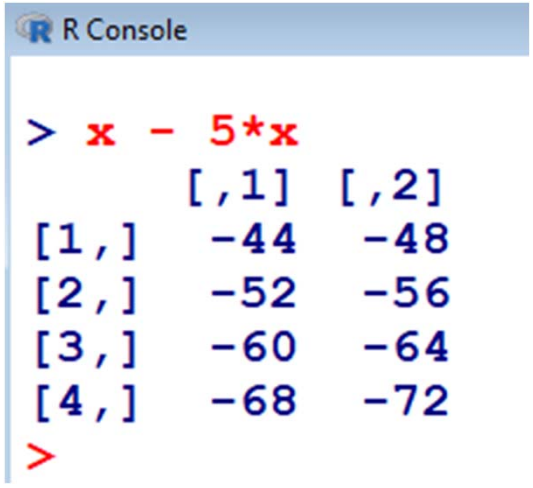
Matrix

Addition and subtraction of matrices (of same dimensions!) can be executed with the usual operators + and -

```
> x + 5*x
     [,1] [,2]
[1,]   66   72
[2,]   78   84
[3,]   90   96
[4,]  102  108
```

```
> x - 5*x
     [,1] [,2]
[1,]  -44  -48
[2,]  -52  -56
[3,]  -60  -64
[4,]  -68  -72
```





Matrix

Matrix Addition:

```
> y = matrix(nrow=2, ncol=2,
data=c(11,12,13,14), byrow=T )

> z = matrix(nrow=2, ncol=2, data=c(21,22,23,
24), byrow=T )
```

```
> y
     [,1]  [,2]
[1,]   11   12
[2,]   13   14
```

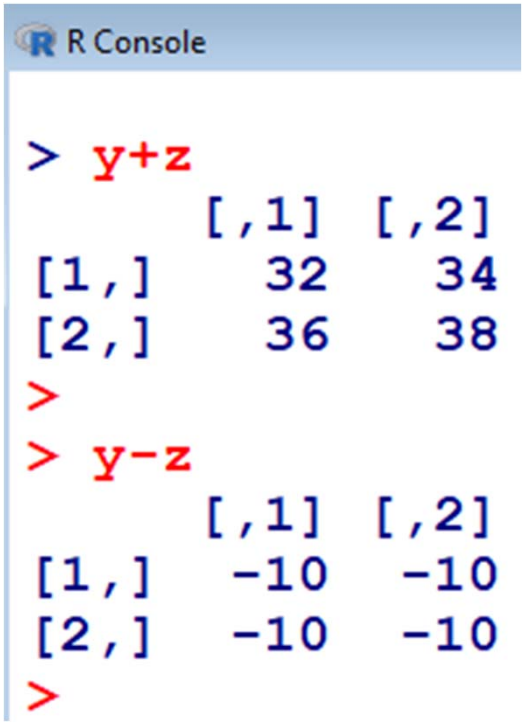
```
> z
     [,1] [,2]
[1,]   21   22
[2,]   23   24
```

Matrix

Matrix Addition and Subtraction:

```
> y+z
     [,1] [,2]
[1,]   32   34
[2,]   36   38
```

```
> y-z
     [,1] [,2]
[1,]  -10  -10
[2,]  -10  -10
```



Matrix

Access to rows, columns or submatrices:

R Console

```
> x = matrix(nrow=4, ncol=2, data=11:18, byrow=T)
> x
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
```

```
> x[4,]
[1] 17 18
```

R Console

```
> x[4,]
[1] 17 18
```

```
> x[,2]
[1] 12 14 16 18
```

R Console

```
> x[,2]
[1] 12 14 16 18
```

Matrix

Access to rows, columns or submatrices:

R Console

```
> x = matrix(nrow=4, ncol=2, data=11:18, byrow=T)
> x
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
[4,]   17   18
>
```

```
> x[1:3, 1:2]
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
```

R Console

```
> x[1:3, 1:2]
     [,1] [,2]
[1,]   11   12
[2,]   13   14
[3,]   15   16
>
```