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Design and Simulation of A 5-DOF Mobile Robotic Manipulator

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ABSTRACT
A mobile robotic manipulator is such a manipulator in which a robotic arm is mounted on a mobile base. Basic mobility greatly increases the size of the robotic work area and allows for better positioning of the manipulator for efficient execution of tasks. Developing and controlling a high performance robotic manipulator is one of the areas of interest in the industry. Effective control of each robot system begins with reliable modeling.This paper proposes a model and simulation of a 5 DOF robotic manipulator for Industrial Warehouse Management. The design of the mobile robotic manipulator is developed using SolidWorks software. This procedure also checks whether the model is true and whether it behaves in accordance with assumptions and requirements. The CAD model is then exported to MATLAB/Simscape which converts it to a multi-body system in the form of a block diagram. Furthermore, in order to obtain the dynamic parameters,a Simscape Multibody simulation is performed. Importing the CAD model into Simscape Multibody creates a basic simulation scheme. Then the PID controller is applied to the system to ensure positional control of the connections in the desired references in MATLAB / Simulink.

Keywords: Mobile Manipulator, Robotics, Computer Aided Design(CAD),

1. INTRODUCTION

As the online marketing and customer requirements is growing, the need for high-mix and low-volume warehouses has also grown. Therefore, the operational efficiency of such bearings must be improved. In such warehouses, picking of the object is the main jobs in which the ordered products are collected by moving them to multiple shelves within a large warehouse area. The physical strain on workers during this operation is not negligible. In order to reduce the operating costs for order picking, there are different types of automation systems[1], [2].

In the automation industry, industrial robots are being used for repetitive tasks instead of human resources because of their speed, precision, and cost-effectiveness. The manipulator's performance depends on the geometrical, environmental and technological constraints and other constraints inherent in the design of the robot and the type of task to be performed[3].

In robot manipulators, motion planning is a critical issue due to the limitations of the end effector. In contrast, the control of mobile robots depends on the geometric conditions of the wheel when the robot is in motion. To support the growth and expand the possibilities of industrial robotics, it makes sense to combine mobility capabilities with manipulation capabilities, creating mobile manipulators[4]. In addition, the mobile manipulator is a kind of robot that combines a manipulator with amobile platform. It has created a new concept and a new direction in the robot applicationand has been a hot topic of research in recent years.

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Mobile manipulators extend to a large extent the manipulator's work space and ability to work effectively [5], there are many applications, such as: for example, material transport in modern factories, the dismantling of bombs in dangerous situations, the movement of nuclear-infected objects, the maintenance of cities [6], military tasks [7], [8],etc. However, the combination of DOF and the mobile platform generally transforms the mobile manipulator into a redundant robot [9]. Therefore, it is necessary to consider a mobile robot application that can help us and serve us well in carrying out a daily task [10].

To solve these problems, we propose a mobile robotic manipulator for large, low volume warehouses. The paper is arranged as follows: Section 2 is related with modelling of the manipulator in Solidworks;section 3 describes the Simscape multibody simulation; section 4 presents the results and the article is concluded in section 5.

2. MODELING OF PICK AND PLACE MOBILE ROBOTIC MANIPULATOR IN SOLIDWORKS

A 5 degree of freedom robotic arm with mobile robotic manipulator was considered in this section for Industrial Warehouse Production. Effective control of robotic system begins withreliable modelling [11]. Each robotic manipulator component that is end-effector, base, andlinks was modeled separately and assembled to get the required results in SolidWorks software.The SolidWorks software design of the mobile robotic manipulator is given in Figure 1.

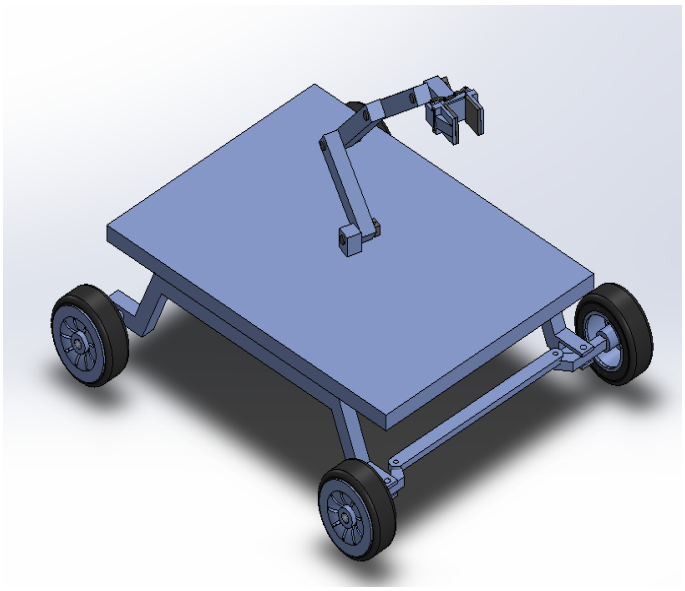

Figure 1.SolidWorks design

A controller block is required for the movement of the robot arm. Therefore, the controller block and reference block are connected to the robotic arm, as shown in the figure 2. The figure describes the control structure which can be used to achieve the desired objective by the robotic manipulator for industrial warehouse management.

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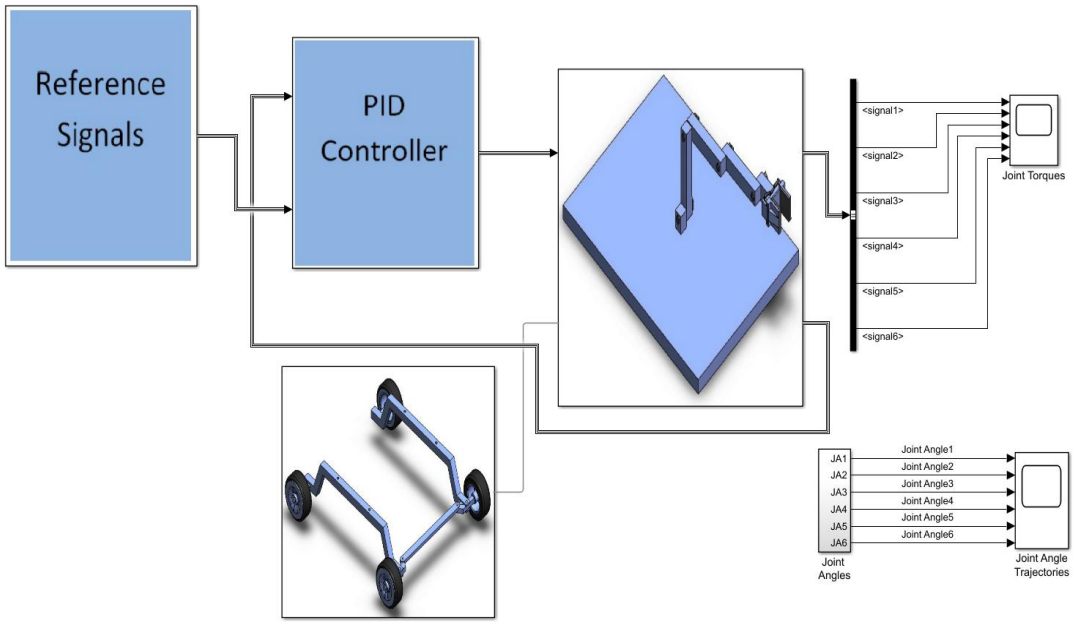

Figure 2.Block diagram with control structure

3. SIMSCAPE MULTIBODY SIMULATION

Simscape Multibody develops and solves motion equations on the basis of a CAD model system. The Simscape Multibody environment offers the freedom to alter the structure, optimize parameters of the system and examine the outcomes in less time. Simscape Multibody can import the CAD model from the SolidWorks modeling platform. The system dynamics are visualized in MATLAB / Mechanics Explorer using automatically generated 3D animation.

3.1 Simulation Methodology

The proposed mobile robotic manipulator CAD model was exported to MATLAB / Simscape Multibody from SolidWorks environment. The model was executable in the XML format using the command window MATLAB. A robot model with CAD blocks representing the prismatic and revolute joints istransformed into a block diagram.

3.2 Simulation Results

The mobile robotic manipulator model simulation is observed with the altered variable of the mobile manipulator structure in the Matlab/Simscape Multibody environment. The reconstructed Simscape Multibody block diagram to determine the position and torque of revolute joints as well as diagram of Robotic Manipulator during simulation is depicted in figure 3. The block diagram describes each joint and the control structure to determine the torque is also given.

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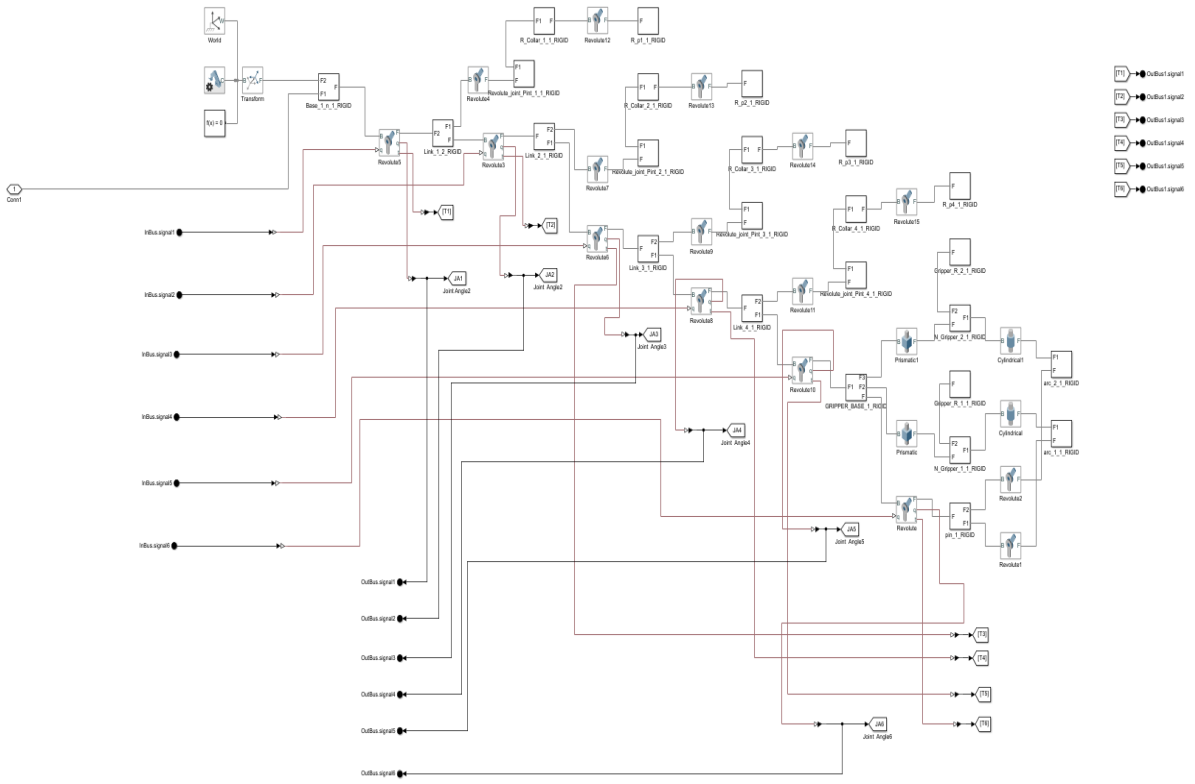

Figure 3.The reconstructed Simscape Multibody block diagram to determine the position and torque of revolute joints

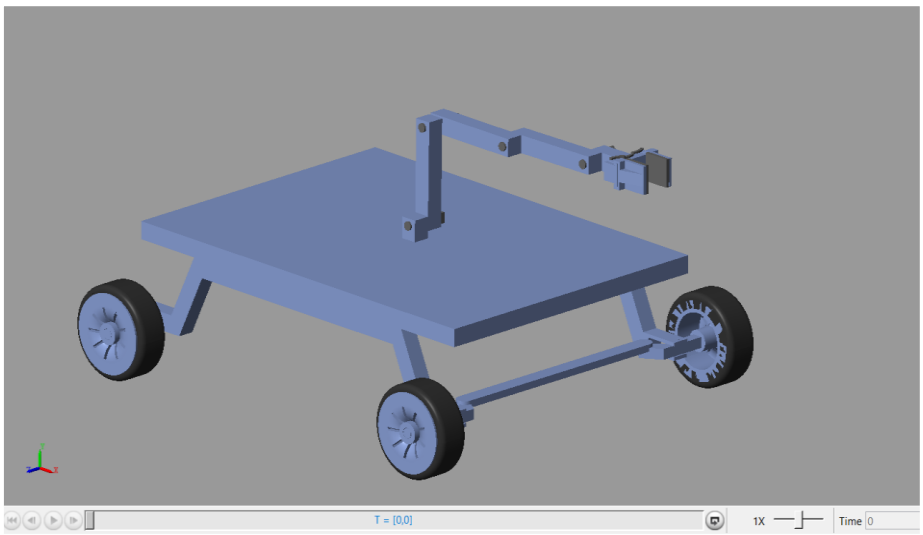

Figure 4.Robotic Manipulator during simulation

3.3 Simulation Results

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The robotic manipulator during simulation is given in figure 4. The simulation waveforms for the response of six PID's controller are given in Fig. 5-10. Theevolution of joint angle trajectories waveforms of robotic arm is depicted in figure 11.

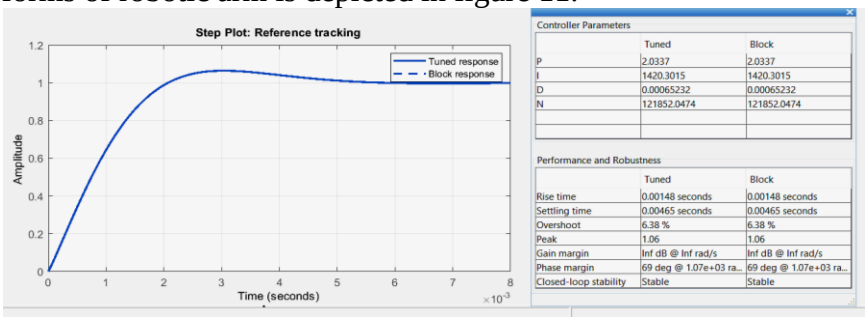

Figure 5.Response of PID Controller 1

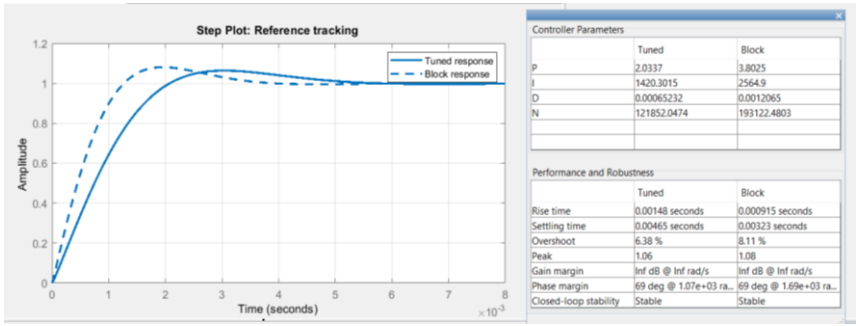

Figure 6.Evolution of output with PID Controller 2

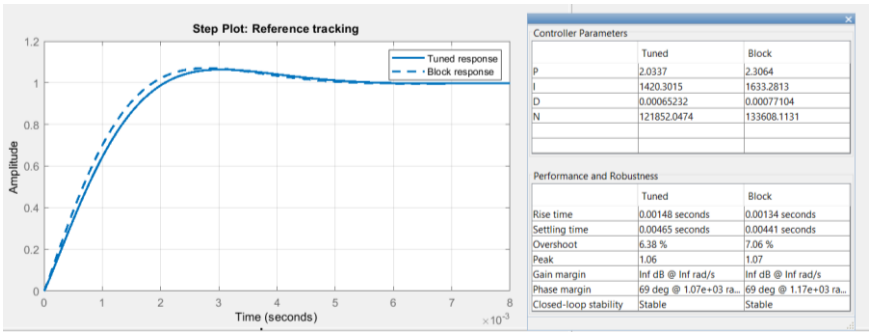

Figure 7.Evolution of output with PID Controller 3

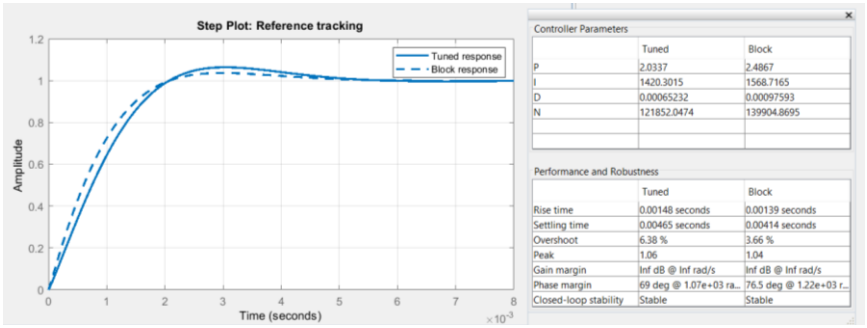

Figure 8.Evolution of output with PID Controller 4

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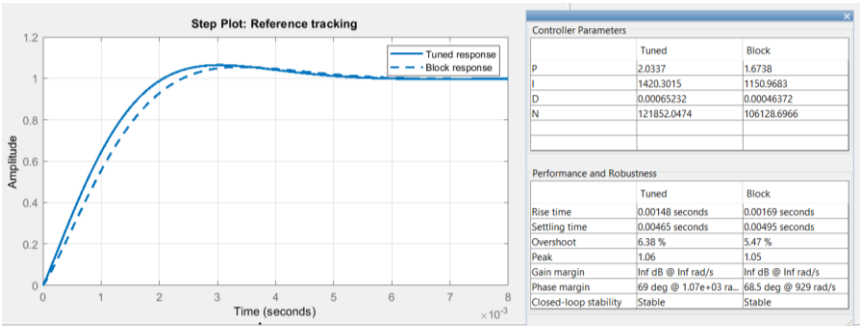

Figure 9.Evolution of output with PID Controller 5

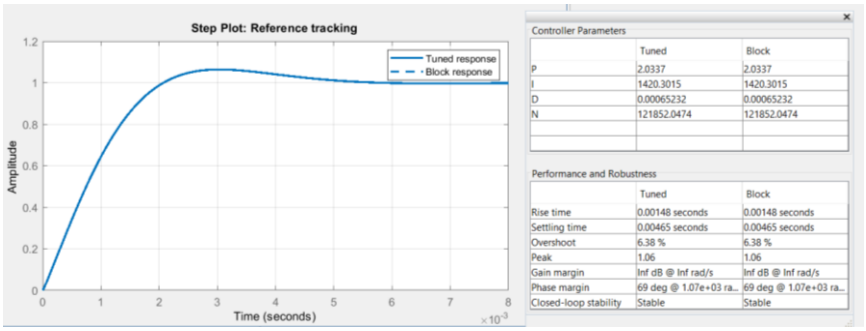

Figure 10.Evolution of output with PID Controller 6

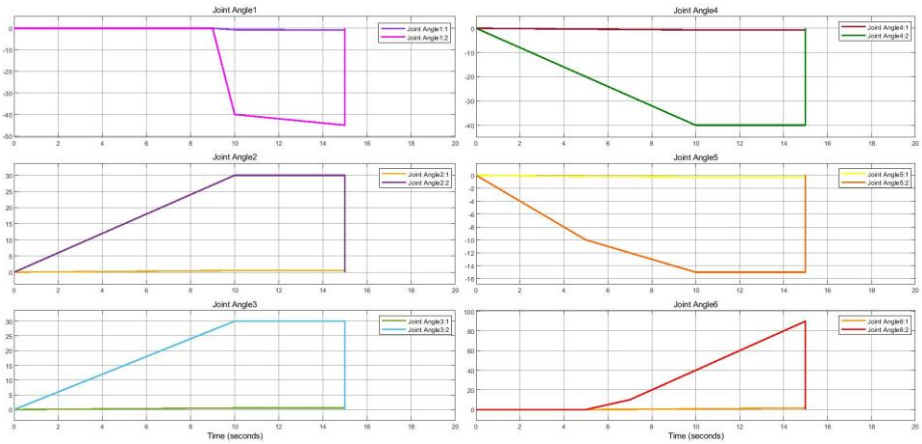

Figure 11.Evolution of Joint Angle Trajectories waveforms of robotic arm

4. CONCLUSION

This study presents the attempts by using CAD and MATLAB / Simscape Multibody Software from SolidWorks to model and simulate a mobile robotic manipulator. The representation of the robot's CAD model and the D-H parameters, a kinematic model has been developed to find the robotic arm positions attached to the mobile manipulator. The simulation was carried out in the MATLAB / Simscape Multibody.

The robotic arm simulation in Simscape Multibody carried out very easily and simulation results show a dynamic position and torque. The development of a robot with the desired

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configuration will, therefore, be economic and easier; this innovative research has produced good results.

REFERENCES

[1] N. Kimura *et al.*, "Mobile dual-arm robot for automated order picking system in warehouse containing various kinds of products," in *2015 IEEE/SICE International Symposium on System Integration (SII)*, 2015, pp. 332–338.

[2] E. Niewiadomska-Szynkiewicz and A. Sikora, "Progress in Automation, Robotics and Measuring Techniques," *Adv. Intell. Syst. Comput.*, vol. 351, pp. 181–190, 2015.

[3] C. Ding, P. Duan, M. Zhang, and H. Liu, "The Kinematics analysis of a redundant mobile manipulator," in *2008 IEEE International Conference on Automation and Logistics*, 2008, pp. 2352–2357.

[4] Z. Li and S. S. Ge, *Fundamentals in modeling and control of mobile manipulators*. CRC Press, 2016.

[5] S. Avilés *et al.*, "Simulation of a Mobile Manipulator on Webots.," *Int. J. Online Eng.*, vol. 14, no. 2, 2018.

[6] T. Kim, C. Ramos, and S. Mohammed, "Smart city and IoT." Elsevier, 2017.

[7] R. Sam, K. Arrifin, and N. Buniyamin, "Simulation of pick and place robotics system using Solidworks Softmotion," in *2012 International Conference on System Engineering and Technology (ICSET)*, 2012, pp. 1–6.

[8] I. Schwartz, "PRIMUS: autonomous driving robot for military applications," in *Unmanned Ground Vehicle Technology II*, 2000, vol. 4024, pp. 313–323.

[9] T. Tomizawa, A. Ohya, and S. Yuta, "Remote book browsing system using a mobile manipulator," in *2003 IEEE International Conference on Robotics and Automation (Cat. No. 03CH37422)*, 2003, vol. 1, pp. 256–261.

[10] B. Graf, U. Reiser, M. Hägele, K. Mauz, and P. Klein, "Robotic home assistant Care-O-bot® 3-product vision and innovation platform," in *2009 IEEE Workshop on Advanced Robotics and its Social Impacts*, 2009, pp. 139–144.

[11] S. M. Mariappan and A. Veerabathiran, "Modelling and simulation of multi spindle drilling redundant SCARA robot using SolidWorks and MATLAB/SimMechanics," *Rev. Fac. Ing. Univ. Antioquia*, no. 81, pp. 63–72, 2016.