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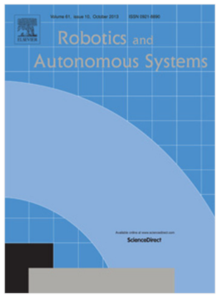

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Azzeddine Bakdi, Abdelfetah Hentout, Hakim Boutami, Abderraouf Maoudj, Ouarda Hachour, Brahim Bouzouia

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Optimal Path Planning and Execution for Mobile Robots using Genetic Algorithm and Adaptive Fuzzy-Logic Control

Azzeddine Bakdi[1], Abdelfetah Hentout[2], Hakim Boutami[3], Abderraouf Maoudj[4], Ouarda Hachour[5], Brahim Bouzouia[6]
[1, 2, 3, 4, 6]Centre de Développement des Technologies Avancées (CDTA)
Division Productique et Robotique (DPR)
BP 17, Baba Hassen, Algiers 16303, Algeria
[1, 3, 5]University M'hamed Bougara de Boumerdès (UMBB)
Institute of Electrical and Electronic Engineering (IGEE)
Boulevard de l'Indépendance, Boumerdès 35000, Algeria
[1]bkdaznsun@gmail.com, [2]ahentout@cdta.dz, [3]Hakim08boutami@gmail.com, [4]amaoudj@cdta.dz, [6]bbouzouia@cdta.dz

***Abstract*—This paper presents preliminary results of the application of two-Kinect cameras system on a two-wheeled indoor mobile robot for off-line optimal path planning and execution. In our approach, the robot makes use of depth information delivered by the vision system to accurately model its surrounding environment through image processing techniques. In addition, a *Genetic Algorithm* is implemented to generate a collision-free optimal path linking an initial configuration of the mobile robot (*Source*) to a final configuration (*Target*). After that, *Piecewise Cubic Hermite Interpolating Polynomial* is used to smooth the generated optimal path. Finally, an *Adaptive Fuzzy-Logic* controller is designed to keep track of a mobile robot on the desired smoothed path (by transmitting the appropriate right and left velocities using wireless communication). In parallel, sensor fusion (odometry sensors and Kinect sensors) is used to estimate the current position and orientation of the robot using *Kalman filter*. The validation of the proposed solution is carried out using the differentially-driven mobile robot, *RobuTER*, to successfully achieve safe motion (without colliding with obstacles) in an indoor environment.**

Index Terms: Mobile robot; Off-line optimal path planning; Path execution; Genetic algorithm; Adaptive fuzzy-logic control; Two-Kinect cameras system.

I. Introduction

Path generation and execution is one of the most important tasks for autonomous mobile robotics. Indeed, the robot has to perform certain interrelated activities [1] including (*i*) task planning (generation of operations plans) [2] [3], (*ii*) environment modeling and multi-sensory fusion [4], (*iii*) path planning [5], (*iv*) localization of the robot inside its environment [6], and (*v*) path execution and tracking [7].

Task planning is the process of generating a sequence of operations deriving from the assigned task to the robot to be able to perform it [8]. Depending on the task complexity, the planning can be carried out by a single-planner or a multi-planner system [9].

In the area of environment modeling and multi-sensory fusion, the robot can obtain and interpret information through its sensors for building maps. This includes for example, image-based sensors (stereovision systems, etc.) [10] [11] [12] [13] and time-of-flight-based sensors (laser-range finders, ultrasonic sensors, etc.) [14] [15] [16] [17]. These last few years, depth cameras are revolutionizing robots perception as a substitution for the previous classical robotic sensors. Indeed, Kinect cameras are able to provide good quality depth information of the surrounding environment of the robot (usually unstructured, unknown or partially known), which makes these sensors significantly attractive as they have been adopted by researches all over the world [18] [19] [20].

The other issue is related to path planning, which mainly tries to identify a sequence of configurations that will cause the robot to move from an initial configuration (*Source*) towards a final configuration (*Target*) [21] [22]. Besides collision avoidance with possible obstacles, the robot must often satisfy other requirements or optimize certain performance criteria [23] such as execution time, path length, energy, etc.

Existing work on path planning can be classified into *off-line* and *on-line planning approaches* [24]. *Off-line planning approaches* generate the entire path to the *Target* before motion begins. These approaches use complete information about the workspace, where an optimization criterion can be used for searching the optimal collision-free trajectory. They are most useful for repeatable tasks in static environments where optimality is essential (industrial applications, etc.). Whereas in *on-line planning approaches*, the trajectory to the *Target* is calculated incrementally during motion. These methods use incomplete information of the environment and build the trajectory step by step. Thus, this type enables fast collision detection and trajectory planning [25]. These approaches are required in applications where obstacles are detected during motion, the computation time required for a global solution delays the task execution, or simply as an alternative to a computationally expensive off-line search.