UNIVERSITI PUTRA MALAYSIA

GENETIC ALGORITHM BASED MASS DISTRIBUTION OPTIMIZATION OF QUADRUPED LEG FOR WALKING PERFORMANCE ENHANCEMENT

LOO SHING YAN

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GENETIC ALGORITHM BASED MASS DISTRIBUTION OPTIMIZATION OF QUADRUPED LEG FOR WALKING PERFORMANCE ENHANCEMENT

By

LOO SHING YAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

December 2013

DEDICATION

This thesis is dedicated to my parents

And my wife.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

GENETIC ALGORITHM BASED MASS DISTRIBUTION OPTIMIZATION OF QUADRUPED LEG ROBOT FOR WALKING PERFORMANCE ENHANCEMENT

By

LOO SHING YAN

December 2013

Chair: Assoc. Prof. Tang Sai Hong, PhD
Faculty: Institute of Advanced Technology

In previous research works, legged robots are typically induce stable locomotion in active compliance and passive compliance approaches. In order to realize active compliance locomotion, the detail studies on robot hardware and environmental factors are required. Hence, a controller is designed to tailor for specific environment. Therefore, designing an all-rounded controller is extremely challenging. On the contrary, passive compliance locomotion relies on the advantage of its own body. Passive compliance mechanism that currently adopted in legged robot such as spring-damper mechanisms, flexible links and components, and adjustable joint stiffness are used to store and release the impact from the environment. Therefore, stable locomotion can be acquired. However, morphological effect on locomotion is an important issue to study.

In this thesis, the study is focused on another approach that utilize the advantage of the robot body to achieve stable locomotion, which is mass distribution of the robot. Genetic algorithm is used to search for the optimal mass distribution that carried out the farthest walking distance on various terrains. In this experiment, quadruped is used to perform repetition tests in simulated environment. In the conditions of fixed walking cycle, preset walking pattern and limited torque generation in actuators, genetic algorithm is adopted to optimize the walking distance of the robot by varying the masses of torso, upper limb and lower limb, ranging from 0.01kg to 5kg. The predefined joint trajectories are generated using Matsuoka neural oscillator network as the central pattern generator of the quadruped. Open Dynamics Engine is adopted for legged robot simulation. The robot is programmed to walk on flat terrain, inclined terrains of 0.1 radian and 0.15 radian, and declined terrains of 0.1 radian and 0.15 radian with different mass distribution, in which the value of the masses (torso, upper limb, and lower limb) are stored in the chromosomes. Thus, it allows genetic operators to take control of the information for optimization.

According to the experiment results, it shows that the mass distribution of the robot substantially affect the walking distance of the robot. It also demonstrates that genetic algorithm successfully implemented to enhance walking performance by maximizing the walking distance in prefix conditions. It also leads to a conclusion that intelligently manipulation of mass distribution can extend walking distance significantly.

Abstract tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

ALGORITMA GENETIK BERASASKAN PENGOPTIMUMAN JISIM PENGAGIHAN ROBOT KUADRUPED UNTUK PENINGKATAN PRESTASI PERJALANAN

Oleh

LOO SHING YAN

Disember 2013

Pengerusi: Assoc. Prof. Tang Sai Hong, PhD
Fakulti: Institut Teknologi Maju

Dalam karya-karya penyelidikan sebelumnya, robot berkaki biasanya menjanakan pergerakan stabil dengan pematuhan aktif dan pematuhan pasif. Dalam usaha untuk merealisasikan pergerakan pematuhan aktif, kajian terperinci mengenai perkakasan robot dan faktor-faktor alam sekitar yang diperlukan untuk mereka bentuk pengawal yang tertentu untuk robot berkaki terhadap alam sekitar tertentu. Oleh itu, reka bentuk pengawal sempurna adalah amat mencabar. Sebaliknya, pematuhan pergerakan pasif bergantung kepada kelebihan badan sendiri. Pematuhan mekanisme pasif yang kini digunakan dalam robot berkaki seperti pegas-peredam mekanisme, rangkaian dan komponen yang fleksibel, dan kekakuan laras sendi digunakan untuk menyimpan dan melepaskan tenaga dari persekitaran. Oleh itu, pergerakan stabil boleh diperoleh. Walau bagaimanapun, kesan morfologi pada pergerakan merupakan satu isu penting untuk belajar.

Dalam tesis ini, kajian ini memberi tumpuan kepada penggunaan kelebihan badan robot untuk mencapai pergerakan stabil, iaitu pengagihan jisim robot. Algoritma genetik digunakan untuk mencari pengagihan jisim optimum yang membenarkan jarak berjalan kaki yang paling jauh pada pelbagai keadaan jalan. Dalam eksperimen ini, berkaki empat digunakan untuk melakukan ujian ulangan dalam persekitaran simulasi. Dalam keadaan persekitaran, penjanaan corak berjalan yang tetap, dan tork motor yang terhad, algoritma genetik telah digunakan untuk mengoptimumkan jarak berjalan kaki robot dengan pengubahan jisim tubuh, anggota atas kaki, dan anggota bawah kaki dari 0.01kg ke 5kg. Trajektori diperoleh dari pengayun rangkaian saraf Matsuoka digunakan sebagai penjana corak robot berkaki. Open Dynamics Engine dipakaikan untuk simulasi robot berkaki. Robot yang diprogramkan untuk berjalan di atas kawasan yang rata, naik cerun pada sudut 0.1 radian dan 0.15 radian, dan turun cerun pada sudut 0.1 radian dan 0.15 radian dengan pengagihan jisim yang berbeza, di mana nilai jisim-jisimnya (tubuh, anggota atas kaki, dan anggota bawah kaki) disimpan dalam kromosom. Oleh itu, ia membolehkan operator genetik untuk mengawal maklumat bagi process pengoptimuman.

Menurut keputusan eksperimen, ia menunjukkan bahawa pengagihan jisim robot berkesan untuk memanjangkan jarak berjalan kaki robot. Ia juga menunjukkan bahawa algoritma genetik berjaya dilaksanakan untuk meningkatkan prestasi berjalan dengan memaksimumkan jarak berjalan kaki dalam keadaan yang ditetapkan. Kesimpulannya, mengawal pengagihan jisim secara bijak membolehkan jarak perjalanan robot dipanjangkan dengan ketara.

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Lastly, thanks to my parents for the financial support and courage to further my study. Also my friends who were helped me around. Without their help, I would not have attained my achievements today.

I certify that an Examination Committee has met on 23/12/2013 to conduct the final examination of Loo Shing Yan on his Master of Science thesis entitled "GENETIC ALGORITHM BASED MASS DISTRIBUTION OF QUADRUPED FOR WALKING PERFORMANCE ENHANCEMENT" in accordance with the Universities and University Colledges Act 1971 and Constitution of the Universiti Putra Malaysia [P. U. (A) 106] 15 march 1998. The Committee recommends that the candidate be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Khairol Anuar bin Mohd Ariffin, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Suhaidi bin Shafie, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Shamsudin Hj Mohd Amin, PhD
Professor
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
(External Examiner)

Zulkarnain Zainal, PhD
Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia
Date:

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

Tang Sai Hong, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

Syamsiah Binti Mashohor, PhD
Senior Lecturer
Faculty of Engineering
University Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

Declaration by graduate student

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