FINITE ELEMENT METHOD DISPLAYED pdf

1: Finite Element Methods with B-Splines - SIAM Bookstore

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History[edit] The origin of finite method can be traced to the matrix analysis of structures [1] [2] where the concept of a displacement or stiffness matrix approach was introduced. Finite element concepts were developed based on engineering methods in s. The finite element method obtained its real impetus in the s and s by John Argyris , and co-workers; at the University of Stuttgart , by Ray W. Earlier books such as by Zienkiewicz [6] and more recent books such as by Yang [7] give comprehensive summary of developments in finite-element structural analysis. Implementing the method in software is described in the classic text by Smith, Griffiths and Margetts. This type of element is suitable for modeling cables, braces, trusses, beams, stiffeners, grids and frames. Straight elements usually have two nodes, one at each end, while curved elements will need at least three nodes including the end-nodes. The elements are positioned at the centroidal axis of the actual members. Two-dimensional elements that resist only in-plane forces by membrane action plane stress , plane strain , and plates that resist transverse loads by transverse shear and bending action plates and shells. They may have a variety of shapes such as flat or curved triangles and quadrilaterals. Nodes are usually placed at the element corners, and if needed for higher accuracy, additional nodes can be placed along the element edges or even within the element. The elements are positioned at the mid-surface of the actual layer thickness. Torus -shaped elements for axisymmetric problems such as membranes, thick plates, shells, and solids. The cross-section of the elements are similar to the previously described types: Three-dimensional elements for modeling 3-D solids such as machine components, dams , embankments or soil masses. Common element shapes include tetrahedrals and hexahedrals. Nodes are placed at the vertexes and possibly in the element faces or within the element. Element interconnection and displacement[edit] The elements are interconnected only at the exterior nodes, and altogether they should cover the entire domain as accurately as possible. Nodes will have nodal vector displacements or degrees of freedom which may include translations, rotations, and for special applications, higher order derivatives of displacements. When the nodes displace, they will drag the elements along in a certain manner dictated by the element formulation. In other words, displacements of any points in the element will be interpolated from the nodal displacements, and this is the main reason for the approximate nature of the solution. From the application point of view, it is important to model the system such that: Symmetry or anti-symmetry conditions are exploited in order to reduce the size of the model. Displacement compatibility, including any required discontinuity, is ensured at the nodes, and preferably, along the element edges as well, particularly when adjacent elements are of different types, material or thickness. Compatibility of displacements of many nodes can usually be imposed via constraint relations. The element mesh should be sufficiently fine in order to produce acceptable accuracy. To assess accuracy, the mesh is refined until the important results shows little change. For higher accuracy, the aspect ratio of the elements should be as close to unity as possible, and smaller elements are used over the parts of higher stress gradient. Proper support constraints are imposed with special attention paid to nodes on symmetry axes. Large scale commercial software packages often provide facilities for generating the mesh, and the graphical display of input and output, which greatly facilitate the verification of both input data and interpretation of the results. From elements, to system, to solution[edit] While the theory of FEM can be presented in different perspectives or emphases, its development for structural analysis follows the more traditional approach via the virtual work principle or the minimum total potential energy principle. The virtual work principle approach is more general as it is applicable to both linear and non-linear material behaviours. The virtual work method is an expression of conservation of energy: The principle of virtual displacements for the structural system expresses the mathematical identity of external and internal virtual work:

2: Finite element method - Wikipedia

Simplifies the teaching of the finite element method. Topics covered include: the approximation of continuous functions over sub-domains in terms of nodal values; interpolation functions for.

This code plots the initial configuration and deformed configuration as well as the relative displacement of each element on them. Results are verified with examples of textbook; arbitrary input geometry, nodal loads, and material properties for each element can be defined by user. Results are verified with examples of textbook ; arbitrary input geometry, nodal loads, and material properties for each element can be defined by user. This code plots the initial configuration and deformed configuration of the structure as well as the forces on each element. This code plots deformed configuration with stress field as contours on it for each increment so that you can have animated deformation. Results are verified with Abaqus results; arbitrary input geometry, nodal loads, and material properties for each element can be defined by user. Penalty method and Lagrange multipliers contact algorithms are implemented. This code is also using large deformation formulations. Results can be animated. I have used Newton-Raphson solver. Green-Lagrange strains are used in these codes. The results can be animated. Results are verified with Fushen Liu and Ronaldo I. What is Finite Element Method? The finite element method FEM is a numerical method for solving problems of engineering and mathematical physics. It is also referred to as finite element analysis FEA. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. What reference books did I use for my codes? Some of the main textbooks I used for codes are: General concepts and basic codes: Finite Element Procedures by K. Bathe The Finite Element Method v. Asghar Bhatti Contact mechanics: Finite Elements in Plasticity by D.

3: The Finite Element Displayed - Gouri Dhatt, Gilbert Touzot - Google Books

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Multi-level shape representation using global deformation and locally adaptive finite elements by Dimitris Metaxas, Eunyoung Koh, Norman I. Badler - International Journal of Computer Vision , " The surface shape is estimated based on the parameters of a superquadric that is subjected to global deformations tapering and bending and a varying number o The surface shape is estimated based on the parameters of a superquadric that is subjected to global deformations tapering and bending and a varying number of levels of local deformations. Local deformations are implemented using locally adaptive finite elements whose shape functions are piecewise cubic functions with C1 continuity. The algorithm first does a coarse fit, solving for a first approximation to the translation, rotation and global deformation parameters and then does several passes of mesh refinement, by locally subdividing triangles based on the distance between the given datapoints and the model. The adaptive finite element algorithm ensures that during subdivision the desirable finite element mesh generation properties of conformity, non-degeneracy and smoothness are maintained. Each pass of the algorithm uses physics-based modeling techniques to iteratively adjust the global and local parameters of the model in response to forces that are computed from approximation errors Show Context Citation Context A new deformable surface by A. Deformable surfaces have many applications in surface reconstruction, tracking and segmentation of range or volumetric data. Many existing deformable surfaces connect control points in a predefined and inflexible way. This means that the surface topology is fixed in advance, and also imposes severe This means that the surface topology is fixed in advance, and also imposes severe limitations on how a surface can be described. For example a rectangular grid of control points cannot be evenly distributed over a sphere, and singularities occur at the poles. In this paper we introduce a new G 1 continuous deformable surface. In contrast to other methods this method can represent a surface of arbitrary topology, and do so in an efficient way. The method is based on a generalization of biquadratic B-splines, and has a comparable computational cost to methods based on traditional tensor product B-splines. For example, when mapping a square domain to a sphere the partial derivatives are singular at the poles. It should be noted that there is an obscure but deep-rooted difficulty 1 in maintaining G 1 continuity for triangular elements [7], which leads to the distinction between conformal and non-conformal Wu, Senior Member - J. Display Tech , " Abstractâ€"The electro-optic properties of a multi-domain in-plane switching liquid crystal display IPS LCD are inves-tigated through a three-dimensional 3-D simulator, which combines the finite element and finite difference methods for fast solutions. The bending angle between the chevron-shaped The bending angle between the chevron-shaped electrodes makes an important contribution to the operating voltage and response time, and suppresses the color shift. Index Termsâ€"Liquid crystal displays LCDs , in-plane switching IPS , multi-domain, response time, wide viewing angle, color shift, phase compensation films. Show Context Citation Context The LC director distributions are calculated by minimizing the total free energy, which is the summation of the electric free energy and the elastic free energy: We present a review of the application of the spectral-element method to regional and global seismology. This technique is a high-order variational method that allows one to compute accurate synthetic seismograms in three-dimensional heterogeneous Earth models with deformed geometry. We first recall the strong and weak forms of the seismic wave equation with a particular emphasis set on fluid regions. We then discuss in detail how the conditions that hold on the boundaries, including coupling boundaries, are honored. We briefly outline the spectral-element discretization pro-cedure and present the time-marching algorithm that makes use of the diagonal structure of the mass matrix. We show examples that illustrate the capabilities of the method and its interest in the context of the computation of three-dimensional synthetic seismograms. DtN operator â€" elastodynamics â€" global seismology â€" regional seis-mology â€" numerical modeling â€" Perfectly Matched Layers â€" potential formulation â€" self-gravitation â€" spectral-element method â€" surface waves â€" synthetic seismograms â€" topography.

4: Finite Element Method Usage Tipsâ€”Wolfram Language Documentation

The finite element method is a powerful numerical analysis technique that has been widely applied in earthquake engineering for modeling the response of structures.

Finite Element Method Usage Tips Introduction The aim of this tutorial is to point out possible issues when using the finite element method with NDSolve and offer best practices to avoid potential issues. Load the finite element package. This is especially true if the boundary conditions or coefficients are time dependent or if the PDE region at hand is three dimensional. An easy way to monitor progress of an integration of a transient PDE is by using an EvaluationMonitor. Here is an example wave equation with a time-dependent Dirichlet condition. Specify an ellipsoidal region with a circular hole in one focal point. Cleanup of the status area. For coupled systems in 3D, the amount of memory provided by the underlying hardware can be a barrier. The following section identifies easy-to-use options to alleviate this potential barrier. During the finite element analysis there are two key memory bottlenecks. The first is the creation of the discretization and the second is the solution LinearSolve of the system of equations. NDSolve provides options to both mesh generation and the LinearSolve step that have an effect on the memory requirement during discretization and solving. As a rough estimate, the number of coordinates in the internal generated mesh multiplied by the spatial dimension gives the degrees of freedom number of rows and columns of the discretized system matrix to be generated. As an example, consider a stress operator from elastostatics. The stress operator is a system of three coupled PDEs in 3D space. Since the main focus of this section is to create a large system of equations, no additional information about the PDE itself is presented. For this purpose, a helper function is implemented. It is also instructive to get a feeling for the size of the system matrices NDSolve internally establishes. The size of the system matrices is its degrees of freedom, or in other words, the number of rows and columns in the system matrices. Create a helper function that calls NDSolve with options. The measured time, memory needed, and degrees of freedom to find the solution are printed. To make this example applicable for a larger class of computers, tetrahedron elements are used. The use of these results in smaller system matrices. Calling NDSolve with settings that enforce tetrahedron elements in the mesh. This will route to a direct solver that is very accurate but has a high requirement of available memory. Visualize the deformed structure. Instruct NDSolve to use a smaller mesh. How many elements a mesh needs to represent an accurate solution is problem dependent. A good method is to start with a coarse mesh and refine until the solutions stop differing substantially. Visualize the difference of the computed results at a cross section. Instruct NDSolve to use a first-order-accurate mesh. Making use of a first-order mesh results in much smaller system matrices, which can be solved more efficiently. Using a first-order mesh may significantly reduce accuracy. The previous suggestions worked by reducing the size of the system matrices internally generated. Instruct NDSolve to use the "Pardiso" solver. The reason that this method is not the default is that the default LinearSolve method is guaranteed to converge if the discretized PDE has a solution. This benevolent property is not true for all solvers implemented in LinearSolve. The options discussed above can also be combined. A more in-depth treatise of options that can be given to NDSolve can be found in the finite element tutorials. Extrapolation of Solution Domains Interpolation functions in the Wolfram Language will extrapolate if they are queried outside of their domain. In a finite element analysis, this is not wanted, since the extrapolation will almost certainly not give the physically correct value. The interpolation functions NDSolve returns from a finite element analysis will return Indeterminate as an extrapolation value. This behavior can be switched off. This shows the solution domain. This will result in a warning message and Indeterminate as an extrapolated value. This solves the equation but gives extrapolation values for query points outside the solution domain.

5: Finite element method in structural mechanics - Wikipedia

Simplifies the teaching of the finite element method. Topics covered include: the approximation of continuous functions over sub-domains in terms of nodal values; interpolation functions for classical elements in one, two, and three dimensions; fundamental element vectors and matrices and assembly techniques; numerical methods of integration; matrix Eigenvalue and Eigenvector problems; and.

The subdivision of a whole domain into simpler parts has several advantages: A typical work out of the method involves 1 dividing the domain of the problem into a collection of subdomains, with each subdomain represented by a set of element equations to the original problem, followed by 2 systematically recombining all sets of element equations into a global system of equations for the final calculation. The global system of equations has known solution techniques, and can be calculated from the initial values of the original problem to obtain a numerical answer. In the first step above, the element equations are simple equations that locally approximate the original complex equations to be studied, where the original equations are often partial differential equations PDE. To explain the approximation in this process, FEM is commonly introduced as a special case of Galerkin method. The process, in mathematical language, is to construct an integral of the inner product of the residual and the weight functions and set the integral to zero. In simple terms, it is a procedure that minimizes the error of approximation by fitting trial functions into the PDE. The residual is the error caused by the trial functions, and the weight functions are polynomial approximation functions that project the residual. The process eliminates all the spatial derivatives from the PDE, thus approximating the PDE locally with a set of ordinary differential equations for transient problems. These equation sets are the element equations. They are linear if the underlying PDE is linear, and vice versa. This spatial transformation includes appropriate orientation adjustments as applied in relation to the reference coordinate system. The process is often carried out by FEM software using coordinate data generated from the subdomains. FEA as applied in engineering is a computational tool for performing engineering analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm. In applying FEA, the complex problem is usually a physical system with the underlying physics such as the Euler-Bernoulli beam equation , the heat equation , or the Navier-Stokes equations expressed in either PDE or integral equations , while the divided small elements of the complex problem represent different areas in the physical system. FEA is a good choice for analyzing problems over complicated domains like cars and oil pipelines , when the domain changes as during a solid state reaction with a moving boundary , when the desired precision varies over the entire domain, or when the solution lacks smoothness. FEA simulations provide a valuable resource as they remove multiple instances of creation and testing of hard prototypes for various high fidelity situations. Another example would be in numerical weather prediction , where it is more important to have accurate predictions over developing highly nonlinear phenomena such as tropical cyclones in the atmosphere, or eddies in the ocean rather than relatively calm areas. Colours indicate that the analyst has set material properties for each zone, in this case a conducting wire coil in orange; a ferromagnetic component perhaps iron in light blue; and air in grey. Although the geometry may seem simple, it would be very challenging to calculate the magnetic field for this setup without FEM software, using equations alone. FEM solution to the problem at left, involving a cylindrically shaped magnetic shield. The ferromagnetic cylindrical part is shielding the area inside the cylinder by diverting the magnetic field created by the coil rectangular area on the right. The color represents the amplitude of the magnetic flux density , as indicated by the scale in the inset legend, red being high amplitude. The area inside the cylinder is low amplitude dark blue, with widely spaced lines of magnetic flux , which suggests that the shield is performing as it was designed to. History[edit] While it is difficult to quote a date of the invention of the finite element method, the method originated from the need to solve complex elasticity and structural analysis problems in civil and aeronautical engineering. Its development can be traced back to the work by A. Hrennikoff [4] and R. Courant [5] in the early s. Another pioneer was Ioannis Argyris. In the USSR, the introduction of the practical application of the method is usually connected with name of Leonard Oganesyan.

Feng proposed a systematic numerical method for solving partial differential equations. The method was called the finite difference method based on variation principle, which was another independent invention of the finite element method. Although the approaches used by these pioneers are different, they share one essential characteristic: The finite element method obtained its real impetus in the s and s by the developments of J. Argyris with co-workers at the University of Stuttgart , R. Clough with co-workers at UC Berkeley , O. Further impetus was provided in these years by available open source finite element software programs. A finite element method is characterized by a variational formulation , a discretization strategy, one or more solution algorithms and post-processing procedures. Examples of variational formulation are the Galerkin method , the discontinuous Galerkin method, mixed methods, etc. A discretization strategy is understood to mean a clearly defined set of procedures that cover a the creation of finite element meshes, b the definition of basis function on reference elements also called shape functions and c the mapping of reference elements onto the elements of the mesh. Examples of discretization strategies are the h-version, p-version , hp-version , x-FEM , isogeometric analysis , etc. Each discretization strategy has certain advantages and disadvantages. A reasonable criterion in selecting a discretization strategy is to realize nearly optimal performance for the broadest set of mathematical models in a particular model class. There are various numerical solution algorithms that can be classified into two broad categories; direct and iterative solvers. These algorithms are designed to exploit the sparsity of matrices that depend on the choices of variational formulation and discretization strategy. Postprocessing procedures are designed for the extraction of the data of interest from a finite element solution. In order to meet the requirements of solution verification, postprocessors need to provide for a posteriori error estimation in terms of the quantities of interest. When the errors of approximation are larger than what is considered acceptable then the discretization has to be changed either by an automated adaptive process or by action of the analyst. There are some very efficient postprocessors that provide for the realization of superconvergence. Illustrative problems P1 and P2[edit] We will demonstrate the finite element method using two sample problems from which the general method can be extrapolated. It is assumed that the reader is familiar with calculus and linear algebra. P1 is a one-dimensional problem P1.

6: MATLAB Finite Element Method Codes | www.enganchecubano.com

We employ the finite element method to represent the continuous surface in the form of weighted sums of local polynomial basis functions. We use a quintic triangular finite element whose nodal variables include positions as well as the first and second partial derivatives of the surface.

7: Finite Element Analysis

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This book offers an in-depth presentation of the finite element method, aimed at engineers, students and researchers in applied sciences. The description of the method is presented in such a way as to be usable in any domain of application. The level of mathematical expertise required is limited to.

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