Microwave heating

MATH0471 – Spring 2018

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v1 (05/01/2018)

This project consists in studying, implementing and validating a numerical scheme for the solution of coupled electromagnetic and heat transfer equations using finite difference methods, in order to model microwave heating.

Two applications are considered: the undesired heating of the human head when exposed to the electromagnetic waves emitted by cellular phones, and the defrosting of frozen food in microwave ovens.

Both the electromagnetic and the heat transfer simulations will be carried out in the time-domain, using the famous explicit FDTD scheme pionneered by K. S. Yee in 1966 for Maxwell's equations, and an implicit finite difference scheme for the heat equation.

The project is organized as follows:

1. Students will be divided in two groups; each group will be assigned one of the two target applications;
2. Each group will write its own solver, with specific features for its target application (see the description of the objectives for each deadline, below);
3. Four intermediate deadlines are given, with a mandatory (but not graded) 8-page progress report that should detail the computer implementation and the mathematical, numerical and physical experiments;
4. The final report (about 60 pages) will present the method and numerical results, the computer implementation and a detailed analysis of physical experiments on non-trivial configurations. An oral presentation of the main project results will be organized during the June exam session; individual theoretical and practical questions will be asked to each member of the two student groups.

The objectives for the four intermediate deadlines are:

1. Group 1 and 2: 3D FDTD Maxwell solver, without boundary conditions, parallelized with MPI and OpenMP. This is an extension of the fall INFO0939 project. Deadline: **February 28th**.

2. Group 1 and 2: 3D implicit FD thermal solver, interfaced with MUMPS. Deadline: **March 21th**.

3. Group 1: Silver-Muller Absorbing Boundary Condition (ABC) and Perfectly Matched Layers (PML) to handle the propagation of electromagnetic waves inunbounded domains; Group 2: Handling of the rotation of the food to unfreeze in the oven. Deadline: **April 4th**.

4. Group 1 and 2: Electromagnetic-thermal coupling. Deadline: **April 25th**

The full C/C++ code (in a single ZIP archive with a corresponding reference to the code on Github, directly configurable and compilable on the NIC4 CECI cluster) should be sent before each deadline to both `cgeuzaine@ulg.ac.be` and `r.boman@ulg.ac.be`.