UTAH TEA POT WITH MATLAB

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Abstract

Utah tea pot is famous tasting data structure of computer graphics. It can be easily developed using Matlab software. There can be done various combination of user made m files and functions of Matlab and especially functions built in its module Image processing

1   Definition of the data structure and some theoretical elements

The pot consists of 32 Bezier patches:(the lid of the pot is created by 8 patches, the body of 12 patches, the bottom, the handle and the pipe of four patches each). Each patch is defined by 16 vertices. All patches and their defining vertices can be easily detected from the figure Fig. 1 bellow. Visualiasion of the defining structure provided here is made by Matlab and its Image processing toolbox.
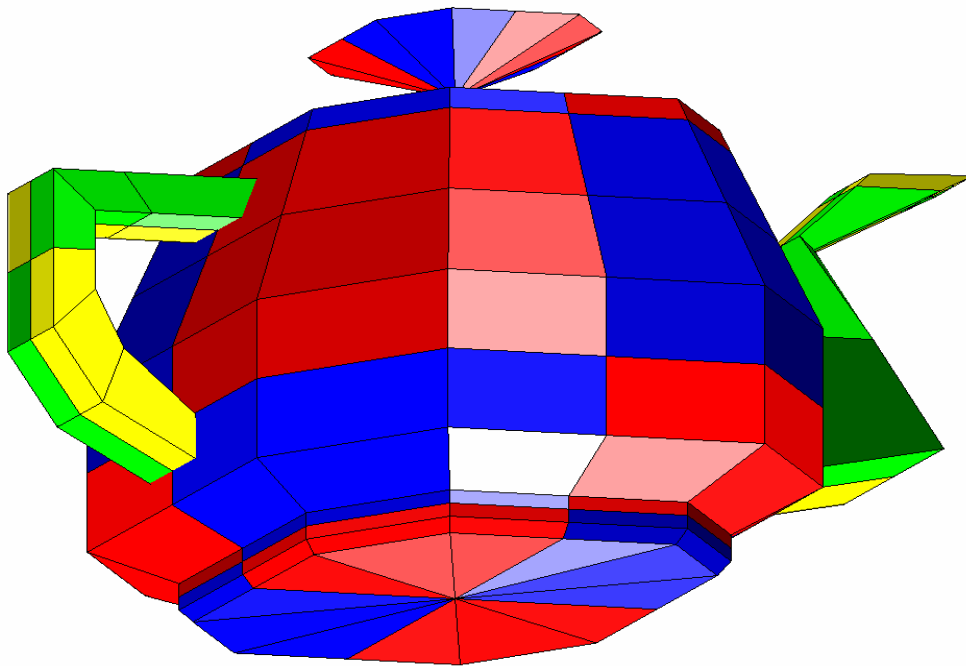

Fig. 1

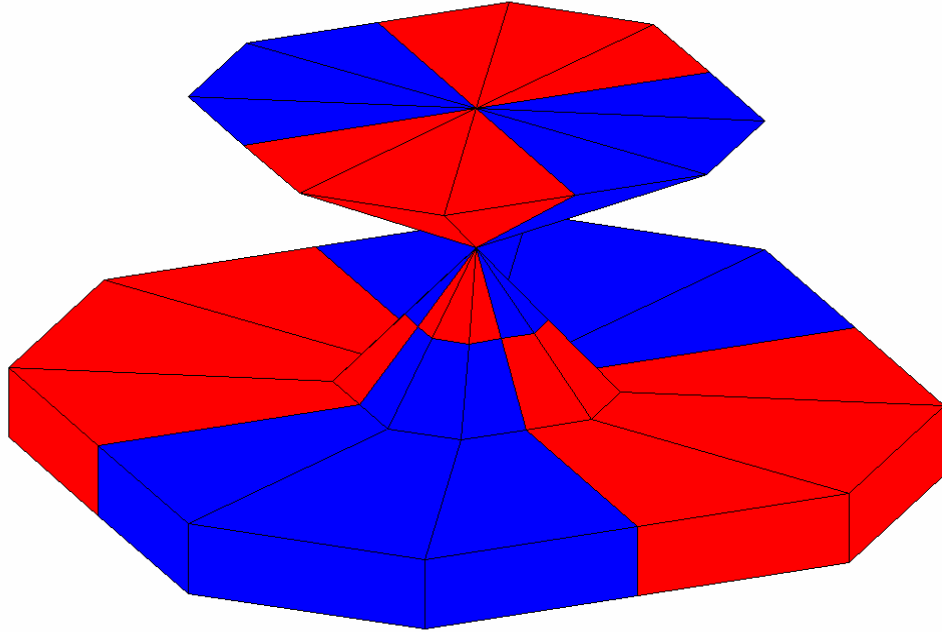Let as look more briefly to the lid of the pot:

Fig. 2

From the figure Fig. 2 it is easily seen, that the lid consists of 8 triangular defining patches. Four of them has one singularity and other four are with 2 singularities each. By singularity we here mean that four defining points are at the same place (the same point). Each defining point consists three coordinates. As the whole structure of the pot consists of 32 patches and each of them defined by 16 points defined by three coordinates the whole structure is defined by 1536 real numbers. The size of defining structure can be substantially reduced. It is easily seen from the visualization of the data structure, that substantial part of the pot is symmetrical. It has two mutually perpendicular plains of symmetry. These parts include lid, body, bottom. Other parts of the pot one plain of symmetry(handle and pipe). As the surface of the pot should be continuous and smooth there exist a lot of triples (quadruples) of defining points coming from neighboring patches. Four points lying at the same line and two of them in addition to it at the same place. These attributes can also be easily seen from the visualization of the defining structure.

The surface of the pot consist 32 parts obtained by subsequent calculations of the patches of defining structure. Each patch of the surface of the pot (defined by 16 points $\mathbf{P_{00}},\ldots, \mathbf{P_{33)}}$ is given by the formula.

$$P(u,v) =$$

$$= \begin{pmatrix} B_0(u) & B_1(u) & B_2(u) & B_3(u) \end{pmatrix} \cdot M \cdot \begin{pmatrix} B_0(v) \\ B_1(v) \\ B_2(v) \\ B_3(v) \end{pmatrix} =$$

$$= \begin{pmatrix} B_0(u) & B_1(u) & B_2(u) & B_3(u) \end{pmatrix} \cdot \begin{pmatrix} \mathbf{P_{00}} & \mathbf{P_{01}} & \mathbf{P_{02}} & \mathbf{P_{03}} \\ \mathbf{P_{10}} & \mathbf{P_{11}} & \mathbf{P_{12}} & \mathbf{P_{13}} \\ \mathbf{P_{20}} & \mathbf{P_{21}} & \mathbf{P_{22}} & \mathbf{P_{23}} \\ \mathbf{P_{30}} & \mathbf{P_{31}} & \mathbf{P_{32}} & \mathbf{P_{33}} \end{pmatrix} \cdot \begin{pmatrix} B_0(v) \\ B_1(v) \\ B_2(v) \\ B_3(v) \end{pmatrix}$$

Parameters u and v are both in the interval <0,1>. By selecting concrete value of u and v from this interval we obtain one point of the surface of the patch. Bi(u) and Bi(v) are called Bernstain polynomials and are defined by the folloving formulas

$$B_{0,3}(t) = \left(1 - t\right)^3$$

$$B_{1,3}(t) = 3 \cdot t \cdot \left(1 - t\right)^2$$

$$B_{2,3}(t) = 3 \cdot t^2 \cdot \left(1 - t\right)$$

$$B_{3,3}(t) = t^3$$

$$t \in \left\langle 0 , 1 \right\rangle$$

They can be implemented in Matlab in the following way

```
function [B] = bezier3(par);
B(1)=(1-par)*(1-par)*(1-par);
B(2)=3*par*(1-par)*(1-par);
B(3)=3*par*par*(1-par);
B(4)=par*par*par;
end


function [Pole] = bezier3vektor(pocetdeleni);
dp=0;
hp=1;
kp=(hp-dp)/pocetdeleni;
for ii=1:pocetdeleni +1
 p=dp +(ii-1)*kp;
 B=bezier3(p);
for i=1:4
 Pole(ii,i)=B(i);
end
end
end
```

2 The results of the modeling and visualization process

The creation of the surface of the pot is not part of Matlab and consequently is must be programmed in the form of M files. The complete programme consists of 10 easy m files
The following figure Fig 3 shows visualization of the surface of the lid of the pot using bult in Matlab functions capable to remove visualize the surface and remove hidden parts of it.

```
Barva = [ Barva1 Barva2 Barva3]
sh2=surface('XData',Polex,'YData',Poley,'ZData',Polez,...
    'FaceColor',Barva,...
    'EdgeColor','white');
view([50,40]);
```
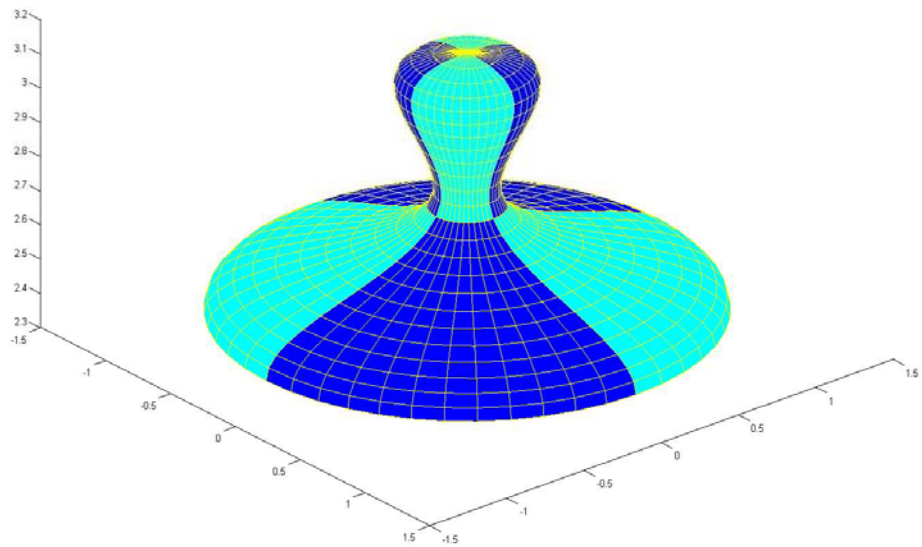
Fig 3

The structure of the pot consists of several building parts. These parts can be used to construct any piece of the crockery. The pot seems from this point of view the most complicated one. The following figure Fig 4 shows building parts of the pot with body omitted.
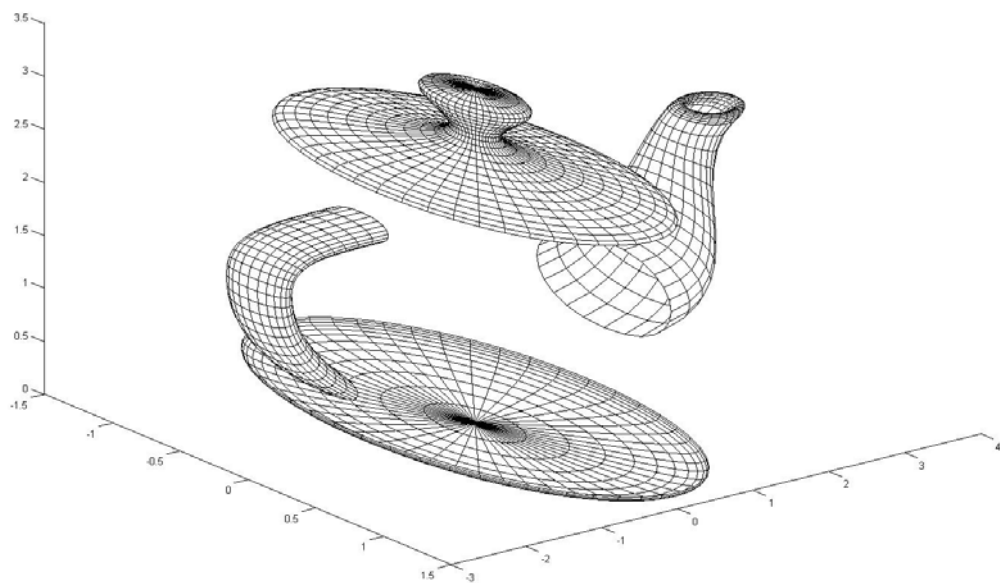

Fig. 4

Better visualization results can be obtained by Phong shading implemented in Image processing module

```
Barva = [ Barva1 Barva2 Barva3]
sh2=surface('XData',Polex,'YData',Poley,'ZData',Polez,...
    'FaceColor',Barva,...
    'EdgeColor','yellow');
    'FaceLighting','Phong',...
'SpecularStrength',2,'DiffuseStrength',0.5,'AmbientStrength',0.5,'SpecularE
xponent',3,...
    'MarkerFaceColor','black',...
```

The result of application of Phong shading to the whole surface of the pot is shown in the following figure Fig. 5.
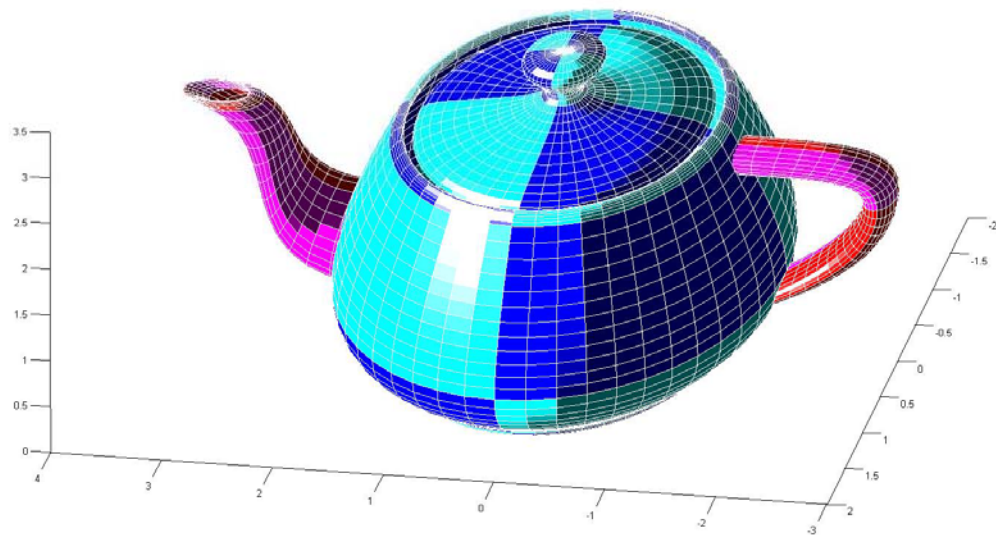

Fig. 5

By adding two other lines into the main file there is possible to map a texture to the surface of the pot also using built in functions Imread for reading texture file and warp for mapping it to some or all of the patches patches.

```
I = imread('may2003.jpg');
warp(Polex,Poley,Polez,I);
```

In our case we used fractal texture which has been developed also as matlab m file. The result of applying this texture is in the following figure Fig.6
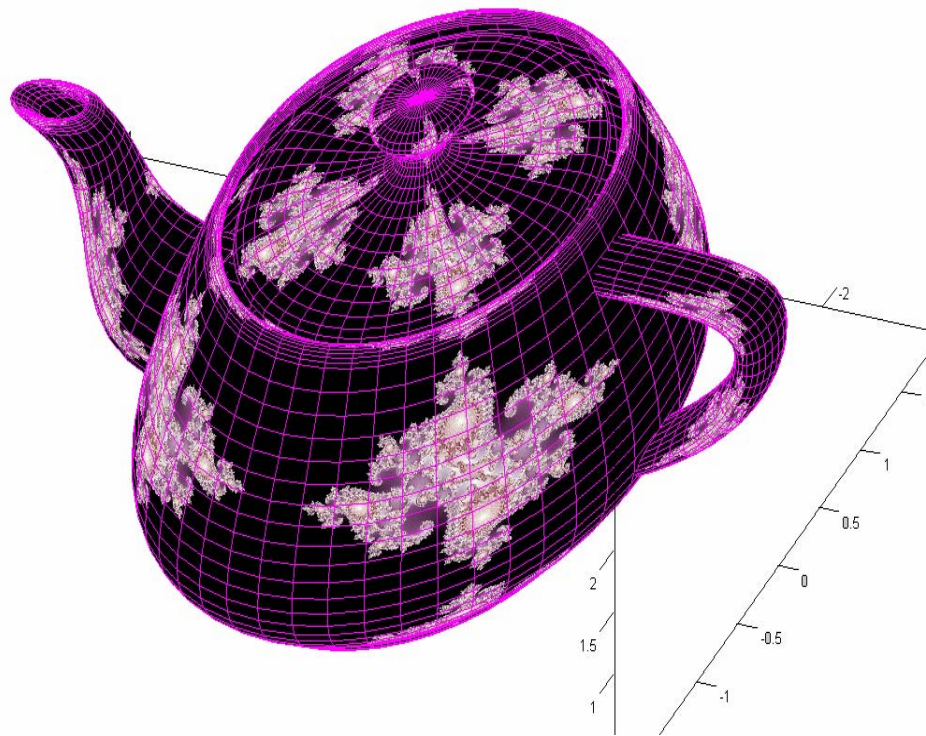
Fig.6

The simplest form of the program application consists of 10 short m files: called: bezier3, bezier3vektor, patch40, dno40, korpus40, pipa40, ousko40, poklice40, konev40, zarazenidat. It can be obtained from the author in case it would not be included into CD containing contributions of the conference

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