Cutting-Edge Techniques and Software Tools in Computer Methods for Applied Mechanics

Sarah Alvarenga[*]

Department of Biomedical Engineering, National University of Singapore, Singapore

DESCRIPTION

Computer methods in applied mechanics are a broad field that combines computational methods with mechanics to solve complex engineering problems. The field is interdisciplinary, drawing from mechanics, physics, mathematics, and computer science, and has numerous applications in areas such as aerospace, automotive, civil, and mechanical engineering.

The development of computer methods in applied mechanics is closely related to the advances in computer hardware and software. In the past, engineers relied on analytical and experimental methods to solve engineering problems.

Analytical methods involve deriving mathematical equations that describe the behavior of a system, while experimental methods involve testing the system under different conditions to determine its behavior. However, as systems became more complex and the need for faster and more accurate solutions increased, engineers turned to computational methods.

One of the earliest computational methods used in applied mechanics was the Finite Element Method (FEM). FEM involves dividing a complex system into smaller, simpler parts called elements. The behavior of each element is then described by a set of mathematical equations, and the behavior of the entire system can be determined by solving these equations. FEM has become a popular method in applied mechanics due to its versatility and ability to handle complex geometries.

Another widely used computational method is the Boundary Element Method (BEM). BEM is a numerical method that solves partial differential equations by discretizing the boundary of the system into a set of surface elements. The behavior of each element is then described by a set of integral equations, and the behavior of the entire system can be determined by solving these equations. BEM has become popular in applied mechanics due to its ability to handle unbounded domains, and its high accuracy in problems involving singularities.

Computational Fluid Dynamics (CFD) is another important field within computer methods in applied mechanics. CFD involves using numerical methods to solve equations that describe the behavior of fluids, such as the Navier-Stokes equations. CFD has numerous applications in engineering, including aerodynamics, hydrodynamics, and heat transfer. CFD simulations can be used to optimize the design of aircraft, ships, and vehicles, and to analyze the flow of fluids in complex systems such as pipelines and chemical reactors.

Another important area within computer methods in applied mechanics is Computational Structural Mechanics (CSM). CSM involves using numerical methods to solve equations that describe the behavior of structures, such as buildings, bridges, and dams. CSM simulations can be used to analyze the strength and stability of structures under different loading conditions, and to optimize the design of structures to improve their performance and safety.

One of the challenges in computer methods in applied mechanics is the development of efficient algorithms and numerical techniques. As systems become more complex, the computational cost of simulating their behavior can become prohibitively expensive. Therefore, researchers have developed a variety of techniques to reduce the computational cost of simulations. For example, parallel computing techniques can be used to distribute the workload of simulations across multiple processors or computers. This can greatly reduce the time required to solve large-scale problems. Another technique is model reduction, which involves simplifying the mathematical models used in simulations to reduce their complexity and computational cost. The development of computer methods in applied mechanics has also led to the development of new software tools and platforms. These tools can be used to create and simulate complex models, and to visualize and analyze simulation results. Examples of popular software tools used in computer methods in applied mechanics include ANSYS, COMSOL Multiphysics, and Abaqus.

In addition to their applications in engineering, computer methods in applied mechanics also have applications in other fields, such as biology and medicine. For example, numerical simulations can be used to model the behavior of biological systems, such as the flow of blood through arteries or the behavior of cells in tissues. These simulations can be used to develop new medical treatments and therapies, and to improve our understanding of biological systems.