Teaching Electromagnetics at IGTE

Der vorliegende Artikel ist die Zusammenfassung eines Berichtes über die Lehraktivitäten unseres Institutes für Grundlagen und Theorie der Elektrotechnik (kurz IGTE) auf dem Gebiet der theoretischen Elektrotechnik. Die Originalarbeit mit Beispielen und Computeranimationen elektromagnetischer Felder wurde für das IEE Electromagnetics Professional Network geschrieben und ist auf unserer Website http://www.igte.tugraz.at unter Forschung/ Teaching Electromagnetics zu finden.

At the Institute for Fundamentals and Theory of Electrical Engineering (IGTE) of the Technical University of Graz, Austria lectures on electromagnetic field theory named „Theory in Electrical Engineering 1" and „Theory in Electrical Engineering 2" are given for students of the third and fourth semester, respectively. These lectures are accompanied by exercises and a laboratory on „Fundamental Electromagnetic Experiments".

The time available in the curriculum for teaching electromagnetic theory has been almost halfed during the last ten years in Graz for dierent reasons and the situation is quite similar in many other European countries. One common argument for further reducing the lectures is that field theory is not really needed and that to be able to deal with electromagnetic fields is not a primary goal in the education of electrical engineers. On the other hand, students are not unhappy about this trend more or less eliminating the „unpopular complicated theory". As a reaction to this situation, we have started an attempt few years ago to make the lectures more attractive by involving modern methods of computational electromagnetics.

At IGTE, during the last 20 years a lot of effort has been made in developing numerical methods for the computation of electromagnetic fields, mainly with the finite element method (FEM). There are, of course various special lectures given at the institute dealing with this topic. In the basic lectures in electromagnetic field theory, we do not discuss the methods of computational electromagnetics themselves, although we offer some very basic information about them. However, we use the software developed as a toolkit to present virtual experiments to support the theoretical lectures.

The students use this in the exercises to work out practical examples or in the laboratory to perform virtual experiments on their own. It must be possible to use the toolkit without having a deeper knowledge about the methods acting inside it. Of course it is not bad, if the user has some ideas about finite elements. At least, he should know that the method of finite elements discretizes the various differential equations formulated in the lectures resulting in large algebraic equation systems and it should also be clear that refining the finite element mesh yields better results.

To make the handling of the programs easy and therefore to increase the acceptance of the tool, we are still working on the development of an appropriate surface together with easy-to- use pre- and postprocessors. It turned out in the past when we used the software in our special lectures that the time needed to model the problems was too high lowering the acceptance level of the programs. This is often the case when using commercially available software packages, too, since the students do not want to spend too much time (they do not have any time) to become familiar with a highly versatile and sophisticated tool.

So, in our opinion, one key point in minimizing such difficulties is primarily the availability of a simple-to-use preprocessor which needs not be designed for modelling complex geometrical structures. To model problems with complex geometry is not very important for education but it is essential that the tool be able to simulate and investigate a large variety of electromagnetic phenomena.

Furthermore, it is desirable that such a tool can deal with some topics which may not be too important for an electrical engineer in practice but which do have considerable educational significance. For instance, in teaching it is very interesting to display the polarization field P and the magnetization M as well as polarization (surface) charge densities and magnetization (surface) currents or free surface charges on metallic electrodes. When designing virtual electromagnetic experiments for demonstration purposes during the lectures, it is also necessary to model the problem very carefully with respect to the finite element mesh and the boundary conditions to get almost perfect field plots.

The students should not have the impression of considering ugly pictures obtained by rough numerical procedures and they should not be confused by numerical shortcomings which impede the physical message of the presented experiment. For instance, geometries with sharp corners producing singularities should be avoided by replacing the corners by smooth surfaces. The finite element mesh near electrodes should be made very fine to get good results when

total charges have to be calculated by integration over the surface of the electrodes. It should be possible to generate computer animations of electromagnetic phenomena, especially for transient problems like quasi static electric and eddy current fields very easily and quickly. At present, the following electromagnetic and thermal phenomena can be investigated:

- Electrostatics
- Time harmonic electric fields
- Current flow
- Time harmonic current flow
- Transient current flow
- Magnetostatics
- Time harmonic eddy currents
- Transient eddy currents
- Steady state thermal
- Transient thermal

A tutorial has been written to make the students familiar with the software. At present, the tutorial consists of 13 examples. In the first examples the presentation of the various features of the toolkit is in the foreground. The tutorial is not yet complete.

Currently available examples:

Electrostatics

1. Infinitely long cylindrical volume charge
2. Infinitely long charged metallic cylinder 1
3. Infinitely long charged metallic cylinder 2
4. Capacitance matrix of a multi electrode system

Magnetostatics

5. Surface current double layer
6. Homogeneous field modelled by prescribing the vector potential on the boundary
7. Conductors near a ferromagnetic plate 1
8. Conductors near a ferromagnetic plate 2

Time harmonic eddy currents

9. Conducting plate in a homogeneous magnetic field 1
10. Conducting plate in a homogeneous magnetic field 2
11. Conducting plate bent at right angle in a homogeneous magnetic field
12. Double conductor system in a homogeneous magnetic field
13. Ferromagnetic conducting plate in a homogeneous magnetic field

Currently, the tutorial is available in German only (except example 1), but an English version will follow in the near future. The tutorial can be downloaded from the following web pages:

German-version: www.igte.tugraz.at/de/elefant/tutorial/

English-version: www.igte.tugraz.at/en/elefant/tutorial/

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Die Premiere...

....das erste E-FEST aller Zeiten!

Am 5. Juni 2003 um 20 Uhr im Tiefparterre und im Hof der Alten Technik war es endlich so weit. Nach langer Vorbereitung haben wir es geschafft ein eigenes E-Fest zusammen mit den Toningenieuren auf die Beine zu stellen.

Wegen der schlechten Wetteraussicht hatten wir anfangs Bedenken ob das Fest wohl gelingen würde. Um so mehr freuten wir uns, als das Event mit ca. 700 Besuchern ein Erfolg wurde.

Aufgrund der tatkräftigen Unterstützung unserer Toni's war es uns möglich gleich zwei Bands (Junk Vibration und zwei Gittarristen) im Hof und DJ's im Tiefparterre zu engagieren.

Dank der Sponsorgelder diverser Firmen und Institute unserer Fakultät gab es am Anfang des Festes 100 Liter Freibier, ein Gewinnspiel - bei dem man als Hauptpreis Essensgutscheine in der Trattoria gewinnen konnte - und weiters hat uns das Augartenkino Kinofreikarten gesponsert.

Rückblickend sind wir sehr froh, dass Risiko eines Studentenfestes auf uns genommen zu haben, da es für uns schön war zu sehen, dass es den Leuten so gut gefallen hat.

Ausserdem gab es keine nennenswerten Zwischenfälle, die die Organisation eines weiteren E-Festes gefährden würden.

Für dieses Jahr wollen wir wieder ein Semesterabschlussfest im Juni planen und an den Erfolg des letztjährigen Festes anknüpfen.

Wir hoffen, dass es allen die dabei waren gefallen hat und dass euer wieder elektrisierende Stimmung aufkommen wird.

Eure Fakultätsvertretung