Volumetric Image Visualization (MO815A)

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1 What is this all about?

X-ray computed tomography (CT), confocal microscopy, magnetic resonance (MR) are examples among several imaging modalities that outcome volumetric (or 3D) images. These imaging modalities provide visual information to study the interior of humans, animals, plants, minerals, with many applications to Medicine, Geology, Biology, and other areas of the Sciences and Engineering. A fundamental problem, however, is the visualization of the content of interest in those 3D images, named *objects*, which might be pores of a rock, organs of a human body, and stem cells of a plant, for instance.

In this course, you will learn the basic operations from Image Processing and Computer Graphics for the visualization of those objects of interest from volumetric images.

2 Location and schedule

Due to the covid-19, the lectures will continue through google hangout every Tuesdays and Thursdays from 8AM to 10AM. This will not affect the evaluation criteria.

3 *Syllabus*

1. Volumetric image acquisition, mathematical definition, and representation in memory.
2. Radiometric transformations and use of color.
3. Geometric affine and projective transformations.
4. Interpolation, reformatting, and planar cuts.
5. Ray casting, planar reformatting, and maximum/average intensity projection.
6. (Differential) Image Foresting Transform (IFT) and interactive segmentation of 3D images.

7. Image segmentation based on object models and interactive correction.
8. Euclidean distance transform (EDT), fast morphological operations by EDT, and reformatting by isosurface cuts.
9. Illumination models with object color and transparency.
10. Object visualization.
11. Image registration and color composition.

4 Evaluation criteria

The students will be evaluated based on their participation during the lectures, C/C++ implementation of the algorithms studied in the classroom, oral questioning about the implemented algorithms, and a final individual report with all implementation results (due to July, 2nd 2020).

We will assign those implementation tasks during the course (they are, usually, four) with deadlines to accomplish each task and present its results in an incomplete version of the final report.

We will score each task within [0,10] in the final report, such that the sum of the scores is at most 10. Finally, we will grade the students with attendance higher than 75% as follows:

- grade A for a total score in [8.5,10];
- grade B for a total score in [7.0,8.5);
- grade C for a total score in [5.0,7.0);
- grade D for a total score in [0.0,5.0);

being grade E assigned to students with less than 75% of attendance.

The final report should have at most 40 pages with letter size 11pt, including figures, tables, graphics, and references. It should present the following organization.

- Cover page: provide the name of the discipline, name of the student, academic identification number (RA), and delivery date, followed by a summary of the implemented techniques and their main results.
- Subsequent pages for each task: present the literature that has been studied to implement the task, its difficulties, solutions you gave, implemented algorithms, and their results with illustration and discussion.
- Final page: present a conclusion about what you have accomplished with this course and provide suggestions to improve it.

5 Bibliography

- D. Hearn and M.P. Baker Computer Graphics, Prentice Hall, 2nd Ed., 1997.
- R. C. Gonzalez & R. E. Woods. Digital Image Processing, Addison-Wesley, 3rd Ed., 2007.
- P. S. Shirley and S. Marschner. Fundamentals of Computer Graphics, ISBN:978-1-56881-469-8, 2009.
- J.K. Udupa and G.T. Herman. 3D Imaging in Medicine. CRC Press, 2nd. Ed., 2000.
- A.C. Telea. Data Visualization: Principles and Practice. A.K. Peters, 2008.
- Atam P. Dhawan, Medical Image Analysis (IEEE Press Series on Biomedical Engineering), IEEE, 2nd. Ed., 2011.
- G. Farin and D. Hansford. Mathematical Principles for Scientific Computing and Visualization. A.K. Petters, 2008;
- Elizabeth Berry, A Practical Approach to Medical Image Processing, Series in Medical Physics and Biomedical Engineering, CRC Press, 1997.
- James Foley and Andries van Dam, Computer Graphics: Principles and Practice in C (2nd Edition), Addison-Wesley, 1982.
- Scientific texts that will be provided during the course.