

One of the numerical methods that was not discussed in the OPTI-547 class in any deserving detail is the finite element method. It is an approach of great practical importance with application in many different fields, including beam propagation modeling. This project is about the research into the subject (it does not require algorithm design and/or programming). Doing this will extend the OPTI-547 material in ways applicable in many different contexts.

Project subject: This project concerns the beam propagation methods that are based on the so-called finite element approach. The goal is to gain sufficient familiarity with the finite-element methods (FEM) as applied to BPM as to be able to write an introductory text explaining the idea and the essential aspects of the method.

Tasks:

- Research the literature and locate publications that describe the finite element approach to beam propagation. There is no need for an exhaustive research (which would be difficult) — you may want to locate several sources that will allow you to describe the essentials of the method as described next.
- Explain the general idea of FEM. Describe how the simulated solution is described with the help of “elements” or shape functions, and describe how this reduces to a (long) vector of coefficients representing the given function.
- Explain how the discretized equations can be obtained. Show how this is done for the beam propagation modeling. This illustration can be done in a simplified context of scalar beam propagation. Note that FEM is often applied in fully vectorial problems which results in complex notations — for the current purpose, it may be instructive to distill the essence of the method in a simplest possible setting.
- Discuss the form of resulting equations and how they can be solved.
- Give illustrative examples (from the literature) of the application of the method in BPM.
- Discuss pros and cons of the FEM-based BPM.

Deliverables:

- The report, which should be written as a (short) textbook chapter.
- PDF files with sources on which the work is based

Notes:

Potentially useful text:

Computational Photonics by Salah Obayya, especially Chapter 2 which contains an easy to read introduction into finite element methods.