Recursive Finite Element Method (RFEM) Flow

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The Recursive Finite Element Method (RFEM) provides a structured approach for solving differential equations in engineering analysis, particularly focusing on the recursive assembly of matrices.

Key Steps

1. **Finite Element Discretization**:

   - Convert the governing differential equation into a weak form suitable for discretization.
   - Represent the solution using **shape functions** N over each element.

2. **Element Matrices**:

   - Define element-wise **stiffness matrix** K_e, **mass matrix** M_e, and **load vector** F_e.
   - Assemble the **global stiffness matrix** K recursively:

   $$K = \sum_{e=1}^{n} K_e$$

   - Recursively add each element's contribution:

   $$K^{(r)} = K^{(r-1)} + K_e$$

3. **Boundary Condition Application**:

   - Adjust the global matrix to enforce **boundary conditions**:

   $$K_{ii} = 1, \quad K_{ij} = 0 \ (i \neq j), \quad F_i = u_i$$

4. **System Solution**:

   - Solve the linear system:

   $$Ku = F$$

- Use methods like **conjugate gradient** for efficient recursive solution, especially for large, sparse matrices.

5. **Adaptive Refinement**:

    - Use **error estimation** to refine elements:

    $$e_e = \|u_e - u_{\text{exact}}\| > \text{threshold}$$

    - Recursively refine elements with high error to improve accuracy.

Summary

RFEM involves recursive matrix assembly, application of boundary conditions, solving the linear system, and adaptive refinement based on error estimates. This approach is well-suited for large-scale engineering problems where efficient handling of matrices and error control is crucial.