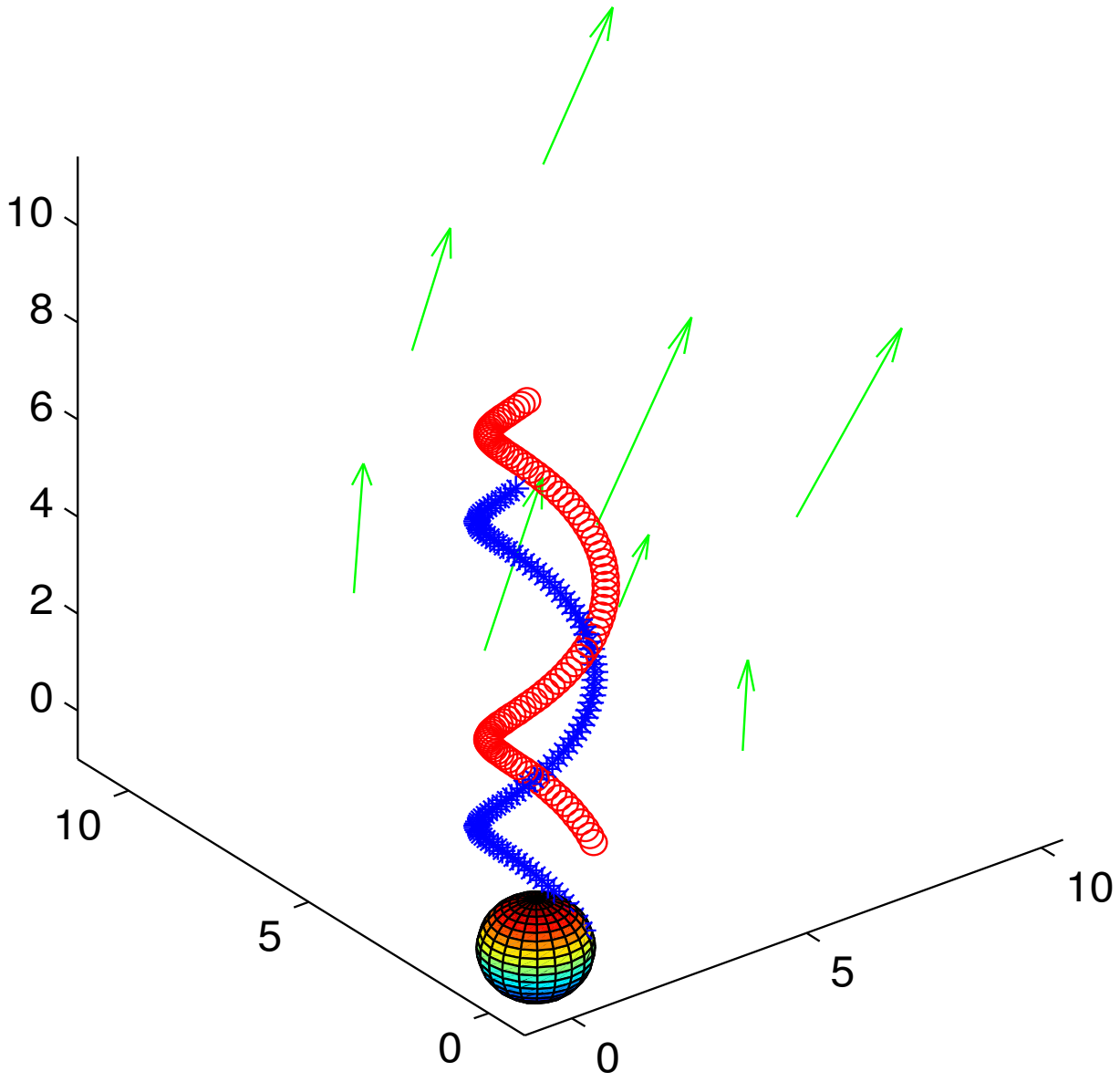
User Manual

FIG2U3D v.0.2

Convert MATLAB Figure to 3D PDF



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Cover: 3-dimensional plot exported from MATLAB using `fig2u3d`.

This work has been typeset by the author using XeTeX & friends.

Chapter 1

Usage

1.1 Introduction

This software package provides two functions for exporting 3-dimensional figures from MATLAB. The figure is exported to either a U3D file which can be included into a PDF, or directly to PDF. The result is an interactive 3D figure within the final PDF, which can be rotated and zoomed by the user. This functionality is useful for illustration of 3-dimensional information, comprising of points, lines and surfaces in $\mathbb{R}^3$.

Examples of figures created using these functions are

- The surface of a two-variable function $f(x, y)$ with its contour lines and gradient field, Fig. 1.1.
- The level set of a function of three variables $g(x, y, z) = c$, Fig. 1.2.
- A crystal lattice, Fig. 1.3.
- The model of a robotic manipulator, Fig. 1.4.
- Trajectories and the velocity field within a fluid, Fig. 1.5.

Examples of using these functions can be found in the file `examples.m`.

The software architecture is shown in Fig. 1.6.

The workflow using this software package is shown in Fig. 1.7. Function `fig2u3d` exports an open MATLAB figure to a `u3d` file and its view settings `vws` file. These can be included in LaTeXcode using the `media9` package [3]. Alternatively, Adobe Acrobat can be used to create a 3D pdf. Function `fig2pdf3d` creates a 3D pdf directly, for independent usage or inclusion as an image in a LaTeXdocument. Note that `fig2pdf3d` requires that a TeXdistribution be installed.

1.2 Dependencies

This software requires

- Universal 3D Sample Software © 1999-2006 Intel Corporation under the Apache License.

Executables cannot be included in the MATLAB Central File Exchange submissions any more. Please download the submission by Alexandre Gramfort “Matlab mesh to PDF with

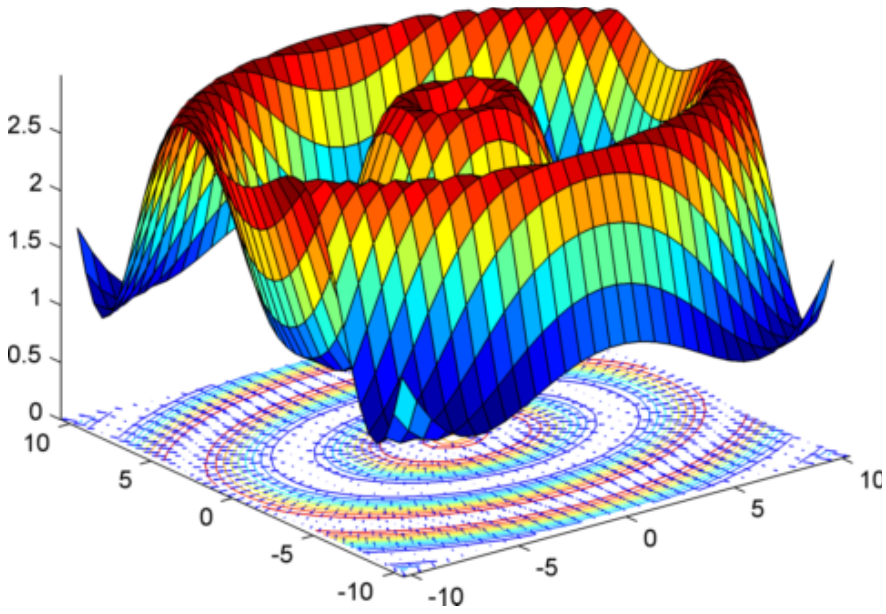

Figure 1.1: Function $f(x,y) = \sin\left(\sqrt{\frac{x^2}{2} + y^2}\right) + 2$, its level sets and gradient field.

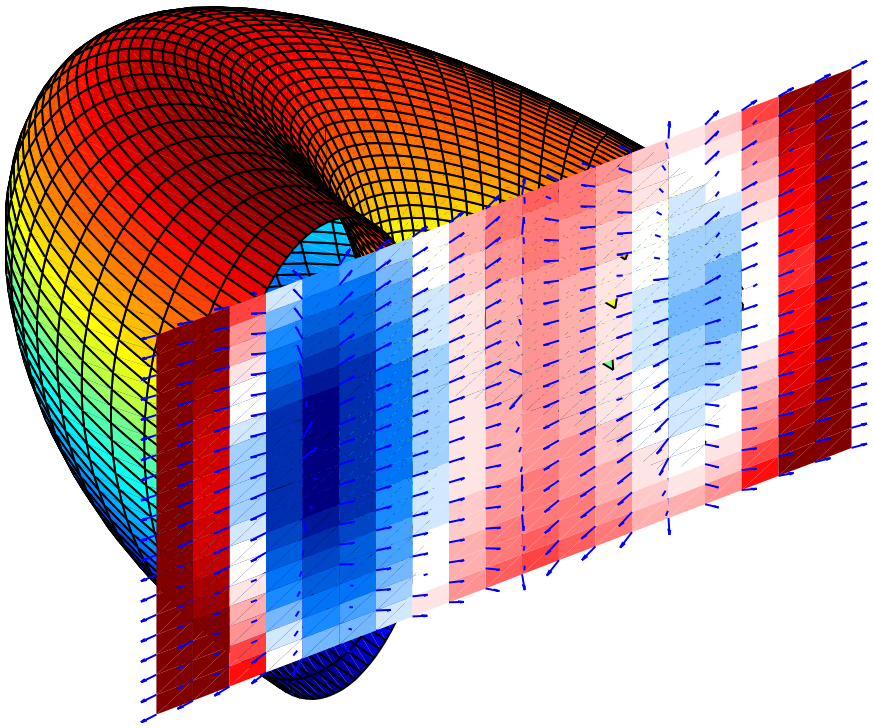

Figure 1.2: The sectioned surface is an elliptic supercyclide, implicitly defined as the zero level set $g(x,y,z) = 0$ of function $g(x,y,z) \triangleq (x^2 + y^2 + z^2 - r_m^2 + R^2 - \Delta r^2)^2 - 4(Rx - \Delta r r_m)^2 - 4(R^2 - \Delta r^2)y^2$. The 2-dimensional plane section colors represent values of function g, red denotes positive values, blue negative and white zero. The gradient field ∇g is also plotted on the section plane.

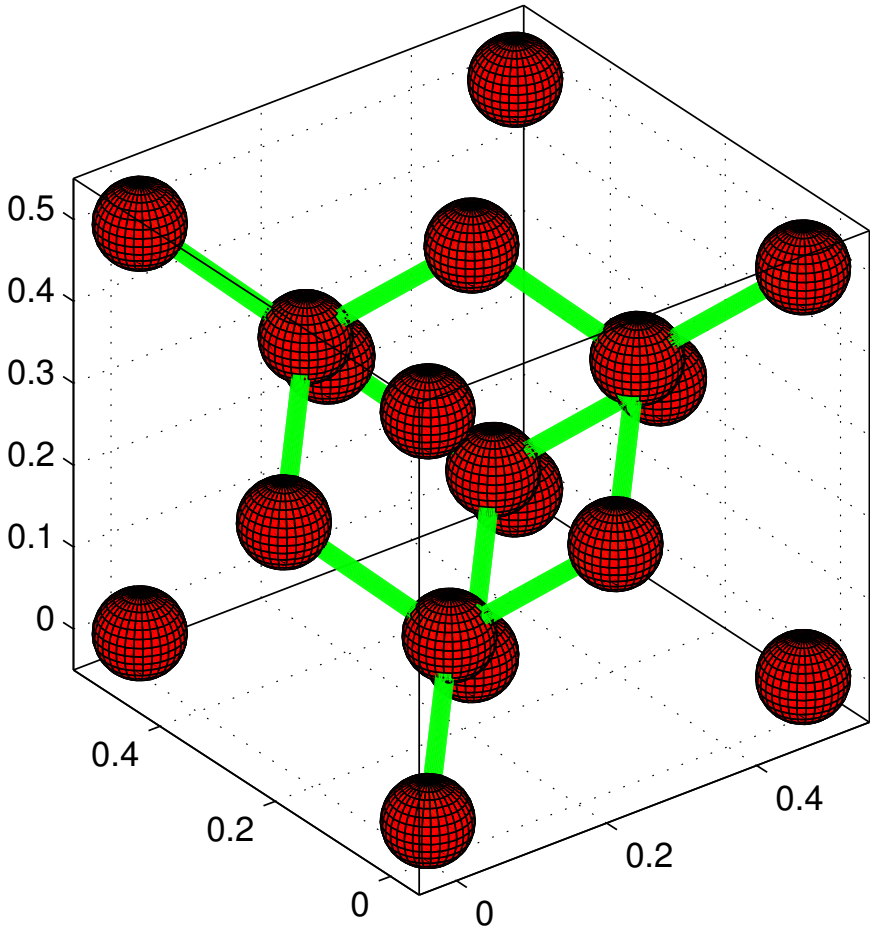

Figure 1.3: The crystal lattice of diamond.

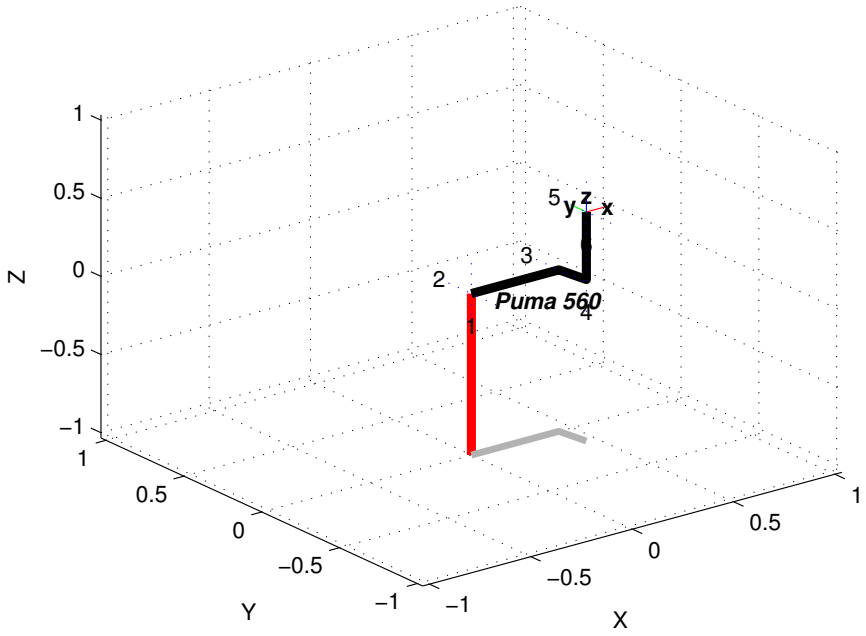

Figure 1.4: The Puma 560 robotic manipulator, plotted using the Robotics Toolbox for MATLAB [*1*].

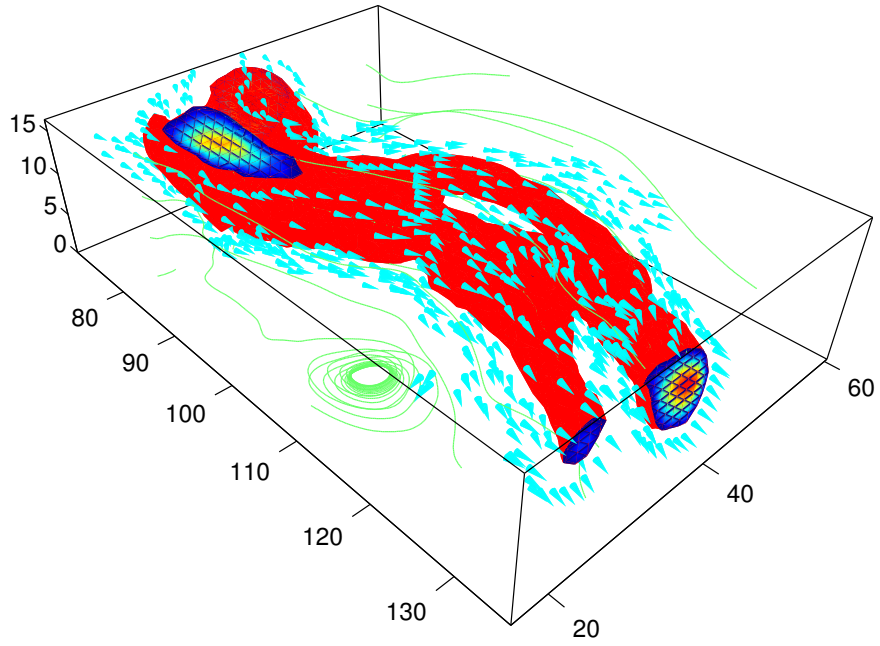

Figure 1.5: Plot of MATLAB's wind dataset using MATLAB Plot Gallery - Wind.

3D interactive object" with file id 25383 from here and place the `bin` directory within the `idtf2u3d` directory of the `fig2u3d` distribution.

This software requires also the following, which are copyright of the authors mentioned.

1. `verbatim` with file id 23194 on the MATLAB Central File Exchange © 2009 by Douglas M. Schwarz under the BSD License.

2. `arclength` with file id 34871 on the MATLAB Central File Exchange © 2012 by John D'Errico under the BSD License.

3. `vnorm` with file id 10708 on the MATLAB Central File Exchange © 2006 by Winston Smith.

For the user's convenience, the above functions have been included in the distribution of this software, together with their respective licenses. In addition, the MATLAB Central File Exchange submissions `cell_extrema, plotmd, quivermd, temphold, vectorized_meshgrid` by the author are required and included.

In order to include the U3D files created by function `fig2u3d` into a PDF, or directly export 3D content from MATLAB to a PDF using `fig2pdf3d`, a LaTeXdistribution needs to be installed. Depending on your Operating System, it can be obtained from

- MiKTeX for Windows.
- TeX Live for Linux and Unix systems.
- The MacTeX Distribution for Mac OS.

Remark: Please put these functions in your MATLAB path. You can do this by using the `pathtool` command).

Remark: Adobe Acrobat supports viewing 3D PDF documents. However, allowing or configuring rendering of 3D content may be required. This can be done in the menu Edit-> Preferences-> 3D & Multimedia tab.

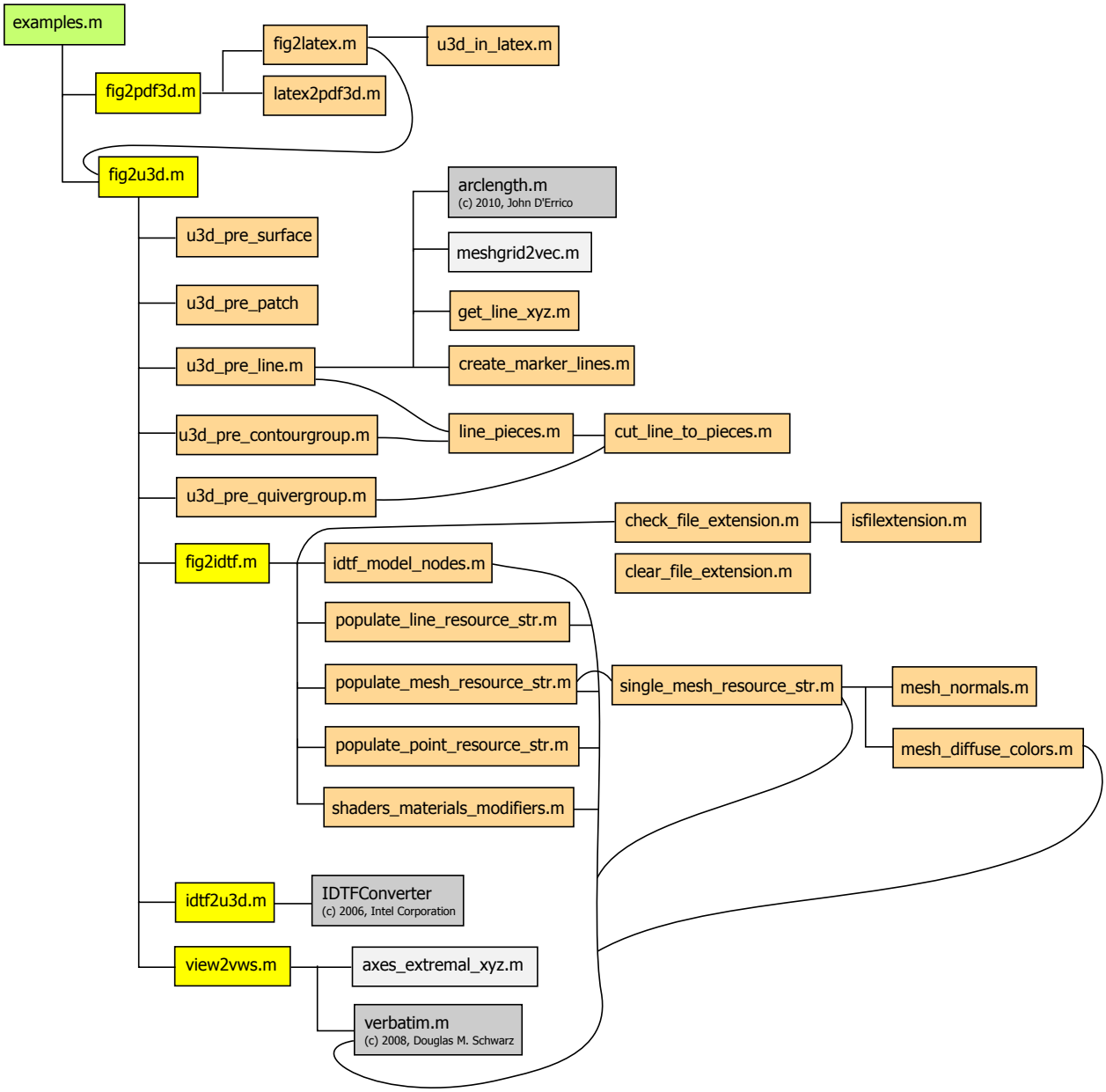

Figure 1.6: Software architecture.

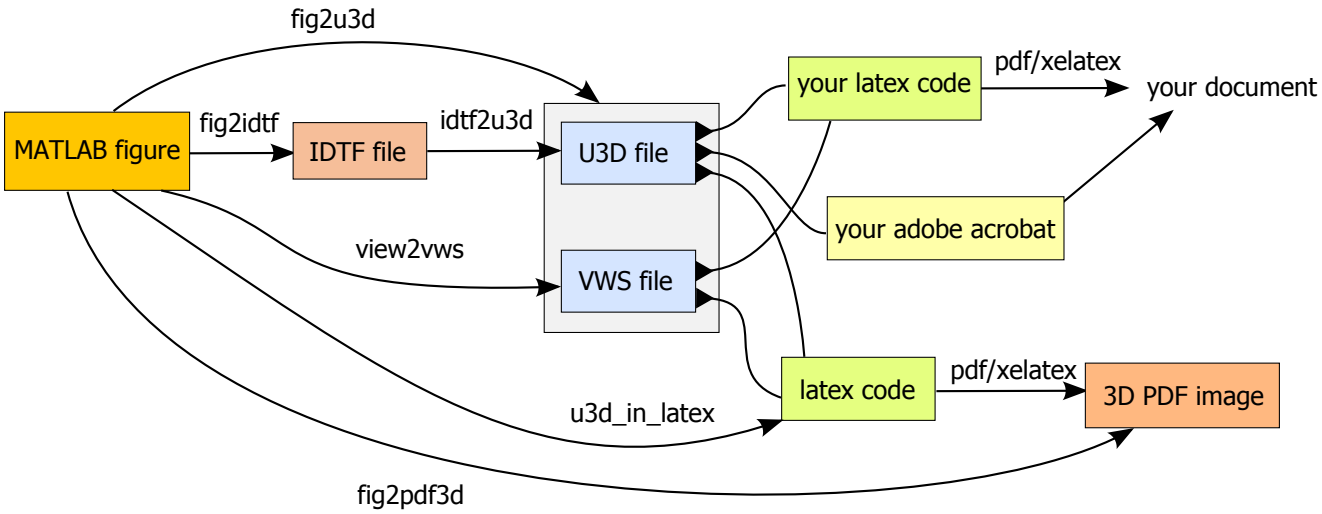

Figure 1.7: Workflow using the functions `fig2u3d` and `fig2pdf3d`.

1.3 Acknowledgments

The author wants to acknowledge the works of:

- Michail Vidiassov, who created the IDTFConverter software for conversion from the IDTF to the U3D file format. The IDTF file format specification can be found in [2]. The `IDTFConverter` executables can be found as part of the Universal 3D Sample Software on SourceForge under the Apache License.

- Alexandre Gramfort for the single surface exporter "Matlab mesh to PDF with 3D interactive object" with file id 25383 on the MATLAB Central File Exchange under the BSD License.

- Sven Körner for the U3D preprocessor for surfaces "Generate vertices, faces and color for u3d format" with file id 27245 on the MATLAB Central File Exchange under the BSD License.

- Francis Esmonde-White for the multiple surface export "Generate U3D files from STL models for making multilayer 3D PDF figures" with file id 31413 on the MATLAB Central File Exchange under the BSD License.

- Alexander Grahn for creating the `media9` package to include 3D graphics in PDF files using LaTeX, which can be found on CTAN under the LaTeX Project Public License.

The present work merges and develops on the codes by Alexandre Gramfort, Sven Körner and Francis Esmonde-White. These codes provided export for multiple surfaces to U3D or directly to a PDF.

This functionality has been extended here to export all point, line, surface, patch, quiver and contour objects in a figure. In addition, the color, markers, shading (surface edges visible or not) and view settings are all exported as well. Finally, the view settings are exported for the new `media9` LaTeXpackage, which is also used for compiling the final PDF in the case of direct conversion.

1.4 Export figure to U3D file

To export a plot from MATLAb to a U3D file use the function `fig2u3d`, by issuing the command `fig2u3d`. This will save the current axes to a U3D file named `surface.u3d`. In addition, it will create a views file `surface.vws`, to be used with the LaTeXpackage `media9` and a 2-dimensional image `surface.png` for display in PDF viewers which do not support 3D objects.

If an axes handle or a file name will be provided, then use the command with arguments `fig2u3d(ax, 'myfig')`, where `ax` is the axes object handle and `'myfig'` is the file name. The file extensions are appended automatically, so `myfig` will become `myfig.u3d`, `myfig.vws` and `myfig.png`.

If a figure handle is provided, then the first axes in it is exported. Further options can be controlled by providing additional arguments. An argument to determine the 2 dimensional figure filetype can be provided. An argument for adding or not the axes objects as vectors is also available, for a result similar to Fig. 1.8. Any other arguments will be passed to the `print` or `export_fig` functions, depending on which is used for saving 2 dimensional graphics.

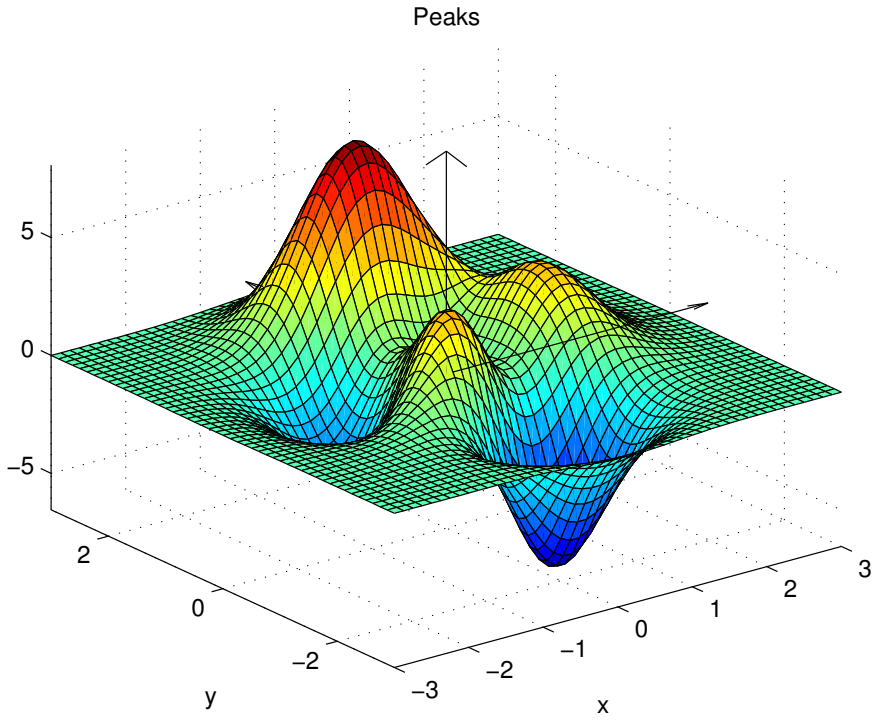

Figure 1.8: MATLAB surface to which the axes have been added, using `fig2u3d(gca, 'peaks', '', 1)`.

1.4.1 Example inclusion in LaTeX

Load the `media9` LaTeXpackage in the preample using the command

```
\usepackage[dvipdfmx]{media9}
```

For more information on the package and its available options, see [3].

```
\begin{figure}
    \centering
    \includemedia[%
        width=\textwidth,%
        activate=pagevisible,%
        deactivate=pageinvisible,%
        3Dtoolbar,%
        3Dviews=./img/myfig.vws%
    ]{%
        \includegraphics[width=0.45\textwidth]{./img/myfig.png}%
    }{%
        ./img/myfig.u3d%
    }
    \caption{My surface.}
    \label{fig:myfig}
\end{figure}
```

The `includemedia` command is provided by the `media9` package, to load 3-dimensional graphics and videos. Option `3Dviews` specifies the path to the views file `VSW` exported from

MATLAB using `fig2u3d`. The `includegraphics` command loads the 2-dimensional image to display in PDF viewers which do not support 3D content. Note that is you use the `\graphicspath{{./img/}}` command in the preamble, then `\includegraphics` does not need the image file's path, but only its file name.

1.5 Export figure to 3D Interactive PDF

The function `fig2pdf3d` can be used to export a plot directly to a 3D pdf. This requires that LaTeXbe installed, together with the `media9` package, because they are used to compile the PDF. The syntax for this command is `fig2pdf3d`, which saves the figure to a PDF file named `surface.pdf` (default file name).

Using more arguments, the axes and file name can be specified with the command syntax `fig2pdf3d(ax, 'myfig')`, where `ax` is the axes object handle and `myfig` is the filename. The file extension will be appended automatically and the file saved will be `myfig.pdf`. A third argument can be used to specify whether the `media9` or the older `movie15` LaTeXpackage is to be used. The syntax in this case is
`fig2pdf3d(ax, 'myfig', 'media9')` and
`fig2pdf3d(ax, 'myfig', 'movie15')`,
depending on which LaTeXpackage used for including the 3d graphics. Finally, a fourth argument can be used to select between the `pdflatex` and the `xelatex` compilers, in this case the syntax is
`fig2pdf3d(ax, 'myfig', 'media9', 'xelatex')`, or
`fig2pdf3d(ax, 'myfig', 'media9', 'pdflatex')`, or
`fig2pdf3d(ax, 'myfig', 'movie15', 'pdflatex')`.

Appendix A

References

[1] P. I. Corke, *Robotics, Vision & Control: Fundamental Algorithms in Matlab*. Springer, 2011.

[2] I. Corporation, "Idtf (intermediate data text file) format description," Intel Corporation, Tech. Rep. Version 100, 2005. [Online]. Available: http://u3d.svn.sourceforge.net/viewvc/u3d/releases/Gold12Update/Docs/IntermediateFormat/IDTF%20Format%20Description.pdf

[3] A. Grahn, *The* `media9` *package*, 0th ed., May 2012. [Online]. Available: http://mirror.ctan.org/macros/latex/contrib/media9/doc/media9.pdf