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DEVELOPMENT OF MACRO-PARAMETRIC METHOD FOR INTEGRATION OF HETEROGENEOUS CAD SYSTEMS AND STRUCTURE OF INTEGRATED COMPUTER-AIDED DESIGN SUBSYSTEM FOR MEMS MOTION SENSORS

In the paper, a macro-parametric method for integration of heterogeneous CAD systems for MEMS motion sensors is proposed. A structure of an integrated design subsystem for MEMS motion sensors is developed based on the proposed macro-parametric method.

Key words: micro-electro-mechanical systems (MEMS), computer-aided design (CAD), MEMS motion sensor, heterogeneous CAD system, homogeneous CAD system, XML, macro-parametric method, integrated design environment.

Запропоновано макропараметричний метод інтеграції гетерогенних САПР для давачів руху мікроелектромеханічних систем. На основі макропараметричного методу розроблено структуру підсистеми інтегрованого проектування для давачів руху мікроелектромеханічних систем.

Ключові слова: мікроелектромеханічні системи (MEMS), системи автоматизованого проектування (САПР), давачі руху MEMS, гетерогенні САПР, однорідні САПР, XML, макропараметричний метод, середовище інтегрованого проектування.

Introduction

Nowadays, components of MEMS motion sensors and other micro-embedded devices are manufactured by using various technologies. During the design of such systems, both electronic and mechanical components have to be designed as well as the detailed simulation of their behavior has to be performed. Most functional elements can be designed in the geographically separated engineer's collectives and manufactured in different factories [1]. Development of micro-electromechanical sensors is defined by using a large amount of interrelated steps for designing and simulation (Fig. 1).

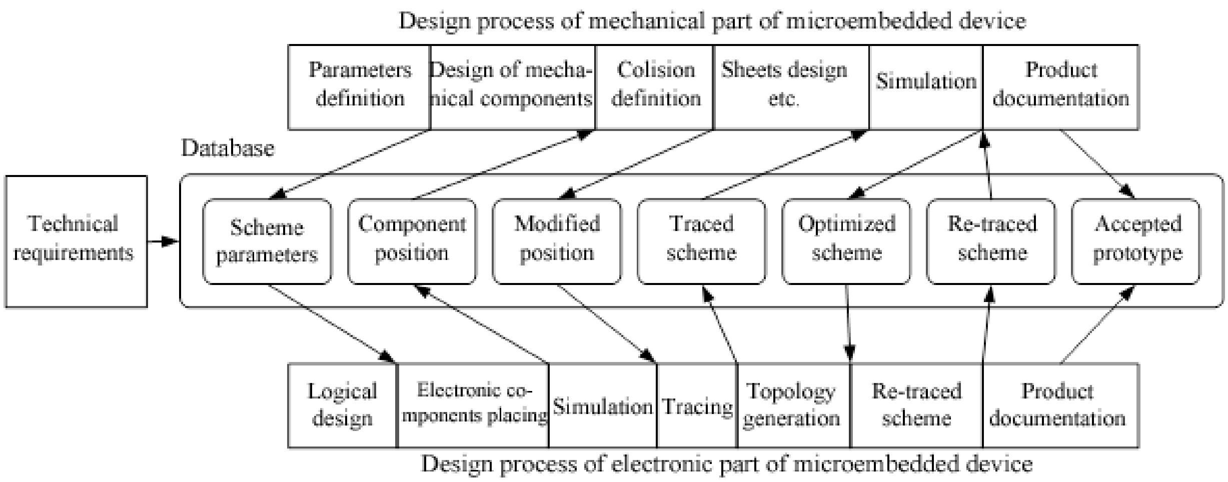

Fig. 1. Schematic view of the design and production process of MEMS sensor

In this connection, a task of integration of design process of the described above elements appears [1]. The CAD integration means that the systems can interchange not only information between each other, and also they must understand each other. They must interchange data that is often kept in different model types with a different information format. There are three methods for model exchange in CAD. The first one uses one type of CAD, which automates the design of the different design processes without the needs for the data exchange of a product model. But in practice, each process needs a dedicated CAD. Besides, the implantation of one CAD is not suitable at the factories with a distributed development environment. Such distributed development environment requires a participation of the different enterprises with the different heterogeneous CAD systems. The second one uses direct translators between the different CAD systems. However, because a core of geometrical modeling in the different CAD systems considerably differs, data during information transferring can be lost and distortion of forms and sizes during the data translation appear. The third approach uses such neutral formats as STEP, IGEG, VDA-FS or DXF which translate models into the neutral data file (Fig. 2).

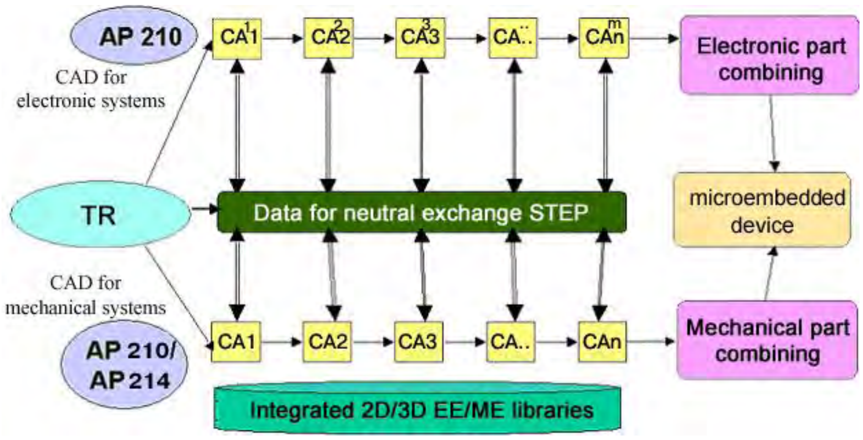

Fig. 2. Interface of a CAD system for MEMS sensor.
Data exchange independently on processes and tools

A pre-processor generates a neutral file from the format of the specific CAD. A post-processor receives a neutral file and converts it into the internal format of receiving CAD. Although, this method needs a permanent translation and double data loss, it is recommended to use in the industry in most cases. Another problem of the neutral format is that it does not store parametric information, such as engineer's ideas, intentions, and only a contour representation of a CAD model. The contour representation of the model without parametric information presents the difficulties for the engineering changes in the process of the general planning, and also leads to unexpected form distortions.

Problem description and aim definition

A key factor in MEMS manufacturing is an increase of the design efficiency with the use of computer-aided design systems. It is not needed to be only limited with the classic use of CAD for the creation of the design-engineering documentation. The developing system has to be dedicated to the creation of the integrated computer-aided design environment and to execute a wide spectrum of tasks, in particular a project documentation management.

Each of such CAD systems and other computer-aided system have its own models for the data presentation and own database management systems (DBMS).

In the use of the existing CAD systems there are a few problems:

- CAD and other computer-aided systems are heterogeneous and distributed;
- CAD and other computer-aided systems are autonomous, because their data is independently processed by different engineers.
- Data exchange is limited to a few formats (neutral format is among them) or to the use of API (application programming interface).

- Systems can generate a large data volume of a complex structure;
- Data exchange between different types of CAD and other computer-aided systems has to be automated;
- Data must constantly be in the actual state and the data changes conducted by one system must be immediately represented for other systems;

Besides:

- Responsibility for the distribution of data changes formally is not defined and not automated.
- Access control realized for each system is own and that is why can not be integral;
- There is not a global look to all data which are used for the design, simulation and manufacturing of the product.

The providing of the effective data exchange is not sufficient for the creation of the end-to-end automation design process for the MEMS sensors. It is needed to develop some kind of software in which the platform for the integration of heterogeneous CAD systems and other computer-aided systems with the management possibility of exchange information are implemented.

The aim of the work is to develop a macro-parametric method for the integration of heterogeneous CAD and structure of computer-aided design subsystem for the MEMS motion sensors.

Development of a macro-parametric method for integration of heterogeneous CAD systems and a structure of an integrated design subsystem for MEMS motion sensors

The integration system of CAD must:

- transmit not only review operators, but and simulation functions to all participants of the product creation process to be able to modify product data;
- size of data transmitting between the systems should be decreased to the necessary minimum, because the transfer channels are still narrow places of telecommunication systems;
- users have to use CAD systems and other systems which are known for them.

It should be noticed that not all CAD systems can be integrated in the developing integrated system. Therefore, two main criterions are defined to choose CAD systems for our realization: the system has to give an opportunity to develop software modules; each operation executed during the product creation must be tracked.

As to the first criterion, most new CAD systems support it. Of course, there are two ways for CAD programming: using a scripting language or using an application programming interface (API). The first variant understands the scripting language as an interpreter. Errors in programs written in this language appear during their execution. In the second variant, programs are translated into machine instructions. The advantage of the second variant is greater speed of the execution and support of communications libraries.

To solve the described above problems, a macroparametric method is proposed. Using this method, exchange of parametric information of a CAD model can be performed in the form of commands array of the constructor between heterogeneous CAD systems. Interchange method based on the macroparametric procedure, which uses a technology of extensible markup language (XML), is proposed to express standard design commands extracted from the CAD model (Fig.1).

The proposed method is based on commands transmission because of this a number of the transmitting data is sufficiently decreased. Models can be created and modified by several engineers simultaneously. The approach is based on the mechanism of translation between system operations of simulation (SOS) and commands of neutral format (CNF). All operations, performed by the engineer in one geographically-remote design team, are converted into CNF and transmitted to all network nodes where designers work. After receiving commands in other network ends they are converted into SOS of a suitable CAD system. Such system is developed on the base of the main server and some software packages that depend on the specific CAD system. Mechanism and structure of integration approach and also the client-side software developed for the proposed integration method are shown in Fig.2-3.

For security support, it is proposed to encrypt and compress the commands of neutral format before transmitting. Comparing this method with other methods for supporting the collaborative development of projects the proposed integration method between heterogeneous CAD systems has the following advantages over the existing ones [2-8]:

- new method allows to create integration platforms of different levels – from Intranet-systems to geographically remote systems;
- new method allows to integrate heterogeneous CAD systems. It means that the users will work with known systems. This advantage can not be given by homogeneous integration environments;
- besides the model visualization the users can perform on-line manipulation of models, it is very necessary for the industrial users;
- creation and modification of the models can be simultaneously performed by several users. The commands of neutral format are only transmitted not the models, consequently the data volume is small, it allows to achieve an instantaneous synchronization even when bandwidths of telecommunication networks are conventional.

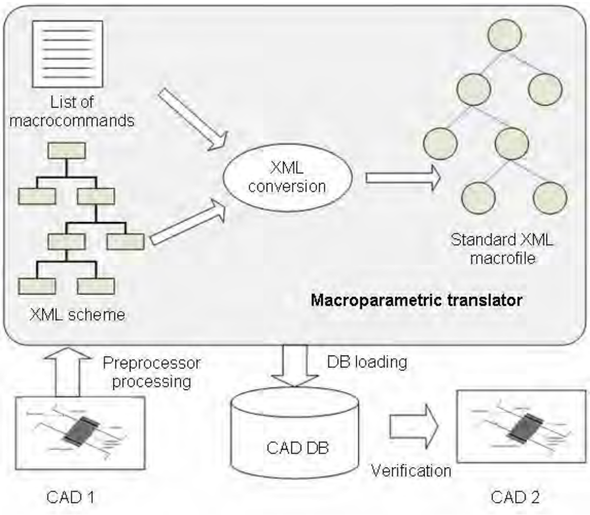

Fig. 3. Macroparametric presentation based on XML technology

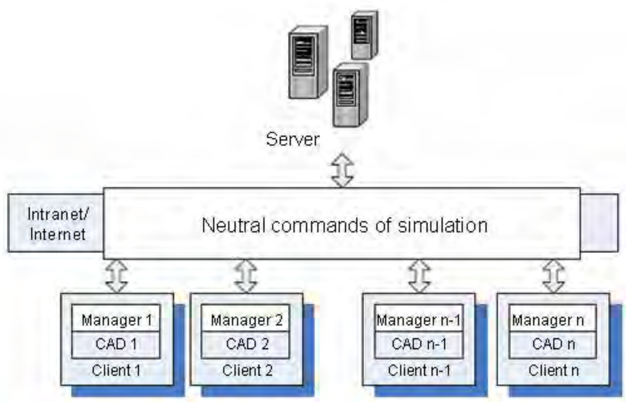

Fig. 4. Structure of the integrated design environment

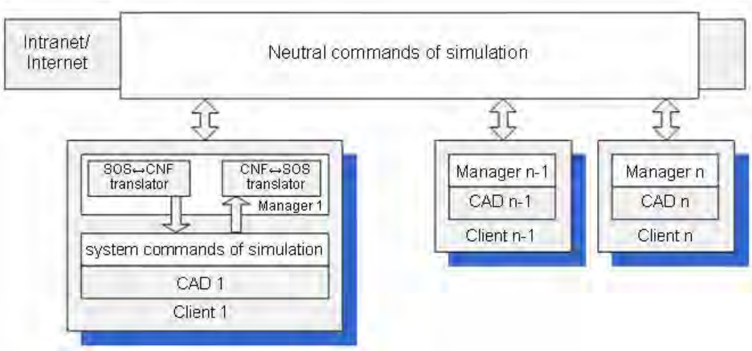

Fig. 5. Structure of the client-side software

A set of user's commands, generated by an engineer during the design process, are written as the design history which obviously includes the engineer's aim. We have defined a term "design aim" as the customer's functional requirements, a set of electronic, geometrical and functional rules (requirements), which the future MEMS sensor has to satisfy. Therefore, the design aim is defined with limitations, parameters, project history and properties. For the transference of the CAD parametric information which includes a project history, we determine a set of standard design commands and they are used as a neutral format. In a macro-file a set of commands is stored which have been executed during a session. The file contains limitations, parameters, properties and history of making changes. The history of user's commands is also stored in the macro-file and it is used for exchanging with a static model. If these commands will be translated into the commands of other CAD system, then the macro-file will recover parametric information for the receiving CAD.

In Fig. 6, the data exchange model is presented which is used in the macro-parametric approach. The data translation using the macro-parametric approach has two levels: translation scheme of user's CAD commands into a set of standard commands and the translation of the actual data between the macro-file of the commercial CAD and the standard macro-file. For the translation of the data models between different CAD systems, the macro-file generated by a commercial CAD system is translated into the standard macro-file, which then is translated into the macro-file of the receiving CAD system.

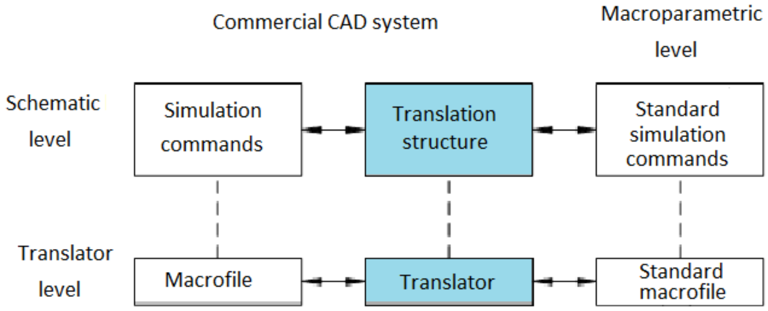

Fig. 6. Conception of the macro-parametric translation

In Fig. 7, the architecture of macro-parametric translator is shown. The translation subsystem has a macro-input module, macro-output module, graphical user interface (GUI) and uses a macro-data translation module. The macro-data translation module for sending geometrical data uses ACIS core and the command translation table. For translation, an inner geometrical model is created using ACIS core. It is also used when it is difficult to translate the commands.

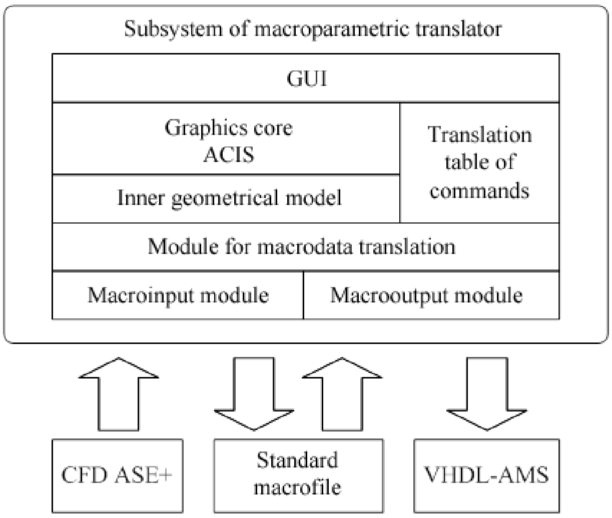

Fig. 7. Architecture of the macro-parametric translator

In Fig. 8-9, the translation process and an example of macro-data exchange (CFD ASE+ and VHDL-AMS) between two different CAD systems are shown. Design commands of the input macro-file are grouped in sections by the functionality application. The commands in each section are divided into two groups: the first group can be transmitted directly, and another one can not be translated directly.

Commands of indirect translation are the commands, arguments of which are difficult to translate. The internal geometrical model is based on ACIS and used for receiving the necessary graphic information for the translation of the arguments. Examples of indirect translation can be the commands coupled with the coordinate system, and commands which are not supported by the receiving CAD system.

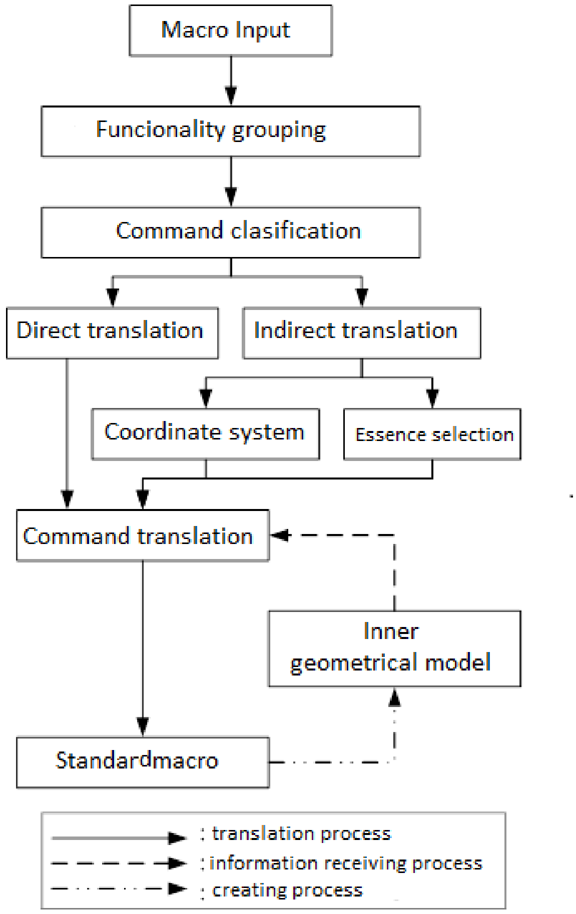

Fig. 8. Translation process

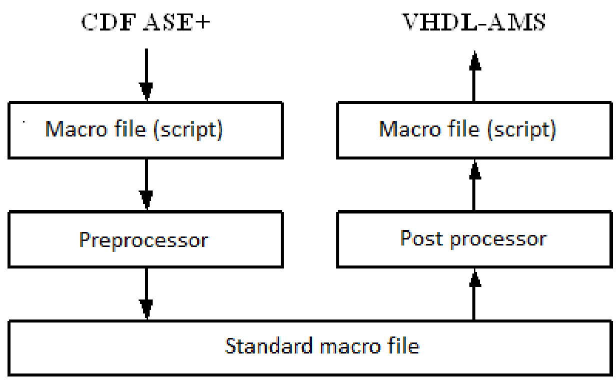

Fig. 9. Example of macro-data exchange between CFD ASE+ and VHDL-AMS

Conclusions

The macro-parametric method for exchanging parametric information of a CAD model of MEMS sensors for integration of heterogeneous CAD systems is developed that allowed to increase design efficiency. The structure of the integrated design subsystem and client-side software for MEMS motion sensors are developed based on the proposed macro-parametric method.

1. Колчин А. Ф. Управление жизненным циклом продукции / А. Ф. Колчин, М. В. Овсянников, А. Ф. Стрекалов, С. В. Сумароков. – М.: Анахарсис, 2002. 2. Лобур М. В. Дослідження параметрів стратегії автоматичного трасування в САПР PCAD / М. В. Лобур, Р. Т. Панчак, З. Ю. Готра, В. В. Григор'єв // Вісник Державного університету "Львівська політехніка": Комп'ютерні системи проектування. Теорія і практика. – Львів, 2000. 3. Reddy Y.V., Ramana. Srinivas, Kanakanahalli, Jagannathan, V. Karinthi, Raghu. Computer support for concurrent engineering, Computer,V26. – P12(4). – Jan, 1993. 4. Three Dimensional CAD Interface Specification for Electro-Mechanical Collaborative Design Using ISO 10303-210, ME009.01.00, 27 February 2001, PDES, Inc: http://pdesinc.aticorp.org. 5. CIMS-ERC.CE Project Final Report, China CIMS-ERC Technical Report. 1997-12. 6. CE'96/ISPE. The Proceedings of the Concurrent Engineering Research and Application. – Toronto University, Canada, 1996-08. 7. Dwivedi. Concurrent Engineering – An Introduction / Dwivedi, Suren N. and Sobolewski Michael // Proc. of the Vth Intern. Conf. on CAD/CAM Robotics and Factories of the Future '90. – Vol. 1: Concurrent Engineering. – New York: Springer-Verlag, 1991. – P. 3–16. 8. Nevins J.L., Whithey D.E. Concurrent Design of Products and Processes. – McGraw-Hill, New York, 1989. – 268 p.

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NON-DESTRUCTIVE TESTING OF MATERIALS BASED ON THE WAVE SCATTERING BY THE SMALL PARTICLES

The theory of scattering of the acoustic waves on the small bodies is applied to solution of problem related to the non-destructive testing of materials with defects. The change of the refraction coefficient of the acoustic wave passing through the steel pattern testifies to presence of microdefects in material. The numerical results are presented for several kinds of steel and they confirm the possibility to apply the asymptotic scattering theory to problems of the non-destructive testing.

Key words: scattering, small bodies, microdefects, non-destructive testing.

Теорія розсіяння акустичних хвиль на малих тілах використовується для розв'язання задачі, пов'язаної з неруйнівним контролем матеріалів з дефектами. Зміна коефіцієнта заломлення акустичної хвилі, яка проходить крізь сталевий зразок, свідчить про наявність мікродефектів у ньому. Числові результати наведено для декількох видів сталі; вони свідчать про можливість застосовувати теорію асимптотичного розсіяння до задач неруйнівного контролю.

Ключові слова: розсіяння, малі тіла, мікродефекти, неруйнівний контроль.

Introduction

The presence and evolution of micro-defects in materials and structures is prevailing cause of their destruction. Microdefects reduce the residual life of production and objects that cause a threat of accidents and failures. Therefore, early diagnostics and identification of degree of the material damage and the nature