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ABSTRACT OF DOCTORAL DISSERTATION:
"Sub-optimal, Lie algebraic algorithms of nonholonomic motion planning in a task space"

Motion planning is one of the fundamental tasks of robotics. With the development of mobile robotics (wheeled, space, on- and underwater) there is an increasing demand for motion planning algorithms for systems with nonholonomic constraints. These systems generate difficult planning tasks due to the smaller number of controls than the dimensionality of a configuration space. The dissertation poses and solves the task of adapting the Lie-algebraic method to take into account an output function and planning in a task space. The practicality of including this function, in addition to broadening the class of solved tasks, results from the natural necessity of checking collisions in environments with obstacles, where not all coordinates of the configuration vector are relevant.

In the literature, the underlying general-purpose, Lie-algebraic motion planning method has only been considered in the configuration space. It allows for controlling a volume of robot manoeuvres easily and also the shape of the planned trajectory and, therefore, it is predisposed to planning in collision environments. The method uses a generalised Campbell-Baker-Hausdorff-Dynkin (gCBHD) formula, the detailed study of which was an additional aim of this dissertation. Besides determining the influence of representation of controls and initial parameters on the generated trajectory, a combinatorial algorithm was proposed to compute pre-controls generated with the gCBHD formula with linear complexity, significantly improving the literature algorithms with exponential complexity.

In this work the objects and concepts related to motion planning in a configuration space have been redefined to adapt them to a task space. The notion of singularity of a system with an output, not occurring for nonholonomic systems in the configuration space, and sources of singularities were analysed. As a part of the transformation of concepts, nonholonomic spheres in the task space were displayed, which are a visual representation of the various difficulty of motion in different directions in a space.

The achievement of the thesis is the design of the author's algorithm for evaluating the difficulty of an intermediate configuration in the case of multistage motion planning using the Lie-algebraic method in a task space. The evaluation of the configuration consists in taking into account both geometrical parameters of vector fields, as well as their layers differentiating the energy efficiency of motion. On the basis of the designed algorithm an algorithm of motion planning in the task space was proposed allowing optimisation of the shape of a planned trajectory, as well as its parameters such as length or energy of motion. The culmination of the work is an original algorithm allowing for planning a motion in a task space in a collision environment in which subgoals are generated by a geometric planner.

All the algorithms proposed in the dissertation have been implemented in *Mathematica* and tested on three models with two inputs, including practical and theoretical, nilpotent and non-nilpotent systems. The results are presented in a tabular and graphical form, and on their basis detailed conclusions are drawn concerning some issues conditioning the efficiency of the algorithms.

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