UNIVERSITI PUTRA MALAYSIA

HUMANOID FULL-BODY MOTION GENERATION BASED ON HUMAN GAIT USING EVOLUTIONARY PARETO MULTI-OBJECTIVE OPTIMIZATION

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By

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August 2012

Chair: Khairulmizam Samsudin, PhD

Faculty: Engineering

Designing and realizing artificial systems in human image have always been a fascinating idea for researchers. Humanoid robots with human-like expression are capable of executing tasks in complex environments within the living space of humans. The first and the most important motion for humanoid robot is the walking in a complicated and dynamically balanced manner which differentiates it from other robots. The primary motivation behind this work is to propose a more realistic full-body motion generation method based on learning and optimization in order to translate the recorded human motion to a dynamically feasible motion for a bipedal humanoid robot. Following the objective of this work, high quality captured human motions are used to show the trajectory sequence of robot joints movements. Evolutionary pareto multi-objective optimization method is used in this work in order to optimize an artificial neural network weights which is responsible of applying appropriate modifications on the reference motion lower-body based on the robot real-time sensory feedbacks. Evolutionary pareto multi-objective optimization method is applied to find an optimized artificial neural network based solution for translating the recorded rough walking motion to a dynamically

balanced one with maximum similarity to the human way of walking. Because of the numerous advantages of computer simulation, the simulated Sony QRIO humanoid in USARSim simulator is utilized in this work as a proper platform for mimicking human motions. According to the communication protocols in USARSim and by importing multithreading from Java to Matlab, a powerful Mobile Robots Communication and Control Framework (MCCF) is developed. It offers faster and easier communication process with the USARSim server within Matlab code. It takes the advantages of other analysis and control methods that have been provided in Matlab tool-boxes. Finally, a full-body motion generation method was introduced which is able to translate the original human motion data to a dynamically stable motion for a specific robot.

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

HUMANOID PENUH-BADAN USUL GENERASI MENGGUNAKAN GAIT MANUSIA BERDASARKAN EVOLUSI PARETO MULTI-OBJEKTIF PENGOPTIMUMAN

Oleh

SAEID MOKARAM GHOTOORLAR

Ogos 2012

Pengerusi: Khairulmizam Samsudin, PhD

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Mereka bentuk dan merealisasikan sistem kecerdikan buatan berdasarkan imej manusia telah sentiasa menjadi satu idea yang menarik bagi para penyelidik. Robot humanoid yang mempunyai ekspresi seperti manusia mampu melaksanakan tugas-tugas dalam persekitaran yang kompleks dalam ruang kehidupan manusia. Ciri-ciri gerakan manusia yang paling penting adalah kemampuan berjalan dengan cara yang seimbang serta rumit dan dinamik dan ini membezakannya dengan robot-robot yang lain. Motivasi utama di sebalik kerja-kerja ini adalah untuk mencadangkan penjanaan yang lebih realistik untuh gerakan penuh badan berdasarkan pembelajaran dan pengoptimuman untuk menterjemahkan gerakan manusia yang dirakam kepada gerakan dinamik yang sesuai bagi robot humanoid yang berkaki dua. Berikutan objektif kerja ini, pergerakan manusia berkualiti tinggi digunakan untuk menunjukkan urutan trajektori pergerakan sendi robot. Kaedah pengoptimuman evolusi Pareto digunakan dalam kerja-kerja ini untuk mengoptimumkan berat rangkaian neural tiruan yang bertanggungjawab membuat perubahan yang sesuai dengan merujuk kepada badan yang lebih rendah maklumbalas deria robot

menggunakan masa sebenar. Kaedah pengoptimuman evolusi Pareto pelbagai objektif digunakan untuk mencari penyelesaian rangkaian berasaskan neural tiruan yang optimum untuk menterjemahkan gerakan berjalan secara kasar yang dirakam kepada sesuatu yang dinamik seimbang dengan persamaan maksimum dengan perjalanan manusia. Oleh kerana simulasi komputer mempunyai banyak kelebihan, simulasi Sony QRIO humanoid di USARSim simulator yang digunakan dalam kerja ini sebagai platform yang sesuai untuk meniru pergerakan manusia. Berdasarkan protokol komunikasi USARSim dan dengan menggunakan thread berbilang dari Java ke Matlab, Mobile Robots Communication and Control Framework (MCCF) telah dibangunkan. Ia menawarkan kaedah komunikasi yang lebih cepat dan mudah dengan pelayan antara USARSim dan kod Matlab. Ia juga mengambil kelebihan analisis dan kaedah kawalan lain yang telah diperuntukkan dalam Matlab. Akhir sekali, kaedah generakan penuh-badan telah diperkenalkan yang mampu untuk menterjemahkan data gerakan asal manusia kepada gerakan yang dinamik dan stabil untuk sesebuah robot.

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I certify that a Thesis Examination Committee has met on 14 August 2012 to conduct the final examination of Saeid Mokaram Ghotoorlar on his thesis entitled "**Humanoid Full-Body Motion Generation Based On Human Gait Using Evolutionary Pareto Multi-Objective Optimization**" 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 Master of Science.

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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 **Master of Science**. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

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SAEID MOKARAM GHOTOORLAR

Date:

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