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3D MODELING OF SPATIALROBOT MANIPULATORS IN THE MAPLE SOFTWARE ENVIRONMENT

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3D modeling of any robotic system has become widespread in the last few years and is used for educational and research purposes, where work with a visual image of an object in three-dimensional space is required. There are currently many 3D modeling tools available for various fields of robotics research with some advantages and limitations. Computer 3D modeling of spatial manipulators and their movements with a visual image of the object allows you to visually observe the results when studying its kinematic, dynamic, power, control and other aspects. In this paper, a three-dimensional computer model of the spatial manipulator RRRRT and its movement was obtained by developing and implementing a program in the Maple environment. To create a 3D model of the manipulator, it is required to obtain 3D models of the components of the manipulator: kinematic pairs, links, grips and combine all parts of the manipulator into one system using the developed program in the Maple environment.

Keywords: computer modeling, 3D manipulator, 3D model, Maple.

Computer 3D modeling of manipulators is one of the most promising directions in the spatial mechanisms studies [1]. Since with the increasing complexity of the designed systems, while their analytical study becomes more difficult, the creation of prototypes costs more expensive, the modeling of spatial manipulators on a computer often turns out to be the leading or even the only available research method [2].

Modeling the spatial manipulators movement even in a kinematic formulation is a complex mathematical task. Using the software packages that work with the construction of three-dimensional models, the creation of objects of any complexity is a painstaking, but solvable task [3].

To create a 3D model of a spatial manipulator can be used CAD systems such as SimMechanics, Autodesk Inventor, SolidWorks, Adams and software environments Matlab, Maple, etc. [4].

Using the SimMechanics program, the modeling of planar and spatial mechanisms is carried out. Modeling tools built into SimMechanics allow describing mechanisms and bodies with high accuracy, taking into account their mass-inertial characteristics, degrees of freedom and connections between them, as well as measuring the parameters of their motion under the action of moments and applied forces in various coordinate systems [5].

Autodesk Inventor is a comprehensive set of solutions for mechanical engineering 3D design. Thanks to Autodesk Inventor, engineers can integrate AutoCAD drawings and other data into a single model, creating a virtual representation of the final product. The program can also be used in research on the dynamics and strength of complex structures.

Adams is a software package for virtual modeling and simulation of complex mechanisms. Adams is used to develop and improve various designs. Using Adams, you can quickly create a fully parameterized product model or import it from other common CAD systems.

The SolidWorks program has a special library with a variety of standard components and products, containing parts with different purposes and parameters. You can quickly find any object in it or use a standard component as a part for modification. The program has the possibility of linking the entire model using equations rendered in a separate created text format document [6].

MATLAB is a package of application programs for solving technical computing problems. MATLAB is a high-level interpreted programming language that includes matrix-based data structures, a wide range of functions, an integrated development environment, object-oriented capabilities and interfaces to programs written in other programming languages.

Maple is also a software package, a computer mathematics system. The software environment is focused on complex mathematical calculations, data visualization and modeling. The Maple system is designed for symbolic calculations, although it has a number of tools for numerical solution of differential equations and finding integrals. It has developed graphic tools. It has its own interpreted programming language.

The process of creating a 3D model of a spatial manipulator is carried out in programs, such as SimMechanics, Autodesk Inventor, SolidWorks, Adams and further modeling of kinematic research is completed in other software packages, such as Matlab, importing a finished 3D model created in one of the above programs [7].

As for the Maple environment in 3D modeling of the manipulator, all operations are performed only in Maple environment, starting from achievement a 3D model of the manipulator components to an analytical study of the kinematic analysis of this spatial manipulator, which is simpler and more efficient.

Modeling and assembling of the RRRRT manipulator links were performed using the Maple operator *parallelepiped*(u, v, w, p, options).

As a result, we received the assembled 3d model of links of the RRRRT manipulator, which is shown in Figure 1.

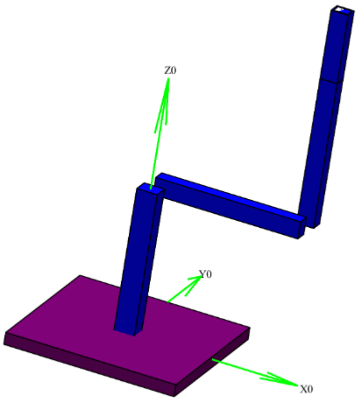

Figure 1: 3D model and assembling of links of the RRRRT manipulator.

Modeling and assembling of kinematic pairs together with the links of the RRRRT manipulator were implemented using the Maple operators *cylinder*(c, r, h, capped=boolean, strips=n, options), *rotate*(q, alpha,beta,gamma), *translate*(q, a, b, c) and the following commands.

As a result, we received the gathered 3d model of the RRRRT manipulator, which is shown in Figure 2.

The modeled RRRRT manipulator has five degrees of freedom. Because of the axes of kinematic links are mutually perpendicular and parallel, it is possible to use the method of constructing a coordinate system proposed by J. Denavit and R. Hartenberg in the formation of coordinate manipulator links systems. Below are the commands for constructing coordinate systems associated with links 0 and 1 using the following Maple operators *arrow*(base, dir, pv, wb, wh, hh, sh, fr, options), *textplot3d*(L, options), *display*(P), similarly constructed for the other links of the RRRRT manipulator.

To associate coordinate systems with the corresponding links, the following commands are sufficient for the 0 and 1 links of the RRRRT manipulator.

The received results of the RRRRT manipulator are shown in Figure 3.

To create a full-fledged visualized moving manipulator model with the given laws of generalized coordinates of a manipulator, it is necessary to combine all parts of the manipulator into one system using programs in the Maple environment, while specifying the main connections between them. This was achieved for the RRRRT manipulator using the Maple operators *display*(P), *rotate*(q, alpha, beta, gamma) and the following commands.

Figure 4 shows one of the positions of the modeled RRRRT manipulator during movements.

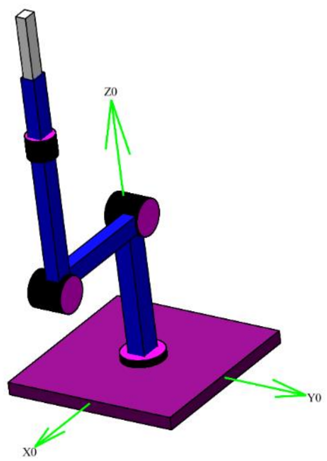

Figure 2: Assembled 3d model of the RRRRT manipulator.

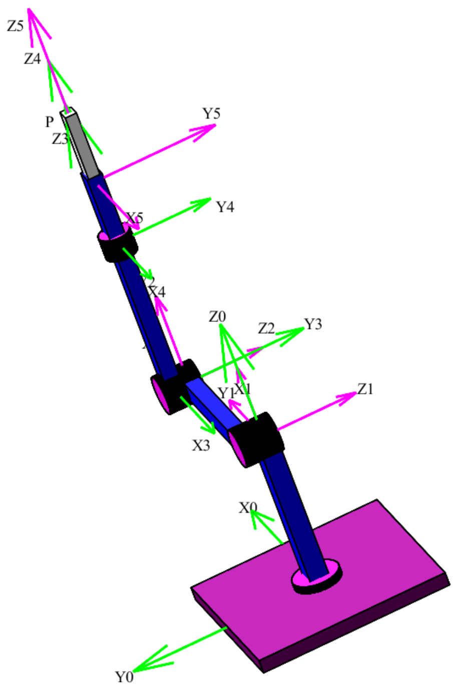

Figure 3: 3d model of the RRRRT manipulator. Each link, which is rigidly connected by its own coordinate systems constructed according to the Denavit-Hartenberg laws.

Conclusion. This study proposes a methodology for creating a 3d model of manipulators and their movement in the Maple environment. It describes simple and understandable methods for creating any three-dimensional virtual model of manipulators for motion modeling and various types of analysis. Using the developed technique, you can quickly simulate any other three-dimensional robot manipulator.

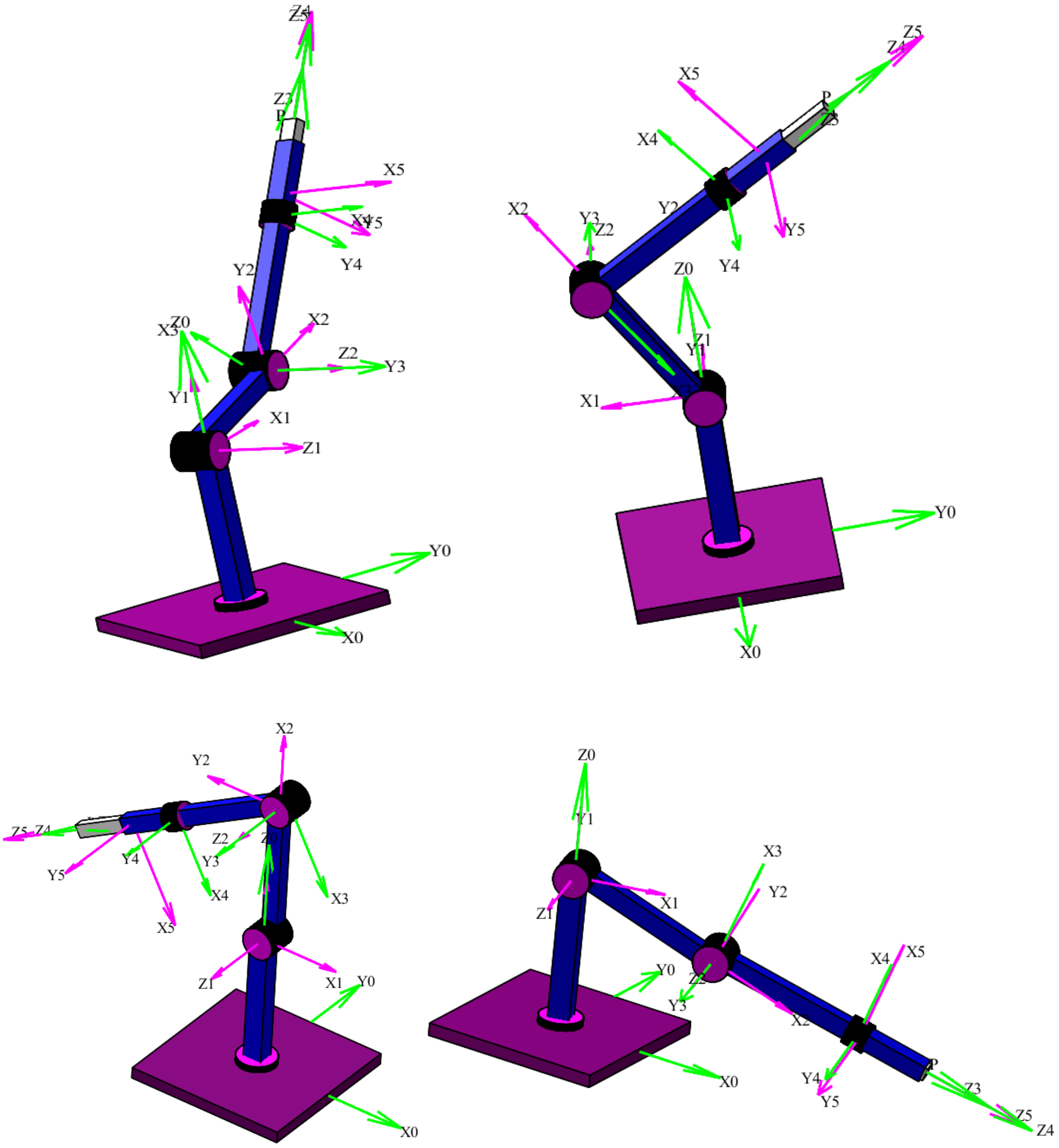

Figure 4: Several of the positions modeled RRRRT manipulator in the movements.

Figure 5 shows the transport position of the RRRRT manipulator.

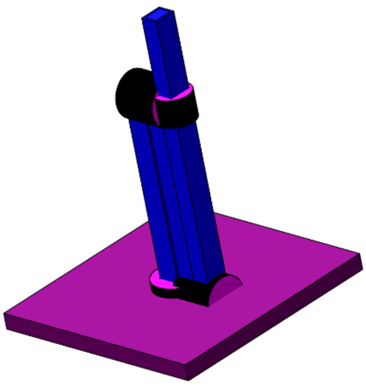

Figure 5: Transport position of the RRRRT manipulator.

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УДК 681.58, 621.355

ҚАТТЫ ЕМЕС ЭЛЕМЕНТТЕРІНІҢ САНЫ ЕРКІН ҒАРЫШ АППАРАТТАРЫНЫҢ МАТЕМАТИКАЛЫҚ МОДЕЛІ

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Ғылыми жетекшісі – М.И.Қасабеков

Бағдарлау жүйелерін әзірлеу барысында ғарыш аппаратының (ҒА) басқарылуы көптеген жағдайларда жоғары дәлдікпен катты дененің қозғалыс теңдеулерімен өрнектеуге болады. Алайда, құрылымында ұзындығы үлкен элементтері бар, жеңіл материалдардан жасалған аппараттар олардың қозғалысын модельдеуге басқадай тәсілді талап етеді. Мұндай элементтерге практикада кеңінен қолданылатын жоғары және аса жоғары шешімді Жерді қашықтықтан зондтау спутниктерінің, геостационарлық байланыс спутниктерінің конструкцияларына енгізілген шығарылатын штангалар, күн панельдері мен антенналар мысал бола алады.

Бағыттау дәлдігі бойынша барған сайын өсіп келе жатқан талаптарға байланысты ҒА конструкциясының жоғарыда көрсетілген элементтерінде орбиталық және бұрыштық маневр жасау барысында туындайтын діріл қозғалыстың қажетті режимдерін тұрақтандыру дәлдігіне теріс әсер етіп қана коймай, тіпті олардың тұрақсыздығына да әкелуі мүмкін фактор болып табылады. Осыған байланысты қатты емес элементтері(ҚЕЭ) бар ҒА бағдарын басқару жүйелерін жобалау кезінде:

- оның конструкциясы элементтеріндегі дірілді ескеретін ҒА қозғалысының дәлдігі жоғары моделін жасау;
- дірілдің ҒА бағдарына әсерін ескеретін ҚЕЭ-мен ҒА бұрыштық қозғалысының берілген режимдерін тұрақтандырудың белгілі әдістерін бейімдеу немесе жаңа әдістерін әзірлеу;
- жұмыс процесінде ҚЕЭ-дегі тербелістер мүмкіндігінше аз болатын ҒА бұрыштық қозғалысының осындай режимдерін құру.