APPM 4380 / 5380 Fall 2009

Modeling

Instructor: Bengt Fornberg
Office Hours: M, W: 11 am - 12 noon, F: 12 noon -1 pm.
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Lectures: MWF 10.00 - 10.50 am in ECEE 1B28

Text book: A manuscript in progress will be posted here soon.

Assignments: A number of assignments will be posted.

Final exam: December 15, 4.30- 7.00 pm (time to be used for final projects that have not been presented earlier)

Final grade: Will mainly be based on projects. Course attendance, if low, can also be a factor.

Course motivation:

The 'life-blood' of all parts of applied mathematics is applications. In spite of that, both analytical and numerical techniques are traditionally taught in very 'encyclopedic' fashions (and as two entirely separate subjects). Key techniques are often enumerated in manners which are better suited for reference works than for first introductions. In contrast, this course will be centered around examples of how one carries through all the steps: problem -> mathematical formulation -> theoretical analysis -> numerical solution. The goals of the course include

- provide illustrating examples of major modeling tasks of current significance,
- convey practical approaches of how to approach problems not originally stated in mathematical form, and
- introduce a number of key techniques from analysis and numerics (only at the points where these are needed).

We will discuss topics only according to what we need to have available in order to resolve specific issues, as they arise in a handful of primary modeling problems. These problems have been selected in such a way that, between them, they involve (and can serve as a first introduction to) a broad range of interconnected analytical and numerical methods. The presently planned topics are (unlikely all will be covered):

- Tomographic image reconstruction - e.g. as applied for medical diagnosis,
- Freak ocean waves - isolated giant waves, which frequently severely damage or sink large ships in certain parts of the oceans,
- GPS - Global Positioning System; satellite-based system for accurate navigation,
- Seismic forward modeling - a key procedure in exploring for oil and gas,
- Automated facial recognition from images,
- Multi-dimensional data display/modeling through use of radial basis functions - novel, revolutionary approach to extract much more information out of complex data sets than previously possible.

The course, in its present form, was first taught in the fall of 96. Its motivation comes from several recent studies of 'industrial needs', for example as expressed in SIAM Report on Mathematics in Industry. This report lists as most significant traits for non-academic mathematicians:

- skill in formulating, modeling and solving problems from diverse and changing areas
- interest in, knowledge of, and flexibility across applications,
- knowledge of and experience with computation,
- communication skills (spoken and written), and
- adeptness at working with colleagues (teamwork).

Many references on mathematical modeling and information on classes taught, books published and projects carried out in this area can be found by searching on 'Mathematical Modeling' on the web.