UNIVERSITI TEKNOLOGI MARA

DESIGN AND IMPLEMTATION OF A REAL-TIME ADAPTIVE LEARNING ALGORITHM CONTROLLER FOR A 3-DOF PARALLEL MANIPULATOR

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of the requirements for the degree of
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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 6th October 2015 to conduct the final examination of Mustafa Jabbar Hayawi on his Doctor of Philosophy of Mechanical Engineering thesis entitled " Design and Implementation of a Real-Time Adaptive Learning Algorithm Controller of a 3-DOF Parallel Manipulator" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners was as follows:

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

A parallel manipulator is a closed loop mechanism which consists of a moving platform that is connected to a fixed base by at least two kinematic chains in parallel. Parallel manipulators can provide several advantages, such as high stiffness, high accuracy, and low inertia but also have some disadvantages, such as small workspace, complicated structures, a high cost, and also pose a major challenge to their analysis and control. To overcome the above shortcomings, progress on the development of parallel manipulators with less than 6-DOF has been accelerated. In this thesis, a new parallel manipulator with three degrees of freedom DOF is designed. Kinematic of the manipulator including inverse kinematic, Jacobian matrix and velocity equation are analyzed. Performance indices such as workspace, dexterity and stiffness, of the parallel manipulator are studied. The parallel manipulator is optimized based on the performance indices to obtain on the optimal design parameters for achieved maximum performance of the parallel manipulator. A prototype was fabricated to demonstrate the manipulator. An electronic board, transistor relay driver circuit, is designed for the purpose of establishing communication interface between the computer, adaptive learning algorithm and the actuator mechanism. Design and development an adaptive learning algorithm controller ALAC of position the actuators is presented in real time parallel manipulator based on artificial neural network ANN. The control of a parallel manipulator based on joint space control is implemented by determine the lengths of the electrohydraulic actuators EHA individually. EHA are known to have nonlinear parameters and dynamic factors such as frictions, load variations and leakage. These effects, if not controlled, would lead to large scale oscillations that would damage system components. System identification is a prerequisite to analysis of a dynamic system. It is performed using neural network Auto Regressive with eXogenous (NNARX) model based on the input/ output experimental data. There some criteria such as loss function, Aikeke's Information Criterion, goodness of fit and correlation analysis of the residual are analyzed to determine the adequate model for representing the EHA. The real time ALAC is coded in MATLAB/ SIMULINK and consists of two inverse ANN, feed forward neural network ANN1 and feedback network ANN2, and proportional feedback controller (P). The ANN2 is used to update the weights and biases online while ANN1 is used to implement the controller. P-controller is designed to improve the controller system and ensure the stability. The updated weights and biases of the ANN1 are same set obtained ANN2. The results of the proposed controller were compared with direct inverse neural controller DINC. It was found from experimentation that the ALAC was able to improve the position control of the parallel manipulator and adjusted the weights according to changing condition and control the system without any changes in the controlling algorithm. It is still effective with few overshoot compared with DINC.

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