UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK TOPOLOGY FOR GENERATING THE MOTION OF ROBOTIC MANIPULATOR

ANG CHUN KIT

DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK TOPOLOGY FOR GENERATING THE MOTION OF ROBOTIC MANIPULATOR

By

ANG CHUN KIT

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy.

July 2014

DEDICATION

I dedicate this thesis to my best companion, Ms. Ong Yien Yien and my family for their endless support and encouragement

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK TOPOLOGY FOR GENERATING THE MOTION OF ROBOTIC MANIPULATOR

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Chair: Assoc. Prof. Tang Sai Hong, PhD
Faculty: Engineering

Motion planning is an important issue in robot industry. Without an appropriate motion planning, a robot may be colliding with obstacles or passing through undesirable points. In order to control the motion of a robot manipulator, a person has to possess the knowledge of kinematics, dynamics, and trajectory planning. However, there are two main problems in using conventional methods. Firstly, the equations are hard to be derived and the calculations are complex. Secondly, the characteristics of different trajectories are different and there is no mathematical solution for unknown trajectory. Hence, the first objective in this research is to simplify the complex calculations in terms of solving kinematics and trajectory planning issues simultaneously. Another objective of this research was to help in computing the motion of a manipulator even though the characteristic of the trajectory is unknown. In order to achieve these research goals, artificial neural network (ANN) was proposed as a solution.

In the early stage, a virtual manipulator was developed and subjected to different primitive trajectories. In order to examine the ability of ANN in tracking the motion of a robot manipulator, a primitive ANN would be used to track the moving path of the virtual robot manipulator's end effector in the virtual environment. This ANN was developed based on the fundamental of back-propagation neural network (BPNN) topology. The topology of ANN would be modified for reducing the errors and deviations. Eventually, the developed ANN would be validated through a real time 5 catalyst robot. Besides, obstacle avoidance planning would be integrated into the developed ANN. Virtual obstacles would be allocated within the robot's workspace randomly and the performances of developed ANN would be observed through simulation experiments.

The results indicated that ANN possessed ability in tracking the motion of a robot manipulator in terms of solving kinematics and trajectory planning issues simultaneously and it was able to compute the motion of a manipulator even though the characteristic of the trajectory was unknown. Obstacle avoidance planning was integrated into the architecture of developed ANN for better performances and the results were satisfactory. With this developed method, a person is able to compute a safe path for a robot manipulator to avoid obstacles (objects which enclosed in a sphere).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN DAN PERKEMBANGAN TIRUAN TOPOLOGI RANGKAIAN NEURAL UNTUK MENJANAKAN PERGERAKAN MANIPULATOR ROBOTIK

Oleh

ANG CHUN KIT

Julai 2014

Pengerusi: Prof. Madya Tang Sai Hong, PhD
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Perancangan gerakan merupakan satu isu penting dalam industri robot. Tanpa perancangan gerakan yang sesuai, robot akan berlanggar dengan halangan atau melalui laluan yang tidak diingini. Dalam usaha untuk mengawal pergerakan manipulator robot, seseorang perlu mempunyai pengetahuan dalam kinematik, dinamik, dan perancangan trajektori. Walau bagaimanapun, terdapat dua masalah utama dalam menggunakan kaedah konvensional. Pertama, persamaan sukar untuk diperolehi dan pengiraan adalah kompleks. Kedua, ciri-ciri trajektori yang berlainan adalah berbeza dan tidak ada apa-apa penyelesaian matematik untuk trajektori yang mempunyai ciri-ciri yang tidak tentu. Jadi, objektif utama untuk kajian ini ialah mempermudahkan pengiraan kompleks dari segi kinematik dan menyelesaikan isu-isu perancangan trajektori secara serentak. Satu lagi objektif kajian ini adalah untuk membantu dalam pengiraan pergerakan manipulator walaupun ciri-ciri untuk trajektori tersebut tidak diketahui. Dalam usaha untuk mencapai matlamat kajian ini, Rangkaian neural tiruan telah dicadangkan sebagai penyelesaian.

Pada peringkat awal, manipulator maya telah dibina dan tertakluk kepada trajektori primitif yang berbeza. Dalam usaha untuk memeriksa keupayaan rangkaian neural tiruan dalam mengesan gerakan manipulator robot, satu rangkaian tiruan primitif akan digunakan untuk mengesan laluan tangan manipulator maya ini dalam persekitaran maya. Rangkaian neural tiruan ini akan dibinakan berdasarkan asas rangkaian neural penyebaran belakang. Topologi rangkain neural tiruan akan diubahsuai untuk mengurangkan kesilapan-kesilapan dan penyelewengan. Akhirnya, rangkaian neural tiruan yang dibina itu akan disahkan melalui robot sebenar. Selain itu, perancangan bagi mengelakkan halangan akan disepadukan dalam rangkaian neural tiruan. Halangan maya akan diletakkan dalam ruang kerja robot secara rawak dan prestasi rangkaian neural tiruan akan diperhatikan melalui eksperimen simulasi.

Keputusan menunjukkan bahawa kaedah rangkaian neural tiruan baru ini memiliki keupayaan untuk mengesan gerakan manipulator robot dari segi kinematik dan menyelesaikan isu-isu perancangan trajektori dengan serentak dan ia mampu mengira pergerakan manipulator walaupun ciri-ciri trajektori itu tidak diketahui. Perancangan mengelakkan halangan telah disepadukan ke dalam senibina rangkaian neural tiruan

untuk prestasi yang lebih baik dan keputusannya adalah memuaskan. Dengan kaedah ini, seseorang itu dapat mengira laluan yang sesuai untuk manipulator robot untuk mengelakkan halangan (objek dalam sfera).

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Finally, for those people who are not mentioned above but have given me a hand, I would also like to say a word of thanks for their contribution in this research.

I certify that a Thesis Examination Committee has met on 11 July 2014 to conduct the final examination of Ang Chun Kit on his thesis entitled "Development of an Artificial Neural Network Topology for Generating the Motion of Robotic Manipulator" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

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