Università degli Studi di Pavia
Dipartimento di Ingegneria Industriale e dell'Informazione

Corso di Identificazione dei Modelli e Analisi dei Dati

Data Import

Prof. Giuseppe De Nicolao, Federica Acerbi, Alessandro Incremona

Outline

1. Introduction
2. Importing Tabular Data
3. Handling Large Dataset
4. Handling Missing Data

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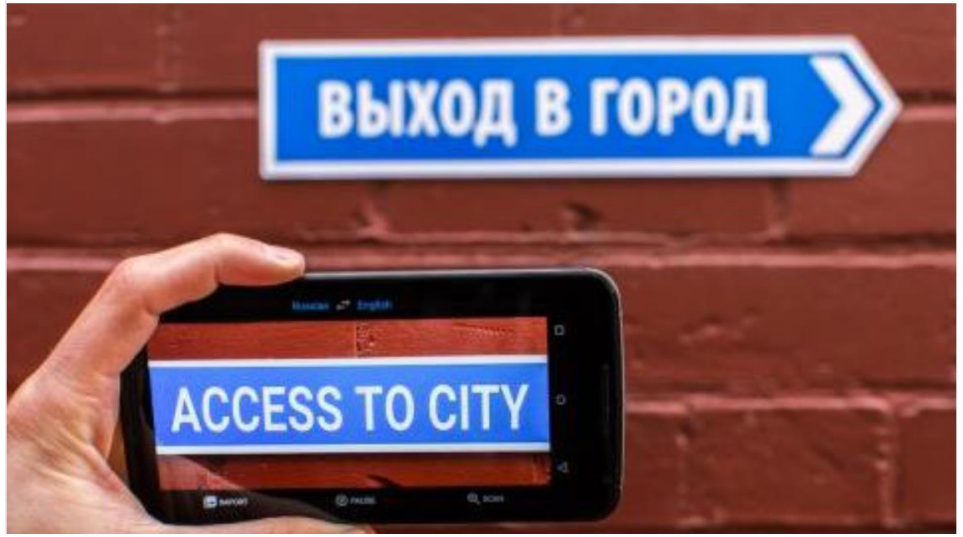
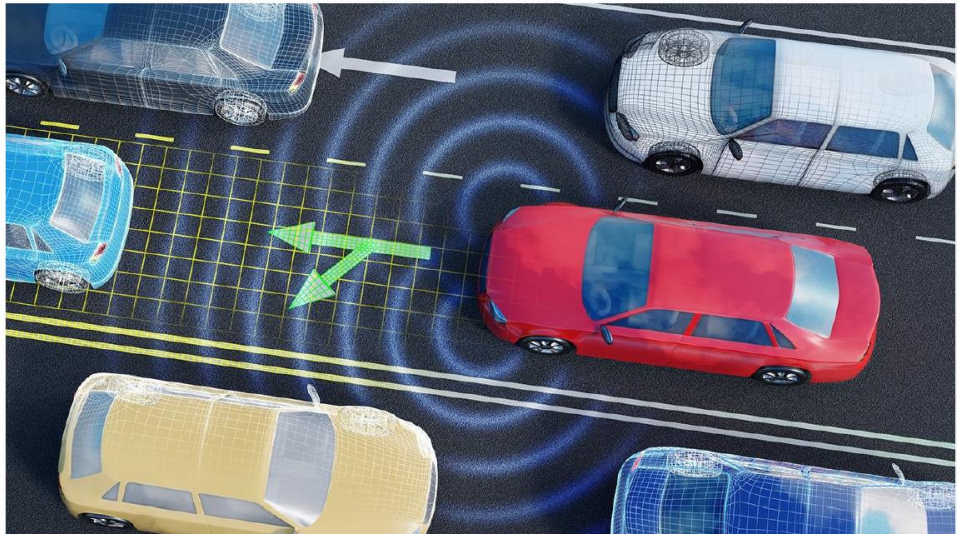
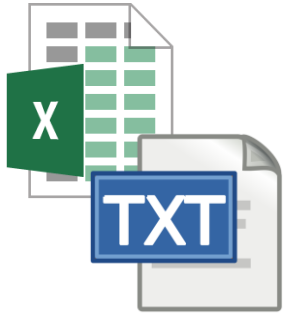




Matlab Expo 2018

Lecture goals:

1. importing data from text files and spreadsheets into a single table or database
2. acquiring fundamentals of data visualization



Timestamp	Country	Windspeed	Pressure
'29-Jun-1991 12:00:00'	'N/A'	23	1012
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'30-Jun-1991 00:00:00'	'N/A'	23	NaN
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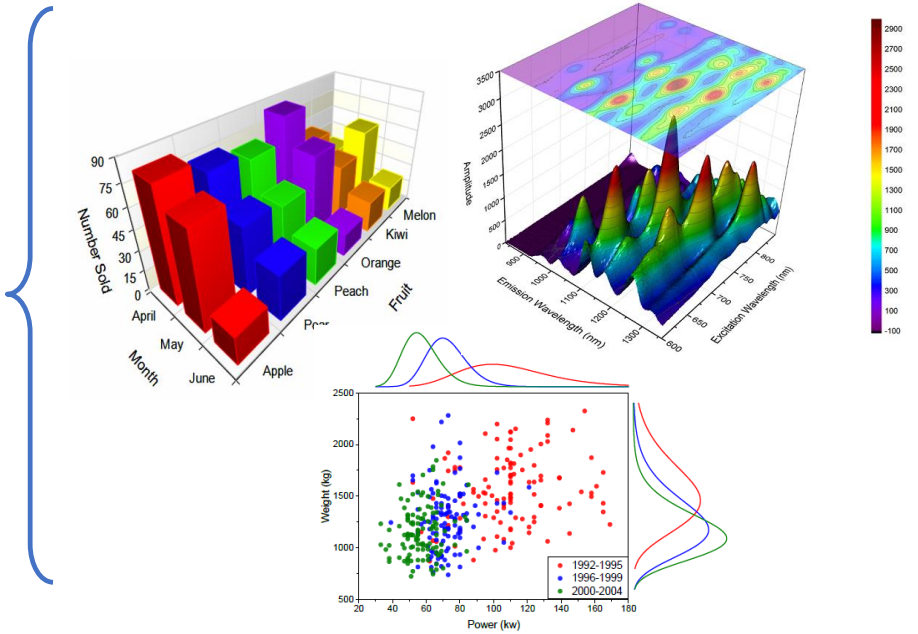
'1-Aug-1991 06:00:00'	'Canada'	70	1050



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There are different types of file formats that you can import and export from the MATLAB® application:

File content	Extension	Description	Import function
Matlab formatted data	MAT	MATLAB variables	`load`
Text	CSV, TXT	Column-oriented delimited numbers or a mix of text and numbers	`readtable`
Spreadsheet	XLS, XLSM, XLSX	Column-oriented data in worksheet or range of spreadsheet	`readtable`
Extensible Markup Language	XML	XML-formatted text	`xmlread`
Image	BMP, GIF, JPEG	Windows bitmap, Graphics Interchange Format, Joint Photographic Experts Group	`imread`
Audio	MP4, WAV	MPEG-4, Microsoft WAVE sound	`audioread`
Video	MP4, AVI	MPEG-4, Audio Video Interleave	`videoreader`

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Importing Tabular Data

Text

Import Option	Description
Import Tool 	Import a file or range of data to column vectors, a matrix, a cell array, or a table. You can generate code to repeat the operation on multiple similar files.
`readtable`	Import column-oriented data into a table.
`csvread`	Import a file or range of comma-separated numeric data to a matrix.
`textscan`	Import a nonrectangular or arbitrarily formatted text file to a cell array.

Spreadsheet

Import Option	Description
Import Tool 	Import a worksheet or range to column vectors, a matrix, a cell array, or a table. You can generate code to repeat the operation on multiple similar files.
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`xlsread`	Import a worksheet or range to numeric and cell arrays.

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Importing Tabular Data

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Unstructured data

Text Files

If you have **regularly formatted tabular** data in a single or a delimited text file, you can use the **edit** function to visualize it in a MATLAB built-in text editor and the **readtable** function to import it into MATLAB

```
>> doc edit
```

edit

Edit or create file

Syntax

```
edit
edit file
edit file1 ... fileN
```

```
>> doc readtable
```

readtable

Create table from file

Syntax

```
T = readtable(filename)
T = readtable(filename,Name,Value)
T = readtable(filename,opts)
T = readtable(filename,opts,Name,Value)
```

Text Files

If you have **regularly formatted tabular** data in a single or a delimited text file, you can use the **edit** function to visualize it in a MATLAB built-in text editor and the **readtable** function to import it into MATLAB

```
>> edit 'hurricaneData1990s.txt'
```

```
Number,Timestamp,Country,Windspeed,Pressure
1,29-Jun-1991 12:00:00,"N/A",23,1012
1,29-Jun-1991 18:00:00,"N/A",23,1012
1,30-Jun-1991 00:00:00,"N/A",,1012
1,30-Jun-1991 06:00:00,"United States",23,1012
1,30-Jun-1991 12:00:00,"United States",23,1012
1,30-Jun-1991 18:00:00,"N/A",23,1012
1,01-Jul-1991 00:00:00,"N/A",23,1012
1,01-Jul-1991 06:00:00,"United States",23,1012
1,01-Jul-1991 12:00:00,"United States",23,1012
```

Text Files

If you have **regularly formatted tabular** data in a single or a delimited text file, you can use the **edit** function to visualize it in a MATLAB built-in text editor and the **readtable** function to import it into MATLAB

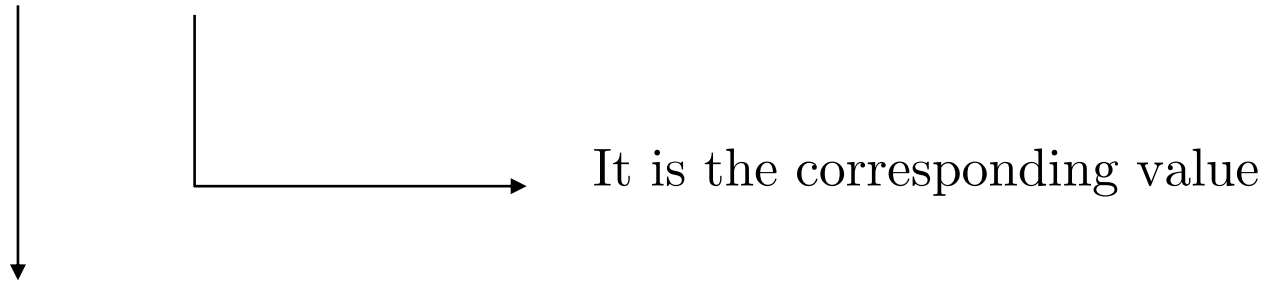
```
>> readtable('hurricaneData1990s.txt')
```

Number	Timestamp	Country	Windspeed	Pressure
1	29-Jun-1991 12:00:00	'N/A'	23	1012
1	29-Jun-1991 18:00:00	'N/A'	23	1012
1	30-Jun-1991 00:00:00	'N/A'	NaN	1012
1	30-Jun-1991 06:00:00	'United States'	23	1012
1	30-Jun-1991 12:00:00	'United States'	23	1012
1	30-Jun-1991 18:00:00	'N/A'	23	1012
1	01-Jul-1991 00:00:00	'N/A'	23	1012
1	01-Jul-1991 06:00:00	'United States'	23	1012
1	01-Jul-1991 12:00:00	'United States'	23	1012

Text Files

When using the **readtable** function, you can specify some additional parameters in order to control how data are read by using the comma-separated pairs of **Name, Value** arguments.

```
>> readtable(filename, Name, Value)
```



Text Files

When using the **readtable** function, you can specify some additional parameters in order to control how data are read by using the comma-separated pairs of **Name, Value** arguments.

```
>> edit 'hurricaneData1990s_v2.txt'
```

```
This file contains the wind speed and pressure data
of hurricanes in the early 1990s.

Units - Number, Date and Time, Text, Number (mbar), Number (mph)

Number,Timestamp,Country,Windspeed,Pressure
1,29-Jun-1991 12:00:00,"N/A",23,1012
1,29-Jun-1991 18:00:00,"N/A",23,1012
1,30-Jun-1991 00:00:00,"N/A",,1012
1,30-Jun-1991 06:00:00,"United States",23,1012
1,30-Jun-1991 12:00:00,"United States",23,1012
1,30-Jun-1991 18:00:00,"N/A",23,1012
```

Text Files

When using the **readtable** function, you can specify some additional parameters in order to control how data are read by using the comma-separated pairs of **Name, Value** arguments.

```
>> readtable('hurricaneData1990s_vs2.txt', 'HeaderLines', 5)
```

Number	Timestamp	Country	Windspeed	Pressure
1	29-Jun-1991 12:00:00	'N/A'	23	1012
1	29-Jun-1991 18:00:00	'N/A'	23	1012
1	30-Jun-1991 00:00:00	'N/A'	NaN	1012
1	30-Jun-1991 06:00:00	'United States'	23	1012
1	30-Jun-1991 12:00:00	'United States'	23	1012
1	30-Jun-1991 18:00:00	'N/A'	23	1012
1	01-Jul-1991 00:00:00	'N/A'	23	1012
1	01-Jul-1991 06:00:00	'United States'	23	1012
1	01-Jul-1991 12:00:00	'United States'	23	1012

Main `Name,Value` pairs:

- **`'HeaderLines', Value`**: skip the first 'Value' rows of the file. 'Value' must be an integer.
  e.g.: `readtable('dataset.txt','HeaderLines',5)`

- **`'Delimiter',Value`**: specify the delimiter between different columns. 'Value' must be any valid character (see documentation).
  e.g.: `readtable('dataset.txt','Delimiter',',')`

- **`'CommentStyle', Value`**: specify the symbol designating test to ignore. 'Value' must be any valid character (see documentation).
  e.g.: `readtable('dataset.txt','CommentStyle','%')`

- **`'EmptyValue', Value`**: set the returned value for empty numeric fields (default is `NaN`).
  e.g.: `readtable('dataset.txt','EmptyValue',999)`

Exercise 1

The file **'hurricaneData1990s_v3.txt'** contains the data of six hurricanes in the early 1990s.

1. Import this dataset as a table where each row must contain an **ID_number** (data type: double), the **date** (data type: datetime), the **country** (data type: char), the **windspeed** (data type: double) and the **pressure** (data type: double). Missing numeric values must be replaced with **-1**.

2. Check that the data type of each column of the table is corrected by using the function **class**

3. Rename the column of the table as: ID, Date, Location, Wind_Speed, Pressure.

TIPS:

- You can use dot indexing to access table columns. e.g.: `table.NameOfCol1`

- If you don't remember how to access the `'VariableNames'` property of a table, check into the documentation **(>> doc table)**

Spreadsheet files

There are **three main approaches** by which you can import data from spreadsheet files into MATLAB®: **interactively, programmatically or by pasting data from the clipboard**.

Import option	Description
Import Tool	Import a worksheet or range to column vectors, a matrix, a cell array, a string array, or a table. You can generate code to repeat the operation on multiple similar files.
`readtable`	Import a worksheet or range to a table.
Copy and Paste	You can paste spreadsheet data from the clipboard into MATLAB.

Import Tool

- On the **Home** tab, in the **Variable** section, click **Import data**  .
- Select the spreadsheet file you want to import. The **Import Tool** opens.
- Select the data you want to import. You can edit the variables names and other options.
- Click the **Import Selection** button  to import the data in your workspace.

Exercise 2

Import the first ten rows of data from the file `'dati_consumo_Italia.xlsx'` (from the sheet 'dati 2010-2012') using the Import Tool. The data must be imported as a table with two columns of numeric values named 'Date' and 'Load'.

Copy and Paste

- Select and copy your spreadsheet data in Microsoft Excel, then use one of the following methods:

  1. On the **Workspace browser** title bar, click and select **Paste**.

  2. Open an existing variable in the Variables editor, right-click  and then select **Paste Excel** (Note: the data types must be the same!).

  3. Use the command 'uiimport-pastespecial'.

readtable

```
readtable(filename, Name, Value)
```

- The sintax is the same as the text file case, but here we need to specify new **Name, Value** pair arguments to correctly select the data that we want to import.

Main **Name,Value** pairs for spreadsheet files*:*

- **'Sheet', Value***:* *w*orksheet to read. 'Value' must be a string containing the worksheet name.
  e.g.: `readtable('dataset.xlsx','Sheet','Foglio1')`

- **'Range', Value***:* portion of the worksheet to read, indicated as a rectangular area. 'Value' must be specify using the sintax 'Corner1:Corner2', where Corner1 and Corner2 are two opposing corners that define a rectangular region.
  e.g.: `readtable('dataset.xlsx','Range','B3:H45')`

Exercise 3

1. Import all the data of the file `'dati_consumo_Italia.xlsx'` from the sheet **'dati 2010-2012'** in a table called **''tab1''** using the **readtable** command.

2. Then import all the data of the same file but from the sheet **''dati 2013-2014''** in a table called **''tab2''**.

3. Rename the columns of the two table as **'Date'** and **'Load'.**

4. Create a table called **''tab_dati''** which is the result of the vertical concatenation of the two previous tables.

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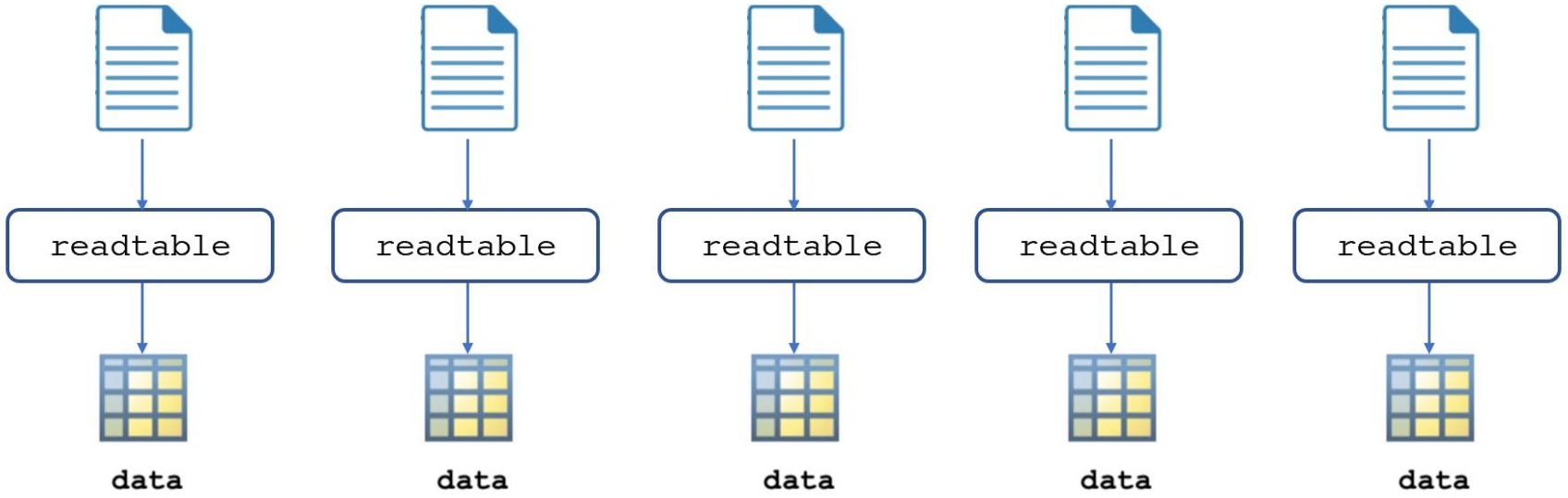
Handling Large Dataset

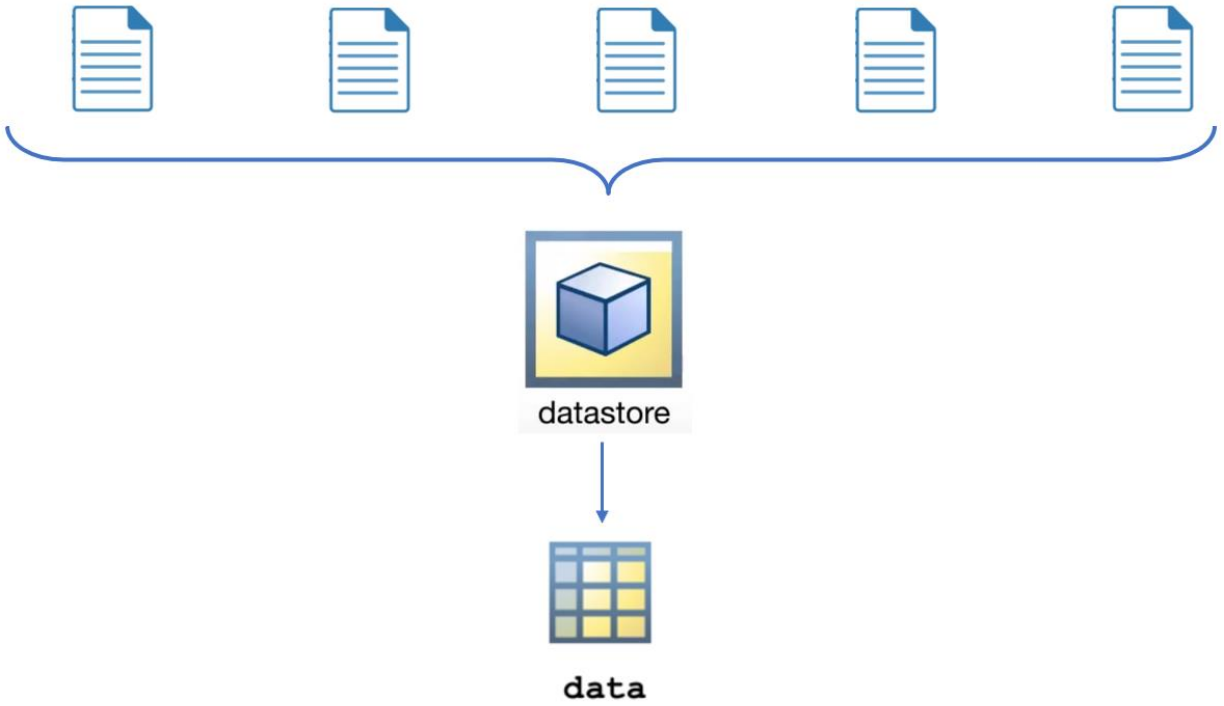
Until now...



N data sheets = N Tables

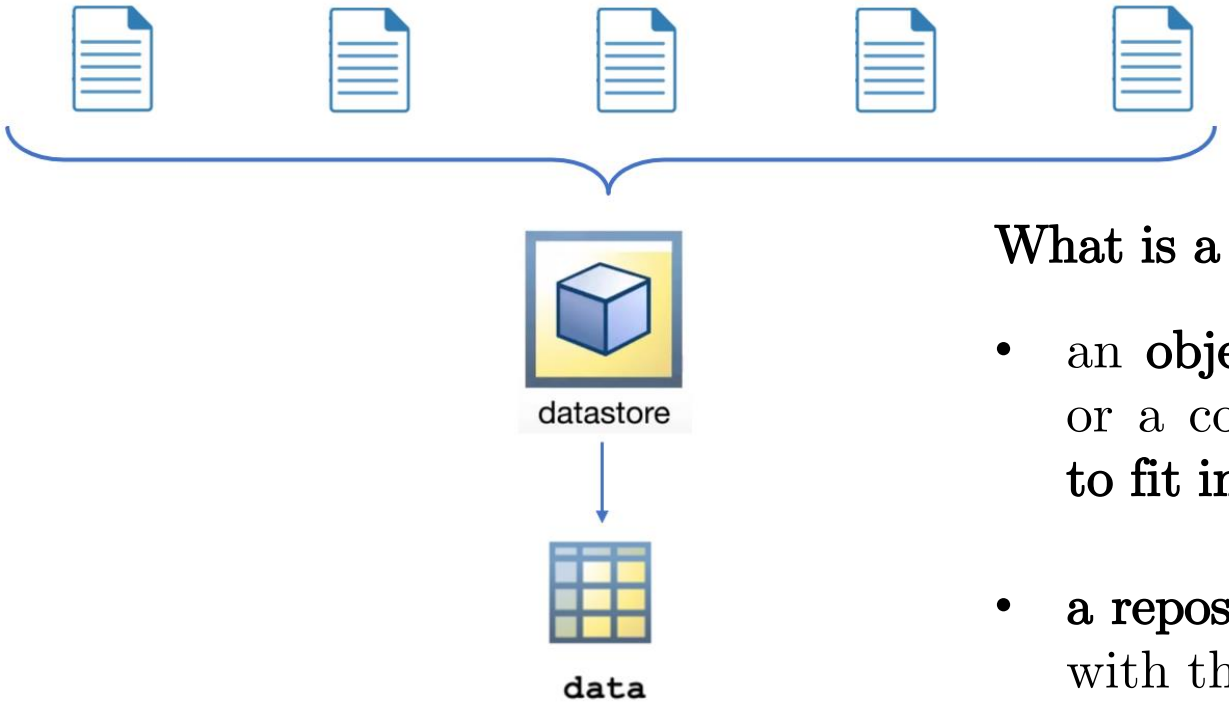
Handling Large Dataset

To easily manage multiple data files:



Handling Large Dataset

To easily manage multiple data files:



What is a datastore?

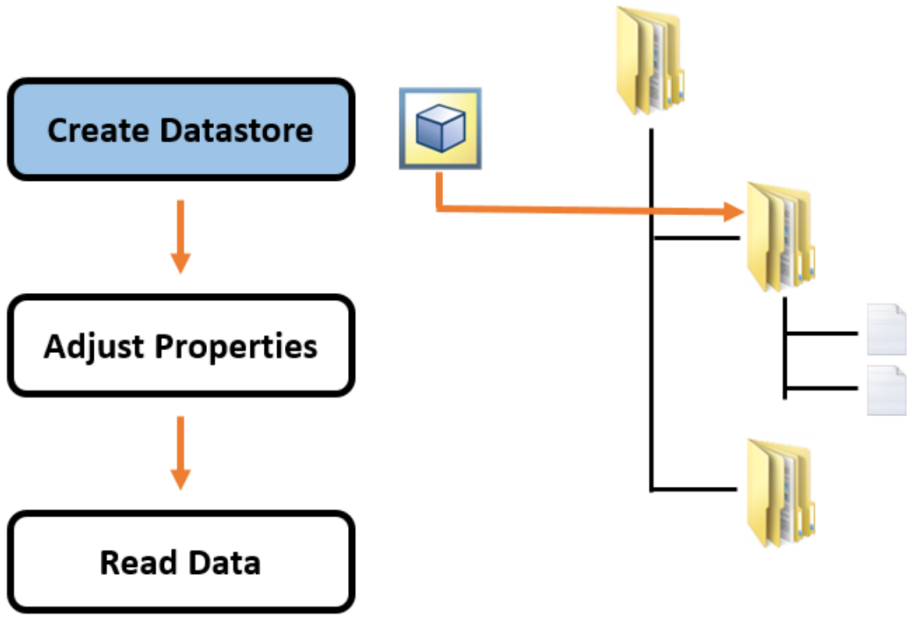
- an **object useful** for reading a single file or a collection of files or data **too large to fit in memory**
- **a repository** for multiple files and folders with the same structure and formatting

Handling Large Dataset

Steps to read data using a datastore:

1. **Creating a datastore** that refers to a single file or a set of files in a directory
2. **Adjusting the properties** of the datastore according to the data contents
3. **Reading the data** from the file
   - Read Selected Columns of Data
   - Read Subsets of Data
   - Read One File at time

Creating the datastore



- To create a datastore use the `datastore` function with the file or folder location as input

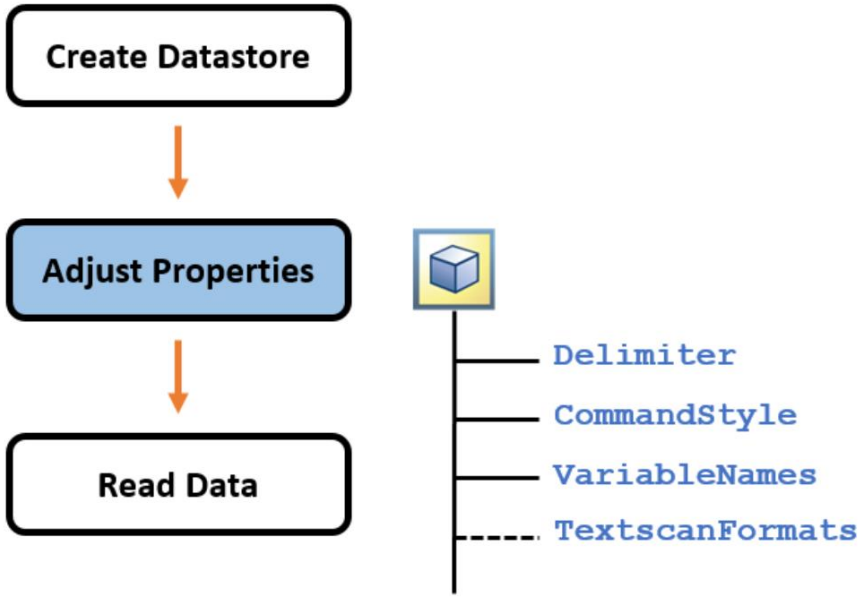
```
ds = datastore(location)
```

- To visualize how the data will be read, the preview function returns a subset of data from datastore

```
data = preview(ds)
```

The datastore variables does not contain any data but meta informations about the data!

Modifying Datastore Properties



Adjusting the datastore properties is possible to customize the data import procedure

Examples:

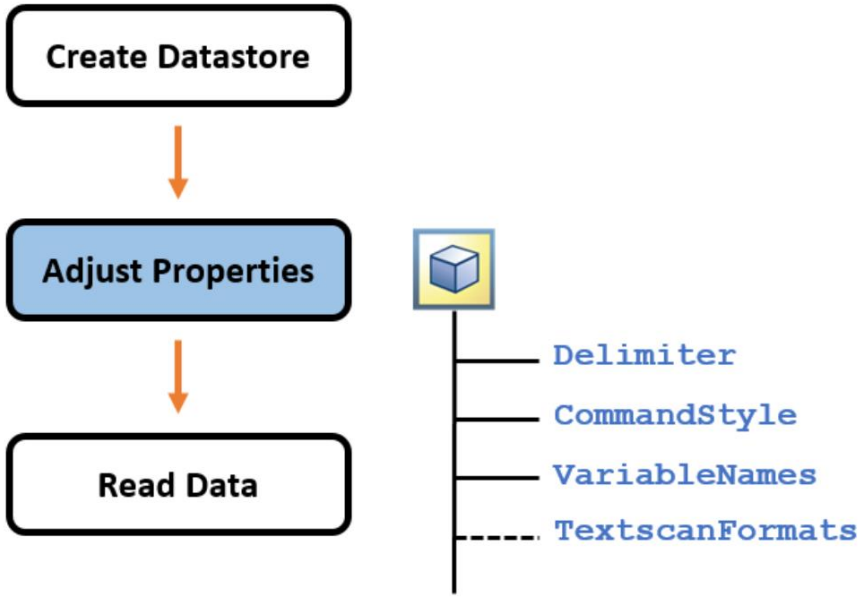
- To ignore lines of data that begins with the character sequence '//':

```
ds.CommentStyle = '//'
```

- To disable the automatic variable name detection:

```
ds.ReadVariableNames = false
```

Modifying Datastore Properties



Adjusting the datastore properties is possible to customize the data import procedure

Examples:

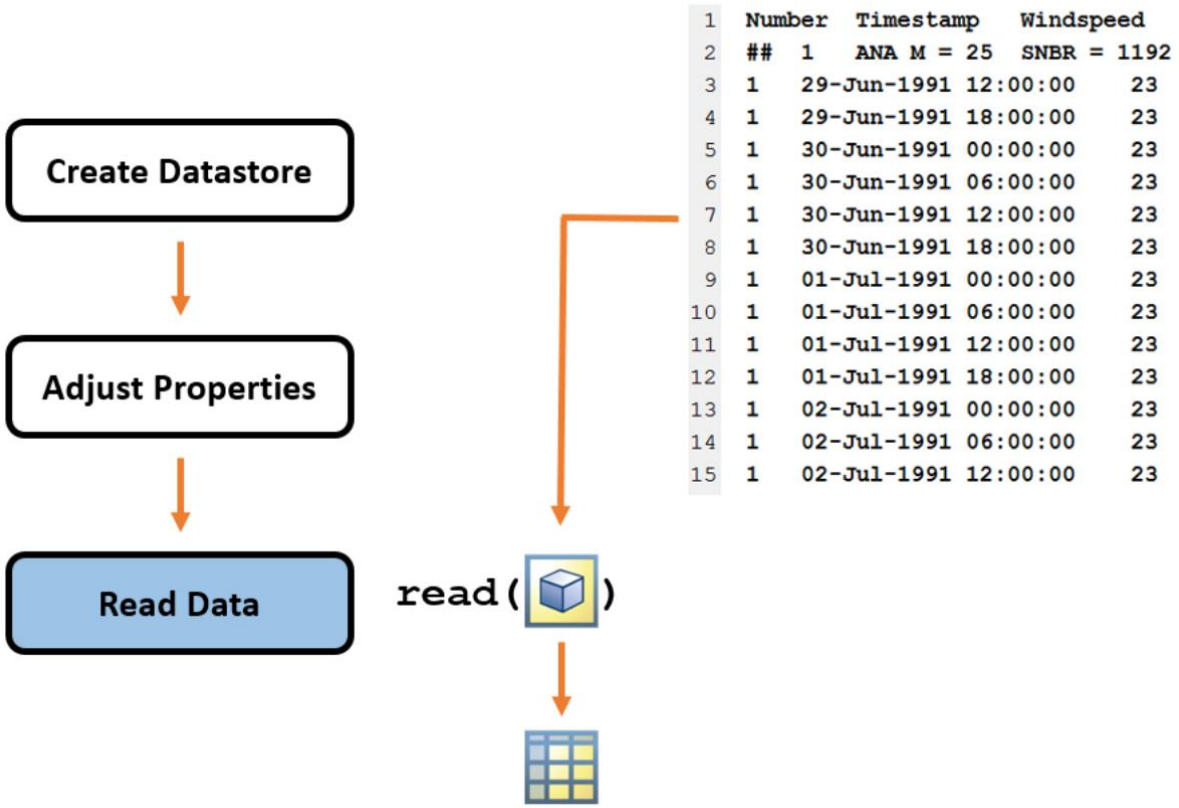
- To skip a number of lines at the beginning of the file:

```
ds.numHeaderLines = 3
```

- To set the amount of data to read in a call to the **`read`** function

```
ds.ReadSize = 'file'
ds.ReadSize = '15000'
```

Reading the data



- The `readall` function allows to import the data from **all files** referenced by the datastore

```
data = readall(ds)
```

- The `read` function allows to import the data from the **first file/fixed amount of lines** referenced by the datastore

```
data = read(ds)
```

Reading the data

Three different ways to use the datastore to work with a dataset that does not entirely fit in the memory of your machine

1. **Read Selected Columns of Data**

```
>> ds.SelectedVariableNames = 'ArrDelay';

>> data = readall(ds);
```

Reading the data

2. Read Subsets of Data

```
>> ds.ReadSize = 15000;
```

```
>> sums = [];
>> counts = [];
>> while hasdata(ds)
>>    T = read(ds);

>>    sums(end+1) = sum(T.ArrDelay);
>>    counts(end+1) = length(T.ArrDelay);
>> end

>> avgArrivalDelay = sum(sums)/sum(counts);
>> reset(ds)
```

Reading the data

3. Read One File at Time

```
>> ds.ReadSize = 'file';
```

```
>> sums = [];
>> counts = [];
>> while hasdata(ds)
>>    T = read(ds);

>>    sums(end+1) = sum(T.ArrDelay);
>>    counts(end+1) = length(T.ArrDelay);
>> end

>> avgArrivalDelay = sum(sums)/sum(counts);
>> reset(ds)
```

Exercise 4 (part 1)

1. Create a datastore named `dat` from the .txt files contained in the folder `hurricaneData`
2. Preview the files contents using the `dat` datastore to check and compare the results with the data in the editor
3. Ignore lines that begins with the character sequence '##'
4. Change the variable names in the datastore with:
   `{'Time','Latitude','Longitude','WindSpeed','Pressure'}`
5. Save the path of the files included in datastore to a variable names `fname`
6. Read the data from the first file referenced by the datastore `dat` and store the imported data in `hurrs1`.

Exercise 4 (part 1)

7. Read the data from the second file referenced by the datastore `dat` and store the imported data in `hurrs2`

8. Select the variable `'WindSpeed'` and save the all the data in the table `wind_speed`

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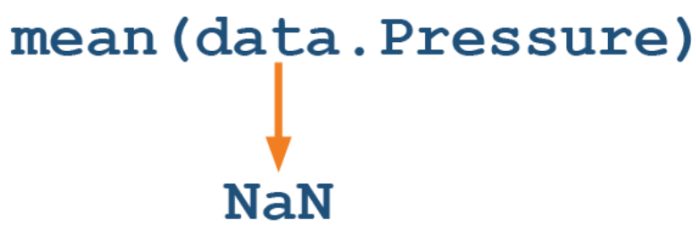
Working with Missing Data

- When you import data into MATLAB, missing numerical values are replaced with NaN, which stands for “not a number”
- If a numerical arrays contains NaN values, many function that operate on such an array will return NaN

Timestamp	Country	Windspeed	Pressure
'29-Jun-1991 12:00:00'	'N/A'	23	1012
'29-Jun-1991 18:00:00'	'N/A'	23	1012
'30-Jun-1991 00:00:00'	'N/A'	23	NaN
'30-Jun-1991 06:00:00'	'United States'	109	957
'30-Jun-1991 12:00:00'	'United States'	109	980
‘1-Aug-1991 06:00:00'	‘Canada'	70	1050



How to ignore NaNs in the data?

- using the **omitnan** flag when you are working with matlab function

```
>> M = mean(A,'omitnan')
```

- deleting the observations with missing data

Timestamp	Country	Windspeed	Pressure
'29-Jun-1991 12:00:00'	'N/A'	23	1012
'29-Jun-1991 18:00:00'	'N/A'	23	1012
'30-Jun-1991 00:00:00'	'N/A'	23	NaN
'30-Jun-1991 06:00:00'	'United States'	109	957
'30-Jun-1991 12:00:00'	'United States'	109	980
'1-Aug-1991 06:00:00'	'Canada'	70	1050

Timestamp	Country	Windspeed	Pressure
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'1-Aug-1991 06:00:00'	'Canada'	70	1050

Exercises

1. Use the mean function to create a variable named `xAvg` that contains the average value of

   ```
   x = [0.32 0.95 NaN 0.87 0.71 0.42];
   ```

   Solution:

   ```
   >> xAvg = mean(x,'omitnan')
   ```

2. Create a variable named `xMin` that contains the smallest value in `x`

   Solution:

   ```
   >> xMin = min(x)
   ```

In some Matlab functions
'omitnan' is the default option

Exercises

3. Remove NaNs from the vector x

```
x = [0.32 0.95 NaN 0.87 0.71 0.42]
```

Solution:

```
>> Ix = isnan(x)

>> Ix = [0 0 1 0 0 0]
```

Exercises

3. Remove NaNs from the vector x

```
x = [0.32 0.95 NaN 0.87 0.71 0.42]
```

Solution:

```
>> Ix = isnan(x)
>> Ix = [0 0 1 0 0 0]
```

- **isnan** checks each element of the input array and returns a logical array in which the true values (displayed as 1) indicate locations of NaNs

Exercises

3. Remove NaNs from the vector x

```
x = [0.32 0.95 NaN 0.87 0.71 0.42]
```

Solution:

```
>> Ix = isnan(x)
>> Ix = [0 0 1 0 0 0]

>> x(Ix) = []
```

```
>> x = [0.32 0.95 0.87 0.71 0.42];
```

- **isnan** checks each element of the input array and returns a logical array in which the true values (displayed as 1) indicate locations of NaNs

Exercises

4. Import the data from the file `hurricaneData1990s.txt` using the function `readtable` and delete the rows of the table that contain missing values

Solution:

```
>> T = readtable('hurricaneData1990s_v2.txt','HerderLines',5)
```

```
>> im = ismissing(T)

>> ridx = any(im,2)

>> T(ridx,:) = []
```

or

```
>> T = rmmissing(T)
```

Reference Documentation:

- https://it.mathworks.com/ 

- http://sisdin.unipv.it/labsisdin/teaching/courses/imadlt/esercitazioni