POLAR3D: A 3-Dimensional Polar Plot Function in Matlab®
Version 1.2

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This technical note describes POLAR3D, a Matlab® function that allows the user to plot 3-Dimensional polar data. Occasionally one is required to plot intensity or magnitude information obtained along an arc or radial direction. Typical examples are surface profiles obtained at several radii, or radial information obtained between given angles. POLAR3D is similar to the polar plot except that it attempts to plot the intensity/magnitude information for given (ρ,θ).

2 March 2006

This version introduces a new plot option: 'meshl'. This option allows the user to plot the data without interpolation and adds the polar axis, tick marks and labels. The output of this option returns Zin in the same size as when input; the other corresponding Xout,Yout Cartesian coordinates are given with the same size as Zin. The 'contourf' option has been removed.

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   J M De Freitas. 'POLAR3D: A 3-Dimensional Polar Plot Function in Matlab®'. Version 1.2. QinetiQ Ltd, Winfrith Technology Centre, Winfrith, Dorchester DT2 8XJ. UK. 2 June 2005.
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POLAR3D V1.2

POLAR3D is a Matlab® function that allows the user to plot 3-Dimensional polar data. The function was designed to plot 3D intensity data over a disc or on a sector of a disc between an inner and outer radius. Moreover, POLAR3D was designed to be simple, and one of the best ways of doing this is to make the plot data available as an output, to cater for a wide range of users with different plot needs.

The syntax of the function is as follows:

```
polar3d(Zin, theta_min, theta_max, Rho_min, Rho_max, meshscale)
polar3d(Zin,theta_min,theta_max, Rho_min, Rho_max, meshscale,plotspec)
polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max, meshscale, interpspec)
polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale, plotspec, interpspec)
[Xout,Yout,Zout] = polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,...)
```

Polar3D(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale) produces a mesh plot of the input data between theta_min and theta_max, radii Rho_min and Rho_max.

Note that when this call is made, the default interpolation over the input data is 'linear' and the default plot type is 'mesh'.

Polar3D(Zin,...,*plotspec*) plots the data as 'surf', 'surfc', 'mesh', 'meshc', 'contour', or 'meshl' as set by *plotspec*. The ‘meshl’ option is new for version 1.2. See page 4.

Note that if *plotspec* = 'off', the plot function is disengaged.

Polar3D(Zin,..., *interpspec*) plots the data as mesh plot with 'linear', 'cubic', 'nearest’, or 'spline' 2D interpolation over the input data as set by *interpspec*. Refer to Matlab® documentation for further details on interpolation types.

[x,y,z] = Polar3D(Zin,...,'off') disengages the plot function and returns the (x,y,z) plot data. Note that x, y, and z are all square matrices whose dimensions depend on *meshscale* (see below).

[x,y,z] = Polar3D(Zin,..., *plotspec*, *interpspec*) carries out 2D interpolation over the input data as set by *interpspec*, plots the data according to *plotspec*, and returns the (x,y,z) plot data. Note that x, y, and z are all square matrices whose dimensions depend on *meshscale* (see below).

Polar3D(Zin,..., *meshscale, plotspec*, *interpspec*) carries out 2D interpolation over the input data as set by *interpspec*, plots the data according to *plotspec*, and changes the size of the squares on the mesh or surf plots as set by *meshscale*.

If *meshscale* is less than 1, the size of the squares on the plots is reduced, whereas if it is greater than 1, the size of the squares is enlarged. Thus for example, if *meshscale* = 0.2, then the size of the squares is reduced to 1/5th of its original size; if *meshscale* = 3.2, then it is magnified by a factor of 3.2.

Note that the dimensions of Zout will be reduced (relative to largest dimension of Zin) by the same scaling as *meshscale* if the latter is greater than 1, or scaled up if it is less than 1, but see the new ‘meshl’ option on page 4.

Polar3D as an interpolation tool

Polar3D can be used purely as an interpolation tool over the Cartesian space i.e. without reference to the polar format. Refer to the **Examples** section of this document for further details.

The New ‘meshl’ Option: Axes and Labels

The ‘meshl’ option allows the user to plot the data *without interpolation* and adds the polar axis, tick marks and labels. The output of this option returns Zin unchanged; the corresponding (Xout,Yout) Cartesian coordinates are given with the same size as Zin.

The ‘contourf’ *option has now been removed*.

It is important to note that the ‘meshl’ option uses a DataAspectRatio of 1:1:1, and as such the plots do not auto-scale. It may be necessary to rescale Zin so that it is visible again. See examples on pages 8 and 9.

This approach allows the user to plot the data without interfering with its size. This could also be useful in simulated data where, for instance, the interpolation may have an influence on the data especially at the boundaries of the data.

In the event that the data needs to be interpolated, and polar axes are required, this can be done by calling polar3d(Zin…) twice as demonstrated on page 9 (**Axes and Labels**).

If this approach does not meet the needs of the user, s/he could resort to plotting the output (Xout,Yout,Zout) in any other suitable format.

Refer to further comments in the help section of the m-file or on pages 8 and 9.

Additional Notes

Zin is the input magnitude profiles where each column in Zin is assumed to represent the radial information in the plot i.e. each column represents the information along a radial line defined by theta, where theta varies between theta_min and theta_max.

Zin is a (M x N) matrix, where M and N are not necessarily equal. If M is not equal to N then the data are interpolated to make them equal. The final size is determined by the larger value of (M,N). However, refer to the new 'meshl' option on page 4 for differences.

The N columns of Zin are assumed to be equally spaced measurements of the radial components, where Zin(1,1) corresponds to (theta_min,Rho_max), Zin(M,1) corresponds to (theta_min,Rho_min), and so on. Zin(1,N) corresponds to (theta_max,Rho_max) and Zin(M,N) corresponds to (theta_max,Rho_min). Theta increases in the anticlockwise direction on the plot. The relationship between Zin, Rho and theta is shown in Table 1. Note that no one dimension of Zin should be less than 3, or if Zin is square it should not be smaller than a 5 x 5 matrix.

The plot function when invoked in Polar3D will cause Zout to be plotted in an anticlockwise direction as shown in Figure 1.

Table 1. Relationship between ρ, θ and Zin

Increasing θ

Increasing ρ

	θ_{min}	θ_{min+1}			θ_{max}
ρ_{max}	Zin(1,1)	Zin(1,2)	...	...	Zin(1,N)
ρ_{max-1}	Zin(2,1)	Zin(2,2)			Zin(2,N)
	•	•			•
	•	•	...	...	•
	•	•			•
ρ_{min+1}	Zin(M-1,1)	Zin(M-1,2)			Zin(M-1,N)
ρ_{min}	Zin(M,1)	Zin(M,2)			Zin(M,N)

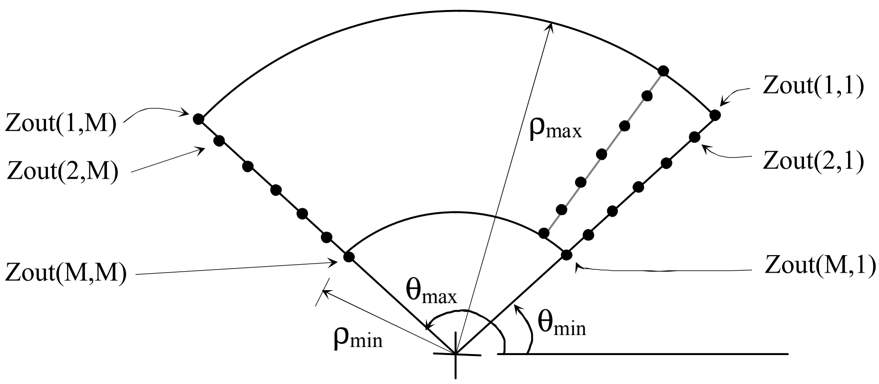
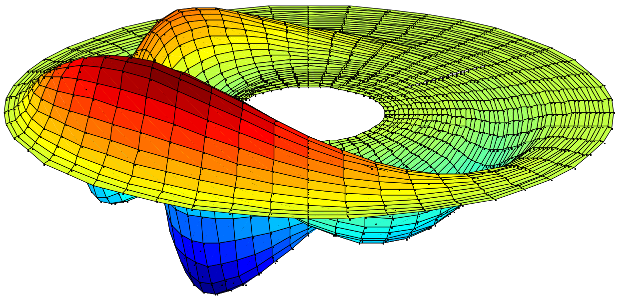
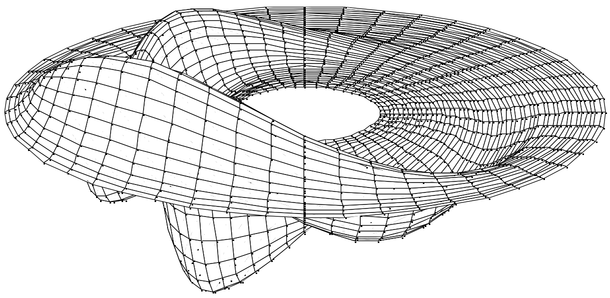


Figure 1

General Applications

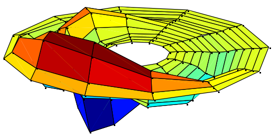


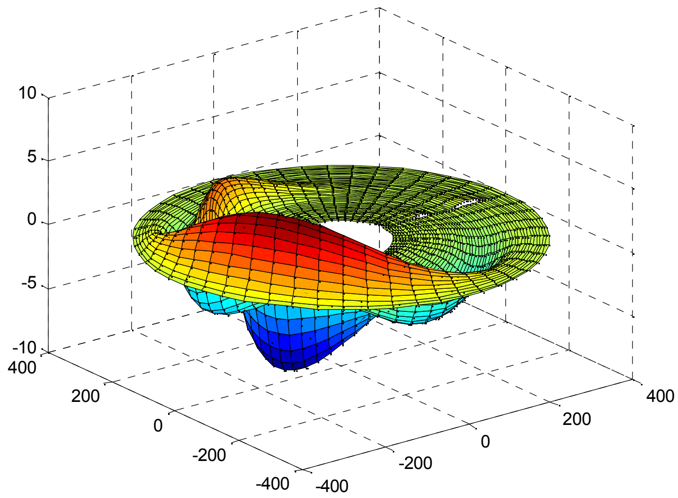
```
P = peaks(49);
Polar3d(-P,0,2*pi,100,400,1,'surf');              %change sign of P for
                                                  %demonstration purposes
```



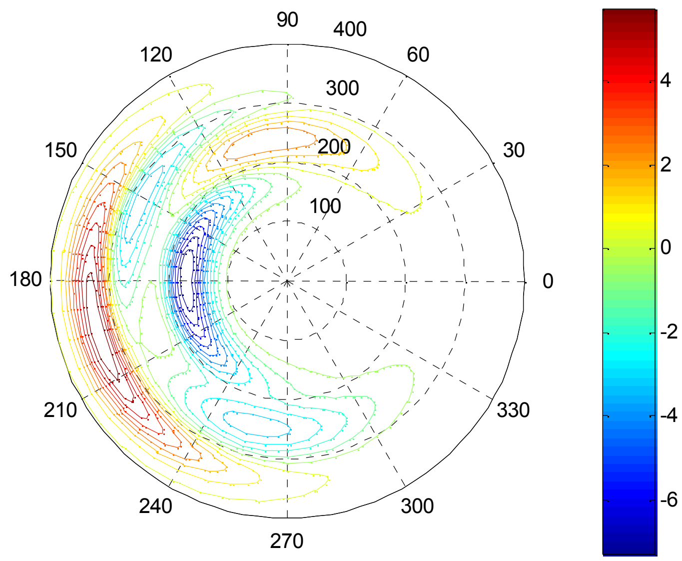
```
P = peaks(49);
Polar3d(-P,0,2*pi,100,400,1);               %change sign of P for
                                            %demonstration purposes
```

peaks(13)



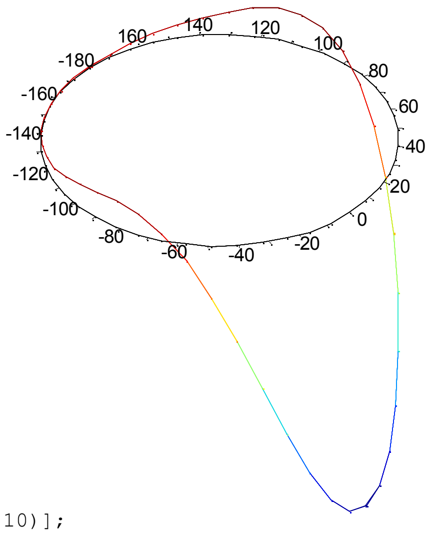



```
P = peaks(13);
[x,y,z] = Polar3d(-P,0,2*pi,100,400,0.25,'off','spline');
surf(x,y,z)
```

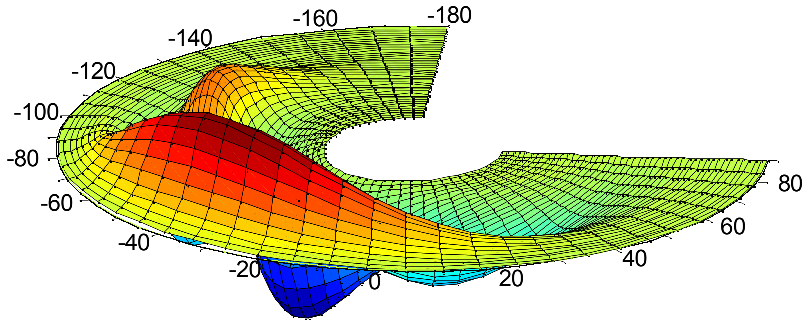


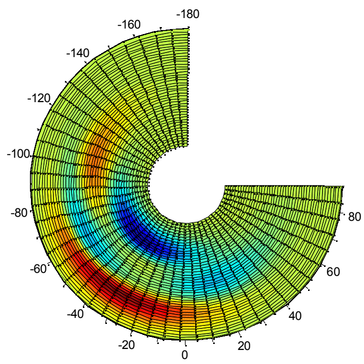

```
P = peaks(49);
Polar3d(-P,0,2*pi,100,400,1,'contour');
```

Applications with Axes and Labels

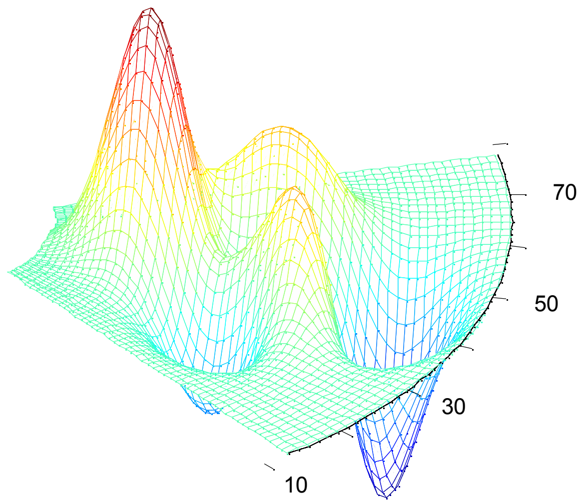



```
P = peaks(45);
Z = [P(:,10) P(:,10) P(:,10)];
polar3d(Z',-pi,pi,1,1.001,1,'meshl');
%
% Here we want to look at a single profile. We set up and look at column 10 of Peaks.
% Now since the input Zin into polar3d must have a minimum of three rows or columns,
% we form the input Z by concatenating P(:,10) three times. Note that the radii of 1
% and 1.001 define the line width of the profile. You may use colormap([0 0 0]) to
% change the profile into black.
```

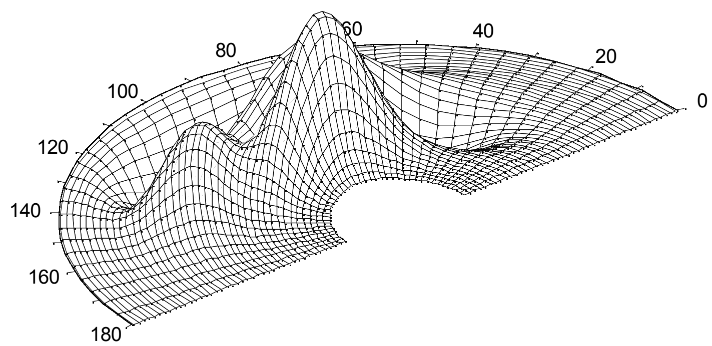





```
P = peaks(45);
Z = zeros(size(P));
polar3d(-20*P,-pi,pi/2,100,400,1,'surf');
hold on
polar3d(Z',-pi,pi/2,400,400.001,1,'meshl');
hold off
%
% In this case we want to put labels onto a surf plot. We make two calls to polar3d,
% the first to create the surf plot, while the second puts the axes on.
%
% The plot on the bottom right was obtained by manipulating the elevation in the
% figure window.
%
% The radius of the axes could be changed by changing ‘Rho_min’ and ‘Rho_max’ in
% the second call to polar3d(…), e.g. polar3d(Z',-pi,pi/2,420,420.001,1,'meshl');
```

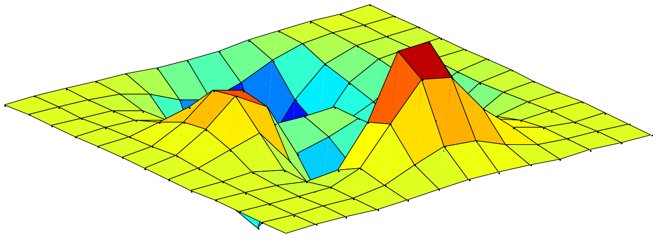



```
P = peaks(51);
polar3d(20*P,13*pi/180,pi/2.31,70,320,1,'meshl');
%
% Note that we have scaled up 'P' by 20, i.e. '20*P'. This is
% necessary because we are using a DataAspectRatio of 1:1:1. To
% change this you could use the script: set(gca,'DataAspectRatio',[l m n]
% to reset the DataAspectRatio to l:m:n.
```

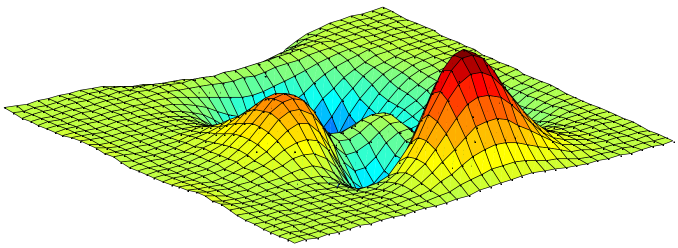



```
P = peaks(21);
[x,y,z] = polar3d(20*P,0,pi,70,320,.5,'off','spline');
z = fliplr(z)'; % change z back into original format as Zin.
                % Use fliplr when z is to be used on its own without x and y.
polar3d(z,0,pi,70,320,1,'meshl');
colormap([0 0 0]);
%
% Note how we use polar3d(…) twice. The first time to generate an
% interpolated version of peaks(21), then the second time polar3d(…)
% uses the output z from the first call as its input. But because
% the 'meshl' option is used, it does not change the input z, but
% merely adds the polar axis, tick marks and labels.
```

Polar3d as an interpolation tool



```
P = peaks(13);
surf(-P); axis off; grid off;
```



```
P = peaks(13);
[x,y,z] = Polar3d(-P,0,2*pi,100,400,0.36,'off','spline');
surf(fliplr(z)');
axis off; grid off;
```

Polar3D.m

```
function [Xout, Yout, Zout] = polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale,varargin)
%
% POLAR3D   Plots a 3D polar surface.
%
%           POLAR3D(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale) plots
%           the profiles as a mesh plot for Zin between radii Rho_min and
%           Rho_max for polar angles equally spaced between theta_min and theta_max.
%
%           POLAR3D(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale,plotspec)
%           plots the profiles Zin between radii Rho_min and Rho_max for
%           polar angles between theta_min and theta_max with a plot type
%           specification. If plotspec = 'surf' a standard Matlab surface
%           is plotted,whereas 'mesh', 'surfc' or 'meshc' will plot mesh,
%           surface with countour, or mesh with contour, respectively.
%           The size of the squares on the mesh or surf plots is determined
%           by meshscale. The default plot is a mesh plot.
%
%
%           [Xout,Yout,Zout] = POLAR3D(Zin,theta_min,theta_max,Rho_min,
%           Rho_max, meshscale)returns Zout values corresponding to the
%           Cartesian positions (Xout,Yout).
%
% SYNTAX    polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale)
%           polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale,plotspec)
%           polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale,interpspec)
%           polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,meshscale, plotspec,interpspec)
%           [Xout,Yout,Zout] = polar3d(Zin,theta_min,theta_max,Rho_min,Rho_max,...)
%
% INPUT     Zin         input magnitude profiles where each column in Zin is
%                       assumed to represent the radial information in the
%                       plot i.e. each column represents the information
%                       along a radial line defined by theta, where theta
%                       varies between theta_min and theta_max.
%
%                       Zin is a (M x N) matrix, where M and N are not
%                       necessarily equal. If M is not equal to N then the
%                       data are interpolated to make them equal. The final
%                       size is determined by the larger value of (M,N).
%
%                       The N columns of Zin are assumed to be equally
%                       spaced measurements of the radial components, where
%                       Zin(1,1) corresponds to (theta_min,Rho_max) and
%                       Zin(M,1) corresponds to (theta_min,Rho_min), and so on.
%                       Zin(1,N) corresponds to (theta_max,Rho_max) and
%                       Zin(M,N) corresponds to (theta_max,Rho_min). Theta
%                       increases in the anticlockwise direction.
%
%           theta_min   the lower value in radians of the angular range
%                       over which the data is defined. Theta_min is a
%                       scalar quantity.
%
%           theta_max   the upper value in radians of the angular range
%                       over which the data is defined. Theta_max is a
%                       scalar quantity.
%
%           Rho_min     the lower value of the radial component for which
%                       the data is defined. Rho_min is a scalar quantity.
%
%           Rho_max     the upper value of the radial component for which
%                       the data is defined. Rho_max is a scalar quantity.
%
%           meshscale   a scalar that determines the size of the squares
%                       on the mesh or surf plots. If meshscale is 1, the
%                       mesh remains unchanged relative to the input grid;
%                       if meshscale is 2, the size of the squares is doubled,
%                       if 3.2, say, it is scaled accordingly. Moreover, if
%                       meshscale is less than 1, e.g. 0.2, the size of the
%                       squares is reduced into a finer mesh. The dimensions
%                       of Xout, Yout and Zout are reduced or enlarged by
%                       meshscale, relative to the largest dimension of Zin.
%
%           plotspec    = 'surf'    produces a surface plot.
%                       = 'surfc'   produces a surface plot with contour.
%                       = 'mesh'    produces a mesh plot.
%                       = 'meshc'   produces a mesh plot with countour.
%                       = 'contour' produces a 2D contour plot.
%                       = 'off' disengages plot function.
%                       = 'meshl'   produces a mesh plot with labelled axes.
%
%                                   It may be necessary for you to scale
%                                   Zin when this option is used because
%                                   the DataAspectRatio is 1:1:1. This is
%                                   done by replacing 'Zin' with 'n*Zin',
%                                   e.g. polar3d(7.12*Zin,...) where the
```

```
%                                   scaling factor in this case is 7.12.
%
%                                   Note also that when this option is
%                                   invoked, the data does not undergo any
%                                   interpolation; the same size matrix is
%                                   returned and plotted. 'meshscale' is
%                                   ignored.
%
%           interpspec  = 'linear'  bilinear interpolation on Zin.
%                       = 'spline'  spline interpolation on Zin.
%                       = 'nearest'  nearest neighbour interpolation on Zin.
%                       = 'cubic'  bicubic interpolation on Zin.
%
% OUTPUT    Zout        output magnitude profiles defined by Zin at
%                       positions (Xout,Yout).
%
%                       Zout is square with dimensions determined by the
%                       maximum dimension of the input matrix Zin. The
%                       dimensions of Zout are reduced or enlarged by meshscale.
%
%                       If 'meshl' option is used Zout is same size as Zin.
%
%           Xout        output X-positions corresponding to polar positions
%                       (rho,theta). Xout is square with dimensions
%                       determined by the maximum dimension of the input
%                       matrix Zin. The dimensions of Xout are reduced or
%                       enlarged by meshscale.
%
%                       If 'meshl' option is used Xout is same size as Zin
%
%           Yout        output Y-positions corresponding to polar positions
%                       (rho,theta). Yout is square with dimensions
%                       determined by the maximum dimension of the input
%                       matrix Zin. The dimensions of Yout are reduced or
%                       enlarged by meshscale.
%
%                       If 'meshl' option is used Yout is same size as Zin
%
% See also POLAR, SPHERE3D, CYL3D, POL2CART and INTERP2

%           Written by JM DeFreitas, QinetiQ Ltd, Winfrith Technology
%           Centre, Dorchester DT2 8XJ, UK. jdefreitas@qinetiq.com.
%
%           Revision 1.0 4 April 2005.
%           Released 5 April 2005. (Beta Release).
%
%           Revision 1.1 17 April 2005
%           1. Inroduced new check on Zin to cover case of dimensions (M x 2)
%              or (2 x N) matrix. These are not allowed.
%           2. Changed L2 so that when meshscale > 1 and theta ranges over
%              360 degrees the data wraps around without spaces.
%           3. Removed Xout1, Yout1 and Zout1.
%           4. Changed 'theta(j,:) = ones([(L2/n) 1])*angl(j);' to
%              'theta(j,:) = ones([1 (L2/n)])*angl(j)'; so that it is
%              compatible with Matlab6 R12.1.
%           5. Reorganised meshgrid so that interpolation now works with
%              meshscale < 1.
%           6. Changed error traps from '((p ~= 1)&(q ~= 1))' to
%              '((p ~= 1)|(q ~= 1))' where used.
%
%           Revision 1.2 2 March 2006
%           1. Changed the 'contourf' option to 'meshl' option. This new
%              option allows the user to plot a standard mesh plot with
%              labelled polar axes.
%           2. The 'meshl' option plots with a DataAspectRatio of 1:1:1 and
%              as such does not automatically scale Zin. It is important for
%              the user to suitably scale Zin in this eventuality.
%           3. The angles are labelled in degrees.
%
%
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%
%           Terms and Conditions of Use
%
%           1.  This function is made available to Matlab® users under the
%               terms and conditions set out in the Matlab Exchange by
%               The Mathworks, Inc.
%           2.  Where the use of POLAR3D is to be cited, the following is recommended:
%               J M De Freitas. 'POLAR3D v1.2: A 3-Dimensional Polar Plot Function
%               in Matlab®'. QinetiQ Ltd, Winfrith Technology Centre, Winfrith,
%               Dorchester DT2 8XJ. UK. 2 June 2005.
%           3.  No offer of warranty is made or implied by the author and
%               use of this work implies that the user has agreed to take full
%               responsibility for its use.
%

if (nargin < 6)
    disp('Polar3d Error: Too few input arguments.');
```

```
    return
elseif (nargin > 8)
    disp('Polar3d Error: Too many input arguments.');
    return
end

[p,q] = size(theta_min);
if (((p ~= 1)|(q ~= 1))|~isreal(theta_min))|ischar(theta_min)
    disp('Polar3d Error: theta_min must be scalar and real.');
    return
end
[p,q] = size(theta_max);
if (((p ~= 1)|(q ~= 1))|~isreal(theta_max))|ischar(theta_max)
    disp('Polar3d Error: theta_max must be scalar and real.');
    return
end
if theta_max <= theta_min
    disp('Polar3d Error: theta_max less than or equal theta_min.');
    return
end
if abs(theta_max - theta_min) > 2*pi
    disp('Polar3d Error: range of theta greater than 2pi.');
    return
end

[p,q] = size(Rho_max);
if (((p ~= 1)|(q ~= 1))|~isreal(Rho_max))|(ischar(Rho_max)|Rho_max < 0)
    disp('Polar3d Error: Rho_max must be scalar, positive and real.');
    return
end
[p,q] = size(Rho_min);
if (((p ~= 1)|(q ~= 1))|~isreal(Rho_min))|(ischar(Rho_min)|Rho_min < 0)
    disp('Polar3d Error: Rho_min must be scalar, positive and real.');
    return
end
if Rho_max <= Rho_min
    disp('Polar3d Error: Rho_max less than or equal Rho_min.');
    return
end

[p,q] = size(meshscale);
if (((p ~= 1)|(q ~= 1))|~isreal(meshscale))|ischar(meshscale)
    disp('Polar3d Warning: mesh scale must be scalar and real.');
    meshscale = 1;
end
if (meshscale <= 0)
    disp('Polar3d Warning: mesh scale must be scalar and positive.');
    meshscale = 1;
end

% Set up default plot and interpolation specifications.
str1 = 'mesh';
str2 = 'linear';
if length(varargin) == 2
% Sort out plot and interpolation specification if both strings given.
    str1 = [varargin{1}(:)]';
    str2 = [varargin{2}(:)]';
    g1 = (~isequal(str1,'mesh')&~isequal(str1,'surf'))&~isequal(str1,'off');
    g2 = (~isequal(str1,'meshc')&~isequal(str1,'surfc'));
    g5 = (~isequal(str1,'contour')&~isequal(str1,'meshl'));
    g3 = (~isequal(str2,'cubic')&~isequal(str2,'linear'));
    g4 = (~isequal(str2,'spline')&~isequal(str2,'nearest'));
    if (g1&g2&g5)
        disp('Polar3d Warning: Incorrect plot specification. Default to mesh plot.');
        str1 = 'mesh';
    end
    if (g3&g4)
        disp('Polar3d Warning: Incorrect interpolation specification.');
        disp('Default to linear interpolation.');
        str2 = 'linear';
    end
elseif length(varargin) == 1
% Sort out plot or interpolation specification from single string input.
    str1 = [varargin{1}(:)]';
    g1 = (~isequal(str1,'mesh')&~isequal(str1,'surf'))&~isequal(str1,'off');
    g2 = (~isequal(str1,'meshc')&~isequal(str1,'surfc'));
    g5 = (~isequal(str1,'contour')&~isequal(str1,'meshl'));
    g3 = (~isequal(str1,'cubic')&~isequal(str1,'linear'));
    g4 = (~isequal(str1,'spline')&~isequal(str1,'nearest'));
    if (g1&g2)&(g3&g4&g5)
        disp('Polar3d Error: Incorrect plot or interpolation specification.');
        return
    elseif isequal(str1,'cubic')
        str2 = str1;
        str1 = 'mesh';
    elseif isequal(str1,'linear')
        str2 = str1;
        str1 = 'mesh';
```

```
    elseif isequal(str1,'spline')
        str2 = str1;
        str1 = 'mesh';
    elseif isequal(str1,'nearest')
        str2 = str1;
        str1 = 'mesh';
    elseif isequal(str1,'off')
        str2 = 'linear';
    end
end;

% Check if dimensions of input data are acceptable.
[r,c] = size(Zin');
if (r < 5)&(c < 5)
    disp('Polar3d Error: Input matrix dimensions must be greater than (4 x 4).');
    return
end
% Check if input data has two rows or columns or less.
if (r < 3)|(c < 3)
    disp('Polar3d Error: One or more input matrix dimensions too small.');
    return
end

% Transpose and setup input magnitude matrix.
temp = Zin';
for j = 1:c
    P(:,j) = temp(:,c-j+1); % swap columns over
end
Zin = P;
[r,c] = size(Zin);

% Check if meshscale is compatible with dimensions of input data.
scalefactor = round(max(r,c)/meshscale);
if scalefactor < 3
    disp('Polar3d Error: mesh scale incompatible with dimensions of input data.');
    return
end

% Set up meshgrid corresponding to larger matrix dimension of Zin
% for interpolation if required.
if ~isequal(str1,'meshl')
    n = meshscale;
    if r > c
        L = r;
        L2 = fix(L/n)*n;
        step = r/(c-1);
        [X1,Y1] = meshgrid(0:step:r,1:r);
        if n < 1
            [X,Y] = meshgrid(0:n:(L2-n),0:n:(L2-n));
        else
            [X,Y] = meshgrid(1:n:L2,1:n:L2);
        end
        T = interp2(X1,Y1,Zin,X,Y,str2);
    elseif c > r
        L = c;
        L2 = fix(L/n)*n;
        step = c/(r-1);
        [X1,Y1] = meshgrid(1:c,0:step:c);
        if n < 1
            [X,Y] = meshgrid(0:n:(L2-n),0:n:(L2-n));
        else
            [X,Y] = meshgrid(1:n:L2,1:n:L2);
        end
        T = interp2(X1,Y1,Zin,X,Y,str2);
    else
        L = r;
        L2 = fix(L/n)*n;
        [X1,Y1] = meshgrid(1:r,1:r);
        if n < 1
            [X,Y] = meshgrid(0:n:(L2-n),0:n:(L2-n));
        else
            [X,Y] = meshgrid(1:n:L2,1:n:L2);
        end
        T = interp2(X1,Y1,Zin,X,Y,str2);
    end

    [p,q] = size(T);
    L2 = max(p,q);

    % Set up angles
    angl = theta_min:abs(theta_max-theta_min)/(L2-1):theta_max;
    for j = 1:L2
        theta(j,:) = ones([1 L2])*angl(j);
    end

    % Set up radial components
    Rho = Rho_min:abs(Rho_max-Rho_min)/(L2-1):Rho_max;
```

```
    % Convert to Cartesian coordinates
    for j = 1:L2
        [Xout(j,:) Yout(j,:) Zout(j,:)] = pol2cart(theta(j,:),Rho,T(j,:));
    end
end %if str1 ~= 'meshl'

% Plot Cartesian surface
switch str1;
case 'mesh'
    colormap([0 0 0]);
    mesh(Xout,Yout,Zout);
    axis off;
    grid off;
case 'meshc'
    colormap([0 0 0]);
    meshc(Xout,Yout,Zout);
    axis off;
    grid off;
case 'surf'
    surf(Xout,Yout,Zout);
    axis off;
    grid off;
case 'surfc'
    surfc(Xout,Yout,Zout);
    axis off;
    grid off;
    hold off
case 'contour'
    axis equal;
    h = polar([theta_min theta_max], [Rho_min Rho_max]);
    delete(h)
    hold on
    contour(Xout,Yout,Zout,20);
    hold off
    colorbar;
case 'meshl'
    % Set up mesh plot with polar axes and labels
    angl = theta_min:abs(theta_max-theta_min)/(r-1):theta_max;
    Rho = ones([1 c])*Rho_max*1.005;
    X = Rho'*cos(angl);
    Y = Rho'*sin(angl);
    Z = zeros(size(X));
    % set up output data - this is exactly the same as the input
    Rho = Rho_min:abs(Rho_max-Rho_min)/(c-1):Rho_max;
    Xout = Rho'*cos(angl);
    Yout = Rho'*sin(angl);
    Zout = Zin';
    % plot the data
    axis equal;
    mesh(Xout,Yout,Zout);
    hold on
    % plot the axis
    mesh(X,Y,Z,'edgecolor',[0 0 0]);
    hold on;
    % set up tic mark and labels
    ticangle = round(theta_min*18/pi)*pi/18:pi/18:round(theta_max*18/pi)*pi/18;
    ticlength = [Rho_max*1.005 Rho_max*1.03];
    Xtic = ticlength'*cos(ticangle);
    Ytic = ticlength'*sin(ticangle);
    Ztic = zeros(size(Xtic));
    Xlbl = Rho_max*1.1*cos(ticangle);
    Ylbl = Rho_max*1.1*sin(ticangle);
    Zlbl = zeros(size(Xlbl));
    line(Xtic,Ytic,Ztic,'Color',[0 0 0]);
    if theta_min == 0 & theta_max == 2*pi
        Ntext = round(length(ticangle)/2)-1;
    else
        Ntext = round(length(ticangle)/2);
    end
    for i = 1:Ntext
        text(Xlbl(2*i-1),Ylbl(2*i-1),Zlbl(2*i-1),...
            num2str(ticangle(2*i-1)*180/pi),...
            'horizontalalignment','center')
    end
    set(gca,'DataAspectRatio',[1 1 1])
    axis off;
    grid off;
end
return
```