

Exploratory Statistical Data Analysis With R Software (ESDAR)

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Lecture 6

Operations with Matrices in R

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**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"), $i = 1, 2, \dots, n, j = 1, 2, \dots, p$.

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:

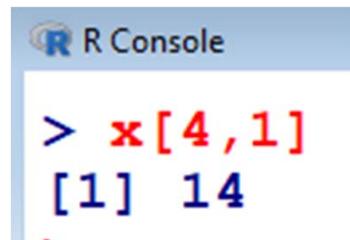
- The parameter **nrow** defines the row number of a matrix.
- The parameter **ncol** defines the column number of a matrix.
- The parameter **data** assigns specified values to the matrix elements.
- The values from the parameters are written column-wise in matrix.

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
```

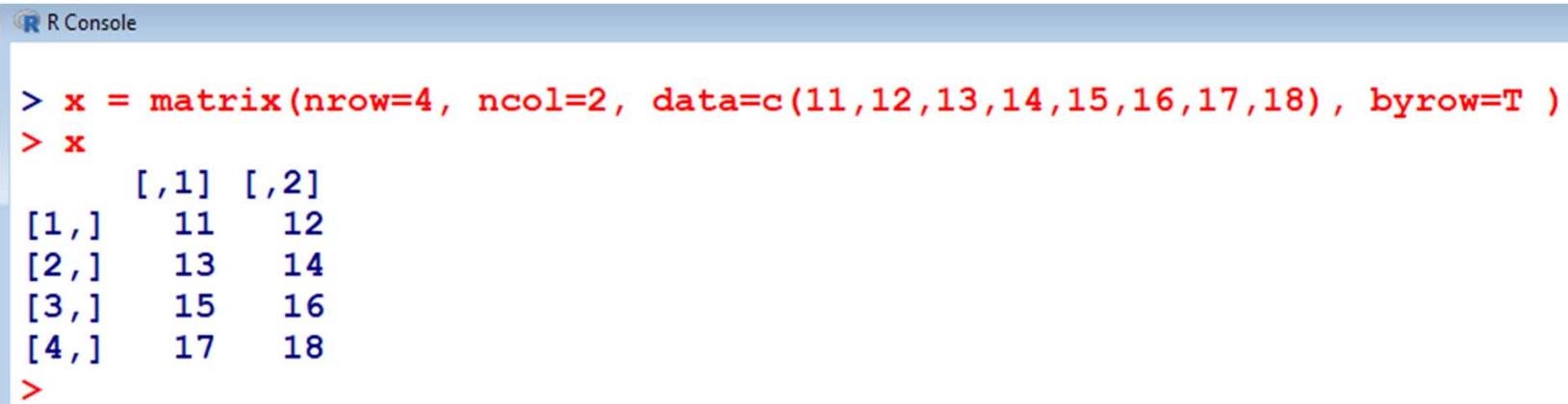
R Console

```
> 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
```



The screenshot shows the R console interface with a blue header bar. Below it, the command line area contains the R code and its output. The code creates a 4x2 matrix 'x' from the vector [11, 12, 13, 14, 15, 16, 17, 18] using the 'byrow=T' option. The resulting matrix is displayed as a 4x2 grid.

```
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  
>
```

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
```

R Console

```
> 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
```

R Console

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

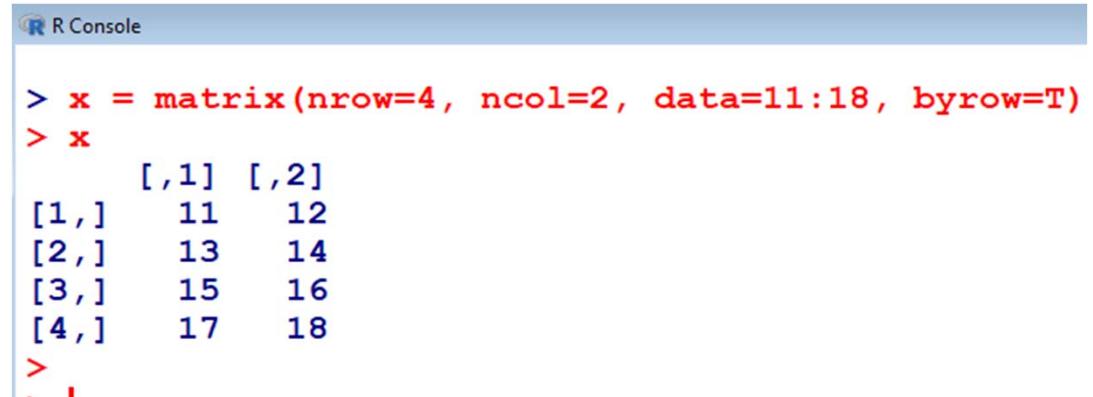
Matrix

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



The screenshot shows the R console interface with a blue header bar labeled "R Console". Below the header, there is a red command line area and a white output area. The command line shows the creation of matrix 'x' with the specified parameters. The output area displays the matrix 'x' with four rows and two columns, containing the values 11 through 18.

```
> x = matrix(nrow=4, ncol=2, data=11:18, byrow=T)  
> x  
[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
```

R Console

```
> 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
```

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

```
R Console  
> 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
```

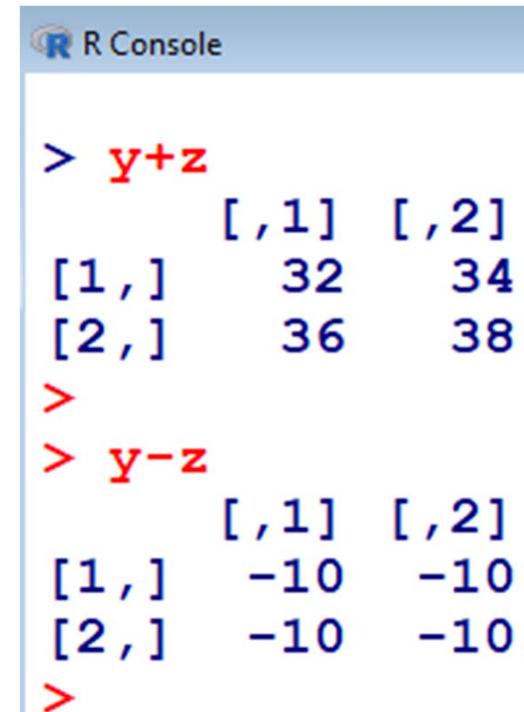
```
> z  
     [,1] [,2]  
[1,]    21   22  
[2,]    23   24
```

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
```



A screenshot of the R console window titled "R Console". It shows the command "y+z" followed by its output, which is a 2x2 matrix with values 32, 34, 36, and 38. Below it, the command "y-z" is shown, followed by its output, which is a 2x2 matrix with values -10, -10, -10, and -10.

```
> 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
>
```