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Integration of the virtual model of a Stewart platform with the avatar of a vehicle in a virtual reality

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Abstract. The development of methods of computer aided design and engineering allows conducting virtual tests, among others concerning motion simulation of technical means. The paper presents a method of integrating an object in the form of a virtual model of a Stewart platform with an avatar of a vehicle moving in a virtual environment. The area of the problem includes issues related to the problem of fidelity of mapping the work of the analyzed technical mean. The main object of investigations is a 3D model of a Stewart platform, which is a subsystem of the simulator designated for driving learning for disabled persons. The analyzed model of the platform, prepared for motion simulation, was created in the "Motion Simulation" module of a CAD/CAE class system Siemens PLM NX. Whereas the virtual environment, in which the moves the avatar of the passenger car, was elaborated in a VR class system EON Studio. The element integrating both of the mentioned software environments is a developed application that reads information from the virtual reality (VR) concerning the current position of the car avatar. Then, basing on the accepted algorithm, it sends control signals to respective joints of the model of the Stewart platform (CAD).

1. Introduction

The development of systems for computer-aided the engineering task allows running virtual researches concerning motion simulation of technical means, both in the CAD/CAE class systems as well as in the VR (virtual reality) class systems. The motion simulation can become the basis for the designation of forces acting on the working system. Such designated forces and fixing method are input parameters for a strength analysis using the finite element method (FEM). All mentioned capabilities of a system of the CAE class enable virtual verification of the concept of a technical mean at the designing and constructing stages. Basing on the virtual tests of the model it is possible to conclude about the proper or improper functioning of the designed technical system. The virtual researches, described in the paper, relate to motion simulation of the Stewart platform model using the system of the CAD/CAE class PLM Siemens NX and the system of the VR class EON Studio. The main object of investigations is a 3D model of a Stewart platform, which is a subsystem of the simulator designated for driving learning for disabled persons. The real system of the simulator [1,2,3] designated for driving learning consists of a Stewart platform (figure 1), on which is mounted the body of a passenger car equipped with all standard elements which operate in the same way as in the real car (figure 1). Platform together with the car body is surrounded with the projection system of the virtual world, in which is moving the avatar of the passenger car. Basing on data from the virtual environment and concerning the motion parameters of the vehicle is executed the control process of the mechanical system of the platform. The control algorithm must allow such operation of the simulator that the person driving the simulator should have a feeling as during driving a real car.

Figure 1. Virtual model and the real system of the simulator for car driving learning.

In the case of operation of a real system of the simulator it is important to determine the safe operating space of the platform and its motion parameters due to the limited workspace (the problem of acceleration, braking, taking turns by the vehicle). Therefore conducting virtual research is justifiable taking into consideration the high risk of unexpected behavior of the real system.

2. Model preparation in the VR environment

Preparation the model in the virtual reality environment lies in defining the interactions between the components of the model. The environment of the VR class is mainly used for “model animation” and not for creating it, as described in the paper [4]. Therefore basing on the imported 3D model of the route was created the virtual environment for the movement of a car (figure 2). In the adopted traffic environment it was created the avatar of the car. To the component avatar_of_car is assigned the maximal speed at which it could move in such created environment.

Figure 2. Model of a route in the VR system.

It was also defined the parameters of the virtual environment such as gravity or collision between the moving avatar of the car and the model of a road. Additionally it was established the procedures for acquiring data concerning the position and orientation of the avatar of the car depending on its interaction with the model of the route (the environment).

3. Stewart platform model preparation for motion simulation in the CAD/CAE class system

The problems related to the preparation of the model for motion simulation in the CAD system, PLM Siemens NX, are described in the next papers [5,6,7]. However the problems of design process of a technical mean is showing in the works [8,9,10,11,12,13]. In the case of creating the model of the Stewart platform, that is prepared for motion simulation (figure 3), one should extract the components of the “link” type and create the components of the “joint” type. The components of the “link” type represent the geometrical form of component of the model, and the components of the “joint” type describe the nature of the possible mutual displacements of components of the “link” type.

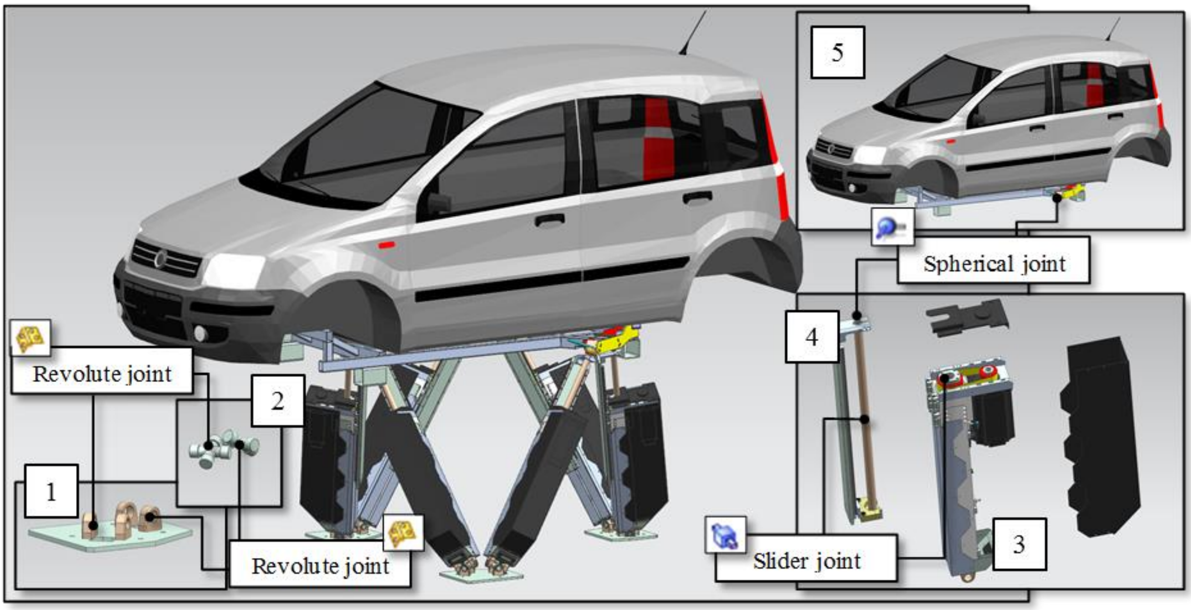

Figure 3. Model prepared for motion simulation in the PLM Siemens NX program [5].

The following assumptions related the model creation (figure 3) are taken:

- The elements included in the given component of the “link” type do not change their position relative to each other,
- All components of the “link” type (1 – base_component, 2 – cross_component, 3 – motor_component, 4 – actuator_component, 5 – frame_component) are treated as rigid bodies.
- In the presented system it was created: 6 components “revolute_joint” allowing rotation around one axis between the components (2) and (1) of the “link” type, 6 components “revolute_joint” allowing rotation around one axis between the components (3) and (2) of the “link” type, 6 components “slider_joint” allowing reciprocating motion between the components (4) and (3) of the “link” type and 6 components “spherical_joint” allowing rotation around three axes between the components (5) and (4) of the “link” type.
- The input signal to the process of motion simulation of the platform model are data from the file of Microsoft Excel.
- Extorsion, in the form of the input signal, is applied to the components “slider joint”. On this basis on could obtain the position of the component (5) of the “link” type, and thus the position of the car body of the simulator.

4. Integration of the Stewart platform model in the CAD/CAE class system with the virtual reality environment

Issues of integration of different environments supporting engineering works with virtual applications or control systems are presented in the papers [14,15,16,17]. In the case of integration of the car avatar, moving in a virtual environment, with the 3D model of the Stewart platform, prepared for motion simulation, it has been used the integration approach based on the control application which was created in Visual Basic environment and the file of data exchange of the Microsoft Excel software (figure 4). The main objective of the proposed integration method is matching the movements of the platform model, which is a subsystem of the simulator for driving learning with the behavior of a car in traffic. The main information transmitted from the VR class software is the location of the avatar of the car, which in a given moment of time depends on the terrain form in which the car is moving. This position is defined by six coordinates (position on the X, Y, Z axis and rotation around the X, Y, Z axis). It should be noted that the vehicle moves in the virtual world without limits (apart from gravitation and collisions), while the working space of the platform is limited. Therefore, the basic task of the control algorithm should be transforming data concerning the position of the avatar of the car into the position of the simulator platform. This transformation should on the one hand provide the platform movements within the extents provided by its workspace. While on the other hand, the transformation should allow adjusting the platform movements in such way to imitate the character of a real car motion (acceleration, braking, driving an arc). Movement of the platform should be so adjusted that a person driving the simulator would has feelings similar to the feelings during driving a real car.

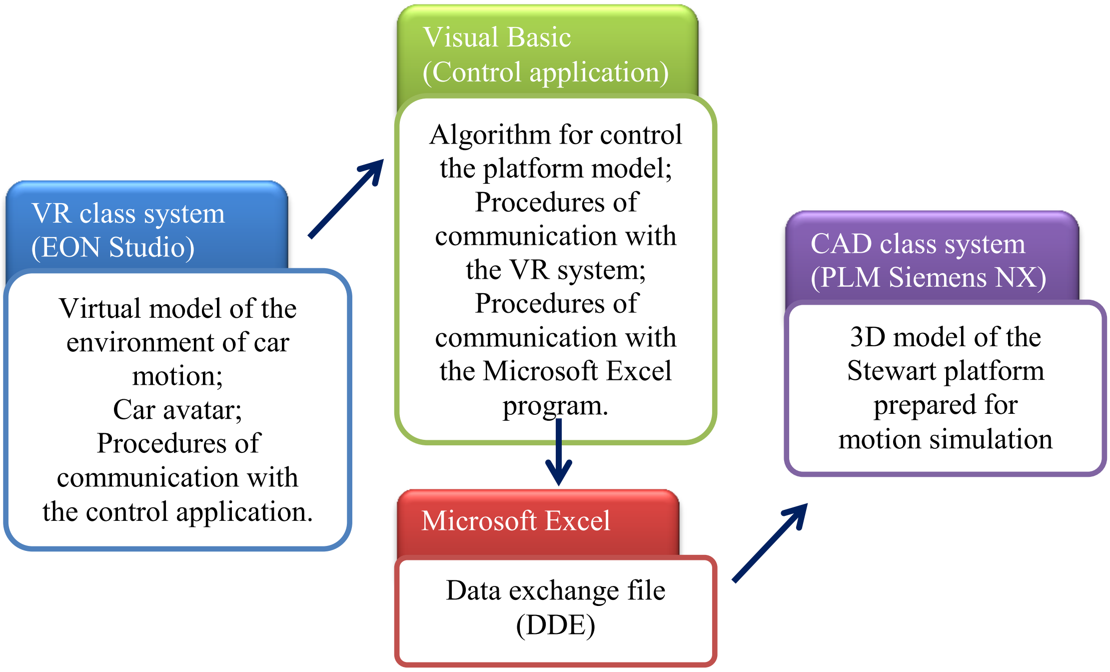

Figure 4. Scheme of integration.

In the paper is considered the following method for platform system control (figure 5):

- Data about the position of the avatar moving in a virtual environment are provided by means of data exchange procedures to the control application.
- The control algorithm, basing on information on the current position of the avatar and its previous position (which is known), determines, on the basis of a mathematical model, displacement values which must be reached by particular drives of platform legs. For this purpose it is necessary to solve the inverse kinematics problem of platform motion.

- The determined values of displacements are transmitted to the platform model, prepared for motion simulation in the CAD/CAE system, to the file of Microsoft Excel software basing on the dynamic data exchange (DDE).
- On the basis of such transmitted data to the system of the CAD/CAE class, the platform model performs a specific move.
- It is assumed that the platform, at the start of movement, is in its intermediate position (in the middle of movement ranges for each axis).

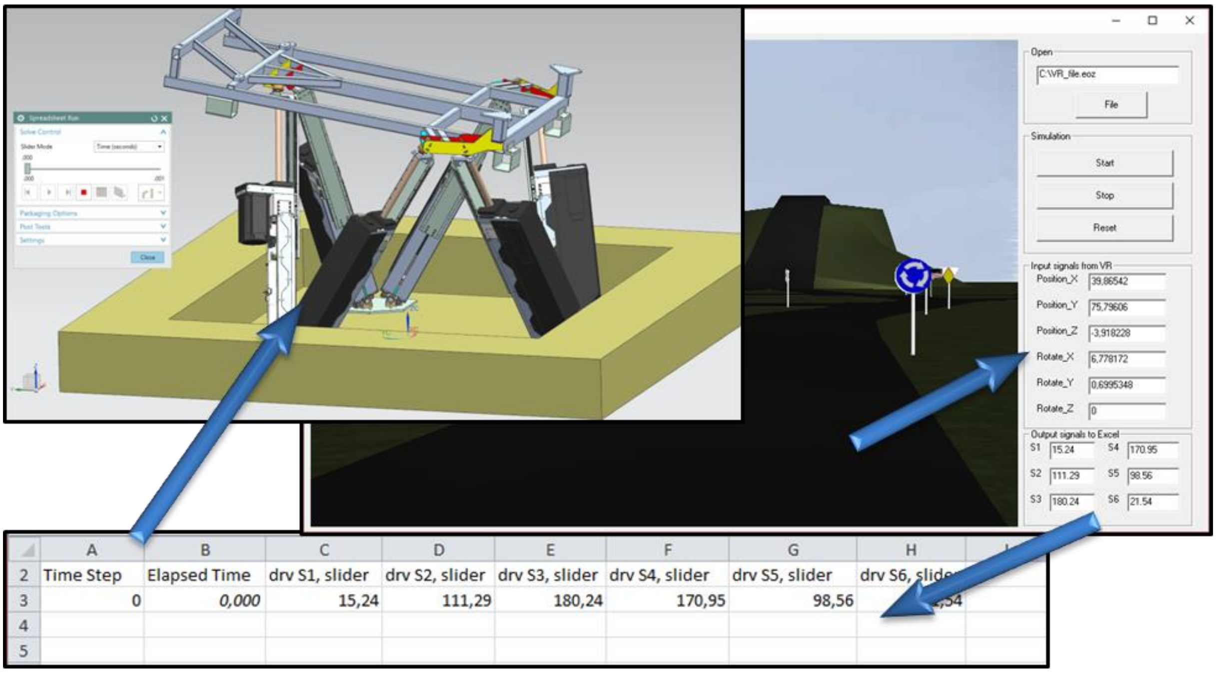

Figure 5. Control of the platform system.

5. Conclusion

The elaborated method of integration the virtual model of the Stewart platform, which is prepared for motion simulation in the system of the CAD/CAE class with the avatar of a car moving in a virtual environment of the VR class system, allows mapping the behavior of a real car in a traffic by the movements of the platform simulator.

The created model of the Stewart platform, prepared for the motion simulation in the module "Motion Simulation" could be implemented to any work environment in the PLM Siemens NX system without loss the possibility of control.

The implemented control algorithm allows determining position of the platform on the basis of the position of the car avatar moving in a virtual reality.

The results of conducting virtual tests may allow for better matching the movements of the real actuator system of the simulator for driving learning.

The developed method of testing the behavior of the platform model using the integrative approach of the CAD class system with the VR class system, allows adjusting the behavior of the platforms depending on passed events in the virtual environment of the car without the risk of physical damage of the real system.

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