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ЦИФРОВЫЕ ТЕХНОЛОГИИ ОБУЧЕНИЯ НА СИМУЛЯТОРАХ

Аннотация*: в статье представлены общие положения о летательных тренажерах с использованием платформы Гью – Стюарта. Раскрываются недостатки платформы в решении непосредственных проблем кинематики. По этому вопросу нами предложено использование и синтез структур параллельного манипулятора SHOLKOR в качестве опоры в подобных тренажерах. Такого рода манипулятор основан на топологической модели двух сопряженных тел. Анализ исследования по синтезу параллельной кинематической схеме робота показывает, что существующая разновидность схемы робота представляет из себя набор решений определенных проблем и не подразумевает системной направленности. В статье раскрыт основной функционал параллельного манипулятора SHOLKOR. Как результат, SHOLKOR позволяет целенаправленно контролировать движения верхней*

платформы. Платформы Гью – Стюарта не могут обеспечить ни пространственного позиционирования лишь одной точки всей платформы ни ее сферического движения.

Ключевые слова: *робот-платформа, параллельный манипулятор, кинематическая цепь, связующие звенья, топологическая модель.*

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DIGITAL TECHNOLOGIES OF TRAINING ON FLIGHT SIMULATORS

Abstract*: the article provides an overview of air trainers with the STEWART platform. Disadvantages of platforms in solving the direct kinematics problem are revealed. In this regard, we consider the use and synthesis of the structure of the SHOLKOR multi-contour parallel manipulator as supports for air trainers. The manipulator is based on a topological model of two interconnected bodies. the Analysis of research on the synthesis of parallel robot architecture shows that the existing variety of robot architectures are a set of solutions to particular problems and do not* *have a system orientation. The main functionality of the SHOLKOR parallel manipulator is revealed. As a result, SHOLKOR allows you to purposefully control the movement of the upper platform. A STEWART platform cannot provide spatial positioning of a single point of the mobile platform and spherical movement of the platform.*

***Keywords**: platform robot, parallel manipulator, kinematic chain, connecting links, topological model.*

Pilot training on a simulator is an important component in ensuring their safe operation. The high efficiency of flight simulators is due to their ability to transfer dynamic loads and to provide training for pilots to operate in emergency situations. Currently, flight simulators have begun to be used, built on the basis of manipulation mechanisms with a parallel kinematic structure, for example, STEWART platforms [1, p. 24]. They are dynamic systems, have six degrees of mobility and are capable of creating controlled movements of a mechanical object. Together with the computer control system, the STEWART platform forms a manipulation flight simulator. The motion control system of such a robot includes a central computer control unit and a complex of executive digital servo drives of degrees of mobility with the necessary set of feedback signal sensors. High accuracy and consistency of movements in all degrees of mobility of the aircraft simulator is achieved due to the construction of the robot as a mechatronic system.

Movable platforms are widely used in training complexes as a means of augmented reality. In addition to visual information from what is happening, the participant receives physical sensations of overload similar to those in reality. Being located inside the simulator, a person feels the impacts created by deviations of the upper platform of the platform and identifies them with virtual reality [2, p. 45].

The basis for creating illusions of any movement in the simulators is the pilot's inertia relative to the aircraft seat, and if otherwise, the difference in inertia forces acting on the participant by his vehicle.

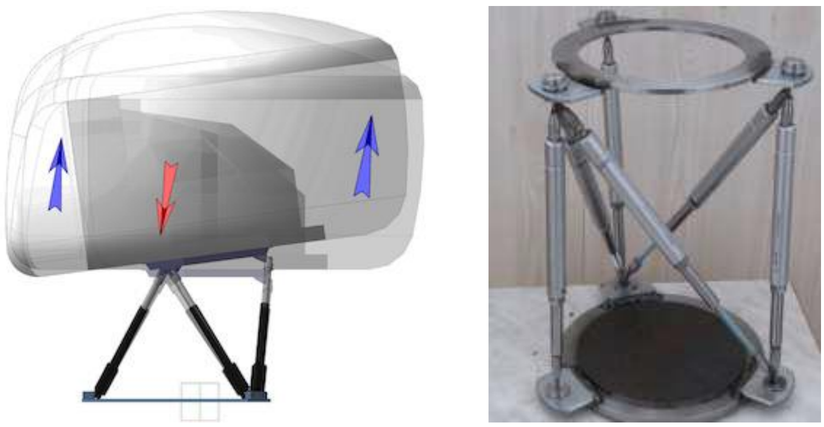
As a result of the computer controlled change in the length of the cylinder rods, the upper platform generates the corresponding accelerations transmitted to the pilot's seat. In most cases, just like when flying in a real plane, these movements are enough for a relatively believable feeling of minor G-forces. At the same time, no ground-based technical solutions allow transmitting weightlessness for more than a fraction of a second. Typically, some deceptive technology is used to make the physical sensations similar. It is likely that after a breakthrough in overcoming gravity and controlling it, this will become possible.

The movable platform creates accelerations exactly in the time interval when the cylinder changes its length. To create long-term effects, a long-term deflection of the platform is used, which is taken by the vestibular apparatus of a person as an actual overload, although in fact, the participant is simply not quite evenly sitting in the chair [3, p. 54; 4, p. 21].

Consideration of the issues of constructing and controlling the movement of an aircraft simulator based on a manipulator with a parallel kinematic structure is inseparable from the consideration of issues related to the drives of the degrees of motion of the robot. It is the set of drives, together with the system of computer control of the movement of the mechanism, that forms the simulator as a dynamic system with the features and properties of a mechatronic system. Various types of actuators can be used in such flight simulators: electric, hydraulic and pneumatic. Hydraulic drives are expensive, and it is advisable to use them in heavy-duty robots with a large load capacity. Electric drives are highly accurate and fast. But they behave too «hard» and are not always suitable for driving simulators. The use of pneumatic actuators to control the degrees of mobility of robotic simulators based on the STEWART platform is promising for flight simulators. Pneumatic servo drives are very smooth, and this property has a positive effect on the transmission of sensation of motion in flight simulators.

However, in the STEWART moving platform, the variable coordinates are interconnected so that movement in any drive requires simultaneous, coordinated movement in other drives connecting the platforms. For manipulators of such platform-type robots, there is no explicit solution to the direct problem of kinematics. In this regard, problems arise when creating control systems, as well as during operation, because failure of one drive leads to failure of the entire robot.

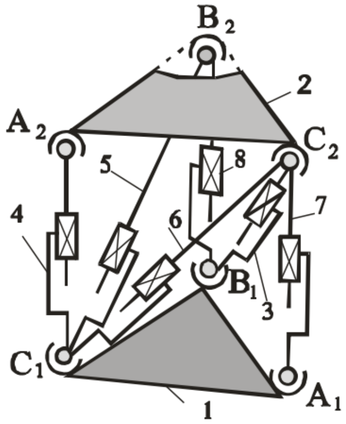
In order to improve the functionality of platform-type parallel manipulators, the SHOLKOR platform robot is proposed, which has a number of advantages over the STEWART platform. Figure 1, a proposes the SHOLKOR platform [5, p. 57] for an airplane simulator with the model shown in Figure 1, b.



a) b)

Pic. 1. Flight simulator with SHOLKOR platform

The mechanical part of the platform robot structure is a SHOLKOR six-movable parallel manipulator with the structure topology shown in Figure 2. The lower platform 1 and the upper platform 2 are shown here, connected by connecting links (SZ) 3–8 that have the ability to change their lengths. In this case, the connecting links form with platforms in the nodes: A1, A2 – two-link spherical connections; in the nodes B1, B2-three-link spherical connections; in the nodes C1, C2 – four-link spherical connections. Next, we note the features of the SHOLKOR parallel manipulator, which determine the important functionality of the new platform robot and are the basis for choosing this robot as an active controlled support.



Pic. 2. Scheme of the structure of the parallel manipulator SHOLKOR

First, it is possible to change the length of any of the six CZs independently of the others using controlled drives. In this case, depending on the length of the SZ, the movable platform occupies a strictly defined position in relation to the fixed platform.

Secondly, by changing the lengths of a certain set of SZ simultaneously or in an arbitrary sequence with the help of controlled drives in a predetermined way, it is possible to obtain any required spatial position of the movable platform. It should be noted that the area of possible positions of the movable platform is limited by the limiting (maximum, minimum) lengths SZ or limiting angles of rotation of the links in spherical joints.

Thirdly, the topology of the structure of the new platform manipulator, on the basis of which the platform robot was created, provides the possibility of spatial movement of any robot platform as a leading link. From the solution of the direct problem of kinematics [6, p. 41] it follows that it is possible to obtain the spatial movements of the upper platform relative to the lower one in two ways: 1 way, (according to Euler) by moving a given point-node C2 in space by changing the lengths SZ-3,6,7, then performing spherical rotation relative to the C2 node by changing the lengths of three SZ – 4.5.8. Since each position of the movable platform corresponds to quite definite lengths of the connecting links, then, conversely, it is possible to move the platform as a leading link, while depending on the position of the movable platform, the lengths of the SZ as driven links will uniquely change. Similarly, you can move the lower platform relative to the upper one, while another set of SZ will change. None of the known STEWART platforms [7, p. 34] have the above capabilities. It is thanks to this functionality that the platform robot under consideration can be used as an active controlled support, in which the lower platform as a leading link, under the action of a source of mechanical influences, can perform spatial movements relative to the upper platform associated with the protected object.

Conclusions

In this work, it is proposed to use the SHOLKOR parallel manipulator as a platform for an aircraft simulator. The features and advantages of this manipulator in comparison with the STEWART platform are shown. As a result, the SHOLKOR parallel manipulator enables purposeful control of the movement of the upper platform, which follows from the topological model. The STEWART platform cannot provide such well-known movements as the spatial positioning of one point of the movable platform and the spherical movement of the platform or the rotation of the platform around a certain axis.

References

1. Aviation simulators of modular architecture: monograph. / E.V. Lapshin, A.M. Danilov, I.A. Garkina [et al.]. – Penza: Information and Publishing Center of PSU, 2010. – 148 p.

2. Principles of creation of end-to-end controlled dynamic systems as applied to aircraft simulators / N.K. Yurkov, A.M. Danilov, E.V. Lapshin [et al.] // Information technologies in design and production. – 2009. – №2. – P. 53–55.

3. Yurkov N.K. State and prospects of development of aviation simulator / N.K. Yurkov, E.V. Lapshin // Information technologies in education, science and production: collection of articles. tr. 2nd Intern. scientific-practical conf. (Serpukhov, June 30 – July 4, 2010). – Serpukhov, 2010. – S. 554–565.

4. Lysenko A.V. Analysis of the peculiarities of the use of modern active vibration protection systems for non-stationary RES / A.V. Lysenko, G.V. Tankov, D.A. Ryndin // Proceedings of the International Symposium Reliability and Quality, 2013. – T. 2. – P. 155–158.

5. Sholanov K. Platformrobot manipulator. WO / 2015/016692. 02/05/2015.

6. Sholanov K.S. Synthesis of the structure scheme and solution of the positioning problem for a parallel platform-type manipulator // Mechatronics, automation and control. – 2014. – №11. – С. 44–50.

7. Sholanov K.S. Combined earthquake protection system (variants). WO2015 / 099519A1, 02.07.2015