Introduction to Finite Elements

Leo M. González

Athens Course Madrid 17-18 March 2009

History

- Variational methods and linear approximation
  - Leibniz
- Triangular meshes
  - Schellbach (1851)

- Local polynomial approximation
  - Courant (1943) Poyla (1952)
- Finite elements vs infinitesimal elements

History

- Modern times: ARGYRIS [1950]
- Engineering applications:

  TURNER, CLOUGH, MARTIN,TOPP [1956]

  Linear Elasticity Equations.

- Fluid Mechanics:
  - ODEN [1970]
- Navier-Stokes equations.
- Everywhere:
  - ZIENKIEWICZ [Since 1967]
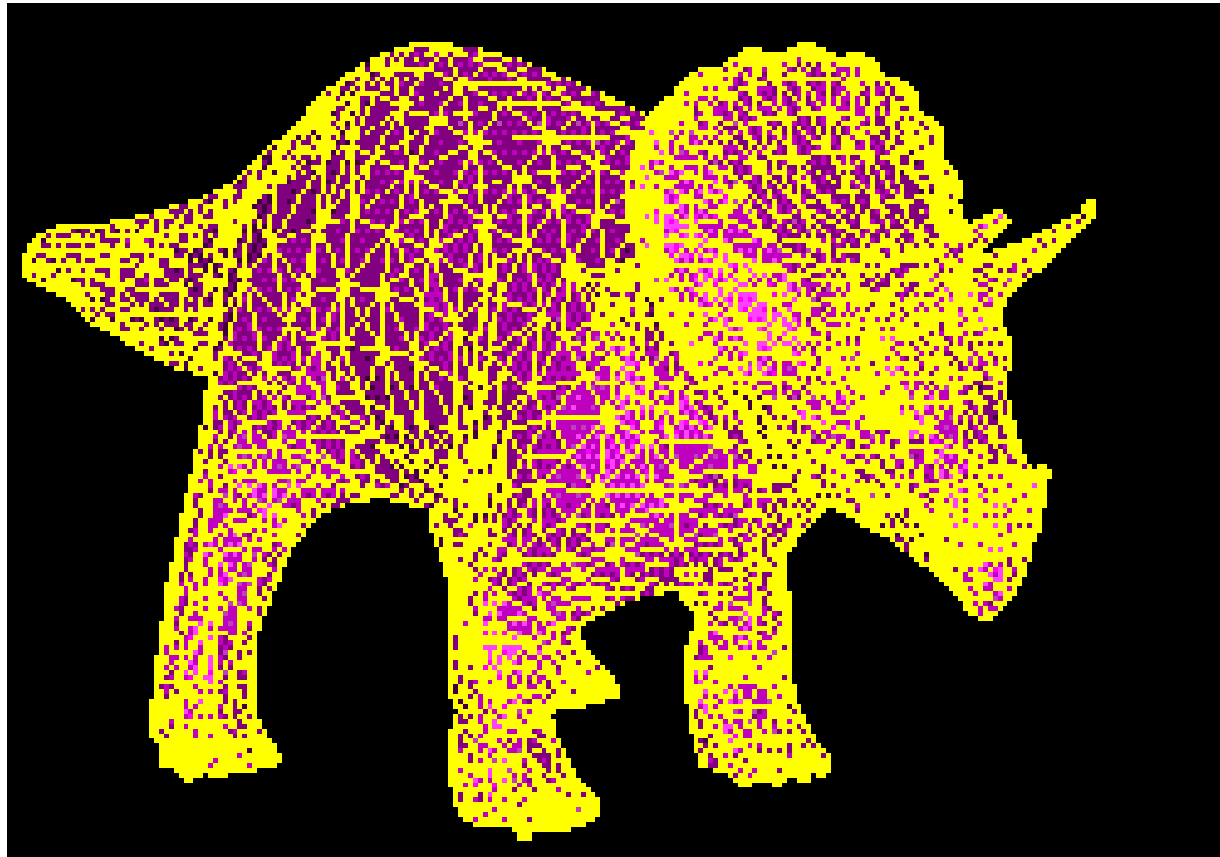
Why finite elements? Advantages

- Geometrical flexibility.
- Unstructured meshes.
-        -Cell tissue.
-        -Aircrafts.
-        -Turbomachines.
- Robustness.
- Solid Mathamatical theory and analysis.
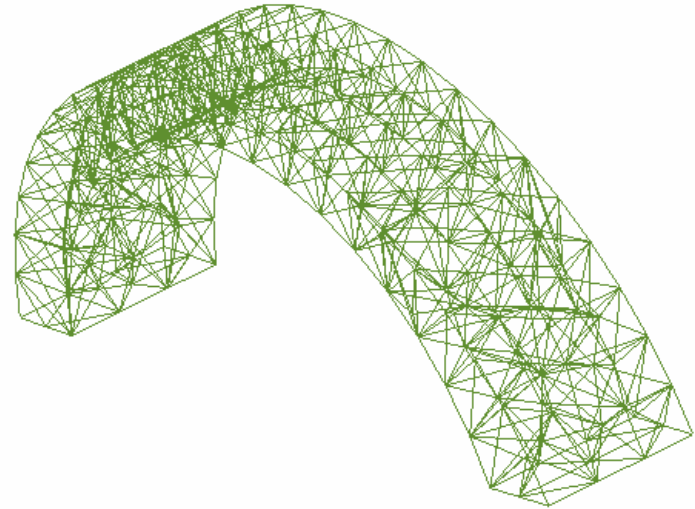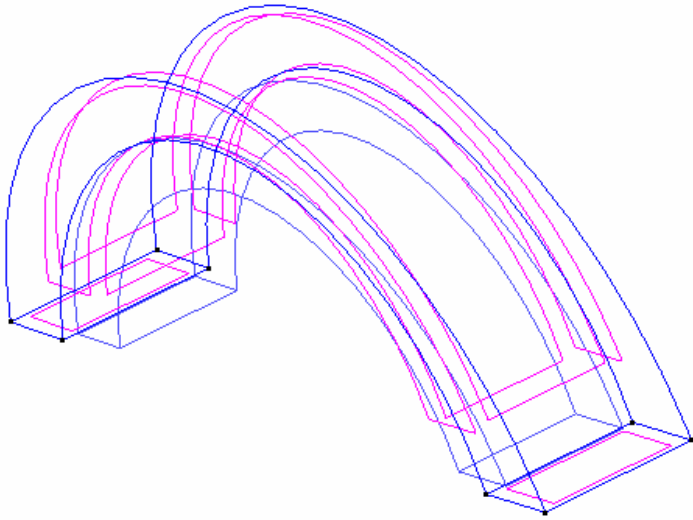
- Local mesh refinement

Outline

- FEM Advantages
- Spatial Discretization
- Our problem
- Mathematical description
- Errors
- Sparse matrix
- Mesh generation
- Examples
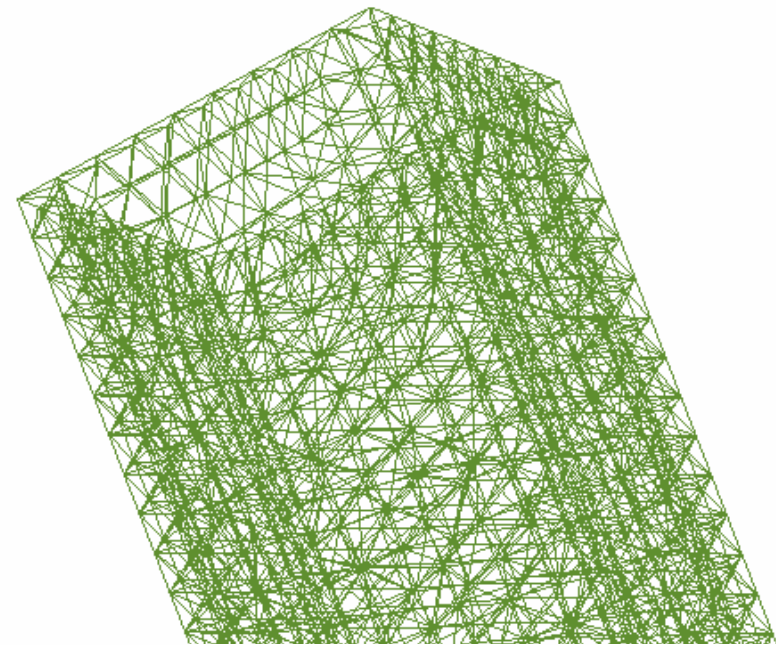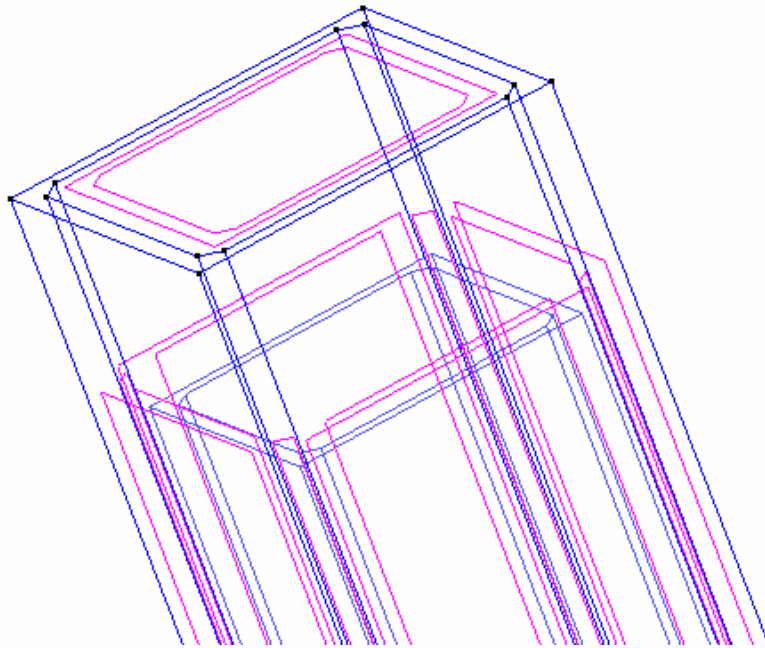- Conjugate gradient

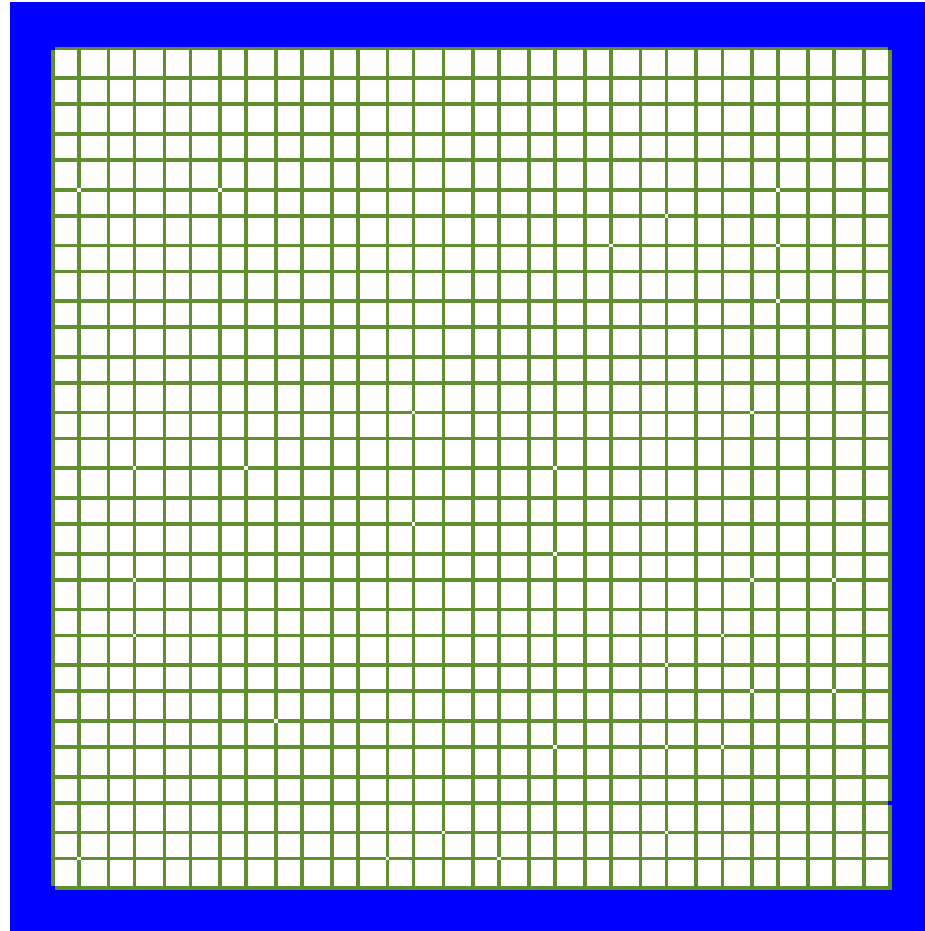# FEM: Advantages

- Geometrical flexibility

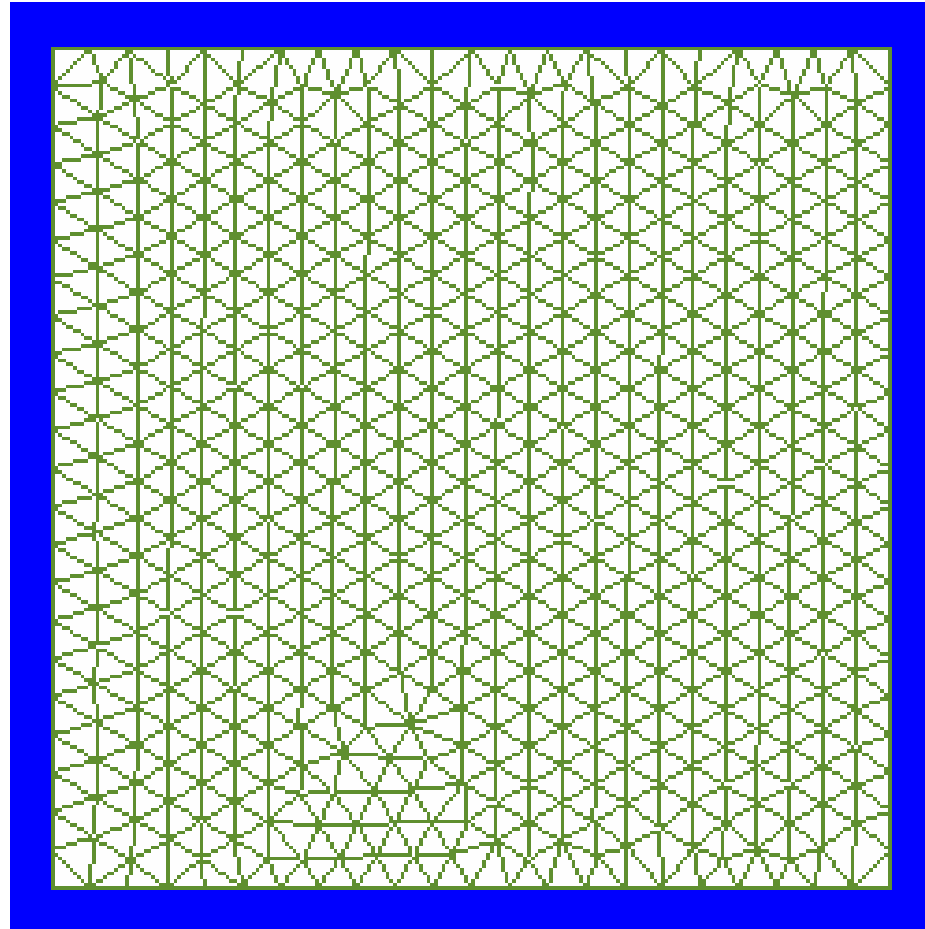# FEM: Advantages

FEM: Advantages

FEM Advantages

- Structured and unstructured mesh generation.
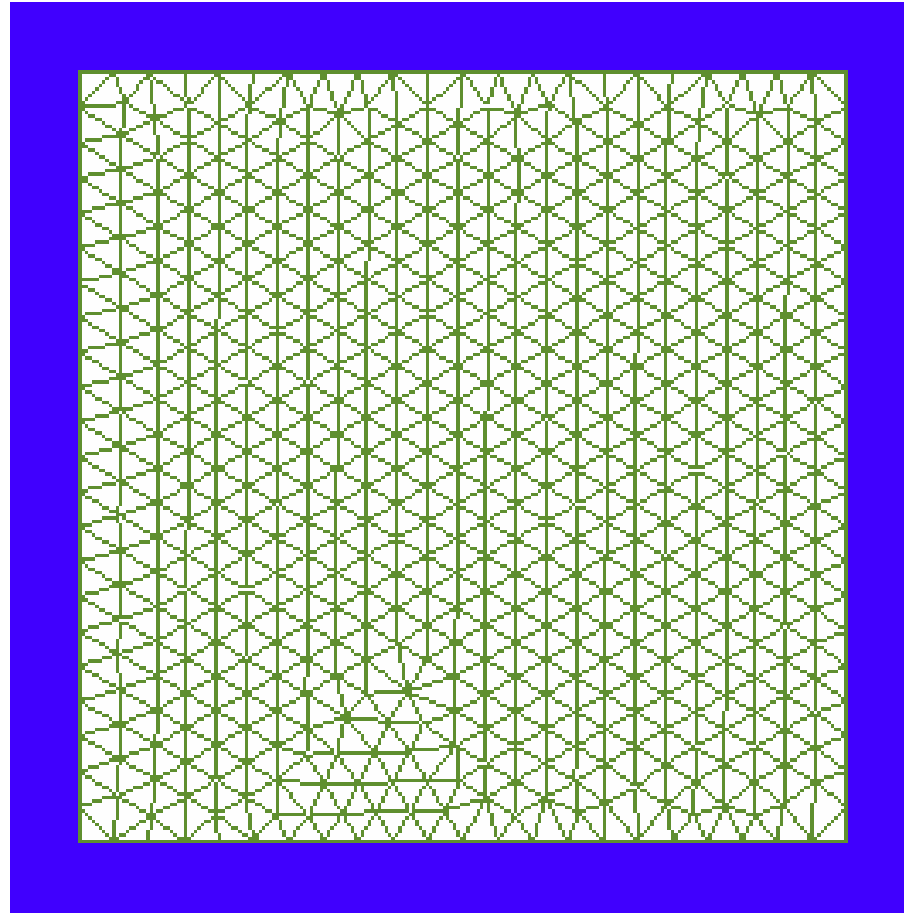
FEM Advantages

FEM Advantages

FEM Advantages

- Robustness
- Solid mathematical background
  - Variational calculus
  - PDE theory
- Mesh refinement

FEM Advantages

FEM Advantages