Note that C is an ASCII string in a column vector. To change it to a row vector in characters we transpose it and then use **setstr** as in:

```
>> C = setstr(C')
C =
MATLAB
```

Finally, we close the file:

```
>> fclose(fid_bin)
ans = 0
```

This value indicates that the file was successfully closed.

# Passing Data Between MATLAB and Excel

A software package used in engineering, science, and finance is Excel. Excel and MATLAB can read and write data to files. In this section we show how such files can be used by any of the packages. For example, MATLAB can write data separated by commas in files with extension csv, for comma separated values, and then read by Excel, and vice versa.

## Exporting Data to Excel

To show how we can export data from MATLAB to Excel we have the following example.

## Example Exporting data to Excel from MATLAB

Let us consider the following data about the five countries with the largest territories in square miles in the American continent together with their capital cities:

Canada, Ottawa, 3849660 United States of America, Washington D.C., 3787319 Brazil, Brasilia, 3300410 Argentina, Buenos Aires, 1073596 Mexico, Mexico D.F., 759589

This data is written by MATLAB to file countries.csv. The following file opens the file countries.csv, writes the data, and closes the file. Each country name must have the same number of characters. Each capital name must have ten characters, including blank spaces.

Archivo	nicio	Ver					~ (
П×.	Couri	er New 🔻 11	• A* A*	ĒŦ		<i>8</i> *8	
Pegar	N	K <u>S</u> abe X <sub>2</sub> X	<u>A</u> • <u>2</u> •	Párrafo	Insertar	Edición	
Portapapeles		Fuente					
	Can,	Ottawa ,					
	Bra,	Washington, Brasilia ,	3300410				
	Bra, Arg,		3300410 1073596				

FIGURE Data in the file countries.csv.

```
% File Example .m
Country = ['Can'; 'USA'; 'Bra'; 'Arg'; 'Mex']
Capital=['Ottawa'; 'Washington'; 'Brasilia'; 'B. Aires '; 'MexicoCity']
Size = [3849660; 3787319; 3300410; 1073596; 759589]
handle = fopen('countries.csv', 'w')
for i = 1: 5
    fprintf(handle, '%10s, %10s, %7d \n',...
        Country(i, :), Capital(i, :), Size(i, :))
end
fclose(handle)
```

Now we open the file countries.csv with the Wordpad and we see the contents shown in Figure 6.3. We note that it is in comma-separated-values format. The commas are called separators or delimiters. Now we proceed to open the file with Excel. Since the file was not created by Excel, it has to be imported to Excel. The Import Wizard is automatically opened. It consists of three windows. The first window is shown in Figure 6.4. Here we indicate that the data is delimited by commas as indicated. After pressing the Next button the second window for the Import Wizard opens and here we indicate that the data is delimited by commas as shown in Figure 6.5. Finally, when we press the Next button we get to the third window in the Import Wizard. Here we select the columns we want to import and set the data format, as shown in Figure 6.6. Finally, the data is shown in Excel as can be seen in Figure 6.7.

he Test Wizard has determined that your data is Fixed Width. this is correct, choose Need, or choose the data type that best describes your data. Orginal data type Choose the file type that best describes your data: ● File guinted - Characters such as commas or tabs separate each field. ● File guinted - Filed are aligned in columns with spaces between each field. ■ file guinted - File grigin: MS-DOS (PC-0) ■ My data has headers. Preview of file CiUsers/David/Documents/MATLAB/countries.ors. ■ Constant of the CiUsers/David/Documents/MATLAB/countries.ors.		- Step 1 of 3				?	×
Original data type Choose the file type that best describes your data: O genimize Filed width Filed are aligned in columns of tabs separate each field. Filed width File grigin: MS-DOS (PC-0) My data has headers. Preview of file C/Users/David/Documents/MATLAB:countries.cvs.	he Text Wizard has	determined that	your data is l	Fixed Width.			
Choose the file type that best describes your data:	this is correct, choi	ose Next, or cho	ose the data t	ype that best describes your da	sta.		
Characters such as commas or table separate each field.     Prined Width - Fields are aligned in columns with spaces between each field.     Separate set field.     Sepa	Original data type						
Fined width - Fields are aligned in columns with spaces between each field.     Iart import at gow:     1     Prie grigin: MS-DOS (PC-0)     My data has headers.     Preview of file C-Users'David/Documents'MATLAB:countries.crs.					D		
Tart Import at powe 1 Pile grigin: MS-DOS (PC-8)							
hty data has headers. Preview of file C/Users/David/Documents/MATLAB/countries.crs.	· Fixed width	- Fields are all	igned in colur	ins with spaces between each	field.		
hty data has headers. Preview of file C/Users/David/Documents/MATLAB/countries.crs.			Eile asiaiat	NE DOS (DC II)			12
		L. Produ	Lue Budur	hardes (ren)			1
	My data has head	lers. sers\David\Doct Ottava , Nashington, Brasilia , B. Aires ,	uments/MATL/ 3849660 3787319 3300410 1073596				<b>^</b>
	<u>My</u> data has head	lers. sers\David\Doct Ottava , Nashington, Brasilia , B. Aires ,	uments/MATL/ 3849660 3787319 3300410 1073596				

FIGURE 6.4: Part 1 of the Import Wizard. Here we indicate that the data is separated by commas or tabs.

	ard - Step 2 of 3				?	>
	ou set field widt s signify a colum		reaks).			
To DELETE a b	oreak line, click a reak line, doubl eak line, click an	e click on the				
Data greview	20	30		50	 70	
Bra,	Ottava , Washington, Brasilia , B. Aires , MexicoCity,	3787319 3300410 1073596				ĺ
	merrenerel'					1

FIGURE 6.5: Part 2 of the Import Wizard. Here we indicate that the data is separated by commas.

his screen li	ets you	select each	column an	d set th	e Data Fo	mat.						
Column dat			and a provide	0.000	0.000							
<u>General</u> <u>O</u> Text			'Gen	eral' co	nverts nur g values t	neric va	lues to	numbe	rs, date	value	s to di	stes, ai
O Date:	DMY	~	40.14		y values o	1611.	Advand	ed_				
O Do not	import	column ichi										
		corumn (se	(p)									
Data grevie	w	veral		1								
Data grevie General	w ter	teral		i0								~
Data grevie General U	w 4.n., 01 53, 54	moral Stava		0 .9								-
Data grevie General G	W 4.0., 0 53, 54 24, 55	esral Itawa ashingto: carilia		0 .9 .0								^
Data grevie General C J J A	w an, 01 SA, 94 rs, B: rg, B	moral ttawa ashington casilia . Aires		0 .9 .0								Î

FIGURE 6.6: Part 3 of the Import Wizard. Here we select each column and set the data format.

A8	• E >	√ fr		
1	А	В	С	P
1	Can,	Ottawa ,	3849660	
2	USA,	Washington,	3787319	
3	Bra,	Brasilia ,	3300410	
4	Arg,	B. Aires ,	1073596	
5	Mex,	MexicoCity,	759589	
6				

FIGURE 6.7: Data from countries.csv in Excel.

Another instruction used in MATLAB to write only numerical data to a file and read it by Excel is the instruction csvwrite('file\_name', m). For example, for the matrix A given by

```
>> A = [1957 10 5; 1950 10 8;1989 5 10 ]
A =
1957 10 5
1950 10 8
1989 5 10
```

We can write this matrix to a file list.csv with

>> csvwrite ('list.csv', A )

The file list.csv can be readily opened with Excel.

#### Exporting Excel Files to MATLAB

The instruction csv also allows numerical data transfer from Excel to MATLAB. To show how this can be done, in Excel define the matrix A given by

$$A = \begin{bmatrix} 1 & 0\\ 100 & 1\\ 2 & 4 \end{bmatrix}$$

The matrix in Excel is shown in Figure 6.8. We save it in a file Numbers.csv.

Now, from the MATLAB Command Window we use the instruction csvread as csvread('Numbers.csv') to obtain the data in MATLAB as follows:

>> csvread('Numbers.csv')

A12	*	$\times$ $\checkmark$ $f_{\rm f}$			
	A	В	С	D	E
1	1	10			
2	100	1000			
3	2	4			
4					
5					

FIGURE 6.8: Data in Excel for Numbers.csv.

```
ans =
1 10
100 1000
2 4
```

#### **Reading Data from Excel Files**

MATLAB can also read data from files with either extension xls or xlsx. To describe the procedure we use the Excel data shown in Figure 6.9. This data is saved in the file years.xlsx in the current directory for the MATLAB session. Now, in MATLAB we look at the Current Directory window and locate the file years.xlsx. We just double click on this file and then the Import Wizard opens requesting the variables to be imported. Selecting the variable to be imported (see Figure 6.10), it is displayed in the right-hand window and then we click on the Finish button to end the importing. In the Workspace window appears the variable which we can now use as any other variable created in MATLAB. This is shown in Figure 6.11.

G10	* 1 8	√ fe			
1	A	В	С	D	1 1
1		1	1950		
2		2	1952		
3		3	1955		
4		4	1958		
5					

FIGURE 6.9: Data in Excel for years.xlsx.

	MPORT				0 0 0
Var	Rang iable Names Rov SELEC	10 Le	Column vect	UNIMPORTABLE CELLS	Import Selection •
ſ	years.xlsx >				
1	A	В	с		
		years			
1		1	1950		
2		2	1952		
3		3	1955		
4		4	1958		
	1977			D	

FIGURE 6.10: Import wizard for Excel files.

Name -	Value	Size	Bytes	Class	Min
A ans Capital Country years	[1975, 1, 14;1950, 10, &;1 [1, 10;100, 1000;2,4] 5x10 char 5x3 char [1, 1950;2, 1952;3, 1955;	3x2 5x10 5x3	48 100 30	double double onar char double	1 💿 1
<					>

FIGURE 6.11: Import wizard for variables.

# Publishing m-files from MATLAB

A very important part in programming is documentation. Sometimes this may be either a very tedious part in the programming process or a very easy one depending upon the programmer's style. Fortunately, in the case of mlanguage programming, MATLAB has a tool to create documentation once a program has been finished. This is known as publishing and the end result is a document that can be created in Word, HTML, XML, LaTeX, or Power Point. Furthermore, it is possible to run the program documented from the published file. We show the procedure with an example. In order to learn how an m-file has to be structured to it, first we have to describe cell programming.

## **Cell Programming**

The MATLAB editor has the option to create cells. These cells are useful to run portions of the m-file and to create sections in the publishing process. A cell is a portion of an m-file having certain characteristics. A cell is composed of the following parts:

1. A beginning row which starts with a double percent sign followed by a space and a title text.

- 2. Comment lines that start with a percent sign followed by a space and text which is the body of the documentation.
- 3. Equations written in LaTeX style, and finally:
- 4. MATLAB instructions. We show the procedure with an example.

#### Example Plotting of a sine function with cells

Let us suppose that we want to plot the sine function from 0 to  $2\pi$  and then we want to modify the plot. To plot the function we use

x = 0: 0.01: 2\*pi; y = sin(x); plot(x, y)

Once the function is plotted we add title, legends to the axes and a label with:

xlabel('x-axis')
ylabel('sine wave')
title('Plot of sin x')

Now we create the m-file using cells. In the first cell we place the first part of the m-file and in the second cell the m-file where we add the text part. We add comments to the m-file to make it self-explanatory. In the comment lines we leave a blank space between the percent sign % and the beginning of the text. The following m-file is in cell form:

```
\%\% Example of m-file using cells
\%\% Plot of a sine wave
\% Here we plot a sine wave going from 0 to 2\pi
\% As we know we have to create a vector for x values
\% and then a vector for y values. The vector y has the
\% information for the sine wave values
x = 0: 0.01: 2*pi;
y = sin(x);
plot(x, y)
\%\% Adding text information to a plot
\% We add a title with title.
\% We add a text to the x axis with xlabel.
\% Finally, we add a text to y axis with yaxis.
%
xlabel('x-axis')
ylabel('sine wave')
title('Plot of sin x')
```

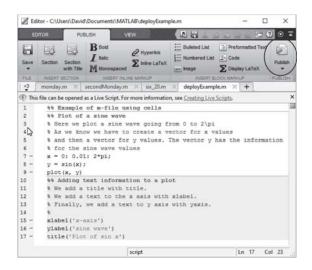


FIGURE 6.12: m-file divided in cells.

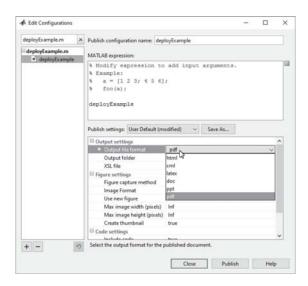


FIGURE 6.13: Publishing preferences.

The editor window is shown in Figure 6.12. We see that each cell is separated by a line and that each cell has different background color. To run the file in this mode, from the main menu we select the icon for Run and Advance and this runs the m-file a cell at a time. After running each cell we see the result of the second cell is the sine function plot, and the last cell result is the same plot with a title and with axes labels. The first cell does not display anything because there are no instructions in that cell. We now proceed to publish this m-file.

### Publishing m-files

Now that we have the m-file in cell mode we can proceed to publish it. The result is a document in the format selected. The first step is to choose the **Publish** tab in the MATLAB m-file editor. In the **Publish** icon we can choose

publishing in Word, HTML, XML, LaTeX, or Power Point. The default option is the HTML format. If we wish to change to any of the other formats we can do so in the Publish icon which displays the preferences window for publishing as shown in Figure 6.13. For the example we choose the default pdf format. In this window we can choose the button Publish . We can also do it with the icon Publish after we close the window for the preferences. This will start the publishing process. After a few seconds we get the pdf document shown in Figure 6.14. We see in the pdf document that it has

- 1. A title,
- 2. A table of contents,
- 3. MATLAB instructions,
- 4. Text explaining the instructions, and
- 5. Plots.

We now describe each part of the document:

1. The title "Example of m-file using cells" is the first line of the first cell (the first cell has only the title of the document).

%% Example of m-file using cells

2. The table of contents is formed by the first line of each cell. That is, the lines with a double percent sign,

%% Adding text information to a plot %% Plot of a sine wave

3. The MATLAB instructions are, for the second cell,

```
x = 0: 0.01: 2*pi;
y = sin(x);
plot(x, y)
```

And for the third cell

```
xlabel('x-axis')
ylabel('sine wave')
title('Plot of sin x')
```

4. The text for each cell is the commented lines. For the second cell: % As we know we have to create a vector for x values % and then a vector for y values.

Traditional	MATLAB LaTeX
Equation	\$\$equation\$\$
a/b	$frac{a}{b}$
$a^2$	$a \wedge 2$
$a_{k,n}$	a_{ k, n }
$\alpha^2$	$\alpha \wedge 2$
$\sqrt{a+b}$	$\operatorname{sqrt}\{a+b\}$
$\int (a+b)dt$	$\inf \{ (a+b)dt \}$
$a \leq b$	a \leq b
$a \ge b$	a\geq b
	$\det$

**TABLE 6.6:**Commands forMATLAB LaTeX

% The vector y has the information % for the sine wave values.

For the third cell:

% We add a title with the instruction title. % We add a text to the x axis with xlabel. % We add a text to y axis with yaxis.

5. Finally, the plots are also displayed in the pdf document.

In the published document we may also include equations. They have to be written in the LaTeX format. Table 6.6 lists some of the more used MATLAB LaTeX formats to write equations. For example, to write

$$\int \sqrt{\alpha \sin(t)} dt$$

We use:

$$\%$$
 (int \sqrt {\alpha sin(t)}\, dt \$

Some rules have to be followed. These rules are:

- 1. If a row has an equation, there must be an empty comment row above and below.
- 2. There must be at least a blank space between the percent sign and the double dollar sign.

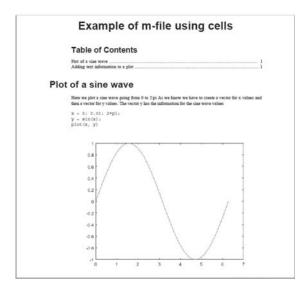


FIGURE 6.14: Top part of the deployed pdf document.

3. After a row with executable MATLAB instructions, the row has to start with a double percent sign, that is, a new cell has to start.

We now show an example to solve a quadratic equation.

### **Example** Publishing an m-file with equations To solve the quadratic equation

$$ax^2 + bx + c = 0$$

We have the solutions:

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

To publish these equations we have to write the m-file as

```
%% Solution of a second order equation
%% Introduction
% A second order equation of the form
%
% $$ ax \land 2 + bx + c = 0 $$
%
% has the solutions
%
% $$ x_{1} = \frac{c - b - \frac{b}{2a}}{2a}
%
% $$ x_{2} = \frac{c - b + \frac{b}{2a}}{2a}
%
% Example
```

```
% As an example we solve the equation
%
% $$ 3x\wedge2 + 6x - 9 = 0 $$
%
% The data are then
a = 3; b = 6; c = -9;
%% Solutions
% The solutions are
%
x1 = (-b + sqrt(b\wedge2 - 4*a*c))/(2*a);
x2 = (-b - sqrt(b\wedge2 - 4*a*c))/(2*a);
%% Results
% Finally, we display the values of the roots. %
fprintf ('x1 is a root of the second order equation %g\n', x1)
fprintf ('x2 is a root of the second order equation %g\n', x2)
```

We publish to HTML and we get the document shown in Figure 6.15.

Solution of a second order equation $\times$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$	Web Browser - Solu	ition of a second order equation	– 🗆 ×
Solution of a second order equation $\begin{array}{l} \textbf{Contents} \\ \hline \textbf{Introduction} \\ \hline \textbf{Solutions} \\ \hline \textbf{Solutions} \\ \hline \textbf{Solutions} \\ \hline \textbf{Results} \\ \hline \textbf{Introduction} \\ \textbf{Ascend order equation of the form} \\ ax^2 + bx + c = 0 \\ \hline \textbf{Ras the solutions} \\ x_1 = \frac{b - \sqrt{b^2 - 4ac}}{2a} \\ x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \\ \hline \textbf{Rample} \\ \hline \textbf{As an example we solve the equation} \\ ax^2 + 6x - 9 = 0 \\ \hline \textbf{The data are then} \end{array}$	Solution of a secon	d order equation 🔀 🕂	
Contents • Introduction • Example • Solutions • Results Hordouction A second order equation of the form $ax^2 + bx + c = 0$ Thas the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	A & C +	Location: 2/Users/David/Documents/MATLAB/	html/deployQuadraticEquations.html ~
• Introduction • Earnple • Solutions • Results Introduction A second order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = -b - \sqrt{b^2 - 4ac}$ $x_2 = -b + \sqrt{b^2 - 4ac}$ $x_2 = -b + \sqrt{b^2 - 4ac}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data methan	Solution of a s	second order equation	
• Example • Solutions • Results Introduction Assecond order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	Contents		
• Solutions • Results Introduction A second order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	<ul> <li>Introduction</li> </ul>		
- Results Introduction A second order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = -\frac{b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = -\frac{b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	<ul> <li>Example</li> </ul>		
Introduction A second order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ <b>Example</b> As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	<ul> <li>Solutions</li> </ul>		
A second order equation of the form $ax^2 + bx + c = 0$ has the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ <b>Example</b> As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	<ul> <li>Results</li> </ul>		
$ax^2 + bx + c = 0$ has the solutions $x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ <b>Example</b> As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	Introduction		
has the solutions $x_1 = -\frac{b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = -\frac{b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3a^2 + 6x - 9 = 0$ The data are then	A second order equi	ation of the form	
has the solutions $x_1 = -\frac{b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = -\frac{b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3a^2 + 6x - 9 = 0$ The data are then	$ar^2 + br + c = 0$		
$x_1 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ $x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then			
$x_2=\frac{-b+\sqrt{b^2-4ac}}{2a}$ Example As an example we solve the equation $3x^2+6x-9=0$ The data are then	has the solutions		
$x_2=\frac{-b+\sqrt{b^2-4ac}}{2a}$ Example As an example we solve the equation $3x^2+6x-9=0$ The data are then	$-b - \sqrt{b^2 - b^2}$	4ac	
Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	$x_1 =$		
Example As an example we solve the equation $3x^2 + 6x - 9 = 0$ The data are then	$-b + \sqrt{b^2} -$	400	
As an example we solve the equation $\label{eq:solution} 3x^2+6x-9=0$ The data are then	$x_2 = $		
As an example we solve the equation $\label{eq:solution} 3x^2+6x-9=0$ The data are then	Example		
The data are then		olve the equation	
The data are then			
	$3x^* + 6x - 9 = 0$		
a = 3r $b = 4r$ $c = -9r$	The data are then		
	a = 3; b = 6;	c = -91	

FIGURE 6.15: Top part of the published file in HTML format.

# **Concluding Remarks**

MATLAB has integrated a powerful programming language called mlanguage. This language allows users to produce complex programs in a very short time when we compare it with other programming languages such as C, C++, Visual Basic, FORTRAN, among others. In the chapter we treated in detail several of the instructions needed to write a program in the m-language. The process was carried out through examples going from very simple to more complex examples containing programs. A treatment in input/output instructions was given, in particular, the case of reading to/from a file. Also the case of transferring information between MATLAB and Excel was seen. More advanced topics such as deployment of m-files to users not having a MATLAB license was also discussed and examples provided a good understanding of the topic. Finally, since program documenting, also known as publishing, is an important part of programming, MATLAB does also provide a tool for documenting m-files. The process can be used for publishing to other different formats, but only the process for an HTML document was used.