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PARALLELIZATION OF COMPUTATIONS DURING SIMULATION OF MECHANICAL COMPONENTS OF MEMS-BASED DIACOPTICAL APPROACH

The article reviews the main factors that determines the relevance of the development of special resolution of mechanical systems equations. We propose to use the diacoptical approach to design mechanical components of MEMS

Key words: diascopic approach, MEMS, parallel computation.

Розглянуті основні фактори, які визначають актуальність розроблення спеціального розв'язання рівнянь, які описують механічні системи. Ми пропонуємо використовувати діаскопічний підхід до проектування механічних компонентів МЕМС.

Ключові слова: діаскопічний підхід, MEMS, паралельні обчислення.

Introduction

Design is a complex and cumbersome process, the essence of which is to build on the inputs of a non-existing object a model of the object. Nowadays, devices and machines saturate electronics that use new materials and increases demands manufacturing precision. Therefore, the design process requires large expenditures of resources. Computer-aided design allows to automate this process, which in turn allows to design more complex objects with better accuracy.

Nowadays computer architecture has changed radically - from serial to parallel. Period of one processor computers has been continued until the family CRAY X-MP / Y-MP - vertical parallel vector computer with 4 - 16 processors, which in turn changed massively the parallel computers, namely computers with hundreds of thousands of processors. [1,2].

Modern Technology of computer parallelization

In computer systems with distributed memory processors operate independently. To organize parallel computations in such circumstances we need to distribute the computational load and organize information interaction between processors. Resolution of these issues provides a message passing interface - MPI.

In general terms, for the distribution of computation among processors we need to analyze the proble solution algorithm, to provide information of independent fragments of computation to their software implementation and then place the received part of the program on different processors. MPI adopts simpler approach that is to solve this problem by developing a single program that runs simultaneously on execution on all available CPUs. To avoid identity computations on different processor, we can substitute different data for the program on different processors and to use the tools available in the MPI to identify the processor on which the program is running. This method of parallel computing is called a single program multiple processes (SPMP).

Essence of tasks of Parallelization using Diacoptic

Diacoptic method is based on the division of some complicated system into simple separate independent subsystems. The calculations are carried out at the level of these subsystems, and results achieved on certain steps are combined and re-formed system which is first. This method is universal to solve physical problems of different types. The advantage of this method is that it combines continuous and discrete calculations. So here is calculated and graph topology that is developed on the basis of the system and the system of equations. This method is widely used in electronics, namele, electrical circuits. The diacoptical approach is suggested to design mechanical components of MEMS.

Figure 1 presents a diagram of complex systems modelled by the diacoptic method.

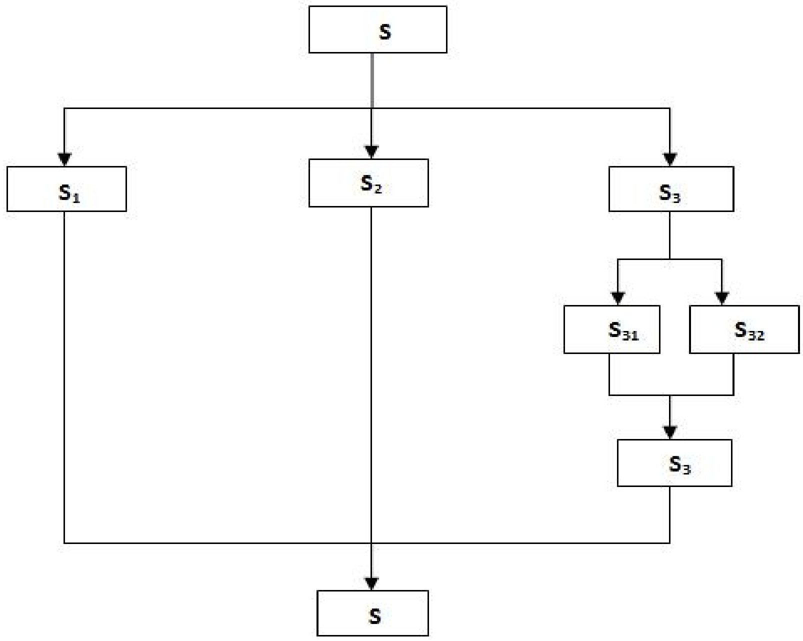

Fig. 1. Modeling complex systems by the diacoptic method

The complex system S is divided into simple systems S_1, S_2, and S_3. Since the subsystem S_3 is not sufficiently simplified we divides it into corresponding subsystems: S_{31} and S_{32}. These subsystems conduct independent calculations and they are merged in system S_3.

Principles of problem solving of mechanical systems

As mentioned above, the diacoptic method allows to split a system into separate components in which the equations are solved. Consider this on the beam. Elementary beam in general, is a spring with two solids at its ends. Since elementary solid has 6 degrees of freedom, the elementary beam has twelve degrees of freedom: six on each end. At each end of the beam attached three forces and moments F and at each end of the beam there will be three linear and three angular displacement D.

In general, the elastic system, we can compare with nodal chains of circuits where the basic equation is:

$$I=RU. \tag{1}$$

In mechanics this equation will look like:

$$F=YD. \tag{2}$$

Where Y is the material stiffness and D - displacement. In contrast to the equation of the electric circuit, which is a scalar. Beam equation is a matrix equation.

$$F_1=Y_1D_1+Y_2D_2,\ F_2=Y_3D_1+Y_4D_2. \tag{3}$$

Where Y_3 is the transposed matrix of Y_2.

The basic equation (1) can be combined equations for subsystems. Equation of isolated beam must first be transformed to the coordinate system of the original system. This transformation returns the beam in the correct position. Only isolated beams can be connected. Figure 2 shows a beam placed randomly in space of Cartesian coordinate.

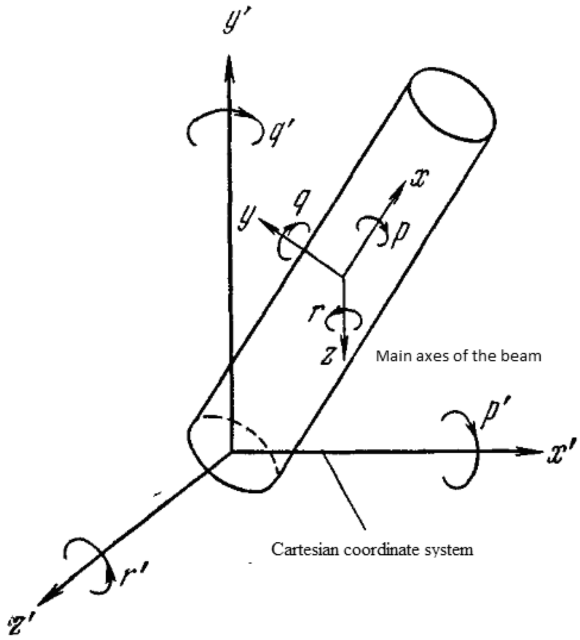

Fig. 2. Random placement of beams in space

The placement of the beam in space is arbitrary, in this case forces acting on it, are not directed along Cartesian axes, and the three main axes of the beam, as shown in Figure2.[3,4]

The circuit imlementation of the parallel algorithm

The circuit implementation of the parallel algorithm:

Transactions of the algorithm, between which there is no way for the chosen circuit computations can be performed in parallel (for computing circuit , for example, can be implemented in parallel all the multiplication first and then subtract the first two steps). Possible way to describe the parallel implementation of the algorithm can be as follows .Let p be the number of processors used for the execution of the algorithm . Then for parallel execution of computations necessary to set multiple (schedule)

$$H_p = \{(i, P_i, t_i) : i \in V\}, \quad (4)$$

where for each operation $i \in V$ indicates the number used for the operation of the processor Pi and the start of the operation t_i. To schedule was implemented, must fulfill the following requirements when setting the set Hp:

$\forall i, j \in V : t_i = t_j \Rightarrow P_i = P_j$ ie, the same processor should not be administered to various operations in the same time;

$\forall (i, j) \in R \Rightarrow t_j \geq t_i + 1$ is appointed to perform the operation since the necessary data are to be calculated.

Efficiency parallel algorithm

Acceleration (speedup), obtained by using parallel algorithm for p processors compared to the serial version of the reduction process is determined by the

$$Sp (n) = T1 (n) / Tp (n), \quad (5)$$

ie as the ratio of time solving problems for scalar computer to the parallel execution time of the algorithm (the value of n is used to parameterize the computational complexity of problem and can be understood , such as the number of input tasks) .Effectiveness (efficiency) processors using parallel algorithms in solving the problem is given by

$$Ep (n) = T1 (n) / (pTp (n)) = Sp (n) / n \quad (6)$$

(the value of efficiency determines high proportion of the execution time of the algorithm, for which the processor actually employed to solve the problem).

From these relations we can show that in the best case, Sp (n) = p and Ep (n) = 1.

In the practical application of these indicators to evaluate the effectiveness of parallel computing to consider two important points:

- Under certain circumstances, the acceleration may be greater than the number of processors Sp (n)> p - in this case we speak of the existence superlinear speedup. Despite these paradoxical situations (acceleration exceeds the number of processors), in practice over linear acceleration can take place. One reason for this phenomenon may be differences in terms of performance serial and parallel applications.
- A careful examination can be noted that attempts to improve the quality of parallel computing on one measure (speed or efficiency) can lead to deterioration in another indicator for the quality parameters of parallel computation are often contradictory. For example , increasing acceleration can usually be achieved by increasing the number of processors , leading usually to a drop in performance. Conversely , increasing the efficiency achieved in many cases while reducing the number of processors (in the extreme case of perfect efficiency Ep (n) = 1 is easily secured using a single CPU). As a result, the development of methods for parallel computing often involves the selection of a compromise based on the metrics of acceleration and efficiency.

When choosing the proper way to solve the problem of parallel may be useful valuation (cost) computation, which is defined as the product of time parallel solution of the problem and the number of processors.

$$Cp = pTp \quad (7)$$

In this regard, it is possible to define the concept of cost-optimal (cost-optimal) parallel algorithm as a method whose value is proportional to the runtime of the best sequential algorithm.

Conclusion

Design processes are becoming more complex and equations that calculate the mechanical condition of objects are more complex. We need new technologies to help quickly solve these systems of equations, which in turn speedup the design process.

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