UNIVERSITI PUTRA MALAYSIA

TOPOLOGICAL MAPPING AND QUALITATIVE LOCALIZATION BASED ON K-ADJACENT UNION CLUSTERING ALGORITHM

BABAK KARASFI

ITMA 2012 12
TOPOLOGICAL MAPPING AND QUALITATIVE LOCALIZATION BASED ON K-ADJACENT UNION CLUSTERING ALGORITHM

By
BABAK KARASFI

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

October 2012
DEDICATION

To

My beloved wife Afsaneh
and two fruits of our lives my
beautiful daughter Parmida and
my sweet son Bardia
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
demand of the requirement for the degree of doctor of philosophy

TOPOLOGICAL MAPPING AND QUALITATIVE LOCALIZATION
BASED ON K-ADJACENT UNION CLUSTERING ALGORITHM

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October 2012

Chairman: Associate Professor Tang Sai Hong, PhD
Faculty: Institute of Advanced Technology

In robotic applications, localization and mapping as parts of the navigation
system are fundamental competence for mobile autonomous systems. The
position of the mobile robot is known as qualitative localization inside a
topological map, where the place recognition is an essential problem to
overcome. Previously, supervised place recognition approaches have been
used to solve global localization in offline mode. The aim of this thesis is to
develop a mobile robot topological mapping and qualitative localization
method based on unsupervised and fully appearance-based place recognition
approach. In this research, two different methods are designed and
implemented to answer the aim of this thesis. These methods focus on
perspective or omnidirectional image similarity based on local features or the
combination of global and local features which are identified as speed-up robust feature (SURF) and hue saturation intensity (HIS) color histogram. Moreover, proposed methods are spatial and sequential based place clustering methods (unsupervised learning) which are try to find the representative image that is more similar to the current adjacent robots query image. Therefore, the topological map graph of the place clusters can be created and qualitative localization can be performed over the topological map graph.

According to the experimental results, the average of recognition precision for the first offline proposed method is 95% and in a different illumination condition is 86%. Moreover this performance in the kidnapped robot experiment is more than 90%. The average of online place recognition percentage for the second online, incremental and expandable proposed method is 93.56% and in different illumination conditions is 86.06%. In addition, the average performance of the topological mapping and qualitative localization results, obtained from expanded-environment experiments is 91.71%. Considering all results, the proposed topological mapping and qualitative localization methods are robust, accurate, cost effective, portable, low power consumption, low weight, easy to install without any camera calibration and can be applied on various mobile robot platforms.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMETAAN TOPOLOGI DAN PENYETEMPATAN KUALITATIF BERDASARKAN ALGORITMA PENGELOMPOKAN KESATUAN K-BERSEBELAHAN

Oleh

BABAK KARASFI

October 2013

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Dalam aplikasi robotik, penyetempatan dan pemetaan sebagai sebahagian daripada sistem navigasi adalah kecekapan asas bagi sistem mudah alih autonimi. Kedudukan robot mudah alih alih dikenali sebagai penyetempatan kualitatif di dalam peta topologi di mana pengiktirafan tempat adalah satu masalah yang penting untuk diatasi. Sebelum ini, pendekatan pengiktirafan tempat diselia telah digunakan untuk menyelesaikan penyetempatan global dalam mod luar talian. Tujuan tesis ini adalah untuk membangunkan satu kaedah pemetaan topologi robot mudah alih dan penyetempatan kualitatif berdasarkan pendekatan tanpa pengawasan dan pengiktirafan tempat yang berasaskan penampilan sepenuh. Oleh itu, dua kaedah yang berbeza direka dan dilaksanakan untuk menjawab matlamat tesis ini. Kaedah-kaedah ini...
memberi tumpuan kepada perspektif atau persamaan imej berbilang-haluan berdasarkan cirri tempatan atau kombinasi cirri-ciri global dan tempatan yang dikenal pasti sebagai cirri peningkatan kelajuan teguh (SURF) dan keamatan warna tepu (HIS) histogram warna. Selain itu, kaedah yang dicadangkan adalah ruang dan berurutan kaedah berasaskan kelompok tempat (pembelajaran tanpa pengawasan) yang cuba untuk mencari imej wakil yang lebih serupa dengan robot semasa pertanyaan imej bersebelahan. Oleh itu, graf peta topologi kelompok tempat boleh dicipta dan penyetempatan kualitatif boleh dilakukan di graf peta topologi.

Menurut keputusan eksperimen, purata ketepatan pengiktirafan bagi kaedah pertama offline dicadangkan ialah 95%; dalam keadaan pencahayaan yang berbeza adalah 86% dan dalam eksperimen robot diculik adalah lebih daripada 90%. Purata peratusan pengiktirafan tempat dalam talian untuk kaedah kedua yang dicadangkan dalam talian, peningkatan dan diperkembangkan adalah 93.56% dan dalam keadaan pencahayaan yang berbeza adalah 86.06%. Di samping itu, prestasi purata pemetaan topologi dan keputusan penyetempatan kualitatif, yang diperolehi dari eksperimen diperluaskan-persekitaran adalah 91.71%. Memandangkan semua keputusan, cadangan pemetaan topologi dan kaedah penyetempatan kualitatif adalah teguh, tepat, kos efektif, mudah alih, penggunaan kuasa yang rendah, berat badan yang rendah, mudah untuk memasang tanpa
penentukuran sebarang kamera dan boleh digunakan pada pelbagai platform robot mudah alih.
ACKNOWLEDGEMENTS

The journey of completing and finalizing this thesis has been challenging and exciting. My warm gratitude goes to the people who inspired me and helped in many ways. Foremost, I would like to express my sincere gratitude to my supervisor Associate Prof. Dr. Tang Sai Hong for the continuous support of my Ph.D study and research, for his patience, motivation, enthusiasm, immense knowledge and for the invaluable freedom I had in my research. His guidance helped me throughout the research and writing of this thesis. Besides my supervisor, I am deeply grateful to my co-supervisors Associate Prof. Dr. Abd Rahman Ramli and Dr. Khairulmizam Samsudin for their advices, valuable technical discussions and constructive criticisms.

The long, hard process of completing a thesis would have been completely impossible without the support of many friends and colleagues at Institute of Advanced Technology and Qazvin Azad University. I would also like to thank to my brother Behruz Karasfi for his help, support and friendship. Last but not the least; I am grateful to my wife Afsaneh, my daughter Parmida and my little son Bardia for their love and valuable support.

Babak Karasfi
APPROVAL

I certify that a Thesis Examination Committee has met on 23 Oct 2012 to conduct the final examination of Babak Karasfi on his thesis entitled "TOPOLOGICAL MAPPING AND QUALITATIVE LOCALIZATION BASED ON K-ADJACENT UNION CLUSTERING ALGORITHM" 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 (PhD.).

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DECLERATION

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 institution.

______________________________
BABAK KARASFI

Date: 23 October 2012
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