DEMO_0005_Multi_Morph_Cylindrical_Gyroid_

Table of Contents

 1
Plot settings 1
Control parameters 1
Example-1: Axial Transition (Figure-5(a)) 1
Example-2: Circumferential Transition (Figure-5(b)) 4

This is a demo for:

- Building geometry for multi-morphology lattices of different gyroid structures in cylindrical domain using hybrid formulation.

1. Example-1: Utilizes hybrid formulation in axial direction.

2. Example-2: Utilizes hybrid formulation in circumferential direction.

Name

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```
Change log:
2023/11/15 MV Created
2024/02/1 MV Sorted for publishing
----------------------------------------------------------------------
```

```
clear; close all; clc;
```

Plot settings

```
fontSize=20;
faceAlpha1=0.8;
markerSize=10;
lineWidth1=3;
lineWidth2=4;
markerSize1=25;
```

Control parameters

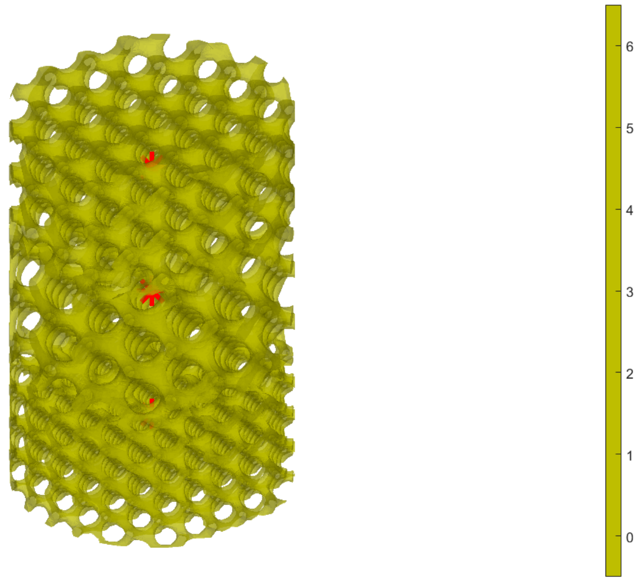
```
res=100; %Resolution

L=9; %Length size
R=3; %Radius size
```

Example-1: Axial Transition (Figure-5(a))

```
inputStruct_A.L=L; % characteristic length
```

```
inputStruct_A.R=R;
inputStruct_A.Ns=res; % number of sampling points
inputStruct_A.isocap=1; %Option to cap the isosurface
inputStruct_A.surfaceCase='g'; %Surface type

inputStruct_B = inputStruct_A;
inputStruct_C = inputStruct_A;

% Set parameters for individual gyroid
inputStruct_A.numPeriods=[8 8 8]; %Number of periods in each direction
inputStruct_A.levelset=-0.7; %Isosurface level
inputStruct_A.gradiantF=0; %Gradiant Factor
levelset_A=inputStruct_A.levelset;

inputStruct_B.numPeriods=[5 5 5];
inputStruct_B.levelset=-0.8;
inputStruct_B.gradiantF=0; %Gradiant Factor
levelset_B=inputStruct_B.levelset;

inputStruct_C.numPeriods=[6 6 6];
inputStruct_C.levelset= -0.6;
inputStruct_C.gradiantF=0 ; %Gradiant Factor
levelset_C=inputStruct_C.levelset;

% Compute individual gyroids
% No need to store faces and vertices, only require underlying S,
% grid coordinates, and levelset values
[F,V,C,S_A,X,Y,Z,~,~]=CylindricalTPMS(inputStruct_A);
[~,~,~,S_B,~,~,~,~,~]=CylindricalTPMS(inputStruct_B);
[~,~,~,S_C,~,~,~,~,~]=CylindricalTPMS(inputStruct_C);

% Define the central location of each individual gyroids in space
% E.g., At center_A, the gyroid will definitely correspond to input_A.
% As we move away from center_A, it will slowly transition into other
% gyroids with input_B and input_C.
center_A = [0, 0, L/6];
center_B = [0, 0, 3*L/6];
center_C = [0, 0, 5*L/6];

% kappa controls the lengthscale of transition between gyroids
% Higher kappa => faster transition
% Lower kappa => slower transition
kappa = 5;

% Using Gaussian (a.k.a. radial basis functions) interpolation.
% One can use any interpolation scheme of choice as long as weights at
% every grid point sum up to 1.

% Computing the weights for each gyroid evaluated on all grid points.
weights_A = exp(-kappa * (Squared_distance_from_point(X,Y,Z,center_A)));
weights_B = exp(-kappa * (Squared_distance_from_point(X,Y,Z,center_B)));
weights_C = exp(-kappa * (Squared_distance_from_point(X,Y,Z,center_C)));

% Weights must sum up to 1.
```

```
sum_weights = weights_A + weights_B + weights_C;

weights_A = weights_A ./ sum_weights;
weights_B = weights_B ./ sum_weights;
weights_C = weights_C ./ sum_weights;

% Interpolating using the above weights
graded_S =  weights_A .* (S_A - levelset_A) ...
            + weights_B .* (S_B - levelset_B)...
            + weights_C .* (S_C - levelset_C);

% Compue isosurface
graded_levelset = 0;

[f,v] = isosurface(X,Y,Z,graded_S,graded_levelset);
c=zeros(size(f,1),1);

% Compute isocaps
[fc,vc] = isocaps(X,Y,Z,graded_S,graded_levelset,'enclose','below');

% Boilerplate code for preparing output for exporting/visualization
nc=patchNormal(fc,vc);
cc=zeros(size(fc,1),1);
cc(nc(:,1)<-0.5)=1;
cc(nc(:,1)>0.5)=2;
cc(nc(:,2)<-0.5)=3;
cc(nc(:,2)>0.5)=4;
cc(nc(:,3)<-0.5)=5;
cc(nc(:,3)>0.5)=6;

% Join sets
[f,v,c]=joinElementSets({f,fc},{v,vc},{c,cc});

% Merge nodes
[f,v]=mergeVertices(f,v);

% Check for unique faces
[~,indUni,~]=unique(sort(f,2),'rows');
f=f(indUni,:); %Keep unique faces
c=c(indUni);

% Remove collapsed faces
[f,logicKeep]=patchRemoveCollapsed(f);
c=c(logicKeep);

% Remove unused points
[f,v]=patchCleanUnused(f,v);

% Invert faces
f=fliplr(f);

% Visualize
center_V=[center_A; center_B; center_C];
Hybrid_vizualize(f,v,c,[], center_V);
```

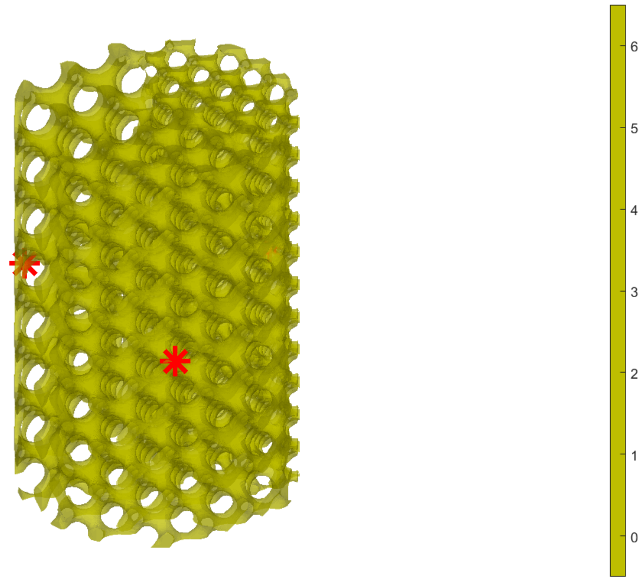


Example-2: Circumferential Transition (Figure-5(b))

```
inputStruct_A.L=L; % characteristic length
inputStruct_A.R=R;
inputStruct_A.Ns=res; % number of sampling points
inputStruct_A.isocap=1; %Option to cap the isosurface
inputStruct_A.surfaceCase='g'; %Surface type

inputStruct_B = inputStruct_A;
inputStruct_C = inputStruct_A;

% Set parameters for individual gyroid
inputStruct_A.numPeriods=[8 8 8]; %Number of periods in each direction
inputStruct_A.levelset=-0.7; %Isosurface level
inputStruct_A.gradiantF=0; %Gradiant Factor
levelset_A=inputStruct_A.levelset;

inputStruct_B.numPeriods=[5 5 5];
inputStruct_B.levelset=-0.8;
inputStruct_B.gradiantF=0; %Gradiant Factor
levelset_B=inputStruct_B.levelset;

inputStruct_C.numPeriods=[6 6 6];
inputStruct_C.levelset= -0.6;
inputStruct_C.gradiantF=0 ; %Gradiant Factor
levelset_C=inputStruct_C.levelset;

% Compute individual spinodoids
```

```
% No need to store faces and vertices, only require underlying S,
% grid coordinates, and levelset values
[F,V,C,S_A,X,Y,Z,r,theta]=CylindricalTPMS(inputStruct_A);
[~,~,~,S_B,~,~,~,~,~]=CylindricalTPMS(inputStruct_B);
[~,~,~,S_C,~,~,~,~,~]=CylindricalTPMS(inputStruct_C);

% Define the central location of each individual gyroids in space
% E.g., At center_A, the gyroid will definitely correspond to input_A.
% As we move away from center_A, it will slowly transition into other
% gyroids with input_B and input_C.

% Converting the grid to cylindrical coordinates
theta_A = 0;
theta_B = 2*pi/3;
theta_C = 4*pi/3;

center_A = [R*cos(theta_A), R*sin(theta_A), L/2];
center_B = [R*cos(theta_B), R*sin(theta_B), L/2];
center_C = [R*cos(theta_C), R*sin(theta_C), L/2];

% kappa controls the lengthscale of transition between gyroids
% Higher kappa => faster transition
% Lower kappa => slower transition
kappa = 5;

% Using Gaussian (a.k.a. radial basis functions) interpolation.
% One can use any interpolation scheme of choice as long as weights at
% every grid point sum up to 1.
% Computing the weights for each gyroids evaluated on all grid points.
weights_A = exp(-kappa * ((X-center_A(1,1)).^2 + (Y-center_A(1,2)).^2));
weights_B = exp(-kappa * ((X-center_B(1,1)).^2 + (Y-center_B(1,2)).^2));
weights_C = exp(-kappa * ((X-center_C(1,1)).^2 + (Y-center_C(1,2)).^2));

% weights_A = exp(-kappa * (theta-theta_A).^2);
% weights_B = exp(-kappa * (theta-theta_B).^2);
% weights_C = exp(-kappa * (theta-theta_C).^2);

% Weights must sum up to 1.
sum_weights = weights_A + weights_B + weights_C;

weights_A = weights_A ./ sum_weights;
weights_B = weights_B ./ sum_weights;
weights_C = weights_C ./ sum_weights;

% Interpolating using the above weights
graded_S =  weights_A .* (S_A - levelset_A) ...
            + weights_B .* (S_B - levelset_B)...
            + weights_C .* (S_C - levelset_C);

% Compue isosurface
graded_levelset = 0;
[f,v] = isosurface(X,Y,Z,graded_S,graded_levelset);
c=zeros(size(f,1),1);
```

```
% Compute isocaps
[fc,vc] = isocaps(X,Y,Z,graded_S,graded_levelset,'enclose','below');

% Boilerplate code for preparing output for exporting/visualization
nc=patchNormal(fc,vc);
cc=zeros(size(fc,1),1);
cc(nc(:,1)<-0.5)=1;
cc(nc(:,1)>0.5)=2;
cc(nc(:,2)<-0.5)=3;
cc(nc(:,2)>0.5)=4;
cc(nc(:,3)<-0.5)=5;
cc(nc(:,3)>0.5)=6;

% Join sets
[f,v,c]=joinElementSets({f,fc},{v,vc},{c,cc});

% Merge nodes
[f,v]=mergeVertices(f,v);

% Check for unique faces
[~,indUni,~]=unique(sort(f,2),'rows');
f=f(indUni,:); %Keep unique faces
c=c(indUni);

% Remove collapsed faces
[f,logicKeep]=patchRemoveCollapsed(f);
c=c(logicKeep);

% Remove unused points
[f,v]=patchCleanUnused(f,v);

% Invert faces
f=fliplr(f);

% Visualize
center_V=[center_A; center_B; center_C];
Hybrid_vizualize(f,v,c,[], center_V);
```



Published with MATLAB® R2021b