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Cell decomposition-based coverage path planning with quasi-dynamic obstacles

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The use of autonomous mobile robots in industry and non-industry environments has become increasingly popular. For example, floor cleaning robots have been distributed successfully in domestic applications. Recently, robots working in these scenarios need to initially generate a representation of the environment as they explore it, because these scenarios are typically developed in partially or completely unknown environments. Generally, robots such as cleaning, mining, painting, exploration and inspection robots require coverage path planning. The aim of coverage path planning is to determine a path that passes over all free space in an environment and to simultaneously avoid obstacles which usually are passive type like furniture. One of the most robust approaches to coverage problem is the utilization of a dividing and conquering strategy that is a general form of the cell decomposition method. In this research, coverage path planning method based on on-line cell decomposition is proposed for an unknown environment with quasi-dynamic obstacles to overcome the coverage and collision problem while the robot is exploring the workspace and localizing in it. The robot uses a laser scanner to sense its surrounding environment. A scan matching method is used to merge environmental information between the reference scan and the current scan which predicts the position of the robot. The robot incrementally constructs cell decomposition while it covers an unknown workspace based on a feature extraction which consists of a set of line features called critical edges. Cell boundaries are formed by extending critical edges, which are the sensed partial contours of walls and objects in the workspace. Sensor measurement is sampled twice in each cell. At each scan sample, a two-directional oriented rectilinear decomposition is achieved in the workspace and presented by a closed map representation. The construction order of the cells is very important in this on-line cell decomposition algorithm. To choose the next target cell from candidate cells, the robot checks for redundancy in the planned path and for possible positions of the ending points of the current cell. While the robot moves in the workspace for coverage, it recognizes the environment that was changed by quasi-dynamic obstacles. If the detected changes are those of the current, the previous, or the next cells, the robot checks that the changed part of the environment is covered or not. If the changed part is already covered, the robot continues coverage task based on path planning by ignoring the change. If the changed part is not covered yet, the robot re-plans coverage path based on on-line cell decomposition by scan matching. Validation and performance evolution of the proposed methods are performed with a simulation and experiment. The proposed algorithm supports online coverage for a robot to explore unknown workspace and to achieve avoiding collision with quasi-dynamic obstacles simultaneously in order to cover the workspace. The experimental results support validity and usefulness of the proposed algorithm.

Biography

Soon-Geul Lee has received his BE degree in Mechanical Engineering from Seoul National University, Seoul, South Korea, MS degree in Production Engineering from KAIST, Seoul, South Korea and his PhD degree in Mechanical Engineering from the University of Michigan in 1983, 1985 and 1993, respectively. Since 1996, he has been with the Department of Mechanical Engineering of Kyung Hee University, Yongin, Korea, where he is currently working as a Professor. His research interests include robotics and automation, mechatronics, intelligent control and biomechanics.

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