DEVELOPMENT OF HIGH-PERFORMANCE MOTION SIMULATOR FOR VIRTUAL REALITY SYSTEMS

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Summary: the paper is concerned with development of the high-performance and simple system of the motion effect simulation on the operator. These mechanisms are widely applied in virtual reality systems: trainers for truck drivers and aircraft pilots; entertainment; medical research application. The new construction of the spherical motion platform on the basis of four-bar linkage has been developed with simple structure, sufficient fidelity of motion and small energy consumption. In the paper the force analysis of spherical motion platform has been presented. The three-dimensional model of developed motion simulator has been given.

The purpose of the motion simulator is to give perception of continuous dynamic motion inside a vehicle or robot to the human nervous system. It is accomplished by a combination of realistic audio and visual presentation. In driving simulators, the driver interacts with a virtual vehicle model reproducing the behavior of a real vehicle under given environmental conditions and under given driven commands. Motion perception is obtained by means of the simulator cabin movement generated by a computer model. The cab is moved by platform ideally reproducing the motion of a seat of the vehicle driver. There are two main types of platform used in motion simulator: Gough-Stewart platform; spherical platform based on arc guiding rails. Gough-Stewart platform (Fig.1) - six-degree of freedom (DOF) parallel mechanism with six identical kinematic chains, composed of a universal joint, a prismatic actuator, and a spherical joint. Gough V.E. [1] devised a six-linear jack system for use as a universal tire testing machine. Stewart D.A. [2] developed a six-degree of freedom platform manipulator for use as an aircraft flight simulator. Spherical motion platform using arc guiding rails (Fig.2) was developed during project SIMUSYS: "*Innovative high-performance motion simulation system for entertainment, research and training applications*" in the university of Saragossa. The SIMUSYS driving simulator is formed by 4-DOF spherical motion platform providing 3 rotation motion and 1 translation motion. The basic spherical surface is created by means of curved sliding guides. This paper is concentrated on development of the rational variants of the movable platform in order to create simulator with more simple structure in comparison with above-mentioned types, sufficient fidelity of motion and small energy consumption under following initial data: position restriction area of the movable platform – 1700X1700 mm; distance from platform center up to the operator head center h – 1220 mm; sphere radius of permissible positions of operator cochlea center r – 100 mm.

Fig.1

Fig.2

Trajectory of the motion of the spherical platform center in projections on plain represents symmetrical arc relatively vertical axis Z. In order to create this trajectory to make the most efficient use of the four-bar linkage with equal length of input and output crank. To simplify design the scheme with usage of one four-bar linkage mounted on the platform making rotational motion relative to the vertical axis Z is developed. Thus the spherical motion is realized by combination of tilting motion created by the four-bar linkage and rotational motion of the supporting platform. Operator tilting simulation in the plane orthogonally to the four-bar linkage position is created by Coriolis force acting on the operator head. Thus platform having only two-DOF gives excellent fidelity of motion. One stage of force analysis has been presented below. The balance equation of forces acting on the dyad 2-3 (Fig.3) in projections on the axis Y is:

$$\sum Y = 0 \Rightarrow \; R_B^{\tau y} + R_B^{ny} + R_D^{ny} + (G + F_y) = 0$$

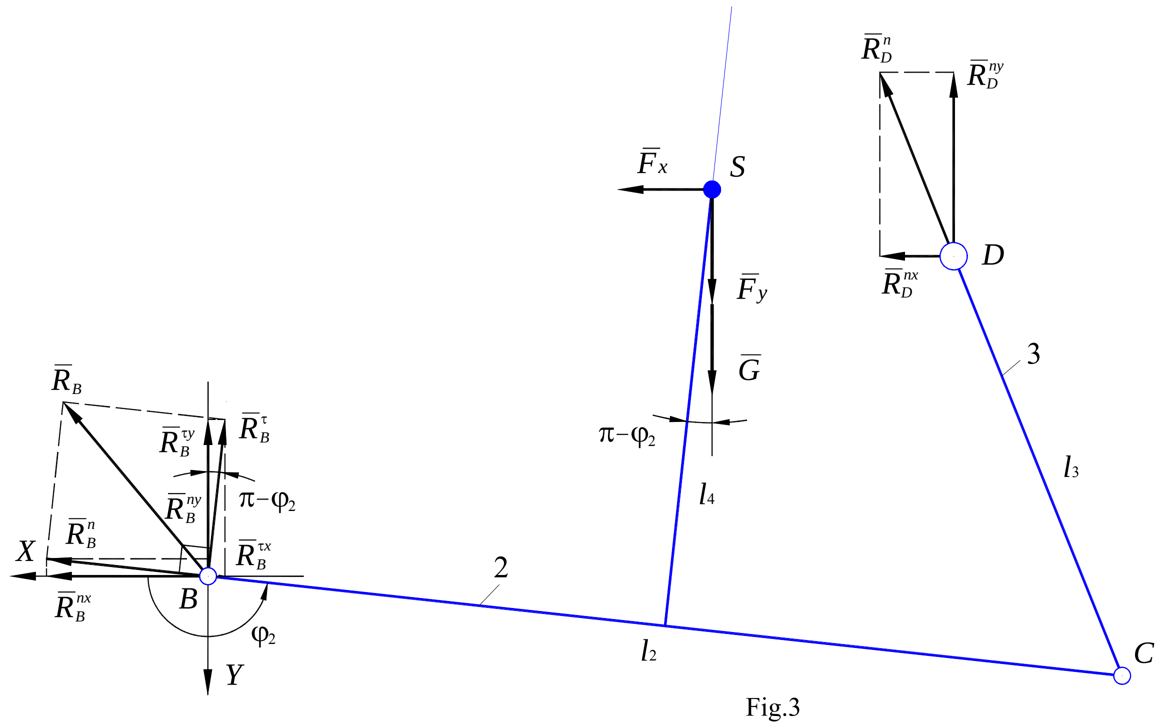

Fig.3

The value of R_D^n can be expressed after mathematical transformation:

$$R_D^n = R_D = \frac{R_B^{\tau} \cdot (\sin(\pi - \varphi_2) \cdot tg(\pi - \varphi_2) - \cos(\pi - \varphi_2)) + F_x \cdot tg(\pi - \varphi_2) - F_y - G}{\cos(\varphi_3 - \pi/2) - \sin(\varphi_3 - \pi/2) \cdot tg(\pi - \varphi_2)}$$

Generalized motion force F_d can be written as:

$$F_d = -R_B^y \cdot \cos\varphi_1 - R_B^x \cdot \sin\varphi_1$$

Motor power without account friction losses is defined:

$$N_{F_d} = F_d \cdot \omega_1 \cdot l_1$$

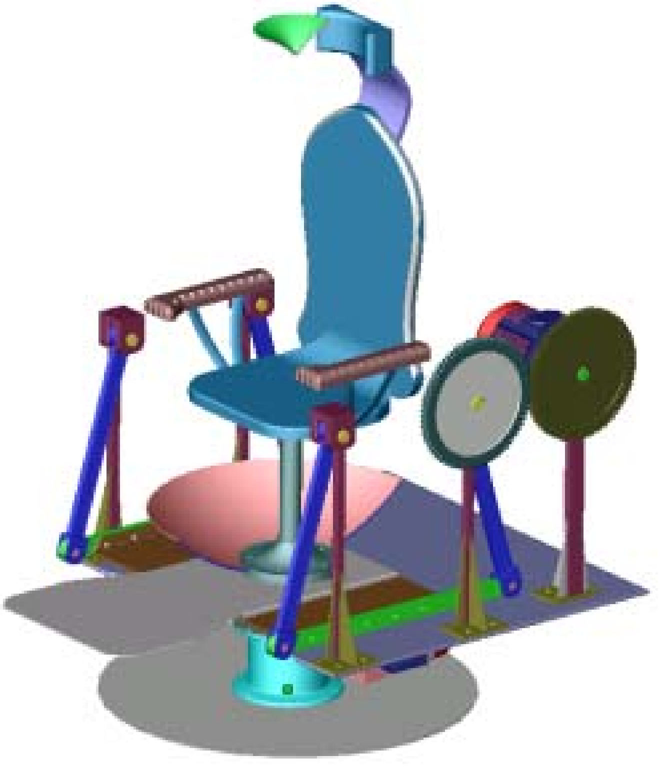

Fig.4

CONCLUSIONS

Developed construction of the spherical motion platform permits under simplicity of the main detail manufacturing and low system cost allows to diminish the overall dimensions of structure in 1,8 times and reduce the required motor power in 1,4 times in comparison with analogs. In addition the required restrictions about sphere of permissible positions of operator cochlea center and angle of chair tilting for extreme positions are secured. Presented results have been obtained during joint research in frame of contract between Institute of mechanics and reliability of machines of the National academy of sciences of Belarus (IMRM of NAS of Belarus) and Centre Robotique Integre en Ile de France (CRIIF).

References

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