UDC 621

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INTERACTIVE VISUALIZATION OF WORKING MOVEMENTS IN PRO/ENGINEER SYSTEM

CAD 3d системи були створені для поліпшення конструкцій. Проте вони з'являються дуже корисним для лідерства різних симулюючих досліджень і візуалізації продукту. Візуалізація може приводитися до цілей, що представляються, але в деякому ряду може також служити, щоб управляти або це може бути елемент діагностики. У статті було описано використання системи CAD в меті візуалізації руху механізмів машин в час приблизне до його реального часу руху. Так затримці в представленні руху доведеться бути таке мале, що це надало б правильну оцінку руху механізму для оператора, який контролює його роботу. Реалізація цього уявлення для машинного устаткування, яке рухи у разі пневматичної і гідравлічної їзди відносно швидкі, не можлива досягти за допомогою звичайних команд зборів або натхнення руху. У представленому папері був запропонований, пишучи власну програму, яка використовує матричні перетворення для заміни позиції. У програмному забезпеченні, що будується, був використовуваним оточенням Pro/інженер з бібліотекою Pro/пакет розробника і C++ мовою програмування. На прикладі вибраного механізму були представленими наступними кроками реалізації процесу візуалізації, як наприклад: будуючись додатку, який використовує бібліотеку Pro/пакет розробника, підготовку даних вхідних даних програм, виконання істотного математичного перетворення і його виконання в програмі. Були також апроксимовані проблеми з'єднався з виконанням методу і висновками, які відбувалися після попередніх аналізів.

CAD 3D systems was mainly made to improve record construction. However they appear very useful for leadership of different simulating researches and visualization of product. Visualization can be led in presentational purposes but in some range can also serve to control or it can be element of diagnostics. In lecture was described making use of CAD system in visualization purpose of machines mechanisms movement in time approximate to its real movement time. So delay in movement presentation has to be such small, that it would give correct evaluation of mechanism movement for operator which is supervising its work. Realization of that presentation for machinery, which movements in case of pneumatic and hydraulic drives are relatively fast, isn't possible to accomplish with help of ordinary commands of assembly or motion animation. In presented paper was proposed writing the own program, which uses matrix transformations for position changing. In software building was used Pro/Engineer environment with Pro/Toolkit library and C++ programming language. On example of chosen mechanism were presented next steps of realization of visualization process, such as: building of application which is using Pro/Toolkit library, program input data preparation, execution of essential mathematical transformation and its implementation in program. There were also approximated problems connected with method implementation and conclusions that were occurred after preliminary analyses.

1 Introduction

Reliability is a very important parameter of each industrial machine. Frequently when the machine works in different conditions some of it's mechanisms could brake-down and damage. Therefore it is significant that work of such machine will be constantly control. When defect occurs the control system informs about that machine operator, and after that repair actions take place. This kind of approach minimize time in which machine couldn't execute of specified work so it's productivity increases. One of main components of such control system, beyond series of sensors which measure machine's work parameters, is work visualization system. Visualization system for perform it's task, must realize virtual motion of machine in the same time when machine moves or time close to machine movement time. Visualization of machine work could be done in many ways, however the best solution for that purpose is using of machine virtual model constructed in CAD system. Three-dimensional model could be used for precise presentation of even most complex work movements of particular mechanisms.

This lecture presents visualization method which uses *Pro/Engineer* CAD system and virtual model of machine. In purpose of method realization was written an application supported by *Pro/Toolkit* library. Application calculates suitable matrix transformations of virtual model during simulation of machine work movements and finally realize machine virtual movement. All operations are executed in real time.

2 Software communication with *Pro/Engineer* system

Creation of client application, which makes a request from CAD system (which performs server part) to execute some operations in system, is connected with usage of suitable for that system application programming interface. In *Pro/Engineer* environment the basic application programming interface stands *Pro/Toolkit*. It is pack of tools delivering for a programmer huge function library written in C language, which enables safe and controlled access to *Pro/Engineer*. Computer program which uses *Pro/Toolkit* library could work in two modes:

- *synchronous* – single thread mode, in which program is an element of CAD system and completely dependent on it;
- *asynchronous* – multi thread mode, in which program could execute operations independently apart from CAD system;

In presented method the asynchronous mode was used. For properly work in asynchronous mode, application must establish connection with *Pro/Engineer* system, which in case of synchronous mode isn't necessary. For establishing such connection application need another program which performs communication function. It's called *pro_comm._msg.exe* and it is integral part of *Pro/Engineer* system. However it is necessary to create a suitable computer system variable which activates communicator. Creation of such variable was presented on fig. 1. After *pro_comm._msg.exe* program activation it is set working when *Pro/Engineer* system starts.

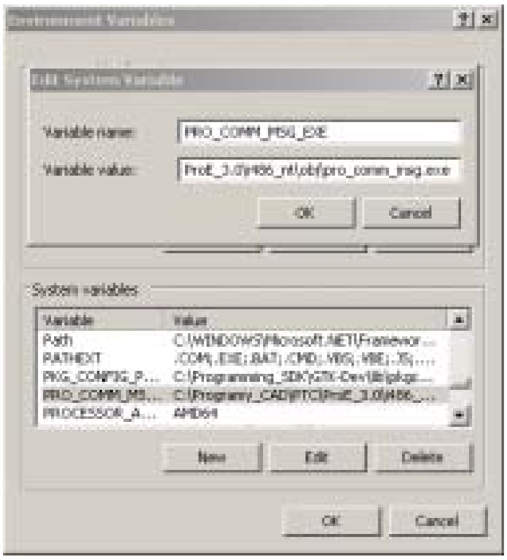

Fig. 1. Definition of system variable

3 Visualization of work movements

In presented algorithm, visualization of work movements is realize in two steps: first includes determining suitable matrix transformations for each assembly component, second enclose process of component visualization after transformation it's position and orientation. For calculate matrix transformations, it is necessary to prepare suitable input data set, which contains initial position matrices of each assembly component. This data set is directly prepared in *Pro/Engineer* system after creation of drives for particular mechanism of machine.

3.1 Preparation of input data set for application

Input data, which are used by application for calculation of suitable matrix transformations, are generate with the aid of *Animation* module of *Pro/Engineer* system. For generate such data, it is necessary to pass into *Animation* mode by choosing suitable position from menu *Applications* (fig. 2a), next create essential drives and conduct simulation of machine work. Building of drives was presented on fig. 2b. In that purpose it is needful to pointing kinematic connection, to which in real machine is applied drive and describing character of input function. When all of drives are create then it is possible to conduct a simulation separately for each of drives. Particular simulations proceed in whole range of movement for a given drive. Export of input data, which are used by external application, was presented on fig. 3. For generate suitable data set for chosen drive, it is necessary to conduct movement simulation by pressing *Start the animation* button (1). When the simulation finish it is possible to write generated data to text file placed on computer hard drive. Exporting data is done by pressing *Export the animation* button (2). Structure of file, in which data are store was shown on fig. 3 in window mark by number (3). As we can see stored data include information about following frames of machine movement animation. Single frame includes set of matrices which contains information about position and orientation of each assembly component. Number of frames and animation time is determined by parameters of input function which initiate the movement and is defined during drive creation process.

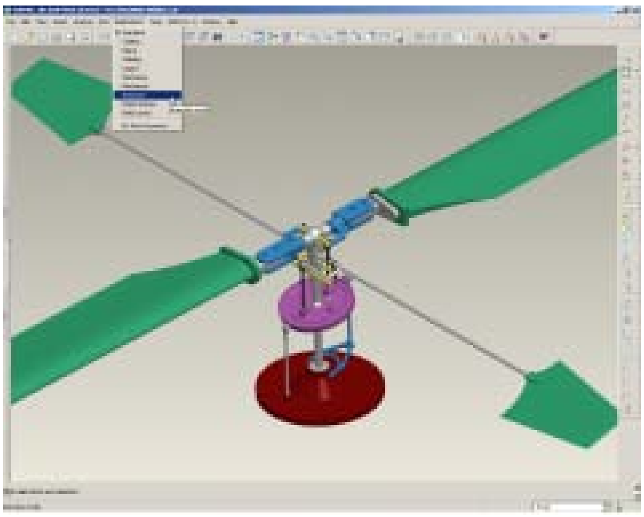
Fig. 2a. Starting *Animation* module

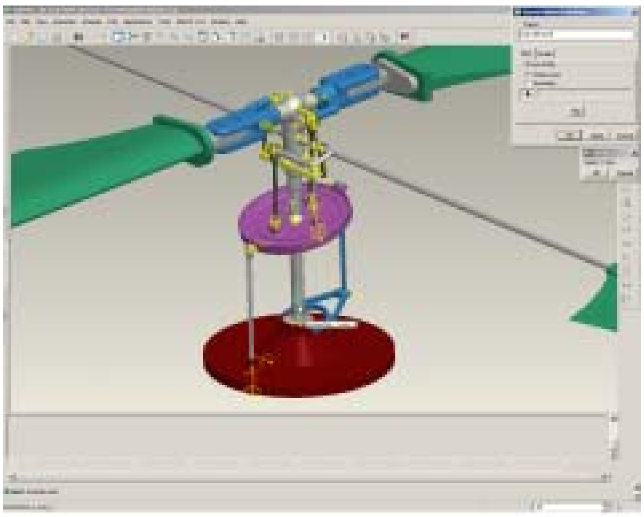
Fig. 2b. Creation of drive

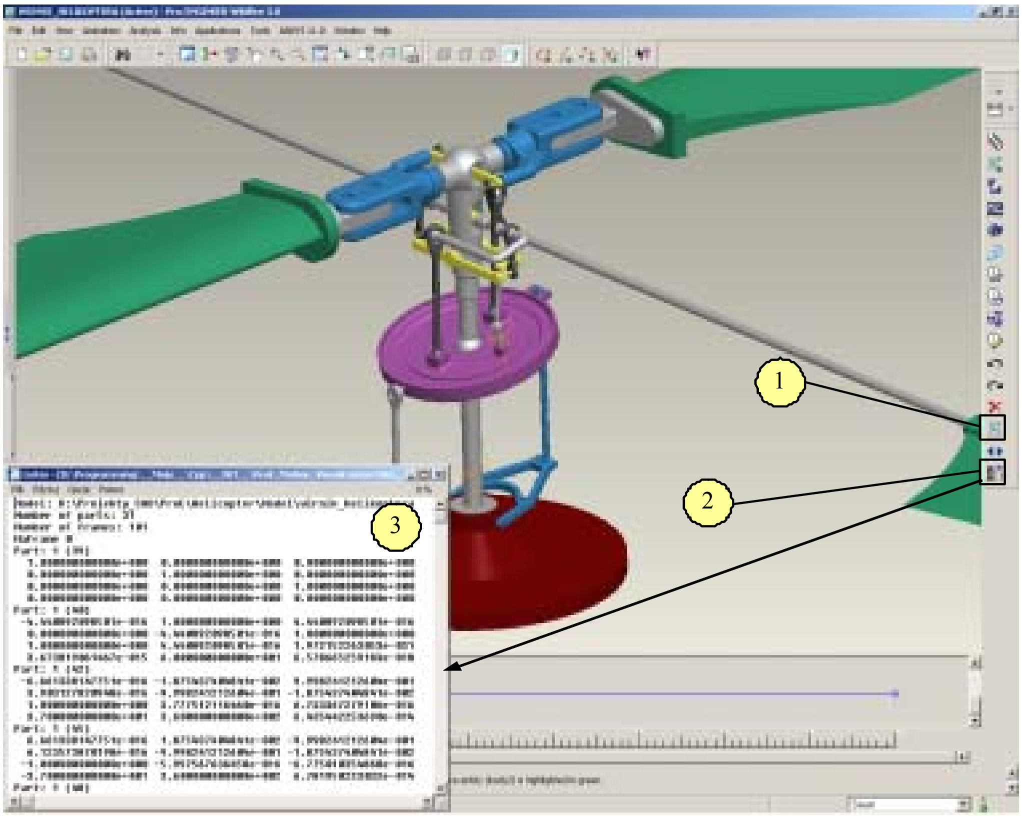

Fig. 3. Export of input data

3.2 Processing input data

Application input date are divided into suitable sets and store in separate files. Single input data file contains information about position and orientation of each assembly component in whole range of movement come from only one specific drive. Amount of files which contains input data sets equals number of machine drives. For assign position and orientation of each assembly component, which arise from complex movement produced by working of all machine drives, it is necessary to calculate some matrix transformations. Algorithm which enables determining of that transformations was presented on fig. 4.

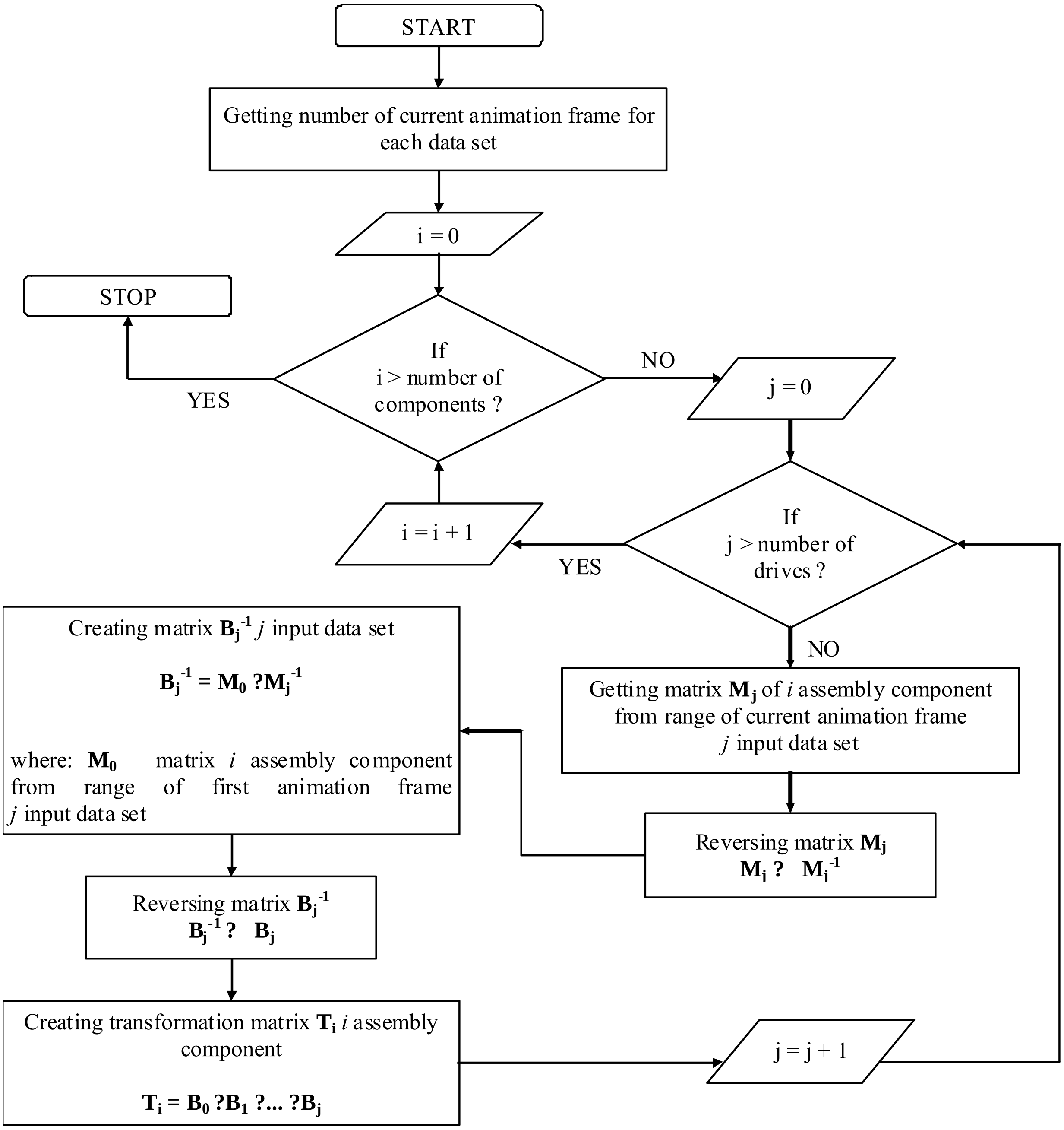

Fig. 4: Calculation of matrix transformations

3.3 Viewing movement animation

When the transformation matrices for each assembly component was determined that it is possible to create animation frames and view complex machine movement. Animation could be create in two ways. First require to collect all frames included in animation and view it by special panel, which enables to control animation process. Second enables to create and view only one chosen specific animation frame. In described method was used second way so the interactivity of visualization process was acquired. Thus first step during movement animation viewing is creation suitable animation frames. The algorithm of it's creation was described on fig. 5.

Next step after animation frame creation is suitable viewing of it. This is realize by calling *Pro/Toolkit* function called *ProSingleAnimationPlay*. Algorithm of viewing movement animation was presented on fig. 6.

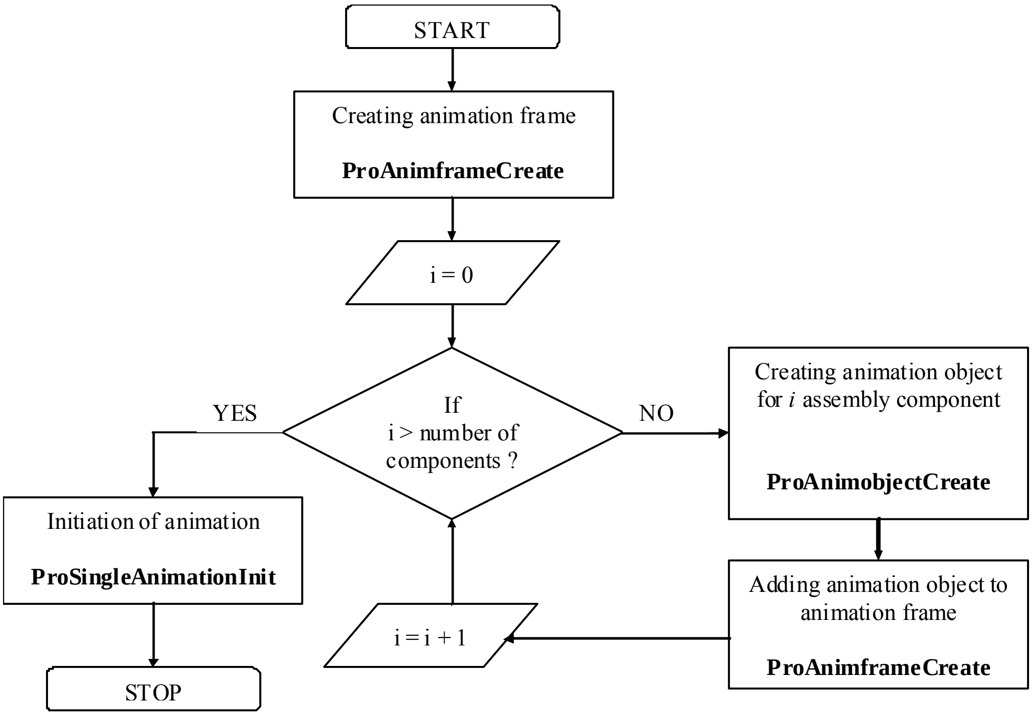

Fig. 5. Creation of movement animation frame

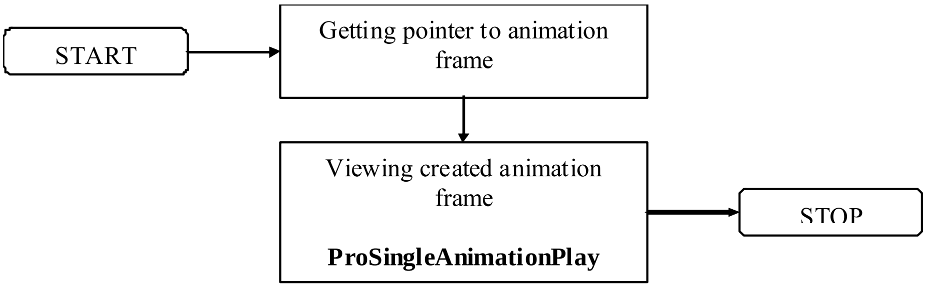

Fig. 6. Viewing of animation frame

Final effect of visualization mechanism performance illustrates fig. 7. In right bottom corner of figure is placed external application, which realize machine motion. Always after setting drive in specific position, which is realized by setting position one of three sliders, is generated complex motion of machine. User is observing that motion in animation form, which is realize in real-time.

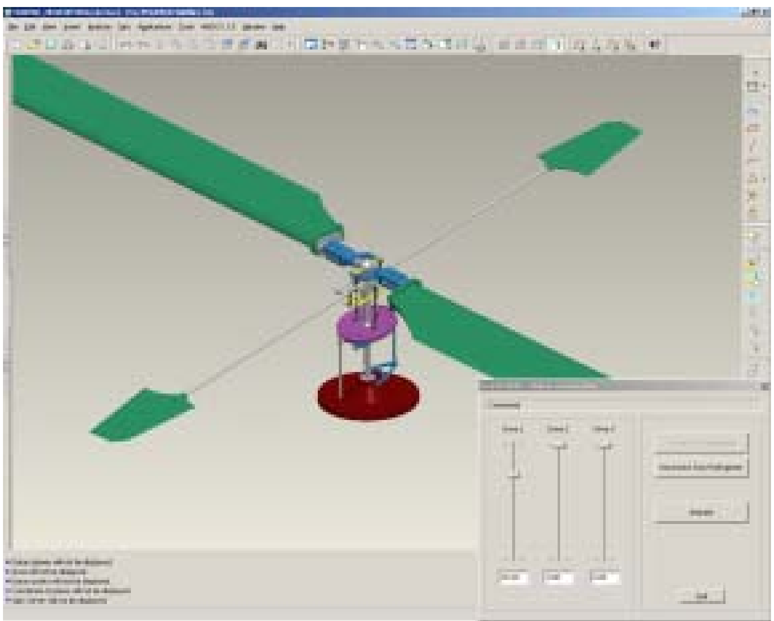

Fig. 7. Visualization mechanism during work

4 Summary and conclusions

In assumption, motion visualization algorithm should be interactive and realized in real-time. Therefore calculations of matrix transformations must be done in possibly shortest time. Most time-consuming are calculations connected with determining reverse matrices. So applying most efficient algorithm, which will be realize that transformation, enables to view movement animation in real-time. External application, which was written in purpose of testing proposed visualization method, determine inverse matrices by using *Gauss-Jordan* method. It is very effective because isn't necessary to calculate matrices determinants or create algebraic complement matrix, which considerable reduce number of mathematical transformations lead up to matrix inversion. It is also very important to match optimal number of movement simulation steps during input data generation. Enlargement number of steps leads to increase accuracy of machine motion representation in CAD system but simultaneously increases number of generated matrices, which could cause substantial decrease of algorithm capacity.

Literature

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