

## High-Performance Computing

2021

Student: Ashutosh Singh

Discussed with: Self

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### Solution for Project 6

Due date: 05.12.2021, 23:59

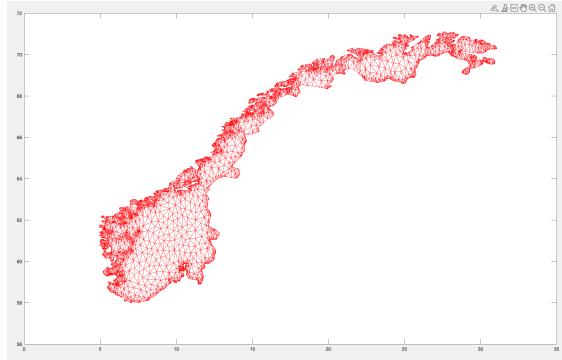
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#### HPC 2021 — Submission Instructions

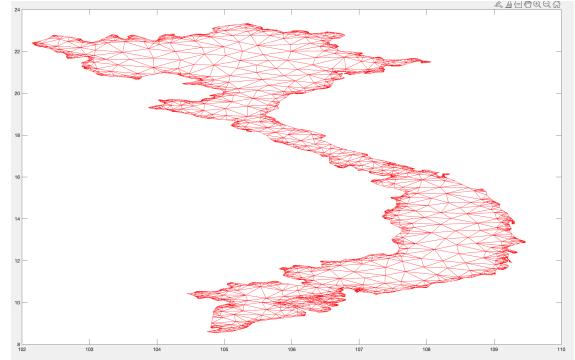
(Please, notice that following instructions are mandatory:  
submissions that don't comply with, won't be considered)

- Assignments must be submitted to [iCorsi](#) (i.e. in electronic format).
- Provide both executable package and sources (e.g. C/C++ files, Matlab). If you are using libraries, please add them in the file. Sources must be organized in directories called:  
*Project\_number\_lastname\_firstname*  
and the file must be called:  
*project\_number\_lastname\_firstname.zip*  
*project\_number\_lastname\_firstname.pdf*
- The TAs will grade your project by reviewing your project write-up, and looking at the implementation you attempted, and benchmarking your code's performance.
- You are allowed to discuss all questions with anyone you like; however: (i) your submission must list anyone you discussed problems with and (ii) you must write up your submission independently.

- 1. Task: Install METIS 5.0.2, and the corresponding Matlab mex interface**
- 2. Task: Construct adjacency matrices from connectivity data [10 points]**



(a) Norway



(b) Vietnam

Figure 1: Graphs for Norway and Vietnam

### 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          | 35       | 38       |
| netz4504_dual | 25         | 23          | 23       | 40       |
| stufe         | 16         | 16          | 16       | 20       |

### 4. Task: Recursively bisecting meshes [15 points]

Table 2: Edge-cut results for recursive bi-partitioning.

| Case     | Spectral |     | Metis 5.0.2 |     | Coordinate |      | Inertial |      |
|----------|----------|-----|-------------|-----|------------|------|----------|------|
|          | 16       | 8   | 16          | 8   | 16         | 8    | 16       | 8    |
| mesh3e1  | 129      | 85  | 117         | 75  | 122        | 75   | 185      | 97   |
| airfoil1 | 633      | 398 | 563         | 320 | 819        | 516  | 1340     | 691  |
| 3elt     | 752      | 469 | 651         | 395 | 1168       | 733  | 1256     | 823  |
| barth4   | 841      | 550 | 689         | 405 | 1306       | 875  | 1547     | 1066 |
| crack    | 1419     | 883 | 1290        | 784 | 1860       | 1343 | 2101     | 1363 |

Table 3: Results for 16 way recursive bisection for various methods

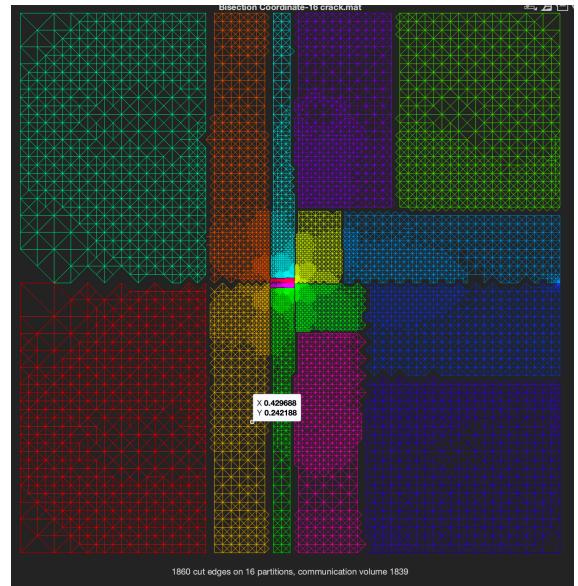
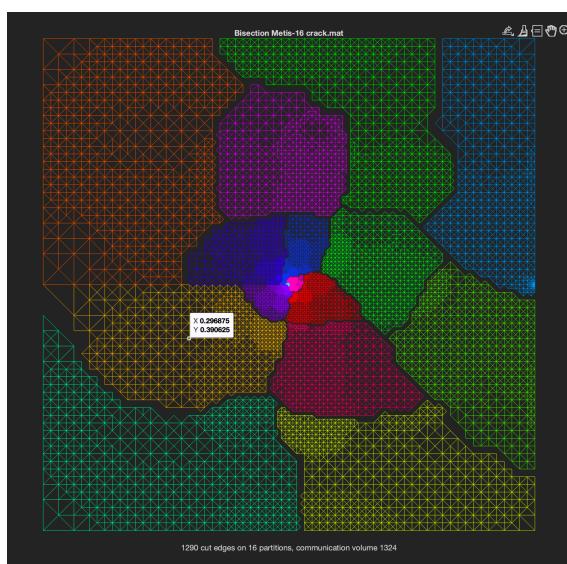


Figure 2: Metis and Coordinate bisection for crack.mat with 16 recursive partitions

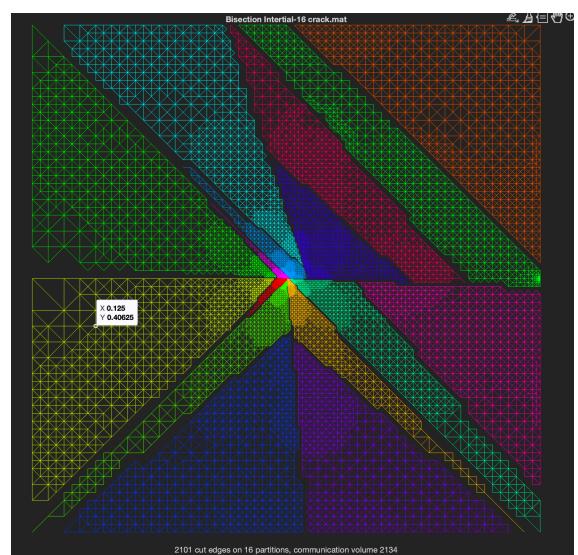
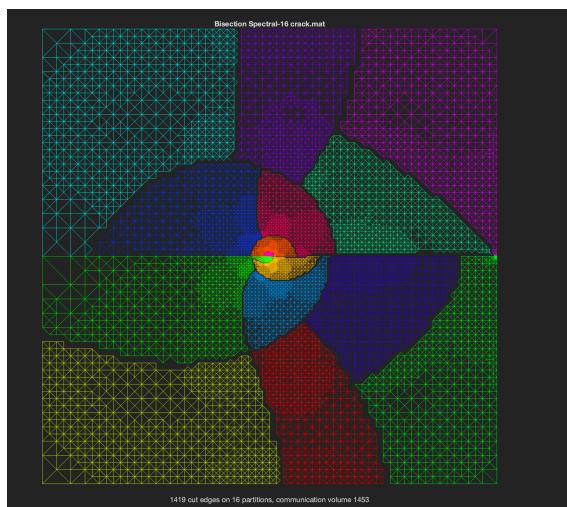
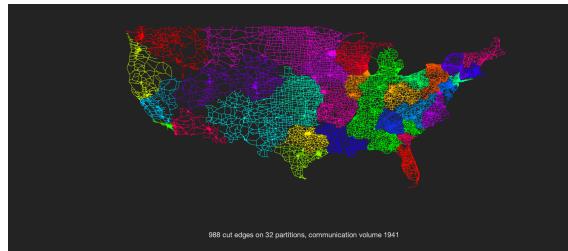


Figure 3: Spectral and Inertial bisection for crack.mat for 16 recursive partitions

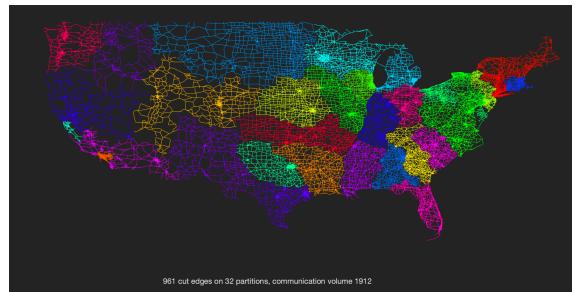
## 5. Task: Comparing recursive bisection to direct $k$ -way partitioning [10 points]

Table 4: Comparing the number of cut edges for recursive bisection and direct multiway partitioning in Metis 5.0.2.  $R$  for Recursive partitioning and  $D$  for direct k-way partitioning

| Partitions | Luxemburg |     | usroads-48 |     | Greece |     | Switzerland |      | Vietnam |     | Norway |     | Russia |     |
|------------|-----------|-----|------------|-----|--------|-----|-------------|------|---------|-----|--------|-----|--------|-----|
|            | R         | D   | R          | D   | R      | D   | R           | D    | R       | D   | R      | D   | R      | D   |
| 16         | 197       | 170 | 607        | 579 | 297    | 278 | 730         | 673  | 245     | 245 | 284    | 255 | 4762   | 661 |
| 32         | 322       | 289 | 988        | 961 | 509    | 471 | 1089        | 1042 | 445     | 411 | 470    | 439 | 5722   | 906 |

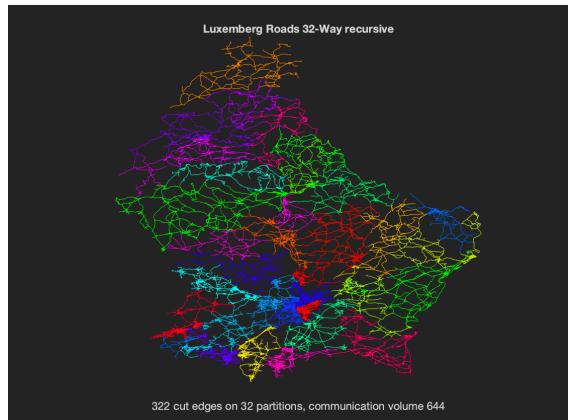


(a) Recursive 32-way

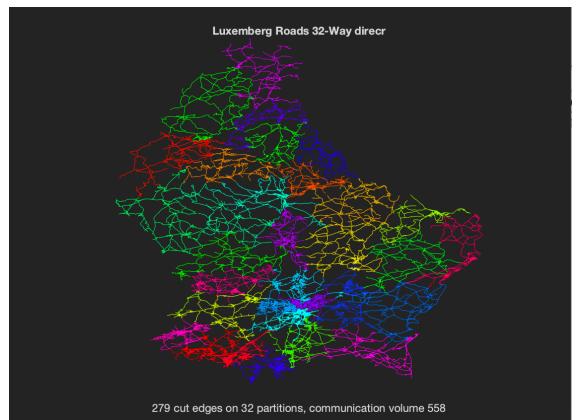


(b) Direct 32-way

Figure 4: Recursive and Direct 32 way partitions for usroads-48

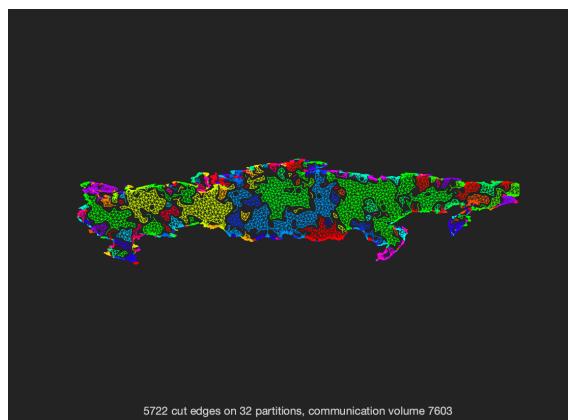


(a) Recursive 32-way

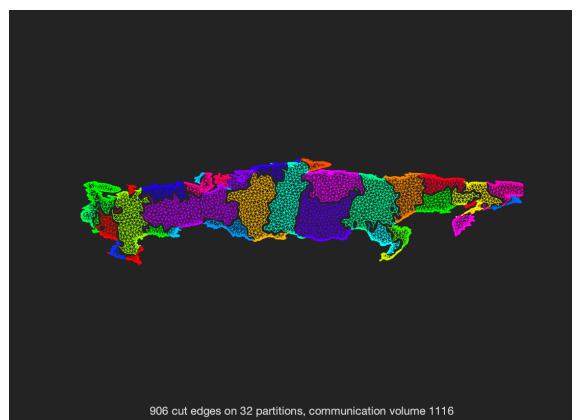


(b) Direct 32-way

Figure 5: Recursive and Direct 32 way partitions for Luxembourg



(a) Recursive 32-way



(b) Direct 32-way

Figure 6: Recursive and Direct 32 way partitions for Russia

## 6. Task: Utilizing graph eigenvectors [25 points]

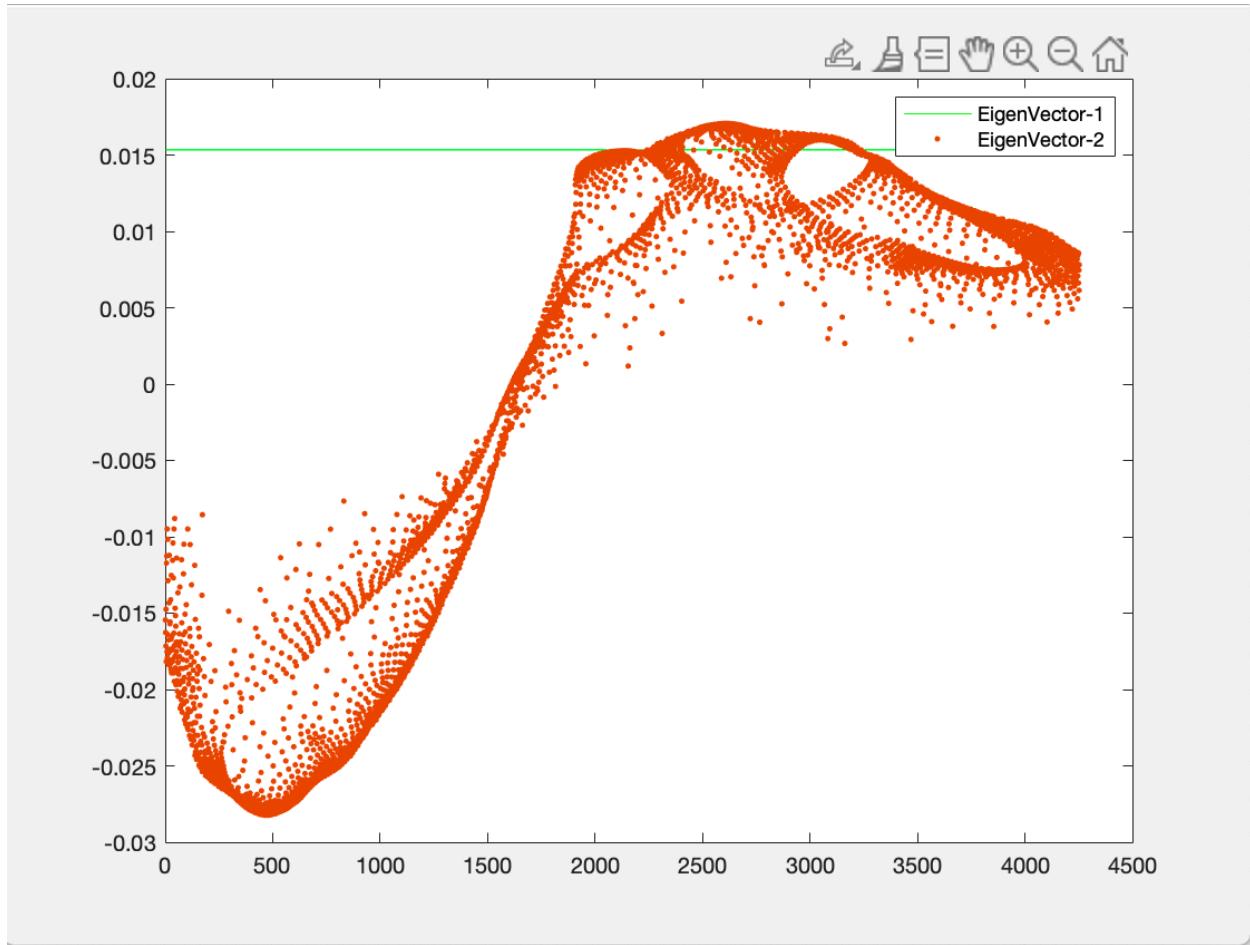


Figure 7: Eigen Vector 1 and Eigen Vector 2 for airfoil.mat

In Figure-7 we can clearly see that the eigen vector associated with smallest eigen value i.e. *Eigen Vector 1* is constant. For *airfoil* matrix  $L$  is singular and the smallest eigen value in  $0$ . We know that  $Lv_1 = 0$  has many solutions and matlab could be setting it to original guess of solver or some random constant value.

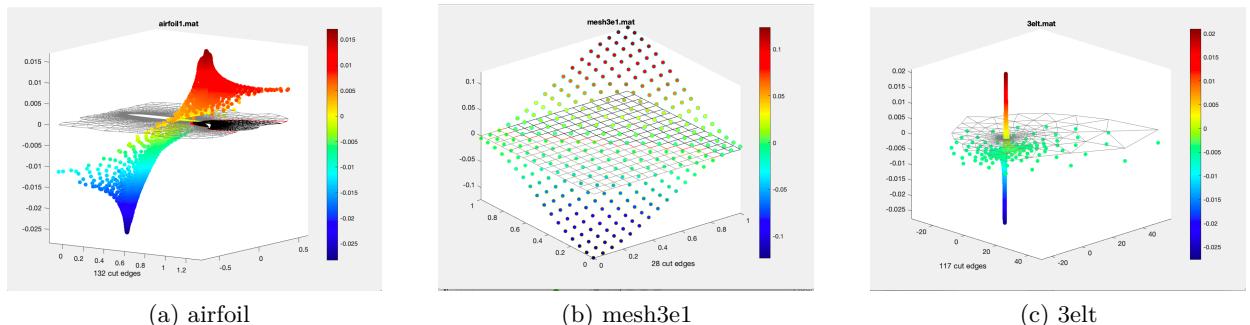
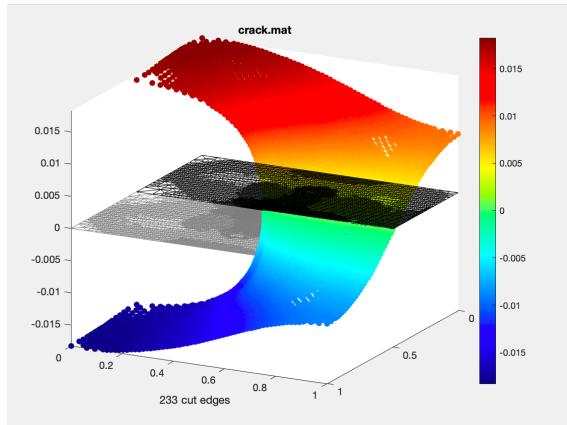
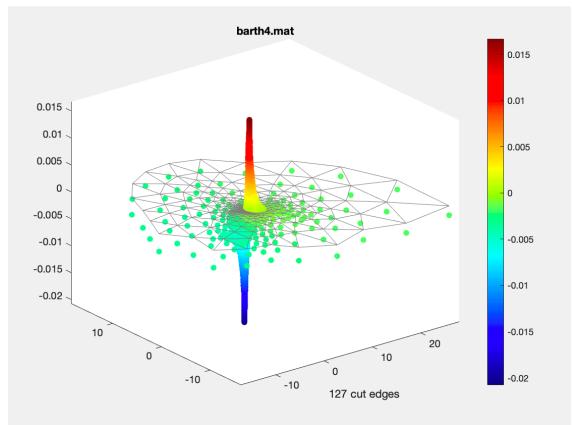


Figure 8: Plots of eigen vector associated with second smallest eigen value of Laplacian and bisected graph of airfoil, mesh3e1 and 3elt

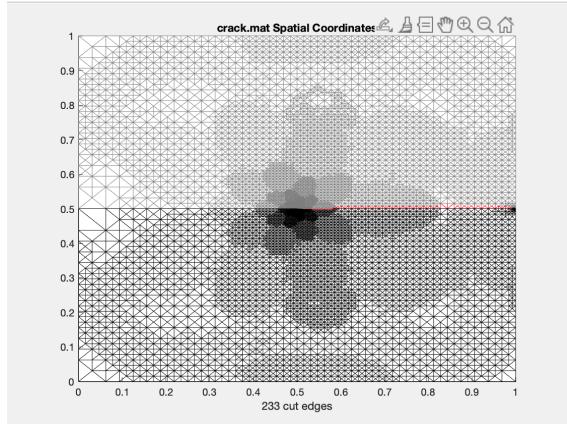


(a) crack

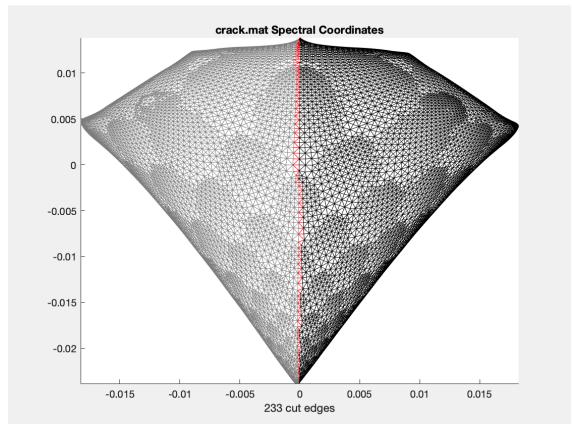


(b) barth4

Figure 9: Plots of eigen vector associated with second smallest eigen value of Laplacian and bisected graph of crack and barth4

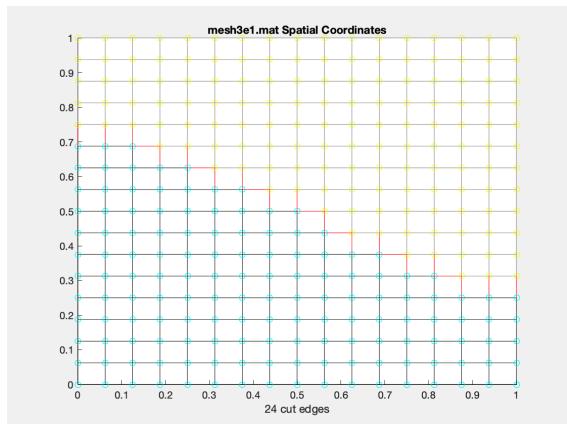


(a) crack-spatial

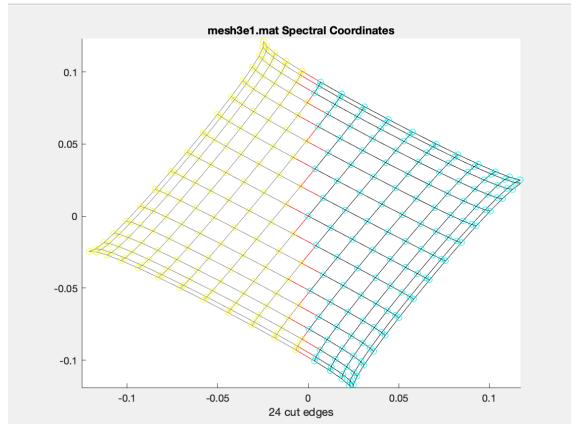


(b) crack-spectral

Figure 10: Plots spatial and spectral bipartitioning of crack

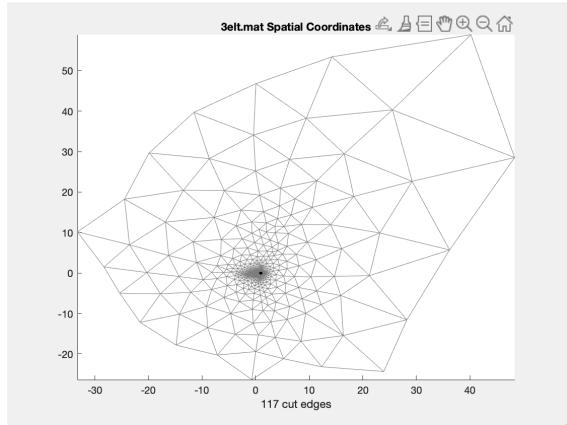


(a) mesh3e1-spatial

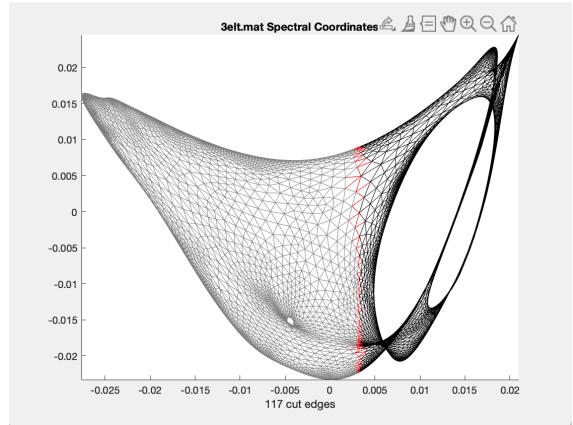


(b) mesh3e1-spectral

Figure 11: Plots spatial and spectral bipartitioning mesh3e1

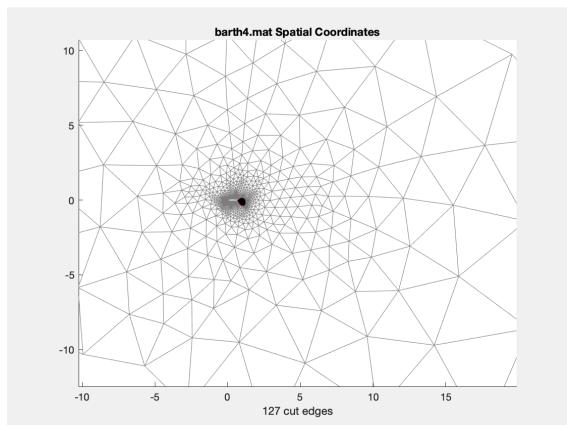


(a) 3elt-spatial

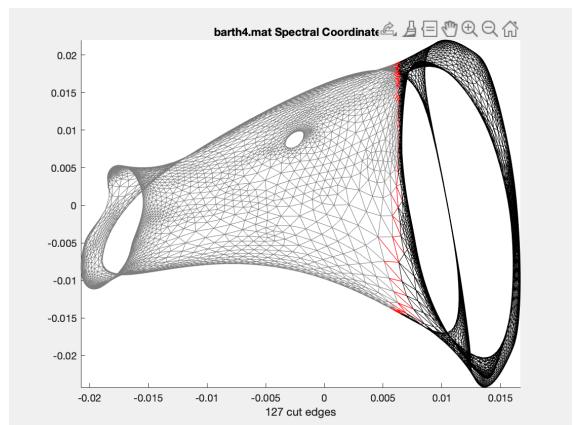


(b) 3elt-spectral

Figure 12: Plots spatial and spectral bipartitioning 3elt



(a) barth4-spatial



(b) barth4-spectral

Figure 13: Plots spatial and spectral bipartitioning of barth4

## References

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

#### Additional notes and submission details

Submit the source code files (together with your used `Makefile`) in an archive file (tar, zip, etc.), and summarize your results and the observations for all exercises by writing an extended Latex report. Use the Latex template from the webpage and upload the Latex summary as a PDF to iCorsi.

- Your submission should be a gzipped tar archive, formatted like `project_number_lastname_firstname.zip` or `project_number_lastname_firstname.tgz`. It should contain:
  - all the source codes of your MATLAB solutions;
  - your write-up with your name `project_number_lastname_firstname.pdf`.
- Submit your `.zip/.tgz` through Icorsi.