Università della Svizzera italiana

Institute of Computing CI

High-Performance Computing **2022**

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Solution for Project 6

Due date: 07.12.2022, 23:59

1. Task: Install METIS 5.0.2, and the corresponding Matlab mex interface

The code worked, but it switched the values between p1 and p2.

2. Task: Construct adjacency matrices from connectivity data [10 points]

First the table data from the .csv files is loaded into the local variables XX_coords and XX_adjacency, where XX stands for the initials of the corresponding country. Then the tables are converted into an array, so that they can be used to actually create and visualize the graphs thanks to the gplotg function, that takes the adjacency array and the coordinate array.
Finally, the data for each country is saved as a .mat file in the folder Countries_Mat following the desired format.

3. Task: Implement various graph partitioning algorithms [25 points]

Table 1: Bisection results

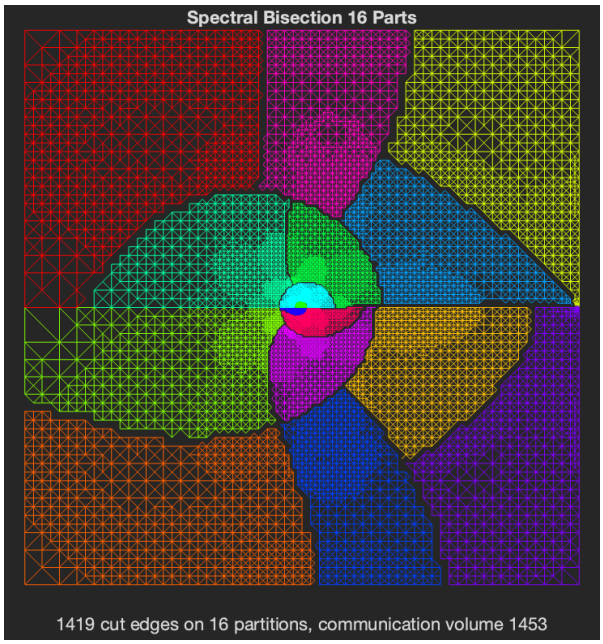
Mesh	Coordinate	Metis 5.0.2	Spectral	Inertial
mesh1e1	18	17	18	20
mesh2e1	37	37	39	47
mesh3e1	19	19	26	19
mesh3em5	19	19	26	19
airfoil1	94	77	132	93
netz4504_dual	25	23	23	27
stufe	16	16	16	16
3elt	172	124	117	257
barth4	206	97	127	208
ukerbe1	32	27	32	28
crack	353	201	233	384

As the data shows, the Metis bisection always uses the least amount of cuts to bisect the given mesh.

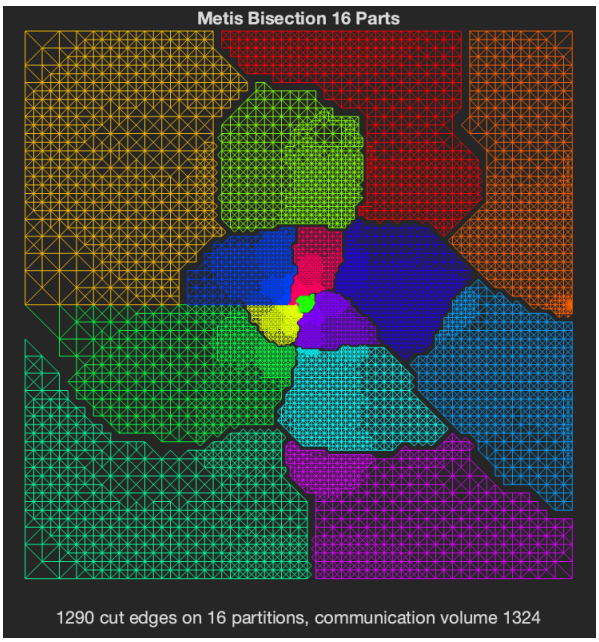
4. Task: Recursively bisecting meshes [15 points]

Table 2: Edge-cut results for recursive bi-partitioning, 8 / 16 partitions

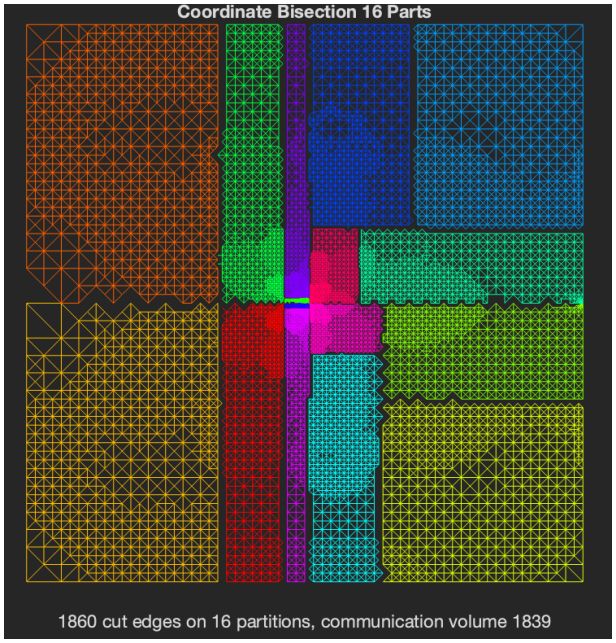
Case	Spectral	Metis 5.0.2	Coordinate	Inertial
airfoil1	398 / 633	320 / 563	516 / 819	670 / 1081
netz4504_dual	111 / 184	110 / 161	127 / 198	165 / 271
stufe	128 / 238	107 / 194	123 / 227	320 / 606
3elt	469 / 752	395 / 651	733 / 1168	814 / 1230
barth4	550 / 841	405 / 689	875 / 1306	977 / 1492
ukerbe1	398 / 695	128 / 224	225 / 374	340 / 499
crack	883 / 1419	784 / 1290	1343 / 1860	1351 / 1884



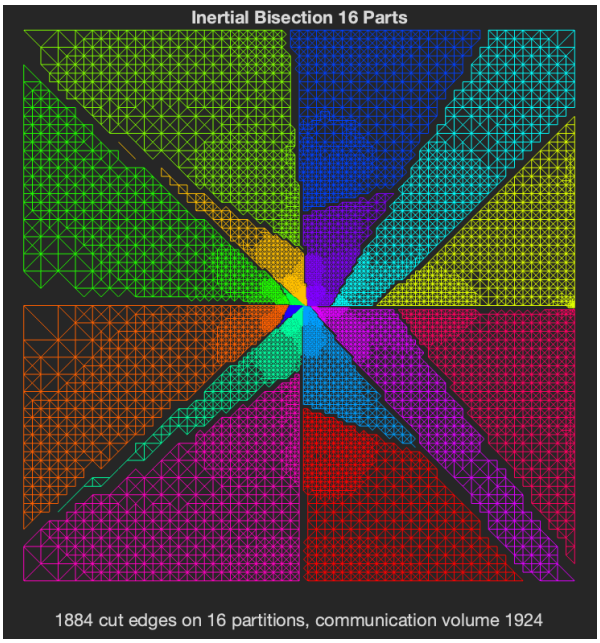
Spectral Bisection in 16 parts done on the "crack" mesh



Metis Bisection in 16 parts done on the "crack" mesh



Coordinate Bisection in 16 parts done on the "crack" mesh



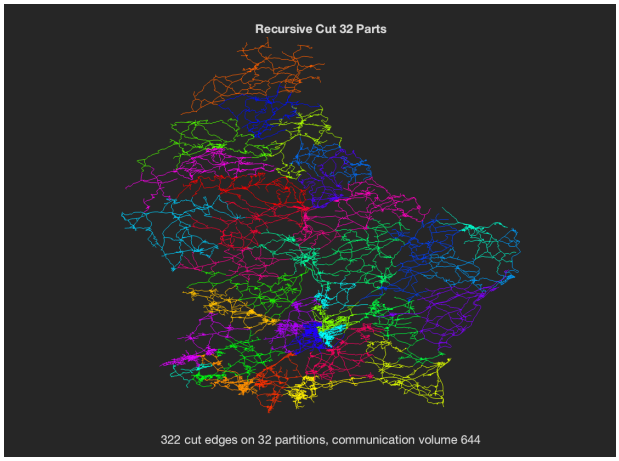
Inertial Bisection in 16 parts done on the "crack" mesh

5. Task: Comparing recursive bisection to direct k-way partitioning [10 points]

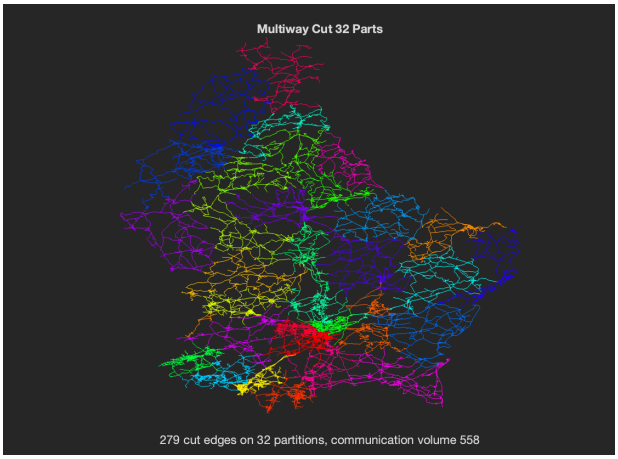
Table 3: Comparing the number of cut edges for recursive bisection and direct multiway partitioning in Metis 5.0.2.

Metis	Luxemburg 16 / 32	usroads-48 16 / 32	Greece 16 / 32	Switzerland 16 / 32	Vietnam 16 / 32	Norway 16 / 32	Russia 16 / 32
Recursive	197 / 322	607 / 988	297 / 509	730 / 1089	245 / 445	284 / 470	616 / 1006
Multiway	170 / 279	579 / 961	278 / 471	673 / 1042	245 / 411	255 / 439	551 / 933

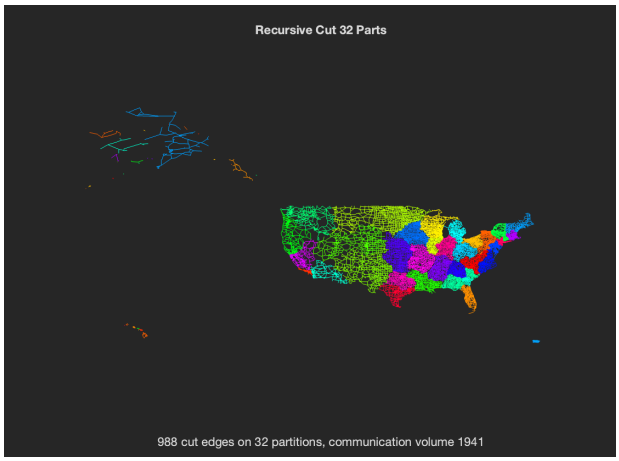
As the data shows, the Multiway Metis partitioning is always more conservative with the amount of cuts done compared to the recursive implementation.
This is working as expected: the recursive partitioning can be less optimal than the k-way one since it doesn't take into consideration the global information about the partitions. The k-way partitioning instead works on the whole graph by refining the partitioning at each step, and so the result can be way more efficient.



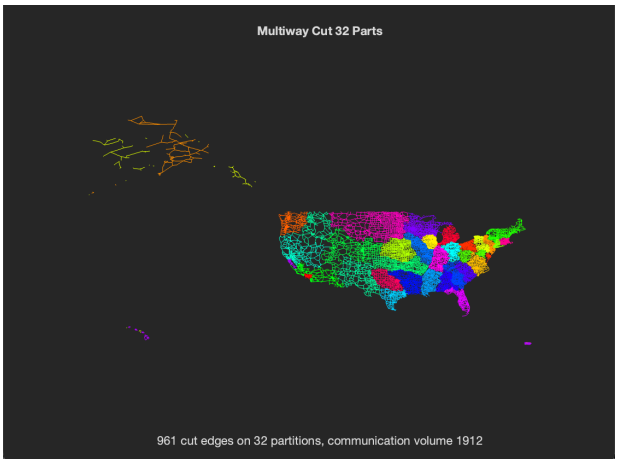
Recursive Metis bisection in 32 parts of the Luxembourg roads mesh



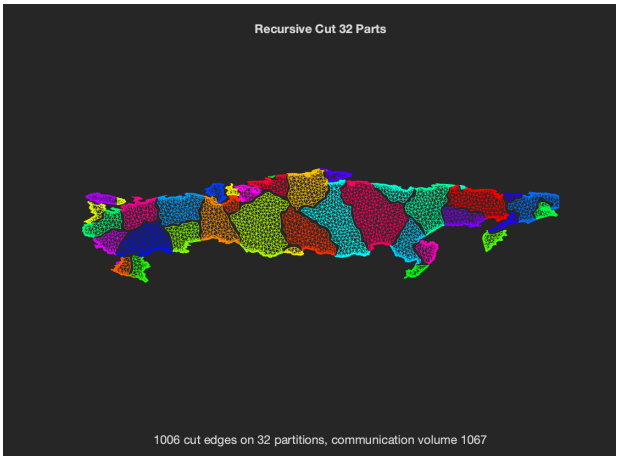
Multiway Metis partitioning in 32 parts of the Luxembourg roads mesh



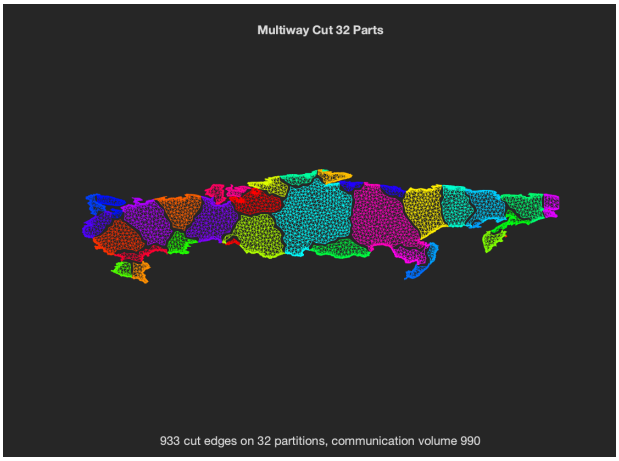
Recursive Metis bisection in 32 parts of the United States roads mesh



Multiway Metis partitioning in 32 parts of the United States roads mesh

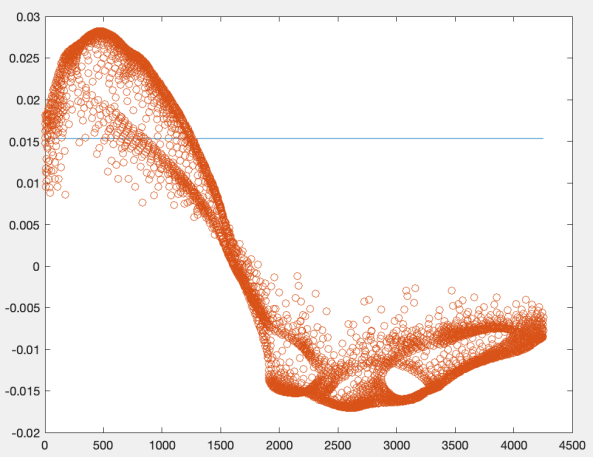


Recursive Metis bisection in 32 parts of the Russia map mesh

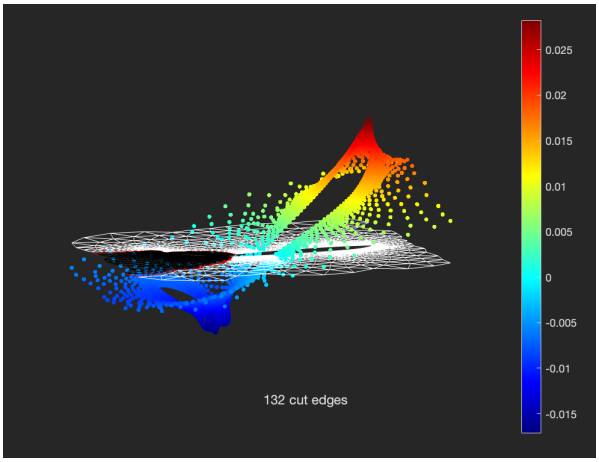


Multiway Metis partitioning in 32 parts of the Russia map mesh

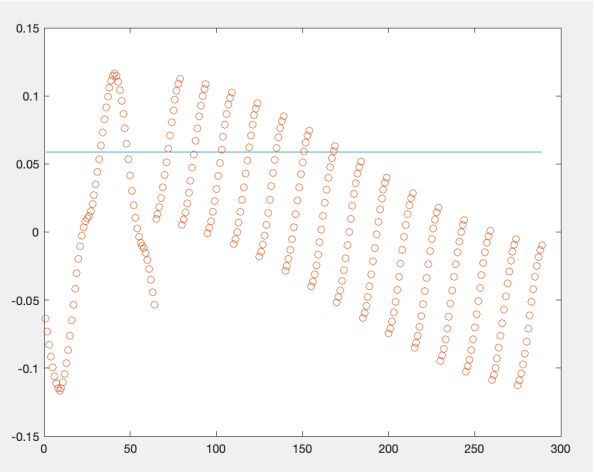
6. Task: Utilizing graph eigenvectors [25 points]



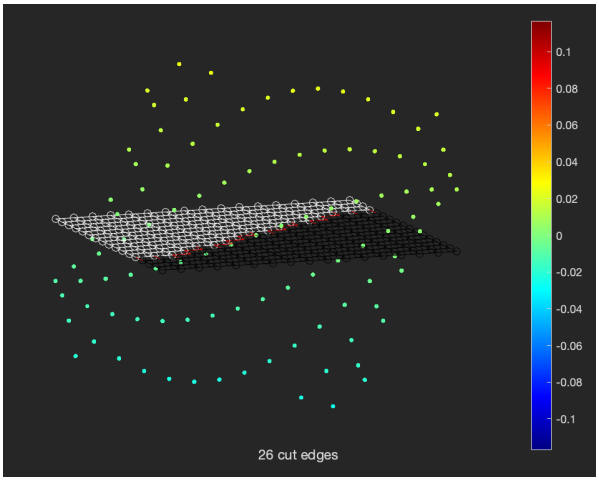
Entries of the eigenvectors associated with the first (blue) and second (red) smallest eigenvalues of the Laplacian matrix L for the graph "airfoil1."



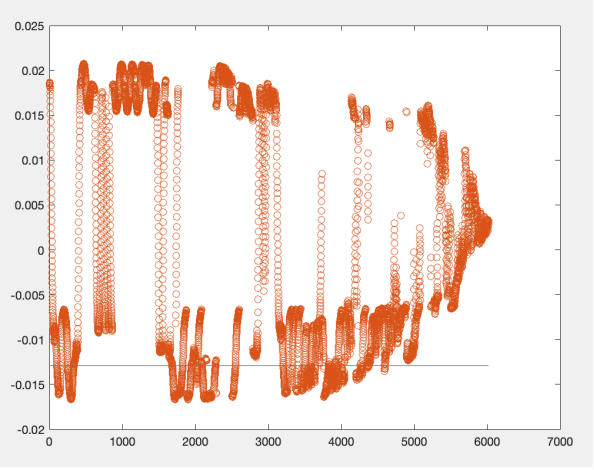
Projection of the entries of the eigenvector associated with the second smallest eigenvalue onto the coordinate system space of the graph "airfoil1."



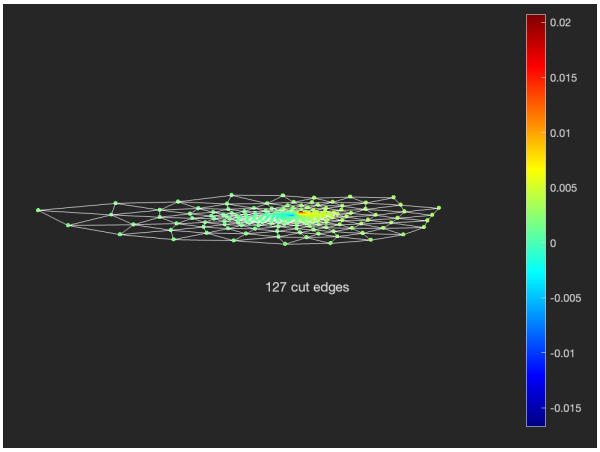
Entries of the eigenvectors associated with the first (blue) and second (red) smallest eigenvalues of the Laplacian matrix L for the graph "mesh3e1."



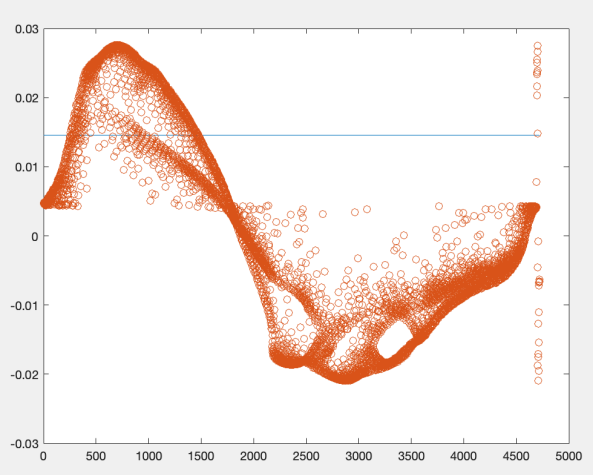
Projection of the entries of the eigenvector associated with the second smallest eigenvalue onto the coordinate system space of the graph "mesh3e1."



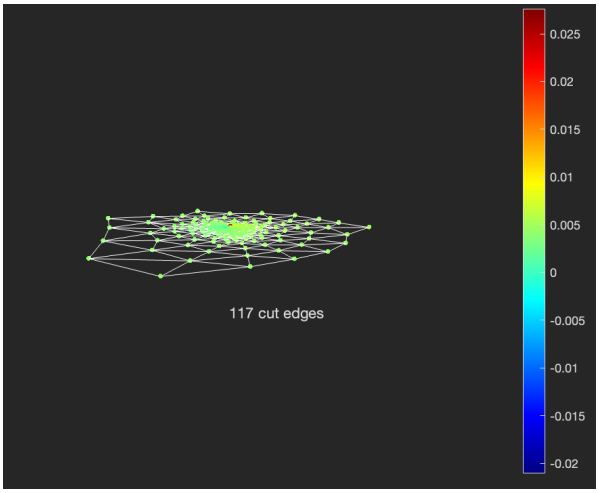
Entries of the eigenvectors associated with the first (blue) and second (red) smallest eigenvalues of the Laplacian matrix L for the graph "barth4."



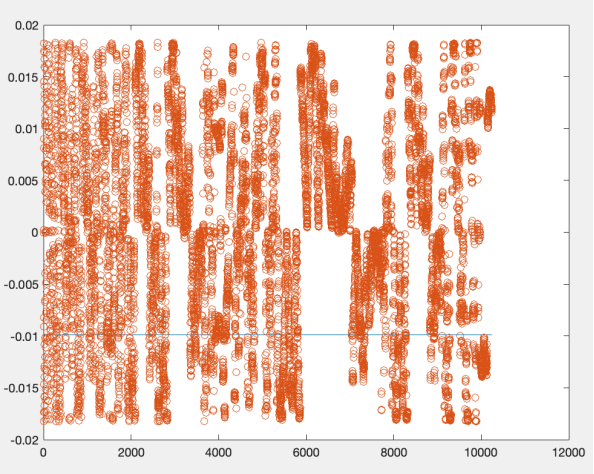
Projection of the entries of the eigenvector associated with the second smallest eigenvalue onto the coordinate system space of the graph "barth4."



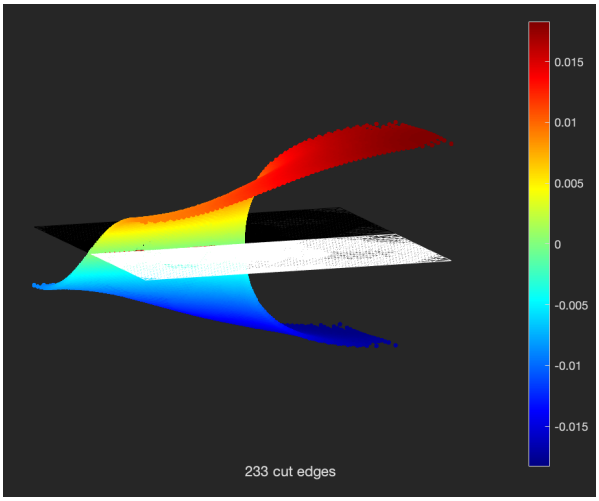
Entries of the eigenvectors associated with the first (blue) and second (red) smallest eigenvalues of the Laplacian matrix L for the graph "3elt."



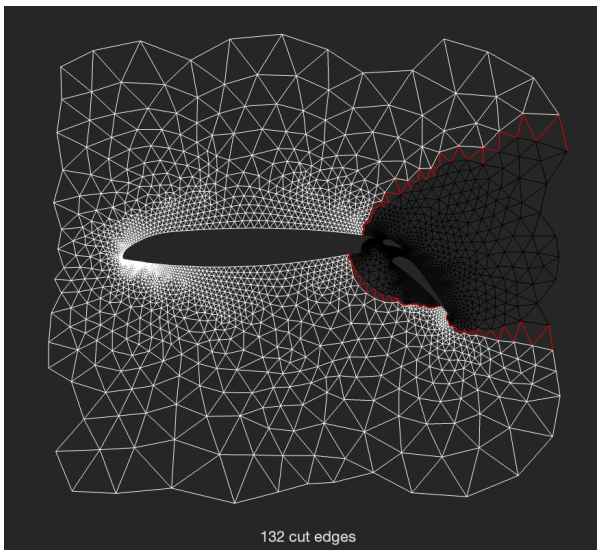
Projection of the entries of the eigenvector associated with the second smallest eigenvalue onto the coordinate system space of the graph "3elt."



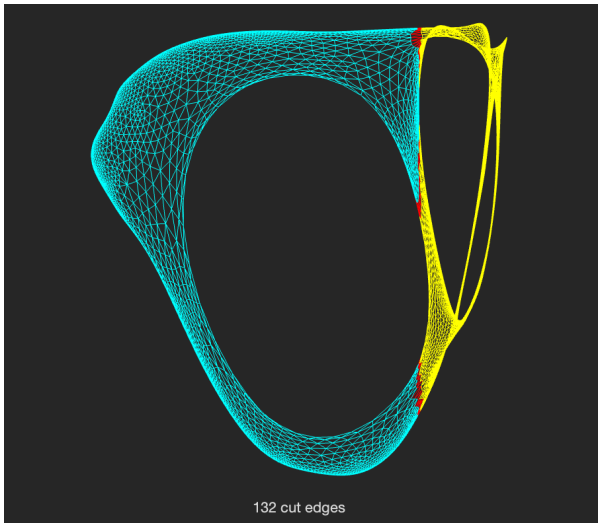
Entries of the eigenvectors associated with the first (blue) and second (red) smallest eigenvalues of the Laplacian matrix L for the graph "crack."



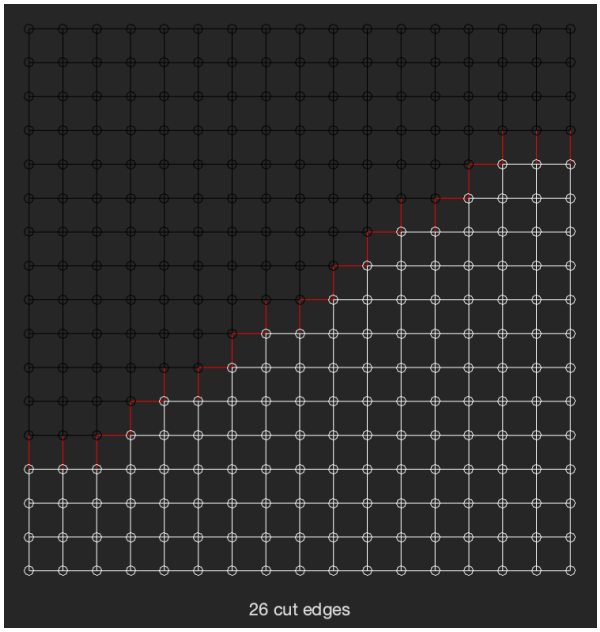
Projection of the entries of the eigenvector associated with the second smallest eigenvalue onto the coordinate system space of the graph "crack."



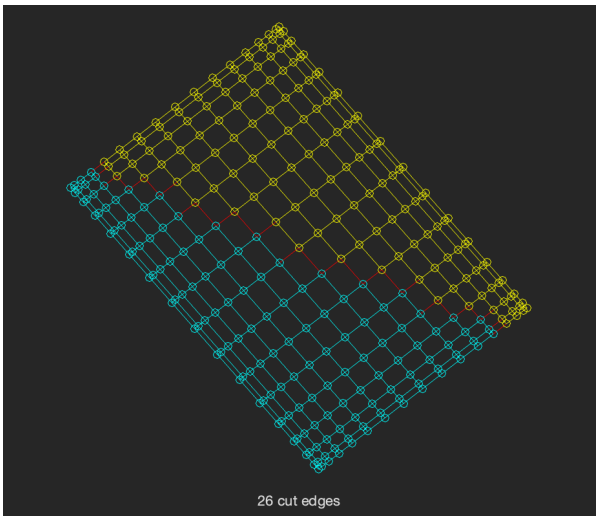
"airfoil1" graph. Red are the cut edges of the mesh, while white is translated to light blue and black to yellow in the corresponding spectral coordinates graph.



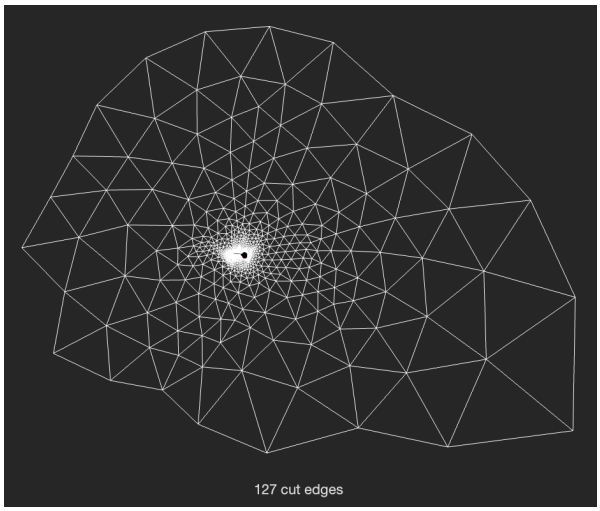
Spectral coordinates graph of the "airfoil1" mesh. Light blue corresponds to white and black to yellow in the spatial coordinates graph.



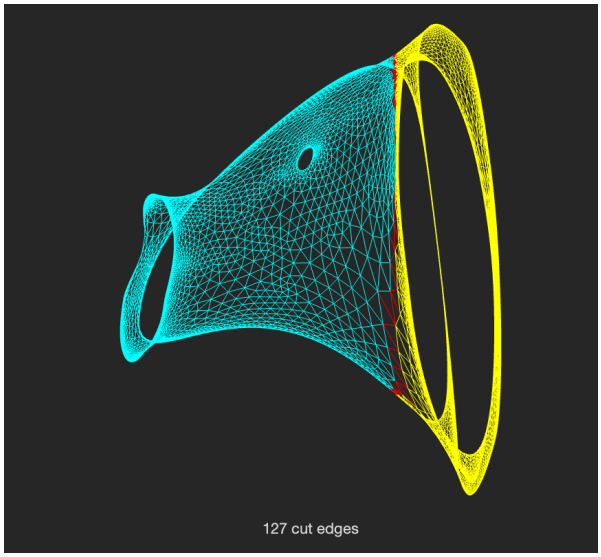
"mesh3e1" graph. Red are the cut edges of the mesh, while white is translated to light blue and black to yellow in the corresponding spectral coordinates graph.



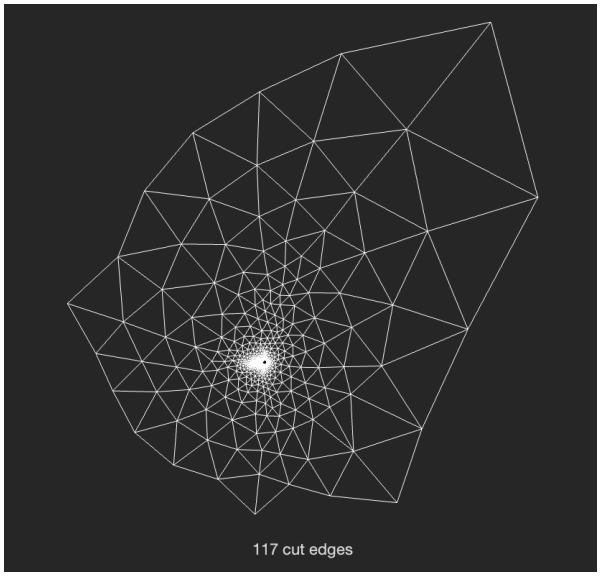
Spectral coordinates graph of the "mesh3e1" mesh. Light blue corresponds to white and black to yellow in the spatial coordinates graph.



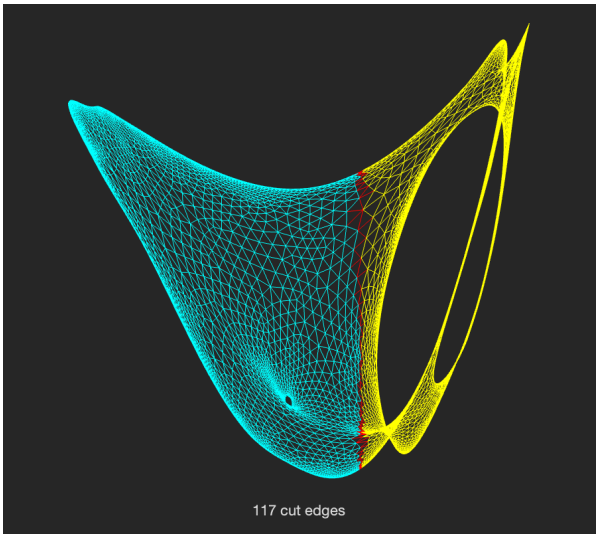
"barth4" graph. Red are the cut edges of the mesh, while white is translated to light blue and black to yellow in the corresponding spectral coordinates graph.



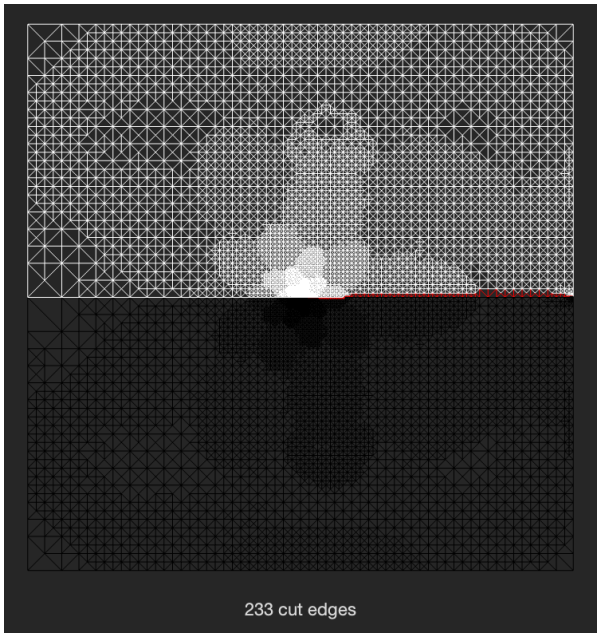
Spectral coordinates graph of the "barth4" mesh. Light blue corresponds to white and black to yellow in the spatial coordinates graph.



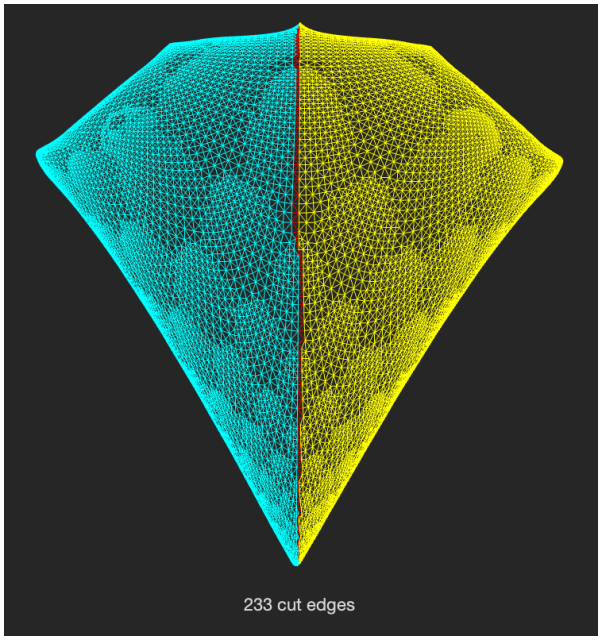
”3elt” graph. Red are the cut edges of the mesh, while white is translated to light blue and black to yellow in the corresponding spectral coordinates graph.



Spectral coordinates graph of the ”3elt” mesh. Light blue corresponds to white and black to yellow in the spatial coordinates graph.



”crack” graph. Red are the cut edges of the mesh, while white is translated to light blue and black to yellow in the corresponding spectral coordinates graph.



Spectral coordinates graph of the ”crack” mesh. Light blue corresponds to white and black to yellow in the spatial coordinates graph.

7. Task: Quality of the Report [15 Points]