International Journal of Engineering, Science and Mathematics
Vol. 10 Issue 08, August 2021,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
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APPLICATION OF GENERALIZED HYPERGEOMETRIC FUNCTIONS TO COMPUTER GRAPHICS

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ABSTRACT

In general, 2D graphics uses a two-dimensional representation of real-world objects, stored as images in the computer for being rendered and manipulated. Transformation, in graphics, is the process of manipulation of images. In this research paper, I have created 2D – Graphics from the generalized hypergeometric function ${}_pF_q\left\{((a));((b));x\right\};\forall a_{i's},b_{j's},x\in\mathbf{R}$ *by using MATLAB software. They can be transformed via multiplication by matrices of generalized hypergeometric function.*

Keyword - Generalized hypergeometric function, MATLAB, Matrices, Computer Graphics.

INTRODUCTION

Computer graphics is the life line of today's computer world. Today, computers and computer-generated images touch many aspects of daily life. Computer imagery is found on television, in newspapers, for example in weather reports, or for example in all kinds of medical investigation and surgical procedures. A well-constructed graph can present complex statistics in a form that is easier to understand and interpret. In the media "such graphs are used to illustrate papers, reports, thesis", and other presentation material. A very popular use of computer graphics is for advertising. Almost every poster, commercial, banner, etc. that you have ever seen was on a computer screen being designed and edited at one point. 'Visual Effects' in movies help enhance the audiences' perception of a film. Businesses need computer graphics for company logos, presentations, and websites. Book covers, video game cases, CD, DVD, and Blu-Ray cases all of those graphics are designed using computers. Almost anything that was not designed manually with a paint brush or pencil used some sort of computer graphics. Of course, many of these graphics are first drafted using a utensil like a pencil or paintbrush, and then a graphics artist might use a computer to transform it further. 2D computer graphics started in the 1950s, based on vector graphics devices. These were largely supplanted by raster-based devices in the following decades. The X Window System protocol and Page description language in the electronic publishing and desktop publishing were landmark developments in the field.

Computer graphics play a fundamental role in engineering design, capturing the visual and quantitative aspects of the geometric objects. Many of the most important programs for computer graphics are written in traditional programming languages (Fortran, Pascal, C, etc.) However, in the last recent years, the general-purpose numerical computation programs (NCPs) are gaining more and more popularity. Today, they are well established as a powerful alternative to the traditional programming languages in many different areas, as mechanical engineering, signal processing, quality control, electronic circuits, etc.

In this context, it seems natural to look for the application of the NCPs instead of the traditional programming languages, in the present work. The main reasons to apply MATLAB as the NCP to be used in this work have been on account of following reasons:

- Spreading MATLAB is used for hundreds of thousands of industrial, government and academic users around the world.
- Graphical capabilities, which raise many of the current graphics-oriented programs.
- Since MATLAB is based on C, it runs faster than other analyzed symbolic and numerical programs. Moreover, its basic element is an array that does not require dimensioning, so it takes less time to be computed.
- MATLAB commands, options and utilities are useful for rendering surfaces.
- MATLAB handles vectors and matrices in a straightforward and intuitive way.

The workers presently engaged in computer graphics are Zhigang Xiang et al (2000), Krishnamurthy (2001), Samuel R. Buss (2003), Jeffrey J. McConnell (2006), John A. Vince (2007) Frank Klawonn (2008), Peter Shirley et al (2009) and John A. Vince (2010).

In the category of applications to computer graphics, I code the work of Ankur Rana et al (2019) in extensive study of 2d transformations in computer graphics. another important work is David J. Eck Hobart et al, (2018) in Introduction to computer graphics. I also see the work of Ms. A. J. Rajeswari Joe et al (2013) in Scaling Transform Methods Advanced Computing.

In the category of applications to computer graphics, I may code the work of Ankur Rana et al (2019) in extensive study of 2d transformations in computer graphics. I also see the work of Ms. A. J. Rajeswari Joe et al (2013) in Scaling Transform Methods Advanced Computing. I see the work of David J. Eck Hobart et al, (2018) Introduction to computer graphics Santos Otto L. et al (1989) in field application of computer graphics for monitoring borehole trajectories. The application of computer graphics interactive techniques to the production of coronary arteriography reports can be seen in the work of Andy Stergachis et al (1991). In the category of other noticeable and relevant works we can cite the names of F.P.Vidal *et al (2006)* for applications of computer graphics in medicine. Another important work is of Steven D. Galbraith (2008) on pairing based cryptography. De Caro D. et al **(2009)** have presented an account of their work on high-performance special function unit for programmable 3-D graphics processors. We can also quote the work of Werner Purgathofer et al (2010) for eye tracking trends in computer graphics.

1 2D GRAPHICS OF LETTER N

The capital letter N in fig 1 is determined by eight points, or vertices which are in the form of a generalized hypergeometric function ${}_pF_q\{((a));((b));x\}$. The coordinates of the point can be stored in the data matrix, D. Here we take Kummer function ${}_1F_1$ (-1; b; x) all the eight vertex defined corresponding to the values of b and x given below

0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1
0.1	0.1	0.7	0.1	0.1	0.1	0.7	0.1	0.1

Values of b

Values of x

0.1	0.3	0.3	0.7	0.7	1.3	1.3	0.1	0.1
0.1	0.1	5.2	0.1	0.9	0.9	1.8	0.9	0.1

Vertex

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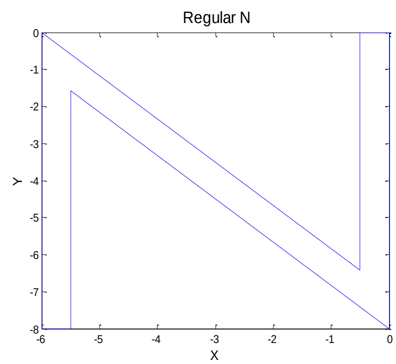
$$\begin{matrix} & 1 & 2 & 3 & 4 \\ \frac{x-Coordinate}{y-Coordinate} & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.1;0.7) \\ & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.7;5.2) & {}_1F_1(-1;0.1;0.1) \end{matrix}$$

$$\begin{bmatrix} {}_1F_1(-1;0.1;0.7) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.7;1.8) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.1) \\ 5 & 6 & 7 & 8 & 9 \end{bmatrix} = D$$

FIG 1



MATLAB PROGRAM FOR FIG 1

```
>>X=[hypergeom(-1,0.1,0.1)     hypergeom(-1,0.2,0.3)     hypergeom(-1,0.2,0.3)     hypergeom(-1,0.1,0.7)
hypergeom(-1,0.1,0.7)  hypergeom(-1,0.2,1.3)  hypergeom(-1,0.2,1.3)  hypergeom(-1,0.1,0.1)  hypergeom(-
1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1)     hypergeom(-1,0.1,0.1)     hypergeom(-1,0.7,5.2)     hypergeom(-1,0.1,0.1)
hypergeom(-1,0.1,0.9)     hypergeom(-1,0.1,0.9)     hypergeom(-1,0.7,1.8)          hypergeom(-1,0.1,0.9)
hypergeom(-1,0.1,0.1)];

>>D = [X; Y];

>>Plot(X,Y);
```

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The main reason behind description of graphical objects as collections of straight-line segments is that the standard transformations in computer graphics map line segments onto other line segments .Once the vertices that describe an object have been transformed, their images can be connected with the appropriate straight lines to produce the complete image of the original object.

Given $A=\begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$, describe the effect of the shear transformation x ⟼ Ax on the letter N in fig 1

By definition of matrix multiplication, the columns of the product AD contain the images of the vertices of the letter N.

$$AD=\begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}\begin{bmatrix} {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.1;0.7) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.7;5.2) & {}_1F_1(-1;0.1;0.1) \end{bmatrix}$$

$$\begin{matrix} {}_1F_1(-1;0.1;0.7) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.7;1.8) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.1) \end{matrix}\Bigg]$$

Vertex

1 2 3 4 5 6 7 8 9

$$AD=\begin{bmatrix} 0 & 0.5 & 2.105 & 6 & 8 & 7.5 & 5.895 & 2 & 0 \\ 0 & 0 & 6.420 & 0 & 8 & 8 & 1.580 & 8 & 0 \end{bmatrix}\frac{x-Coordinate}{y-Coordinate}$$

(Result of this multiplication with the help of MATLAB)

The transformed vertices are plotted in fig 2, along with connecting line segment that correspond to those in the original figure. The italic N in Fig 3 looks a bit too wide. To compensate, we can shrink the width by a scale transformation.

FIG 2

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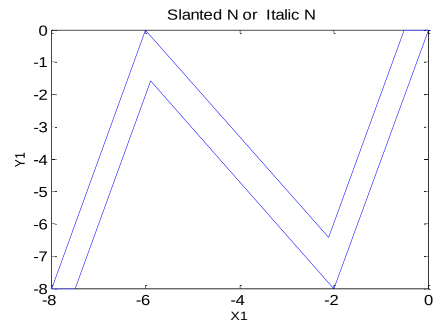

MATLAB PROGRAM FOR FIG 2

```
>>X=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.2,0.3) hypergeom(-1,0.2,0.3) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.7) hypergeom(-1,0.2,1.3) hypergeom(-1,0.2,1.3) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.7,5.2) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.9) hypergeom(-1,0.7,1.8) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.1)];

>> D = [X; Y];

>>A=[hypergeom(-1,0.1,0) hypergeom(-1,0.4,0.3); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>> AD = A*D;

>> X1 = AD (1, :);

>> Y1 = AD (2, :);

>> Plot(X1, Y1);
```

Compute the matrix of the transformation that performs a shear transformation, as in fig 1, and then scales all x- coordinates by a factor of ${}_1F_1$ (-1, 0.4, 0.1).

The matrix that multiplies the x- coordinates of a point by ${}_1F_1$ (-1, 0.4, 0.1) is

$$B=\begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$$

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So the matrix of the composite transformation is

$$BA = \begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$$

By definition of matrix multiplication, the columns of the product BAD contain the images of the vertices of the letter N.

$$BAD = \begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.2;0.3) & {}_1F_1(-1;0.1;0.7) & {}_1F_1(-1;0.1;0.7) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.2;1.3) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.7;5.2) & {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.7;1.8) & {}_1F_1(-1;0.1;0.9) & {}_1F_1(-1;0.1;0.1) \end{bmatrix}$$

Vertex

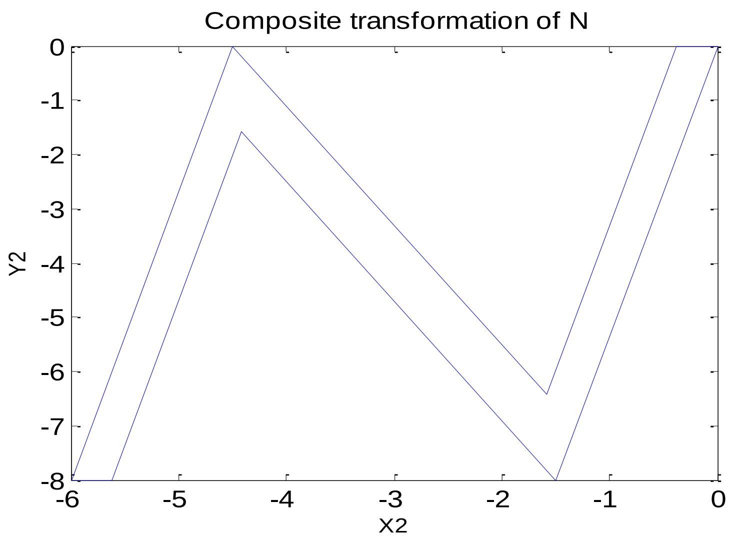
1 2 3 4 5 6 7 8 9

$$BAD = \begin{bmatrix} 0 & -0.375 & -1.5804 & -4.5 & -6 & -5.625 & -4.4196 & -1.5 & 0 \\ 0 & 0 & -6.4286 & 0 & -8 & -8 & -1.5714 & -8 & 0 \end{bmatrix} \frac{x-Coordinate}{y-Coordinate}$$

(Result of this multiplication with the help of MATLAB)

The result of this composite transformation is shown in fig 3

FIG 3



MATLAB PROGRAM FOR FIG 3

```
>>X=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.2,0.3) hypergeom(-1,0.2,0.3) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.7) hypergeom(-1,0.2,1.3) hypergeom(-1,0.2,1.3) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.7,5.2) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.9) hypergeom(-1,0.7,1.8) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.1)];

>> D = [X; Y];

>>A=[hypergeom(-1,0.1,0) hypergeom(-1,0.4,0.3); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>>B=[hypergeom(-1,0.4,0.1) hypergeom(-1,0.1,0.1); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>> BA = B*A;

>> BAD = BA*D;

>> X2 = BAD(1,:);

>> Y2 = BAD(2,:);

>> plot(X2, Y2);
```

2. 2D GRAPHICS OF LETTER W

The capital letter W in fig 4 is determined by ten points, or vertices which are in the form of a generalized hypergeometric function ${}_pF_q\left\{\left(\left(a\right)\right);\left(\left(b\right)\right);x\right\}$. The coordinates of the point can be stored in the data matrix, D. Here we take

Kummer function ${}_1F_1$ (-1; b; x) and all the ten vertex defined corresponding to the values of b and x given below

Values of b

0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.7	0.4	0.7	0.1	0.1	0.1	0.2	0.1	0.1

Values of x

0.1	0.3	0.3	0.4	1.3	1.3	0.7	0.7	0.4	0.1	0.1
0.1	0.1	5.2	1.8	5.2	0.1	0.1	0.9	1.1	0.9	0.1

Vertex

1 2 3 4 5

$$\frac{x-Coordinate}{y-Coordinate}\begin{bmatrix} 1F1(-1,0.1,0.1) & 1F1(-1,0.2,0.3) & 1F1(-1,0.2,0.3) & 1F1(-1,0.1,0.4) & 1F1(-1,0.2,1.3) \\ 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.7,5.2) & 1F1(-1,0.4,1.8) & 1F1(-1,0.7,5.2) \end{bmatrix}$$

$$\begin{bmatrix} 1F1(-1,0.2,1.3) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.4) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) \\ 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.2,1.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.1,0.1) \end{bmatrix} = D$$

6 7 8 9 10 11 FIG 4

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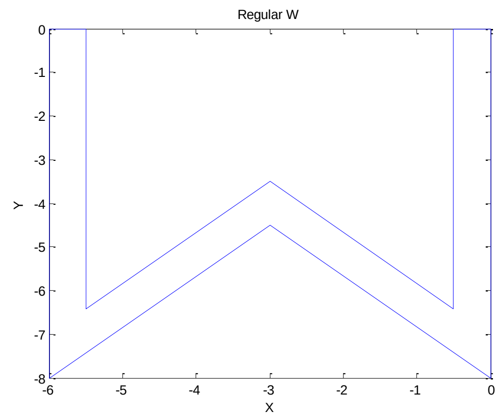


MATLAB PROGRAM FOR FIG 4

```
>>X=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.2,0.3) hypergeom(-1,0.2,0.3) hypergeom(-1,0.1,0.4) hypergeom(-1,0.2,1.3) hypergeom(-1,0.2,1.3) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.4) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.7,5.2) hypergeom(-1,0.4,1.8) hypergeom(-1,0.7,5.2) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.2,1.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.1)];

>>D = [X; Y];

>>plot(X,Y);
```

The main reason graphical objects are described by collections of straight-line segments is that the standard transformations in computer graphics map line segments onto other line segments .Once the vertices that describe an object have been transformed, their images can be connected with the appropriate straight lines to produce the complete image of the original object.

Given $A = \begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$, describe the effect of the shear transformation x ⟼ Ax on the letter W in fig 4. By definition of matrix multiplication, the columns of the product AD contain the images of the vertices of the letter W.

$$AD=\begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}\begin{bmatrix} 1F1(-1,0.1,0.1) & 1F1(-1,0.2,0.3) & 1F1(-1,0.2,0.3) & 1F1(-1,0.1,0.4) & 1F1(-1,0.2,1.3) & 1F1(-1,0.2,1.3) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.4) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) \\ 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.7,5.2) & 1F1(-1,0.4,1.8) & 1F1(-1,0.7,5.2) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.2,1.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.1,0.1) \end{bmatrix}$$

Vertex

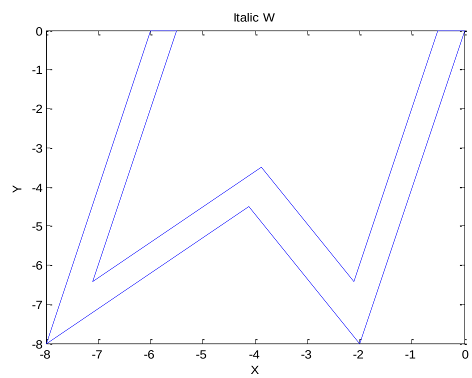
1 2 3 4 5 6 7 8 9 10 11

$$AD=\begin{bmatrix} 0 & -0.5 & -2.1071 & -3.875 & -7.1071 & -5.5 & -6 & -8 & -4.125 & -2 & 0 \\ 0 & 0 & -6.4286 & -3.5 & -6.4286 & 0 & 0 & -8 & -4.5 & -8 & 0 \end{bmatrix}\frac{x-Coordinate}{y-Coordinate}$$

(Result of this multiplication with the help of MATLAB)

The transformed vertices are plotted in fig 5, along with connecting line segment that correspond to those in the original figure. The italic W in Fig 5 looks a bit too wide. To compensate, we can shrink the width by a scale transformation.

FIG 5



MATLAB PROGRAM FOR FIG 5

```
>>X=[hypergeom(-1,0.1,0.1)    hypergeom(-1,0.2,0.3)    hypergeom(-1,0.2,0.3)    hypergeom(-1,0.1,0.4)
hypergeom(-1,0.2,1.3) hypergeom(-1,0.2,1.3) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.7) hypergeom(-
1,0.1,0.4) hypergeom(-1,0.1,0.1)    hypergeom(-1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1)    hypergeom(-1,0.1,0.1)    hypergeom(-1,0.7,5.2)    hypergeom(-1,0.4,1.8)
hypergeom(-1,0.7,5.2) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.9) hypergeom(-
1,0.2,1.1) hypergeom(-1,0.1,0.9)    hypergeom(-1,0.1,0.1)];
```

International Journal of Engineering, Science and Mathematics
Vol. 10 Issue 08, August 2021,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

```
>>D = [X; Y];

>>A=[hypergeom(-1,0.1,0) hypergeom(-1,0.4,0.3); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>> AD = A*D;

>> X1 = AD (1, :);

>> Y1 = AD (2, :);

>> plot(X1,Y1)
```

Compute the matrix of the transformation that performs a shear transformation, as in fig 4, and then scales all x- coordinates by a factor of ${}_1F_1$ (-1, 0.4, 0.1).

The matrix that multiplies the x- coordinates of a point by ${}_1F_1$ (-1, 0.4, 0.1) is

$$B = \begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$$

So the matrix of the composite transformation is

$$BA = \begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix}$$

By definition of matrix multiplication, the columns of the product BAD contain the images of the vertices of the letter W.

$$BAD = \begin{bmatrix} {}_1F_1(-1;0.4;0.1) & {}_1F_1(-1;0.1;0.1) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;0) & {}_1F_1(-1;0.4;0.3) \\ {}_1F_1(-1;0.1;0.1) & {}_1F_1(-1;0.1;0) \end{bmatrix} \begin{bmatrix} 1F1(-1,0.1,0.1) & 1F1(-1,0.2,0.3) & 1F1(-1,0.2,0.3) & 1F1(-1,0.1,0.4) & 1F1(-1,0.2,1.3) & 1F1(-1,0.2,1.3) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.7) & 1F1(-1,0.1,0.4) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) \\ 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.7,5.2) & 1F1(-1,0.4,1.8) & 1F1(-1,0.7,5.2) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.2,1.1) & 1F1(-1,0.1,0.9) & 1F1(-1,0.1,0.1) \end{bmatrix}$$

Vertex

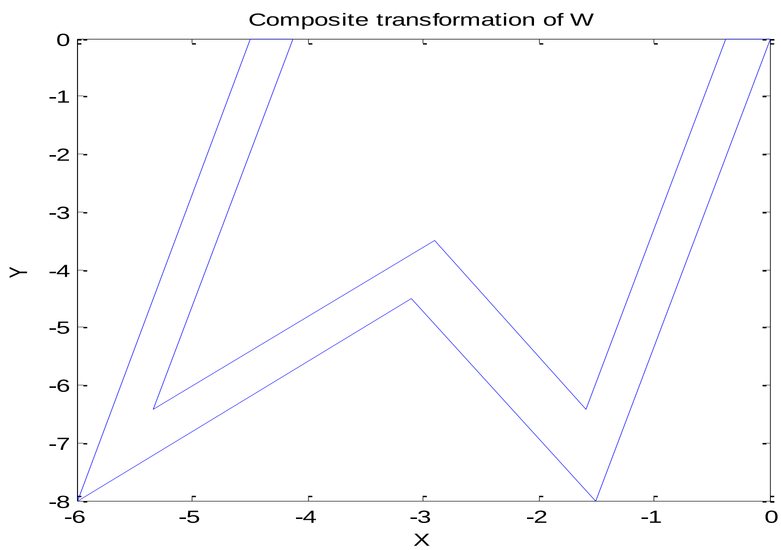
1 2 3 4 5 6 7 8 9 10 11

$$BAD = \begin{bmatrix} 0 & -0.375 & -1.5804 & -2.9.63 & -5.3304 & -4.125 & -4.5 & -6 & -3.0938 & -1.5 & 0 \\ 0 & 0 & -6.4286 & -3.5 & -6.4286 & 0 & 0 & -8 & -4.5 & -8 & 0 \end{bmatrix} \frac{x-Coordinate}{y-Coordinate}$$

(Result of this multiplication with the help of MATLAB)

The result of this composite transformation is shown in fig 6

FIG 6



MATLAB PROGRAM FOR FIG 6

>>X=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.2,0.3) hypergeom(-1,0.2,0.3) hypergeom(-1,0.1,0.4) hypergeom(-1,0.2,1.3) hypergeom(-1,0.2,1.3) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.7) hypergeom(-1,0.1,0.4) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1)];

>>Y=[hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.7,5.2) hypergeom(-1,0.4,1.8) hypergeom(-1,0.7,5.2) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.2,1.1) hypergeom(-1,0.1,0.9) hypergeom(-1,0.1,0.1)];

>> D = [X; Y];

>>A=[hypergeom(-1,0.1,0) hypergeom(-1,0.4,0.3); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>>B=[hypergeom(-1,0.4,0.1) hypergeom(-1,0.1,0.1); hypergeom(-1,0.1,0.1) hypergeom(-1,0.1,0)];

>> BA = B*A;

```
>> BAD = BA*D;

>> X2 = BAD(1,:);

>> Y2 = BAD(2,:);

>> plot(X2, Y2);
```

3 HOMOGENEOUS COORDINATES

Each point (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$) ∈ R^2can be identified with the point (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$, 1) on the plane in R^3 that lies one unit above the xy-plane. We say that (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$) has homogeneous coordinates (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$, 1). For instance, the point (${}_1F_1$ (-1; 0.1; 0.2), ${}_1F_1$ (-1; 0.1; 0.3)) has homogeneous coordinates (${}_1F_1$ (-1; 0.1; 0.2), ${}_1F_1$ (-1; 0.1; 0.3), 1). Homogeneous coordinates for points are not added or multiplied by scalars, but they can be transformed via multiplication by 3X3 matrices of generalized hypergeometric function.

3.1 TRANSLATION

A translation of the form (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$) ↦ (${}_pF_q\{((a));((b));x\}+{}_pF_q\{((a));((b));h\}$, ${}_pF_q\{((a));((b));y\}+{}_pF_q\{((a));((b));k\}$) is written in homogeneous coordinates as (${}_pF_q\{((a));((b));x\}$, ${}_pF_q\{((a));((b));y\}$, 1) ↦ (${}_pF_q\{((a));((b));x\}+{}_pF_q\{((a));((b));h\}$, ${}_pF_q\{((a));((b));y\}+{}_pF_q\{((a));((b));k\}$,1). This transformation can be computed via matrix multiplication:

$$\begin{bmatrix}1 & 0 & {}_pF_q\{((a);((b));h\}\\ 0 & 1 & {}_pF_q\{((a);((b));k\}\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}{}_pF_q\{((a);((b));x\}\\ {}_pF_q\{((a);((b));y\}\\ 1\end{bmatrix}=\begin{bmatrix}{}_pF_q\{((a);((b));x\}+{}_pF_q\{((a);((b));h\}\\ {}_pF_q\{((a);((b));y\}+{}_pF_q\{((a);((b));k\}\\ 1\end{bmatrix}$$

Any linear transformation on R^2 is represented with respect to Homogeneous coordinates by a partitioned matrix of the form

International Journal of Engineering, Science and Mathematics
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$\begin{bmatrix} A & 0 \\ 0 & 1 \end{bmatrix}$, where A is a 2X2 matrix.

Typical examples are

$$\begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & -\cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

Counterclockwise rotation about the origin, angle ϕ

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

Reflection through ${}_pF_q\{((a));((b));x\}$ = x

$$\begin{bmatrix} {}_pF_q\{((a);((b));s\} & 0 & 0 \\ 0 & {}_pF_q\{((a);((b));t\} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

scale ${}_pF_q\{((a));((b));x\}$ by ${}_pF_q\{((a));((b));s\}$

and ${}_pF_q\{((a));((b));y\}$ by ${}_pF_q\{((a));((b));t\}$

3.2 Composite Transformations

The movement of a figure on a computer screen often requires two or more basic transformations. The composition of such transformations corresponds to matrix multiplication when homogeneous coordinates are used.

The 3X3 matrix that corresponds to the composite transformation of a scaling by ${}_1F_1$ (-1; 1; 0.7), a rotation of 90^0, and finally a translation that adds (${}_1F_1$ (-1; 0.2; 0.3), ${}_1F_1$ (-1; 0.1; 0.3)) to each point of a figure,

If $\phi = \pi / 2$, then $\sin\phi = 1$ and $\cos\phi = 0$.We have

International Journal of Engineering, Science and Mathematics
Vol. 10 Issue 08, August 2021,
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$$\begin{bmatrix} {}_1F_1(-1;0.1;x) \\ {}_1F_1(-1;0.1;y) \\ 1 \end{bmatrix} \xrightarrow{Scale} \begin{bmatrix} {}_1F_1(-1;1;0.7) & 0 & 0 \\ 0 & {}_1F_1(-1;1;0.7) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;x) \\ {}_1F_1(-1;0.1;y) \\ 1 \end{bmatrix}$$

$$\xrightarrow{Rotate} \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;1;0.7) & 0 & 0 \\ 0 & {}_1F_1(-1;1;0.7) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;0.1;x) \\ {}_1F_1(-1;0.1;y) \\ 1 \end{bmatrix}$$

$$\xrightarrow{Translate} \begin{bmatrix} 1 & 0 & {}_1F_1(-1;0.2;0.3) \\ 0 & 1 & {}_1F_1(-1;0.1;0.3) \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;1;0.7) & 0 & 0 \\ 0 & {}_1F_1(-1;1;0.7) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} {}_1F_1(-1;0.1;x) \\ {}_1F_1(-1;0.1;y) \\ 1 \end{bmatrix}$$

the matrix for the composite transformation is

$$\begin{bmatrix} 1 & 0 & {}_1F_1(-1;0.2;0.3) \\ 0 & 1 & {}_1F_1(-1;0.1;0.3) \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} {}_1F_1(-1;1;0.7) & 0 & 0 \\ 0 & {}_1F_1(-1;1;0.7) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -{}_1F_1(-1;1;0.7) & {}_1F_1(-1;0.2;0.3) \\ {}_1F_1(-1;1;0.7) & 0 & {}_1F_1(-1;0.1;0.3) \\ 0 & 0 & 1 \end{bmatrix}$$

CONCLUSION

2D computer graphics are mainly used in applications that were originally developed upon traditional printing and drawing technologies, such as typography, cartography, technical drawing advertising etc. In those applications, the two-dimensional image is not just a representation of a real-world object, but an independent artifact with added semantic value; two-dimensional models are therefore preferred, because they give more direct control of the image than 3D computer_graphics (whose approach is more akin to photography than to typography). In this paper I have discussed various transformations along with their matrix representations. I have created different *2D – Graphics from the generalized hypergeometric function* ${}_pF_q\{((a));((b));x\}$ different graphics Translation, Rotation, Reflection and their combinations are the rigid transformations because in these transformations the pre-image and image are of same size and shape (congruent). Scaling and Shearing are not rigid transformations because they produce images with different size or shape.

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