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AUTOMATION OF COMPUTATIONAL TASKS IN CAD SYSTEMS

AUTOMATYZACJA PROCESÓW OBLICZENIOWYCH W SYSTEMACH CAD

A b s t r a c t

Carrying out suitable engineering analyses is an essential part of designing process of machines and devices. Conducting them with the aid of CAD system force the designer to create additional models which have to be properly defined for the particular type of analysis. Therefore, during rebuilding of models very often some information are lost, and designer has to input this once again for each new created model. Even in case of small models consisting of only dozens of elements, inserting mentioned information significantly elongate the designing process. Using of API interface for working out a software which allows automation of computational tasks of mechanism and devices was proposed in this paper. It enables correlation of different types of assemblies and also unbounded information exchange between them.

Keywords: CAD system API interface, C++ programming, automation of computational tasks

S t r e s z c z e n i e

Niezbędnym elementem w procesie projektowania mechanizmów i maszyn jest prowadzenie odpowiednich analiz inżynierskich. Prowadzenie tych analiz za pomocą systemu CAD zmusza konstruktora do tworzenia dodatkowych modeli odpowiednio zdefiniowanych dla danego typu analizy. W związku z tym podczas przebudowywania modeli bardzo często dochodzi do utraty pewnych informacji, co zmusza konstruktora do wprowadzania ich na nowo do każdego nowo tworzonego modelu. Już w przypadku niewielkich modeli liczących zaledwie kilkadziesiąt elementów wprowadzanie wspomnianych informacji znacznie wydłuża cały proces projektowania. W niniejszym artykule zaproponowano wykorzystanie interfejsu API do opracowania oprogramowania pozwalającego na zautomatyzowanie procesów obliczeniowych maszyn i mechanizmów. Pozwoliło to na skorelowanie ze sobą różnych typów modeli, a co za tym idzie swobodną wymianę informacji pomiędzy nimi.

Słowa kluczowe: interfejs API systemu CAD, programowanie C++, automatyzacja procesów obliczeniowych

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1. Introduction

Dynamic development of computer science and CAD systems contribute to formation of many advanced tools which brings new perspectives in designing process. Increasing possibilities of CAD systems involve enlargement of requirements for contemporary designer. Thus it is expected that design process will last shorter and project will fulfill all briefs and requirements. During the design, suitable strength, kinematic and dynamic analyses taking into account operation features and environment parameters of designed product must be carried out. Creating of models and defining of suitable computational cases, could be very labour-consuming even with the use of the newest achievements in CAD systems. It is related to geometry complexity of the designed product. That problem could be solved by writing suitable software, which will automatically generate necessary computational cases for solution variants by the use of CAD system API interface. After defining of particular spatial configurations of mechanisms, calculations will run sequentially which make evaluation of most disadvantageous cases possible.

Using of API interface for working out a software allowing for automation of computational tasks of mechanism and devices was proposed in this paper.

2. Automation algorithm of computational tasks

Scheme of proposed automation algorithm of computational tasks is shown in Fig. 1. For its implementation it is necessary to work out a software, which allows for definition of working components of mechanism under investigation in convenient way, generation of geometric transformations matrices and carrying out calculations with the use of CAD system API interface.

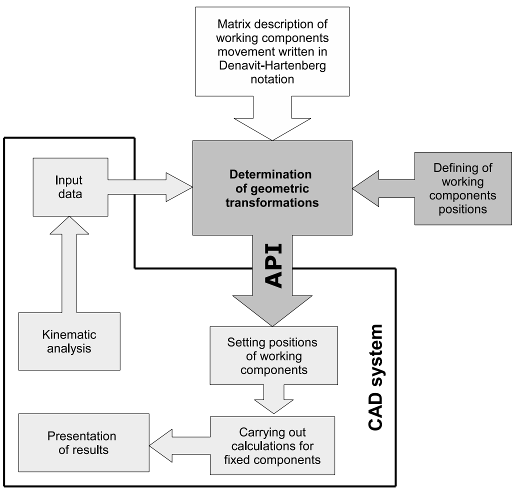

Fig. 1. Automation algorithm of computational tasks in CAD system

Rys. 1. Algorytm automatyzacji procesów obliczeniowych w systemie CAD

Software for it is correct functioning needs properly prepared set of input data which is acquired in result of preliminary kinematic analysis carried out in CAD system and matrix movement description of particular working components written in Denavit-Hartenberg notation.

Automation of computational tasks is implemented in four steps: first consists in determining of suitable matrix transformations for each assembly component, second encloses setting process of components positions in CAD system, third concerns carrying out calculations by appropriate module of CAD system and fourth is responsible for result presentation. For determining matrix transformations it is necessary to prepare suitable set of input data, which are initial position matrices of each assembly component. The data is prepared directly in CAD system by carrying out preliminary kinematic analysis and storing acquired results on computer hard drive.

2.1. Data structures used in generation process of geometric transformations

In proposed algorithm data which describe movement of particular working components as well as information about orientation and position of assembly components in CAD systems are stored in fourth rank matrices. It enables generation of proper geometric transformations in uniform coordinates, which are commonly used in 3D graphics. After getting acquainted with structure of matrices, which are used in Denavit-Hartenberg notation and CAD system matrices, it is possible to ascertain similarity of its construction. Similarities in construction of both types of matrices are shown in Fig. 2. Both CAD system matrix and Denavit-Hartenberg matrix contains information about orientation of working component as the orientation matrix with dimensions 3 x 3 and data about position

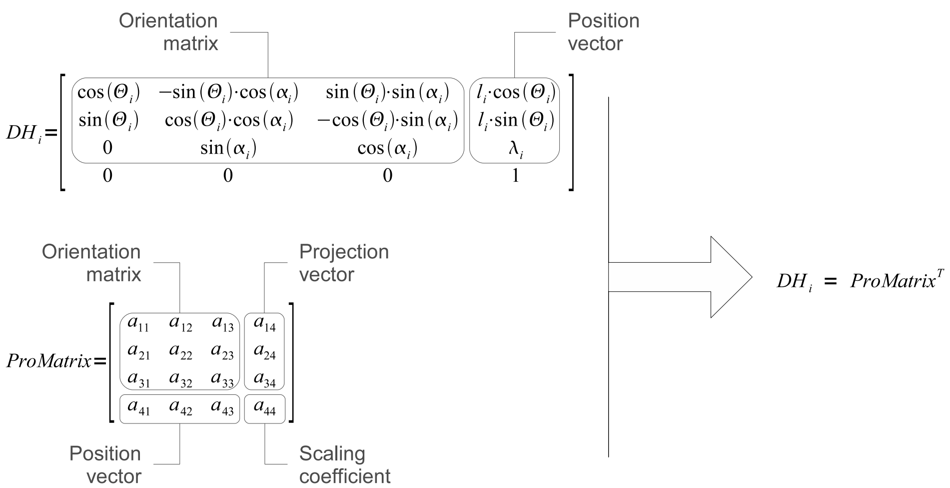

Fig. 2. Data structures

Rys. 2. Struktury danych

as the position vector. Additionally CAD system matrix owns projection vector and scaling factor. In case of assembly component description the projection vector is zero vector and scaling factor is equal to 1. Thus, when matrix of arbitrary component is transposed, then in the terms of construction it will be identical to Denavit–Hartenberg matrix. In consequence synchronous operation on Denavit–Hartenberg matrices and CAD system matrices will not involve time-consuming process of data conversion during information exchange between these structures.

3. Example of application

3.1. Hydraulic crane

The model of hydraulic crane used to test the prepared algorithm is presented on Fig. 3. Crane model was created in *ProEngineer* system in a form of static and kinematic assembly. Application of proposed algorithm enables correlation of both assemblies and in result, changes applied in one assembly automatically will be updated in another assembly. It enables using of information acquired in result of kinematic assembly movement range analysis in strength analysis of crane structure.

Fig. 3. Model of hydraulic crane

Rys. 3. Model hydraulicznego dźwigu samochodowego

3.2. Course of experiments

Conducted researches consisted in determination of object working area, definition of trajectory on which extension arm end is moving and writing it in form of matrix series which describes positions of particular kinematic links, and finally defining of computational cases for each of these positions. After defining values of position components the prepared software automatically generates computational cases. Calculations were carried out using of *ProMechanica* module, which is a part of *ProEngineer* system. After finishing of calculations the results was automatically presented in *ProEngineer* system. Trajectory on which extension arm end was moved during experiments and determined positions for which the strength analyses were carried out is presented in Fig. 4.

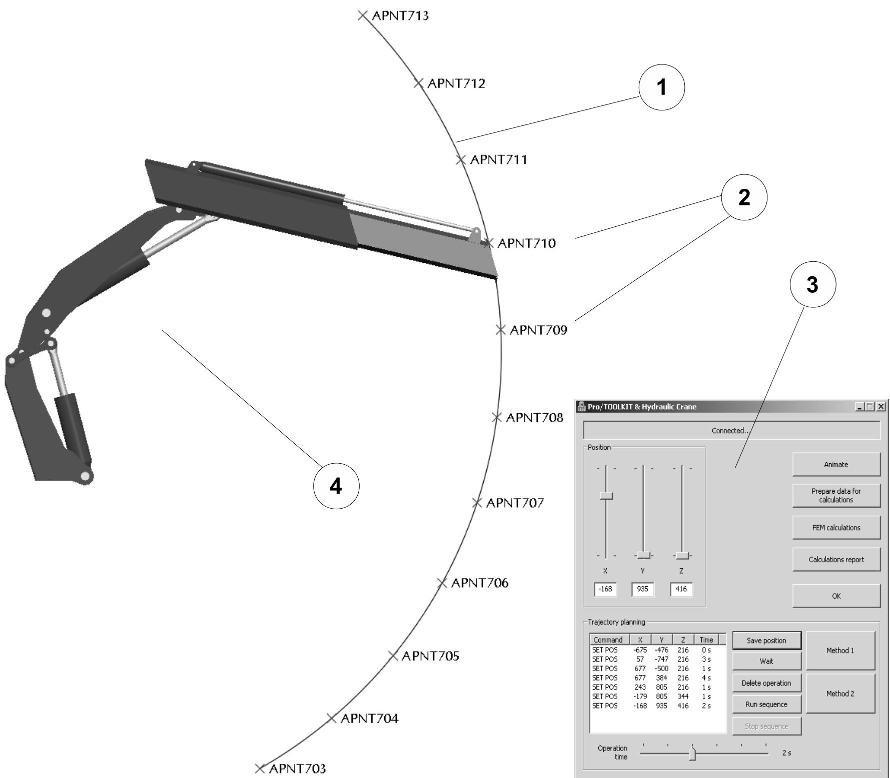

Fig. 4. Determining of positions for particular computational cases: 1 – extension arm end's movement trajectory, 2 – considered positions, 3 – application based on CAD system API interface, 4 – model of the researched object

Rys. 4. Określanie położeń dla poszczególnych przypadków obliczeniowych: 1 – tor ruchu końcówki wysięgnika, 2 – badane położenia, 3 – aplikacja wykorzystująca interfejs API systemu CAD, 4 – model obiektu badań

3.3. Experiment results

Obtained results enable to determine the most disadvantageous position of kinematic links of the object. Distribution of von Mises stress for most disadvantageous position of crane components is presented in Fig. 5. Distribution of total displacement produced by loads in most disadvantageous configuration is shown in Fig. 6.

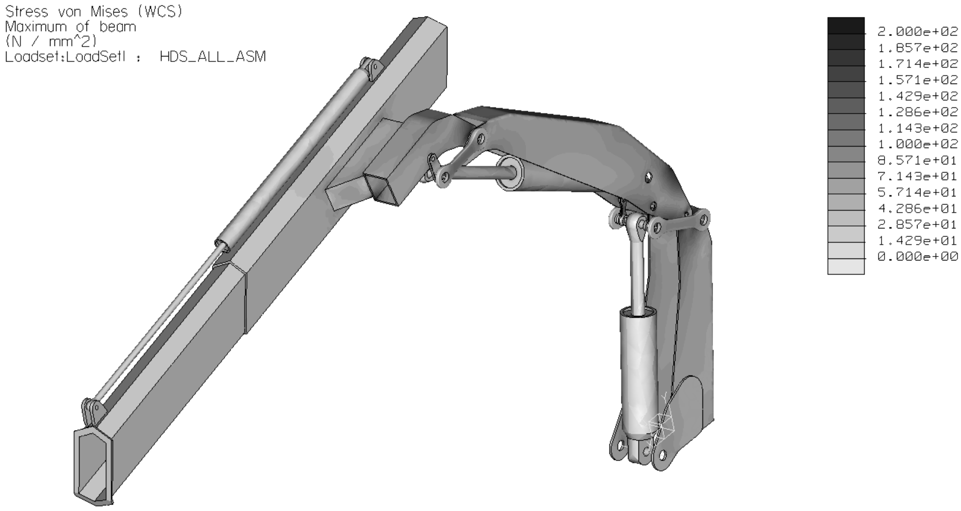

Fig. 5. Von Mises stress [MPa]

Rys. 5. Rozkład naprężeń zredukowanych [MPa]

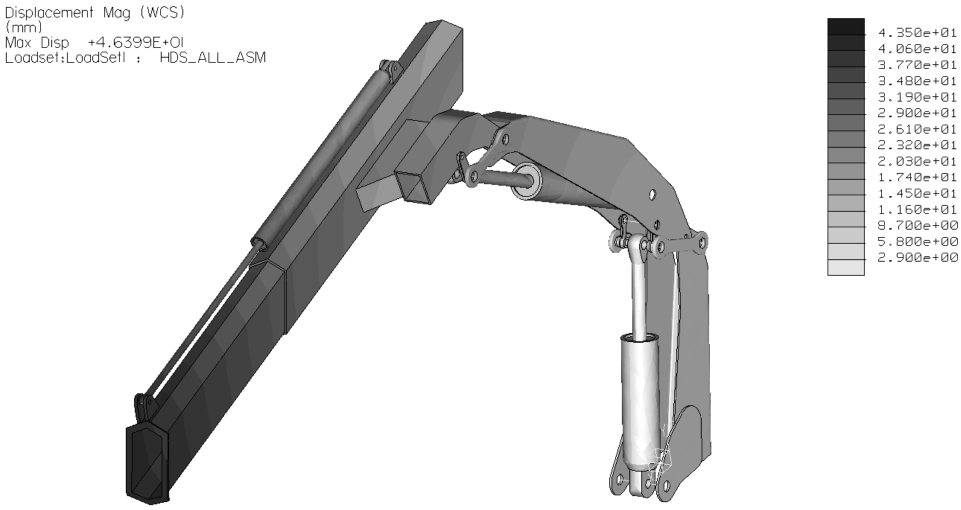

Fig. 6. Distribution of displacement [mm]

Rys. 6. Rozkład przemieszczeń [mm]

4. Conclusions

The paper presents the method of computational processes automation carried out in CAD system. Automation is realized by suitable software, which uses API interface and is integrated with CAD system. As an result it was possible to correlate two types of assembly used in CAD systems: static and kinematic. Connection of assemblies enables to exchange information between them and results in very fast position change of hydraulic crane's working components in static assembly. Thanks to position changing in static assembly it was possible to carry out strength analyses and determine the most disadvantageous position (which generates largest values of stress and displacement of structure). Furthermore, presented algorithm could be used not only in designing and machinery analysis but also like a training simulator for machine operators. Training conducted in virtual environment does not involve risks connected with accidents caused by inexperienced person during machine operation, as well as costs of heavy machinery repairing.

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