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Modelling and Analysis of Manipulator System Having Two Links

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ABSTRACT

When it comes to massive machinery in industries and factories, an autonomous system is a must in order to keep up with market expectations. Robotization is an answer to all of the above-mentioned challenges. The construction of a full humanoid robot is a difficult work, but we may utilize robotic manipulators (the arms of the robot) as a replacement, which will give semi-automation and assist balance the scarcity of manpower. In this study, the design of a dynamical model for a manipulator is described in depth, and an optimization approach is also discussed in order to make it acceptable for application in industry. This manipulator might be used in welding, underwater robots, industries, painting, pot welding, and many other fields if an improved controller could manage the un-certainties and alter the parameter based on the external and internal disturbances.

Keywords: *Robotization; Humanoid; Manipulator; Multiple Links; Autonomous System.*

1.0 Introduction

There are several reasons why robotics is sorely required in the industrial environment. Because it is difficult for humans to learn and do specific tasks with flawless precision compared with robots, skilled labour scarcity is also a major concern. Another element is enhanced quality product, which is impossible to obtain by human means, such as by the use of robots. As a third reason, there is a lot of pressure to boost production rates to meet this demand, which necessitates the use of robots. The use of robots allows us to produce large quantities of goods in a shorter period of time while maintaining high quality. As a result, the waste generated during production is significantly reduced, and we are able to achieve lower reject rates and less waste than with traditional labor-intensive methods. In the last several years, robots have begun to function in real-world settings and to make life easier for humans. A vast variety of robotics applications may be found in almost every industry, from manufacturing to painting to welding to pick-and-place to working underwater. Robotics is an interdisciplinary area that encompasses a wide range of technical issues including design, modelling, invention, and programming. Nowadays, robots are also frequently employed in the medical area, where they have begun to replace human caregivers in hospitals. Robotics may be found in practically every facet of everyday life. The Czech word "robot" literally means "slave labour," and it first appeared in print in 1920. Human bodily components, in particular, are duplicated in robots by using a controller, which makes robots operate like machines. As a robotic manipulator, this human hand

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consists of three Hs: the human hand, heart, and head. This programmable and multi-functional gadget allows us to move and hold objects. We may use it in a variety of ways. There are two branches of robotics: [2] and [3]. To achieve high accuracy in manipulator trajectory tracking, we require high and improved control strategies in the fields of electronics and mechanical manufacturing, designing and kinematics, which aid in manipulator positioning and orientation. Dynamic models of robotic manipulators also play an important role. Two link stiff robotic manipulators are employed in industry, and a second-order non-linear differential equation is being used to build a dynamic model for the two-link rigid manipulator [5]. A separate control system was required to regulate the manipulator's position and speed, which proved more difficult for control engineers as the number of linkages rose in complexity [6].

2.0 Literature Review

Nonlinear systems are more difficult to govern because of their complexity. With the advancement of technology, the control sector has benefited from the combination of a typical PID controller with artificial intelligence. A two-link manipulator's perfect trajectory tracking has been made possible thanks in large part to advances in feedback-based feedback control (FBFD). While using PSO, Z. Kong and his colleagues were able to minimise the number of normal parameters inside a soft set in a very short period of time, while also boosting the efficiency of dispensable core-related parameters. I'm here to assist you out in [13] if you need it. A Ghanbari et.al used genetic algorithms, fuzzy controls, and ant colony optimization in this study. This algorithm is very flexible and responsive. There's a good chance that this approach will improve both the precision and the consistency of the results. The firefly algorithm was utilised by K. Jagatheesan et al. in [14]. The algorithmic performance is improved by increasing the number of iterations, but this strategy takes longer to settle. According to [15], the cuckoo search strategy was employed to precisely specify parameters when comparing it to other algorithms like GA or PSO. It is also possible that using cuckoo in conjunction with other algorithms might be quite helpful when attempting to solve NP-hard issues. To create a better algorithm, researchers drew on the echolocation of bats. Slide mode and fuzzy logic were combined in an unique way to control the manipulator by Ohtani and his colleagues, who used the sliding mode concept together with fuzzy logic to control the manipulator. The fuzzy rule may be fine-tuned indefinitely using this way as a teaching tool. As a result of eliminating overshoot, hardly affecting rise time, and having the greatest disturbance rejection, A. Hazzab introduced a hybrid fuzzy/classic PID controller. The approach proposed by Sharma et al. combines proportional order PID with fuzzy logic of fractional order. Models of two-link manipulators are presented by Lin in An paper by George Thuruthel, Thomas, and colleagues provides an overview of the various control algorithms that may be used for soft robotic manipulators . In Zhang, Shuang et al. successfully dealt with nonlinearity and uncertainty by using adaptive neural control for robotic manipulators. Zhang, Shuang, and colleagues used adaptive neural control for the control of robotic manipulators. Xiao Bing et al. investigated how to keep track of a robotic manipulator's kinematics and dynamics as they changed. Khairudin mohammad et al. did a research on how to manage flexible robotic manipulators since they are more challenging to operate than rigid robotic manipulators.

3.0 Manipulator Dynamics

By the help of the equations given below a dynamic model has been developed

$$\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}\begin{bmatrix} \ddot{\theta}_{11} \\ \ddot{\theta}_{22} \end{bmatrix}+\begin{bmatrix} P_{11} \\ P_{21} \end{bmatrix}+\begin{bmatrix} f_{r1} \\ f_{r2} \end{bmatrix}+\begin{bmatrix} fn_{1p} \\ fn_{2p} \end{bmatrix}=\begin{bmatrix} \tau f_{1p} \\ \tau f_{2p} \end{bmatrix} \quad \ldots(1)$$

Where

$$S_{11} = I_{1p} + I_{2P} + m_{11}l_{c1}^2 + m_{22}l_{c2}^2 + 2m_{22}l_{11}l_{c2}\cos\theta_{22} + m_{vp}l_{11}^2 + m_{vp}l_{22}^2 + 2m_{vp}l_{11}l_{22}\cos\theta_{22} \quad \ldots(2)$$

$$S_{12} = I_{2P} + m_{22}l_{c2}^2 + m_{22}l_{11}l_{c2}\cos\theta_{22} + m_{vp}l_{22}^2 + m_{vp}l_{11}l\cos\theta_{2222} \quad \ldots(3)$$

$$S_{21} = S_{12} \quad \ldots(4)$$

$$S_{22} = I_{2P} + m_{22}l_{c2}^2 + m_{vp}l_{22}^2 \quad \ldots(5)$$

$$P_{11} = -\,m_{22}l_{11}l_{c2}(2\dot{\theta}_{11} + \dot{\theta}_{22})\dot{\theta}_{22}\sin\theta_{22} - m_{vp}\,l_{11}l_{22}(2\dot{\theta}_{11} + \dot{\theta}_{22})\theta_{22}\sin\theta_{22} \quad \ldots(6)$$

$$P_{21} = m_{22}l_{11}\dot{\theta}_{11}^2 l_{c2}\sin\theta_{22} + m_{vp}\,l_{11}\dot{\theta}^2{}_{11}l_2\sin\theta_{22} \quad \ldots(7)$$

$$f_{r1=}b_{1vp}\theta_{11} \quad \ldots(8)$$

$$f_{r2} = b_{2vp}\dot{\theta}_{22} \quad \ldots(9)$$

$$fn_{1p} = m_{11}l_{c1}g\cos\theta_{11} + m_{22}g(l_{c2}\cos(\theta_{11} + \theta_{22}) + l_{11}\cos\theta_{11} + m_{vp}g(l_{22}\cos(\theta_{11} + \theta_{22}) + l_{11}\cos\theta_{11} \quad \ldots(10)$$

$$fn_{2p} = m_{22}l_{c2}g\cos(\theta_{11} + \theta_{22}) + m_{vp}l_2 g\cos\ (\theta_{11} + \theta_{22}) \quad \ldots(11)$$

Final equations

$$\ddot{\theta}_{11} = \frac{\tau f_{1p} - f_{n1p} - f_{r1} - P_{11} - S_{12} * \ddot{\theta}_{22}}{S_{11}} \quad \ldots(12)$$

$$\ddot{\theta}_{22} = \frac{\left(\tau f_{2p} - f_{n2p} - f_{r2} - P_{21} - S_{12} * \ddot{\theta}_{11}\right)}{S_{22}}$$

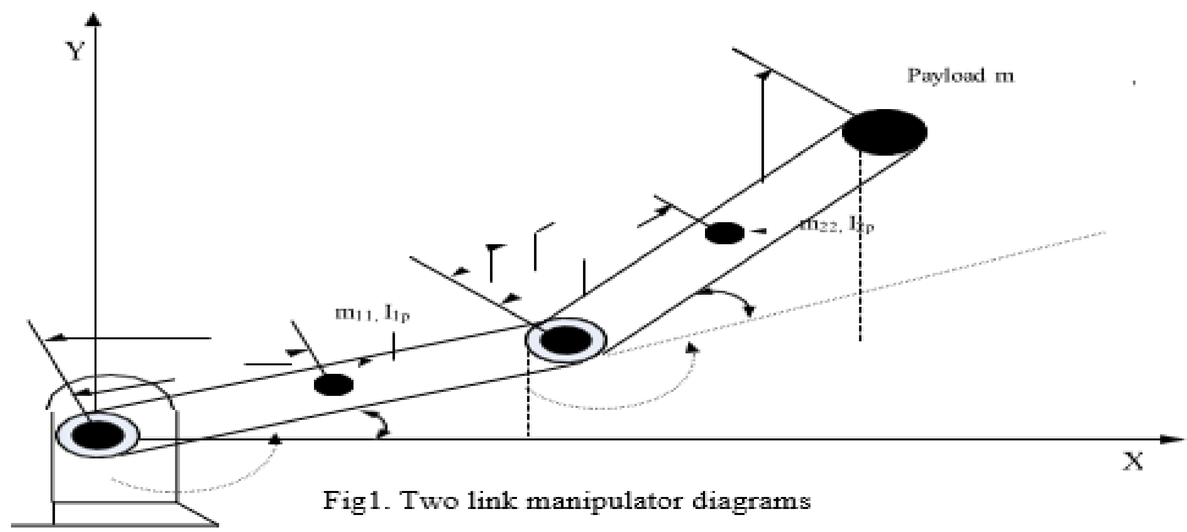

Fig1. Two link manipulator diagrams

4.0 Manipulator Dynamics and Modelling

MATLAB/SIMULINK is the programme we're using to assist us develop this dynamic model since it offers a vast library of tiny blocks of adder/subtractor/and many more operators. It was necessary to begin by simplifying equations and arranging them in terms of theta, and it was from these two final equations that an individual dynamic model for each block was constructed.

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Fig 2: Simulink Model of Controller

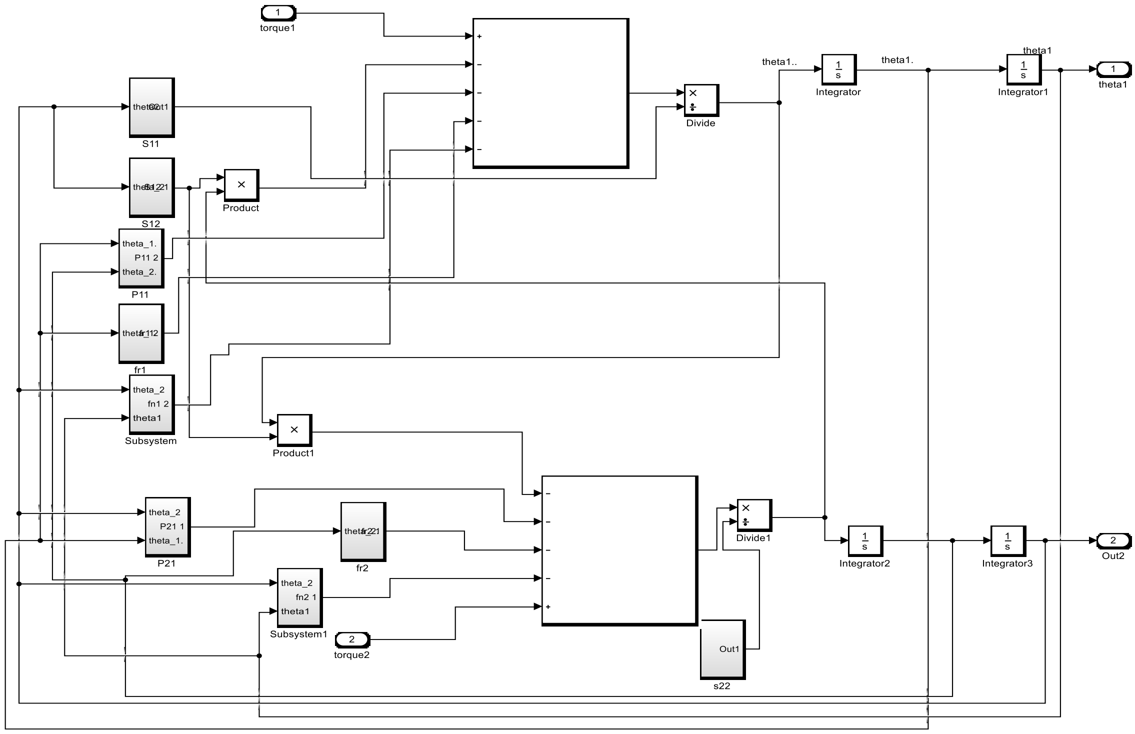
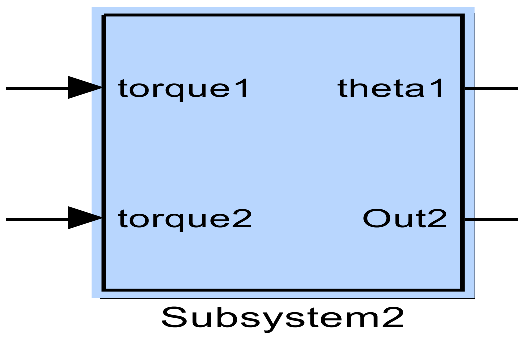


Fig 3: Schematic Diagram Explaining the System



5.0 Conclusion

A dynamic robotic manipulator model was investigated in this study, and we also learned about the kinematics involved. Two link stiff robotic manipulator dynamic model using Simulink was built to handle this dynamic model after a comprehensive analysis of the manipulator's orientation and location.the tuning of this manipulator has been done with the help of genetic algorithm In today's scenario, where the world is moving towards automation, we should be extremely cautious when choosing the tuning algorithm, especially after designing a dynamic model. It is difficult to attach a precise and powerful controller to the plant that could deal with non-linearites and uncertainties. CSA, PSO, and genetic algorithms are just a few of the various tuning methods available today for optimising a computer programme.

References

1. M. W. Spong, M. Vidyasagar, Robot Dynamics and Control, 2nd Edition, John Wiley and Sons,2004.

2. M. Gopal. Digital Control and State Variable Methods, 3rd edition, Tata McGraw Hill,2009.

3. RachidManseur, Robot Modeling and Kinematics, Firewall Media, 96-100,2007.

4. M. W. Spong, Seth Hutchinson and M. Vidyasagar, Robot Modeling and Control, 1st Edition, John Wiley &Sons,Inc.

5. M. Loudini, "Modeling and Intelligence Control of an Elastic link Robot manipulator, " Int. J. Adv. Robot System, vol. 10, pp. 1-18, January 2013

6. A. F. Amer, E.A. Sallam, W. M. Elawady, "Adaptive Fuzzy Sliding Mode Control usingSupervisoryFuzzyControlfor3DOFplanerRobotmanipulators,"Appl.Soft Compt., vol. 11, pp. 4943-4953, December2011.

7. Sayahkarajy, M., Mohamed, Z., & Mohd Faudzi, A. A. (2016). Review of modelling and control of flexible-link manipulators. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 230(8), 861-873.

8. V. Kumar, K.P.S. Rana, J. Kumar. Mishra and S.S. Nair, "A robust fractional order fuzzy *P*+ fuzzy *I*+ fuzzy D controller for nonlinear and uncertain system," *International Journal of Automation and Computing ,* vol. 14, no. 4, pp. 474-488, August 2017.

9. V. Kumar and K.P.S. Rana, "Nonlinear adaptive fractional order fuzzy PID control of a 2-link planar rigid manipulator with payload, "*Journal of the Franklin Institute vol. 354, no. 2, pp. 993-1022,* 2017

10. Dwivedy, S. K., & Eberhard, P. (2006). Dynamic analysis of flexible manipulators, a literature review. Mechanism and machine theory, 41(7), 749-777.

11. D.S. Weile,& E. Michielssen. "Genetic Algorithm Optimization applied to electromagnet-ics," A review. IEEE Transactions on Antennas and Propagation, Volume: 45 , Issue: 3 , Mar 1997C. I-Chuan; Y. Jeng-Rern, "2 – 13GHz broadband CMOS low voltage mixer with active balun designed for UWB systems," *IEEE International Conference on Electron De-vices and Solid-State Circuits 2010*, pp.1-4, 15-17 Dec. 2010.

12. Z. Kong, JiaWenhua, Zhang Guodong& Wang Lifu. "Normal parameter reduction in soft set based on particle swarm optimization algorithm". Applied Mathematical Modelling, Volume 39, Issue 16, August 2015

Doi: 10.51976/jfsa.111804

13. A Ghanbari,SMRKazemi, F Mehmanpazir.,& MM Nakhostin. “A cooperative ant colony optimization-genetic algorithm approach for construction of energy demand forecasting knowledge based expert systems”. Knowledge-Based Systems, Volume 39, February 2013

14. Zebin, T., & Alam, M. S. (2010, December). Dynamic modeling and fuzzy logic control of a two-link flexible manipulator using genetic optimization techniques. In 2010 13th International Conference on Computer and Information Technology (ICCIT) (pp. 418-423). IEEE.

15. X.S. Yang, & S. Deb, “Cuckoo Search via Lévy Flights. Proceedings World Congress on Nature & Biologically Inspired Computing,” India, 978-1-4244-5053-4,january 2009