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On Virtual Integrated Model of a 6DoF Manipulator Arm for Emergency Cases Interventions

This research deals with a virtual integrated model for a 6DoF manipulator arm dedicated to use for emergency situations intervention. The virtual model can simulates both the entire structural and mechanical configuration of the manipulator, and the driving system with automated command unit. The basic idea supposes to develop a complex simulator for kinematical and dynamic behavior analysis of 6DoF robot manipulator, and for facilely cross correlation and comparative evaluation between essential parameters and extremely bearing cases defining the manipulator working state. The analysis was developed in Matlab© - SimScape© software. The conclusions dignify the main functional capability of the manipulator supposing the capacity of driving system and mechanical structure.

Keywords: *manipulator robot, integrated virtual model, emergency situations, dynamics, SimScape©*

1. Introduction

The manipulator arm proposed and analyzed by the authors is depicted in Figure 1. A schematic view (image from Autodesk-Inventor© software) of the entire ensemble is shown in Fig.1. The configuration of the proposed manipulator arm provides six degree of mobility. Rotational mobility for each of the six elements was adopted, thus that the type of this manipulator equipment is 6R.

The manipulator arm will be mounted on the bearer system and this additional system will assure the movement through and into the working area. But, for this research the virtual model does not include any bearer equipment. Hereby the arm support was fixed at ground.

The basic computational model with respect in Denavit - Hartenberg convention was depicted in Figure 2. The rotational joints was denotes with caps letters as follows: A' means the basic positional joint; A is the shoulder joint; B means the elbow joint; C-D-E denotes the wrist complex joint.

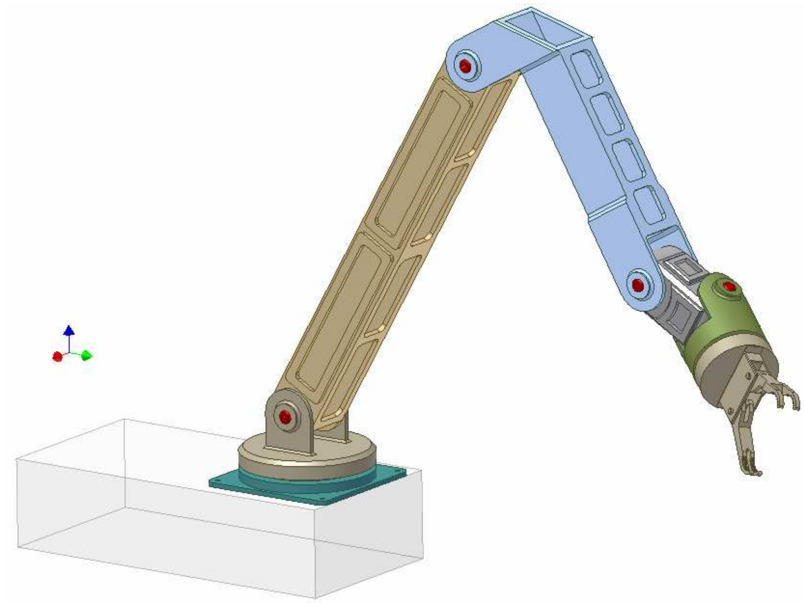


Figure 1. General view of the 6DoF manipulator arm model

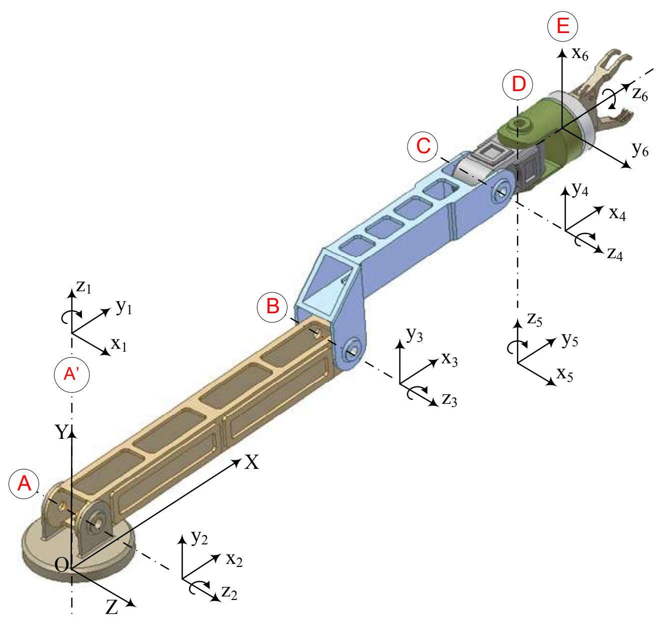


Figure 2. Computational model of 6R manipulator arm

The kinematical schematic diagram is depicted in Figure 3. The numerical symbols used in Fig.3 have the next signification: (0) support element; (1) rotational platform; (2) main arm; (3) handler; (4) coupler; (5) prehensile port-device; (6) prehensile main device.

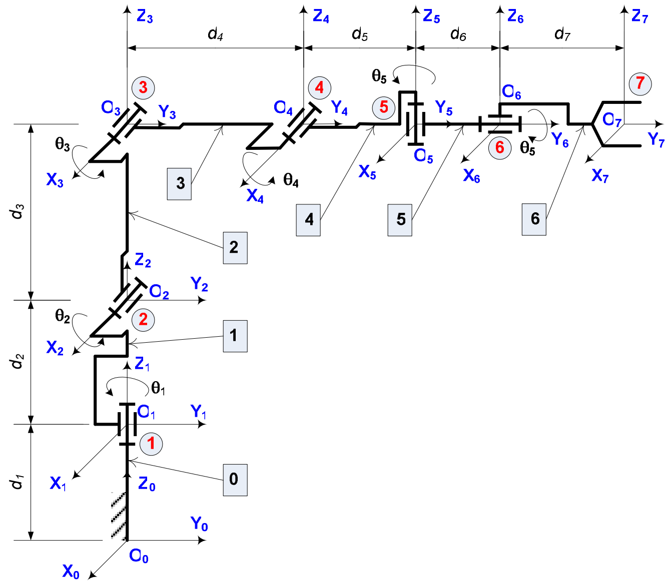


Figure 3. Kinematical diagram of 6R manipulator arm

2. Simulation Results

Assembling the suiting parts for each structural and functional component of the manipulator arm results a complete diagram depicted in Figure 4.

Complete testing of the virtual model for manipulator arm was performed by three steps as follows: first, the mechanical structure, using direct angular inputs for each rotational joint; second, the hydraulic driving system, for each actuator separately, and for the entire scheme working simultaneous after that; third, the complete model, with mechanical parts driven directly through the hydraulic actuators and manually operating by imposed angular references.

A simple behaviour test example, performed especially for mechanical ensemble analysis, was depicted in Figure 5.

Figure 6 shows the basic performance envelopes for this manipulator arm, in plan view and elevation. These diagrams were effectively computed based on the virtual model simulation results.

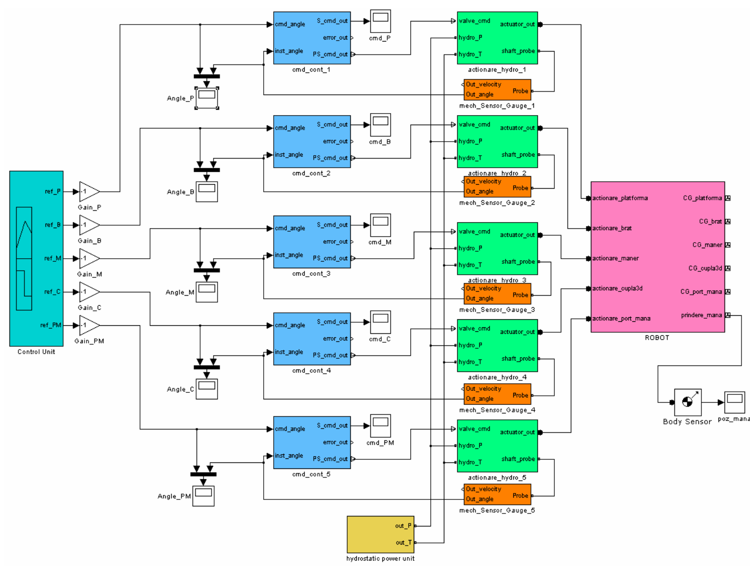
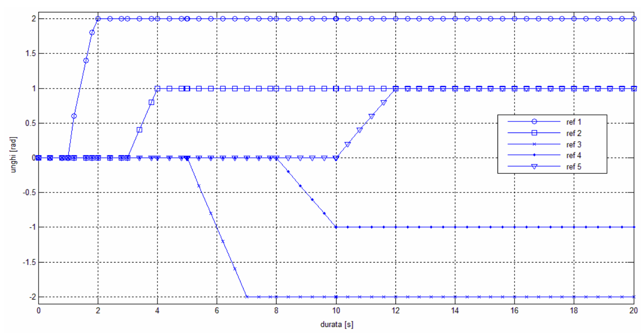
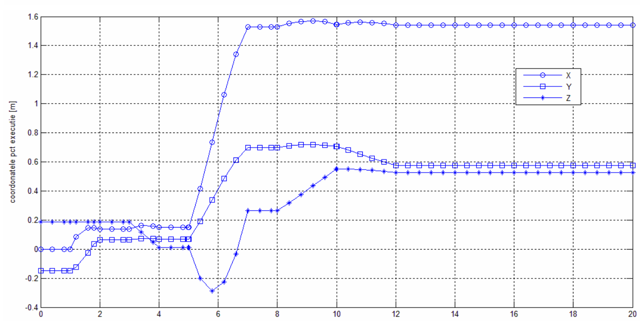


Figure 4. Complete Simulink© diagram of the 6R manipulator virtual model

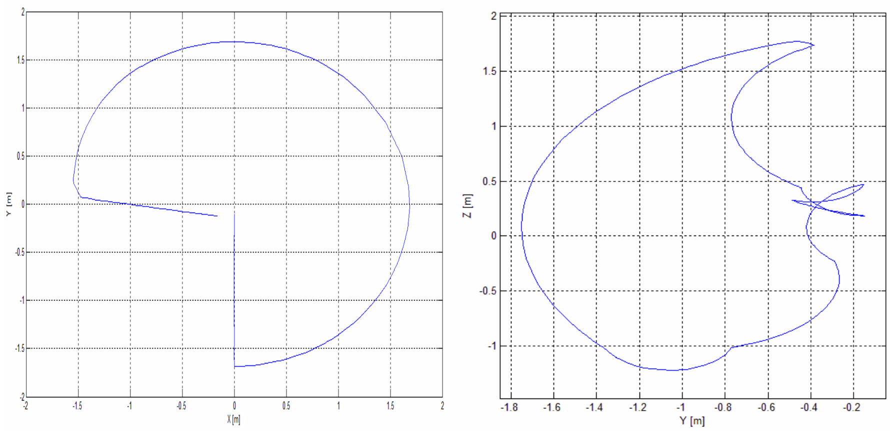


(a)



(b)

Figure 5. Test example: input signals (a) and final effector coordinates (b)



(a) (b)

Figure 6. Basic performance envelopes: (a) plan view and (b) elevation

3. Conclusions

The example shown in Fig. 5 denotes one of the multiple tests performed on 6DoF manipulator. It is a primer test of the virtual model utilization, and it was adopted because any of the others imposes a great number of diagrams in respect of the entire set of monitoring parameters which does not allow was being included in this paper.

The example given in Fig.5 reveals the capability of the proposed model to dignify completely the requirements of the dynamic behaviour of this proposed manipulator arm. The movement respects the input and the final effector coordinates acquires suiting timed evolution. General utilization of this model imposes simultaneous movements for each of the five elements. The virtual instrument can analyze both individual part behaviour, and the global evolution of the manipulator. Hereby the local dynamic aspects can be reveals for the involved components, and the general transitory states can be dignified both for hydraulic power unit and for effective execution of the command.

The envelopes depicted in Fig. 6 was obtained for basic extremely condition in relationship with the maximum capability of angular movement for each joint. It was excluded the sixth degree of freedom because it have not any influences on global envelope capability and requires additional computational resources.

From the graphs depicted in Fig. 6 results that this kind of manipulator arm respect the classical envelope shape for this category of serial open chain manipulators both on plan view, and on elevation view. Limit values of the two areas cover by the entire robot arm results directly from the length capacity of each main linkage such as main arm, handler and entire gripper device.

The conclusions of this work frame the capacity of the presented virtual model to dignify the complete and complex dynamics of a multiple degree of mobility manipulator arm. The facilely developing procedure of the virtual model using mathematical computations software such as Matlab©-SimScape© can be observed in basic schematic diagram previous presented in this paper. This software also allows structural and hierarchical programming of the complex applications. Using specific toolboxes and elements for each design direction (mechanical, hydraulic, automation) offer the advantages of predefined and very well tested components which includes most of the desirable serviceable characteristics.

Finally it has to be mentioned that this virtual model was tested with the real parameters of two consecrate manipulator equipments.

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