Matlab Programs for Pedagogical and Graphical Applications of Generalized Hypergeometric Function

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ABSTRACT

The present work is an attempt to use meshgrid and ndgrid functions of matlab for creating matrix data of 2-D grid space. Generalized hypergeometric function has been used for finding the height of a surface displayed in a 3-D view. It has been corroborated that if

$$Z = X \cdot {}_pF_q \left[a \ ; \ b \ ; f(X,Y) \right] ; \forall a_{i's}, b_{j's} \in \mathbf{R}$$

is a matrix for which the elements Z (i, j) define the height of a surface over an underlying (i, j) grid, then mesh (Z) generates a colored, wire-frame view of the surface and displays it in a 3-D view. Similarly, surf (Z) generates a colored, faceted view of the surface and displays it in a 3-D view.

Keywords

Mesh, Surf, Generalized Hypergeometric Function, Multiple hypergeometric Function, Meshgrid, Ndgrid

1. INTRODUCTION

In creating three-dimensional representations of data, it is often necessary to have data defined over evenly spaced, two-dimensional grids. The `SURF`, `MESH`, `CONTOUR`, and `QUIVER` functions are examples of graphics functions that use data. We can map data in the form of vectors or matrices containing X, Y, and Z = f(X, Y) coordinate points onto grids for use with the above plotting routines.

The meshgrid function transforms the domain specified by two vectors, x and y, into matrices X and Y. We then use these matrices to evaluate functions of two variables: The rows of X are copies of the vector x and the columns of Y are copies of the vector y.

$$[xx, yy, zz] = \mathbf{meshgrid}\ (x, y, z)$$

Given vectors of *x* and *y* and *z* coordinates, and returning 3 arguments, return three-dimensional arrays corresponding to the *x*, *y* and *z* coordinates of a mesh.

$$[y_1, y_2 ... y_n] = \mathbf{ndgrid}(x_1, x_2 ... x_n)$$

$$[y1, y_2 ... y_n] = \mathbf{ndgrid}\ (x)$$

The work on a mesh and curve plot program for the output of a finite element analysis can be seen in the research paper of Amy P. Gilkey et al (1989). The prominent work in MATLAB applications can be seen in the books of Andrew James Knight (2000), Hunt et al (2001), Sergey Edward Lyshevski (2003) etc. Flat panel display process has been performed by Suk Bong-kyung Chang et al (2003) by the application of MATLAB. We also find the application of this software on Electron Temperature Control in Plasmas with Mesh Grid Bias and its Application to Hydrogen Negative Ion Production by Osamu Fukumasa at el (2007). The work of Tateishi Kazuyoshi et al (2008) can also be quoted for corona current control by mesh grid. Compendium of MATLAB applications can be seen in the works of Raj Kumar Bansal et al (2009), Huu Tue Huynh et al (2009), Amos Gilat (2010), Dukkipati (2010) etc. to mention only a few.

Solutions of many problems require the use of computers. Several software programs are available to solve problems that arise in different emerging areas. MATLAB is popular software that is used for the solutions of problems from scientific areas. We have made attempts to generate programs in   MATLAB software so that the three

dimensional figures envisaging surface concepts and four dimensional figures merged in three dimensional cases with color effects could be drawn by the utilization of infinite convergent series expressions of Generalized and multiple hypergeometric functions. The logic behind making the use of numerical computational programs of MATLAB instead of traditional programming languages is the fact that it can handle vectors and matrices in a straightforward and intuitive way.

2. Application of MESHGRID in the fitting of vector data and Plotting of evenly spaced data

Evenly spaced data is best illustrated in the case of three spatial dimensions. In this case, each (X, Y) coordinate pair lies on an evenly spaced grid. For every coordinate pair in the grid, there is a corresponding Z coordinate. Making the use of following MATLAB program we can plot the Generalized Hypergeometric function by MESHGRID function:

```
>> [X, Y] = meshgrid(-2:.2:2,-2:.2:2);
>> Z = X.*hypergeom(1,1,-X.^2-Y.^2);
>> [X, Y] = meshgrid(-2:.2:2,-2:.2:2);
>> plot3(X, Y, Z);
>> Z = X.*hypergeom(1,1,-X.^2-Y.^2);
>> Surf(X, Y, Z);
```

TABLE1: X, Y AND Z MATRICES

X- Coordinates

−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2
−2	−1.8	−1.6	−1.4	−1.2	−1	−0.8	−0.6	−0.4	−0.2

0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2

Y- Coordinates

$$Z= {}_1F_1 \,(1;\, 1;\, X^2\text{-}Y^2) – \text{Coordinates}$$

-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6
-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4
-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
0	0	0	0	0	0	0	0	0	0
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1	1	1	1	1	1	1	1	1	1
1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
2	2	2	2	2	2	2	2	2	2

-0.00067093	-0.0012912	-0.0022654	-0.0036119	-0.0052074	-0.0067379	-0.0077262
-0.0014346	-0.0027609	-0.0048441	-0.0077232	-0.011135	-0.014408	-0.016521
-0.0028318	-0.0054496	-0.0095616	-0.015245	-0.021979	-0.028439	-0.03261
-0.0051598	-0.0099298	-0.017422	-0.027778	-0.040048	-0.051819	-0.059419
-0.008679	-0.016702	-0.029305	-0.046723	-0.067362	-0.087161	-0.099944
-0.013476	-0.025934	-0.045502	-0.072546	-0.10459	-0.13534	-0.15518
-0.019315	-0.037171	-0.06522	-0.10398	-0.14992	-0.19398	-0.22243
-0.025557	-0.049183	-0.086294	-0.13758	-0.19836	-0.25666	-0.2943
-0.031215	-0.060072	-0.1054	-0.16804	-0.24228	-0.31349	-0.35946
-0.035195	-0.067731	-0.11884	-0.18947	-0.27317	-0.35345	-0.40529
-0.036631	-0.070495	-0.12369	-0.1972	-0.28431	-0.36788	-0.42183
-0.035195	-0.067731	-0.11884	-0.18947	-0.27317	-0.35345	-0.40529
-0.031215	-0.060072	-0.1054	-0.16804	-0.24228	-0.31349	-0.35946
-0.025557	-0.049183	-0.086294	-0.13758	-0.19836	-0.25666	-0.2943
-0.019315	-0.037171	-0.06522	-0.10398	-0.14992	-0.19398	-0.22243
-0.013476	-0.025934	-0.045502	-0.072546	-0.10459	-0.13534	-0.15518
-0.008679	-0.016702	-0.029305	-0.046723	-0.067362	-0.087161	-0.099944
-0.0051598	-0.0099298	-0.017422	-0.027778	-0.040048	-0.051819	-0.059419
-0.0028318	-0.0054496	-0.0095616	-0.015245	-0.021979	-0.028439	-0.03261
-0.0014346	-0.0027609	-0.0048441	-0.0077232	-0.011135	-0.014408	-0.016521
-0.00067093	-0.0012912	-0.0022654	-0.0036119	-0.0052074	-0.0067379	-0.0077262

-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6
-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4
-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
0	0	0	0	0	0	0	0	0	0	0
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1	1	1	1	1	1	1	1	1	1	1
1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
2	2	2	2	2	2	2	2	2	2	2

-0.007667	-0.006243	-0.0035195	0	0.0035195	0.006243	0.007667
-0.016394	-0.013349	-0.0075257	0	0.0075257	0.013349	0.016394
-0.03236	-0.02635	-0.014855	0	0.014855	0.02635	0.03236
-0.058964	-0.048013	-0.027067	0	0.027067	0.048013	0.058964
-0.099179	-0.080759	-0.045528	0	0.045528	0.080759	0.099179
-0.154	-0.12539	-0.070691	0	0.070691	0.12539	0.154
-0.22073	-0.17973	-0.10132	0	0.10132	0.17973	0.22073
-0.29205	-0.23781	-0.13406	0	0.13406	0.23781	0.29205
-0.35671	-0.29046	-0.16375	0	0.16375	0.29046	0.35671
-0.40219	-0.32749	-0.18462	0	0.18462	0.32749	0.40219
-0.41861	-0.34086	-0.19216	0	0.19216	0.34086	0.41861
-0.40219	-0.32749	-0.18462	0	0.18462	0.32749	0.40219
-0.35671	-0.29046	-0.16375	0	0.16375	0.29046	0.35671
-0.29205	-0.23781	-0.13406	0	0.13406	0.23781	0.29205
-0.22073	-0.17973	-0.10132	0	0.10132	0.17973	0.22073
-0.154	-0.12539	-0.070691	0	0.070691	0.12539	0.154
-0.099179	-0.080759	-0.045528	0	0.045528	0.080759	0.099179
-0.058964	-0.048013	-0.027067	0	0.027067	0.048013	0.058964
-0.03236	-0.02635	-0.014855	0	0.014855	0.02635	0.03236
-0.016394	-0.013349	-0.0075257	0	0.0075257	0.013349	0.016394
-0.007667	-0.006243	-0.0035195	0	0.0035195	0.006243	0.007667

0.0077262	0.0067379	0.0052074	0.0036119	0.0022654	0.0012912	0.00067093
0.016521	0.014408	0.011135	0.0077232	0.0048441	0.0027609	0.0014346
0.03261	0.028439	0.021979	0.015245	0.0095616	0.0054496	0.0028318
0.059419	0.051819	0.040048	0.027778	0.017422	0.0099298	0.0051598
0.099944	0.087161	0.067362	0.046723	0.029305	0.016702	0.008679
0.15518	0.13534	0.10459	0.072546	0.045502	0.025934	0.013476
0.22243	0.19398	0.14992	0.10398	0.06522	0.037171	0.019315
0.2943	0.25666	0.19836	0.13758	0.086294	0.049183	0.025557
0.35946	0.31349	0.24228	0.16804	0.1054	0.060072	0.031215
0.40529	0.35345	0.27317	0.18947	0.11884	0.067731	0.035195
0.42183	0.36788	0.28431	0.1972	0.12369	0.070495	0.036631
0.40529	0.35345	0.27317	0.18947	0.11884	0.067731	0.035195
0.35946	0.31349	0.24228	0.16804	0.1054	0.060072	0.031215
0.2943	0.25666	0.19836	0.13758	0.086294	0.049183	0.025557
0.22243	0.19398	0.14992	0.10398	0.06522	0.037171	0.019315
0.15518	0.13534	0.10459	0.072546	0.045502	0.025934	0.013476
0.099944	0.087161	0.067362	0.046723	0.029305	0.016702	0.008679
0.059419	0.051819	0.040048	0.027778	0.017422	0.0099298	0.0051598
0.03261	0.028439	0.021979	0.015245	0.0095616	0.0054496	0.0028318
0.016521	0.014408	0.011135	0.0077232	0.0048441	0.0027609	0.0014346
0.0077262	0.0067379	0.0052074	0.0036119	0.0022654	0.0012912	0.00067093

DIFFERENT 3-D PLOTS OF ABOVE MATRIX DATA FORM BY MESHGRID FUNCTION
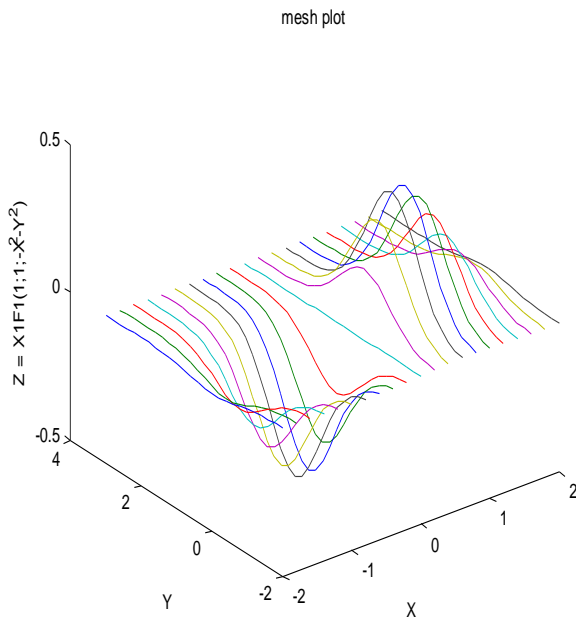
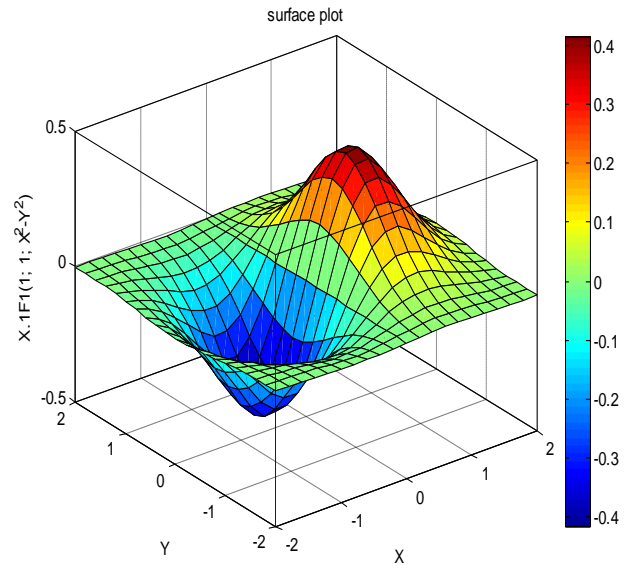### FIG 1(a)

mesh plot

FIG 1(b)

surface plot

FIGURE 1: plotting of generalized hypergeometric function on an evenly spaced X-Y grid (square form)

We have produced a surface plot and a vertical strip of color corresponding to the colormap. The colorbar indicates the mapping of data value to color with the axis labels.

A function has been generated that defines a grid space (the X and Y matrices), and reorganizes our data (the Z = $_1F_1$ (1; 1; X^2-Y^2) matrix) into the corresponding matrix that fits the grid space.

MATLAB PROGRAM FOR THREE DIMENSIONAL PLOTTING OF THE GENERALIZED HYPERGEOMETRIC FUNCTION BY MESHGRID
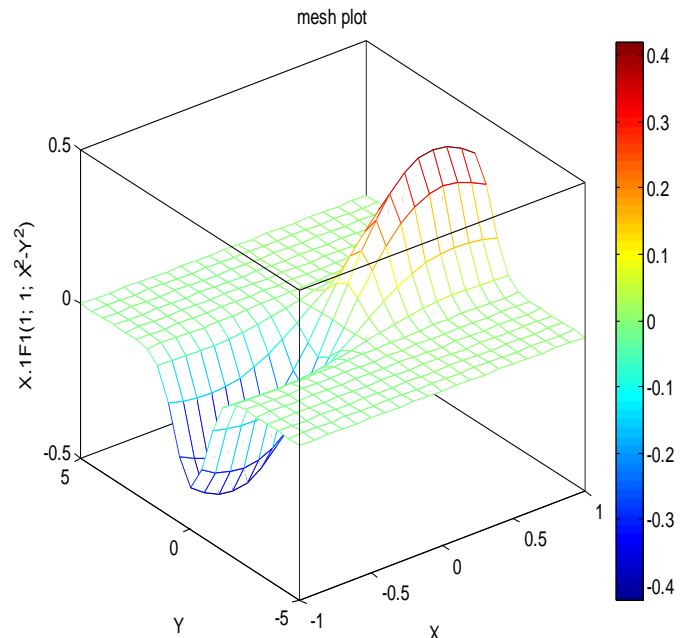
```
>> [X, Y] = meshgrid(-1:0.1:1,-5:0.5:5);
>> Z = X.*hypergeom(1,1,-X.^2-Y.^2);
>> plot3(X, Y, Z);
>> [X, Y] = meshgrid(-1:0.1:1,-5:0.5:5);
>> Z = X.*hypergeom(1,1,-X.^2-Y.^2);
>> Surf(X, Y, Z);
```

TABLE 2: X, Y AND Z= $_1F_1$ (1; 1; X^2-Y^2)

MATRICES

X- Coordinates

−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1
−1	−0.9	−0.8	−0.7	−0.6	−0.5	−0.4	−0.3	−0.2	−0.1

0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Y- Coordinates

−5	−5	−5	−5	−5	−5	−5	−5	−5	−5
−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5
−4	−4	−4	−4	−4	−4	−4	−4	−4	−4
−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5
−3	−3	−3	−3	−3	−3	−3	−3	−3	−3
−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5
−2	−2	−2	−2	−2	−2	−2	−2	−2	−2
−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5
−1	−1	−1	−1	−1	−1	−1	−1	−1	−1
−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5
0	0	0	0	0	0	0	0	0	0
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1	1	1	1	1	1	1	1	1	1
1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
2	2	2	2	2	2	2	2	2	2
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
3	3	3	3	3	3	3	3	3	3
3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
4	4	4	4	4	4	4	4	4	4
4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
5	5	5	5	5	5	5	5	5	5

−5	−5	−5	−5	−5	−5	−5	−5	−5	−5	−5
−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5	−4.5
−4	−4	−4	−4	−4	−4	−4	−4	−4	−4	−4
−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5	−3.5
−3	−3	−3	−3	−3	−3	−3	−3	−3	−3	−3
−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5	−2.5
−2	−2	−2	−2	−2	−2	−2	−2	−2	−2	−2
−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5	−1.5
−1	−1	−1	−1	−1	−1	−1	−1	−1	−1	−1
−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5
0	0	0	0	0	0	0	0	0	0	0
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1	1	1	1	1	1	1	1	1	1	1
1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
2	2	2	2	2	2	2	2	2	2	2
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
3	3	3	3	3	3	3	3	3	3	3
3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
4	4	4	4	4	4	4	4	4	4	4
4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
5	5	5	5	5	5	5	5	5	5	5

Z= $_1F_1$ (1; 1; X^2-Y^2) – Coordinates

4.7338e-012	5.408e-012	5.8136e-012	5.9557e-012	5.8584e-012	5.5603e-012	5.1091e-012
5.4715e-010	6.2508e-010	6.7196e-010	6.8838e-010	6.7714e-010	6.4269e-010	5.9053e-010
3.8358e-008	4.3821e-008	4.7108e-008	4.8259e-008	4.7471e-008	4.5056e-008	4.1399e-008
1.631e-006	1.8633e-006	2.0031e-006	2.052e-006	2.0185e-006	1.9158e-006	1.7603e-006
4.2065e-005	4.8056e-005	5.166e-005	5.2923e-005	5.2058e-005	4.941e-005	4.54e-005
0.00065801	0.00075172	0.0008081	0.00082785	0.00081433	0.0007729	0.00071017
0.006243	0.0071321	0.007667	0.0078545	0.0077262	0.0073331	0.0067379
0.035926	0.041042	0.044121	0.045199	0.044461	0.042199	0.038774
0.12539	0.14325	0.154	0.15776	0.15518	0.14729	0.13534
0.26546	0.30327	0.32601	0.33398	0.32852	0.31181	0.2865
0.34086	0.3894	0.41861	0.42884	0.42183	0.40037	0.36788
0.26546	0.30327	0.32601	0.33398	0.32852	0.31181	0.2865
0.12539	0.14325	0.154	0.15776	0.15518	0.14729	0.13534
0.035926	0.041042	0.044121	0.045199	0.044461	0.042199	0.038774
0.006243	0.0071321	0.007667	0.0078545	0.0077262	0.0073331	0.0067379
0.00065801	0.00075172	0.0008081	0.00082785	0.00081433	0.0007729	0.00071017
4.2065e-005	4.8056e-005	5.166e-005	5.2923e-005	5.2058e-005	4.941e-005	4.54e-005
1.631e-006	1.8633e-006	2.0031e-006	2.052e-006	2.0185e-006	1.9158e-006	1.7603e-006
3.8358e-008	4.3821e-008	4.7108e-008	4.8259e-008	4.7471e-008	4.5056e-008	4.1399e-008
5.4715e-010	6.2508e-010	6.7196e-010	6.8838e-010	6.7714e-010	6.4269e-010	5.9053e-010
4.7338e-012	5.408e-012	5.8136e-012	5.9557e-012	5.8584e-012	5.5603e-012	5.1091e-012

MESHGRID shall take specified vector ranges for the grid under study and shall return the grid matrices X and Y, such as those in Table 2.

-5.1091e-012	-5.5603e-012	-5.8584e-012	-5.9557e-012	-5.8136e-012	-5.408e-012	-4.7338e-012
-5.9053e-010	-6.4269e-010	-6.7714e-010	-6.8838e-010	-6.7196e-010	-6.2508e-010	-5.4715e-010
-4.1399e-008	-4.5056e-008	-4.7471e-008	-4.8259e-008	-4.7108e-008	-4.3821e-008	-3.8358e-008
-1.7603e-006	-1.9158e-006	-2.0185e-006	-2.052e-006	-2.0031e-006	-1.8633e-006	-1.631e-006
-4.54e-005	-4.941e-005	-5.2058e-005	-5.2923e-005	-5.166e-005	-4.8056e-005	-4.2065e-005
-0.00071017	-0.0007729	-0.00081433	-0.00082785	-0.0008081	-0.00075172	-0.00065801
-0.0067379	-0.0073331	-0.0077262	-0.0078545	-0.007667	-0.0071321	-0.006243
-0.038774	-0.042199	-0.044461	-0.045199	-0.044121	-0.041042	-0.035926
-0.13534	-0.14729	-0.15518	-0.15776	-0.154	-0.14325	-0.12539
-0.2865	-0.31181	-0.32852	-0.33398	-0.32601	-0.30327	-0.26546
-0.36788	-0.40037	-0.42183	-0.42884	-0.41861	-0.3894	-0.34086
-0.2865	-0.31181	-0.32852	-0.33398	-0.32601	-0.30327	-0.26546
-0.13534	-0.14729	-0.15518	-0.15776	-0.154	-0.14325	-0.12539
-0.038774	-0.042199	-0.044461	-0.045199	-0.044121	-0.041042	-0.035926
-0.0067379	-0.0073331	-0.0077262	-0.0078545	-0.007667	-0.0071321	-0.006243
-0.00071017	-0.0007729	-0.00081433	-0.00082785	-0.0008081	-0.00075172	-0.00065801
-4.54e-005	-4.941e-005	-5.2058e-005	-5.2923e-005	-5.166e-005	-4.8056e-005	-4.2065e-005
-1.7603e-006	-1.9158e-006	-2.0185e-006	-2.052e-006	-2.0031e-006	-1.8633e-006	-1.631e-006
-4.1399e-008	-4.5056e-008	-4.7471e-008	-4.8259e-008	-4.7108e-008	-4.3821e-008	-3.8358e-008
-5.9053e-010	-6.4269e-010	-6.7714e-010	-6.8838e-010	-6.7196e-010	-6.2508e-010	-5.4715e-010
-5.1091e-012	-5.5603e-012	-5.8584e-012	-5.9557e-012	-5.8136e-012	-5.408e-012	-4.7338e-012

FIG 2(a)

-3.8078e-012	-2.6687e-012	-1.375e-012	0	1.375e-012	2.6687e-012	3.8078e-012
-4.4012e-010	-3.0846e-010	-1.5893e-010	0	1.5893e-010	3.0846e-010	4.4012e-010
-3.0855e-008	-2.1625e-008	-1.1142e-008	0	1.1142e-008	2.1625e-008	3.0855e-008
-1.312e-006	-9.195e-007	-4.7375e-007	0	4.7375e-007	9.195e-007	1.312e-006
-3.3836e-005	-2.3714e-005	-1.2218e-005	0	1.2218e-005	2.3714e-005	3.3836e-005
-0.00052929	-0.00037095	-0.00019112	0	0.00019112	0.00037095	0.00052929
-0.0050218	-0.0035195	-0.0018133	0	0.0018133	0.0035195	0.0050218
-0.028898	-0.020253	-0.010435	0	0.010435	0.020253	0.028898
-0.10086	-0.070691	-0.036422	0	0.036422	0.070691	0.10086
-0.21353	-0.14965	-0.077105	0	0.077105	0.14965	0.21353
-0.27418	-0.19216	-0.099005	0	0.099005	0.19216	0.27418
-0.21353	-0.14965	-0.077105	0	0.077105	0.14965	0.21353
-0.10086	-0.070691	-0.036422	0	0.036422	0.070691	0.10086
-0.028898	-0.020253	-0.010435	0	0.010435	0.020253	0.028898
-0.0050218	-0.0035195	-0.0018133	0	0.0018133	0.0035195	0.0050218
-0.00052929	-0.00037095	-0.00019112	0	0.00019112	0.00037095	0.00052929
-3.3836e-005	-2.3714e-005	-1.2218e-005	0	1.2218e-005	2.3714e-005	3.3836e-005
-1.312e-006	-9.195e-007	-4.7375e-007	0	4.7375e-007	9.195e-007	1.312e-006
-3.0855e-008	-2.1625e-008	-1.1142e-008	0	1.1142e-008	2.1625e-008	3.0855e-008
-4.4012e-010	-3.0846e-010	-1.5893e-010	0	1.5893e-010	3.0846e-010	4.4012e-010
-3.8078e-012	-2.6687e-012	-1.375e-012	0	1.375e-012	2.6687e-012	3.8078e-012

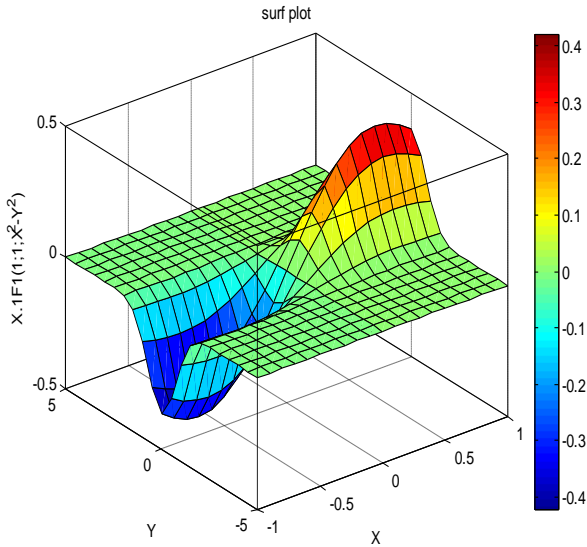mesh plot

FIG 2(b)

surf plot

FIGURE2: plotting of a generalized hypergeometric function on an evenly spaced X-Y grid (rectangular form)

MESH AND SURFACE PLOTS

We have made MATLAB to define a surface by the generalized hypergeometric function

$$_pF_q\left[\ a\ ;\ b\ ;f(x,y)\ ;\forall a_{i's},b_{j's},x,y\in \mathbf{R}\right] \quad \text{as}$$

points above a grid in the x-y plane, using straight lines to connect adjacent points. The mesh and surf plotting functions display surfaces in three dimensions. Mesh produces wireframe surfaces that color only the lines connecting the defining points. Surf displays both the connecting lines and the faces of the surface in color.

Meshgrid is better suited to problems in two- or three-dimensional Cartesian space, while Ndgrid is better suited to multidimensional problems.

The range of coordinates x, y, z are -5:0.5:5; NDGRID converts into 3-D data x, y, z of dimension 21x21x21; first of all we convert the x, y, z in matrix form X,Y,Z of dimension

21x441; to create a grid space then surf plot of the database of Kampe De Feriet function as follows:

$$F_{C:D}^{A:B}\left[\begin{array}{c}(a):(b);(b');\\(c):(d);(d');\end{array} X,Y\right]$$

MATLAB PROGRAM FOR HIGHER DIMENSIONAL SURFACE PLOTTING OF THE MULTIPLE HYPERGEOMETRIC FUNCTION BY NDGRID FUNCTION IN FIG 3(a)

```
>> [x,y,z] = ndgrid(-1:0.1:1,-1:0.1:1,-1:0.1:1);
>> X=x(:,:);
>> Y=y(:,:);
>> Z=z(:,:);
>> p=hypergeom(1,1,X+Y+Z);
>> surf(p);
```

FIG 3(a)

surf plot of Kampe De Feriet function

MATLAB PROGRAM FOR HIGHER DIMENSIONAL SURFACE PLOT OF THE MULTIPLE HYPERGEOMETRIC FUNCTION BY NDGRID FUNCTION OF FIG 3 (b)

```
>> [x,y,z] = ndgrid(-1:0.1:1,-1:0.1:1,-1:0.1:1);
>> X=x(:,:);
>> Y=y(:,:);
>> Z=z(:,:);
>> p=hypergeom(1,1,X+Y+Z);
>> surf(X,Y,Z,p);
```
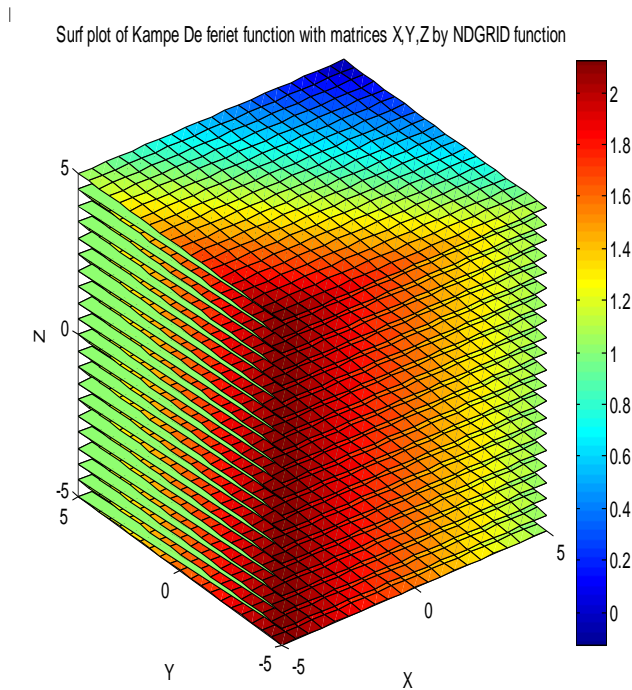
FIG 3(b)

Surf plot of Kampe De feriet function with matrices X,Y,Z by NDGRID function

FIG 3 surface plots of

$$F_{C:D}^{A:B}\left[\begin{matrix}(a):(b);(b');\\(c):(d);(d');\end{matrix}\ X\ ,Y\ \right]$$

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