Preparation of Papers for IEEE Sponsored Conferences & Symposia*

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I. INTRODUCTION

Kinematic redundancy enables a manipulator to follow a predefined task space trajectory using the endeffector (EE), while simultaneously, optimising for an additional task with the remaining movement capacity without impacting the trajectory adherence. This is possible because the robot's degrees of freedom (DOF) go beyond what is required to perform the primary task. Consequently, the robot can adopt different joint configurations optimised according to the secondary task while performing the primary task. Common secondary tasks include avoiding singularities, optimising the manipulability measure, minimising joint torques and avoiding obstacles in the operating space.
citations

Motion planning [1] is a fundamental problem in robotics. It consists of finding a sequence of joint configurations for a robot so that the robot can move along this path from its initial configuration to the goal configuration without colliding with static obstacles or other robots in the environment. In addition to collision avoidance, motion planning for manipulators can optionally take into account various constraints, such as position, velocity, acceleration or jerk constraints for the joint angle or end effector, precision of the end effector with respect to position and orientation, stability of the manipulator, avoidance of singularities, or any number of other criteria.

There are numerous methods for planning manipulator movements. Sampling-based methods such as PRM, RRT, RRT*, RRT-Connect, Informerd RRT*, BIT* and others offer a solution based on a global search in configuration space. However, the generated trajectories are not always smooth or optimal, and the performance of the methods may be insufficient for real-time operation. Recently, a number of learning-based methods using data-driven techniques have been proposed to improve or accelerate the functionality of sampling-based methods. examples Trajectory optimisation methods such as CHOMP, STOMP and TrajOpt, on the other hand, use optimization to improve an initial seed trajectory.

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Consequently, the optimality of the solution is highly dependent on this initial trajectory. Nevertheless, these methods are capable of generating smooth trajectories, and although they can be too computationally intensive for dynamic real-time environments, they are generally effective in finding constrained motion plans. The inverse kinematics with task prioritisation, which is based on finding a locally optimal least squares solution, and linear quadratic programming are two of the local optimization methods. Both methods are fast, suitable for real-time applications in dynamic environments and provide smooth solutions. However, since they do not plan further than one step ahead, they tend to get stuck in local minima. Therefore, they are often integrated with a higher-level planner, usually based on sampling, for global path search, while local optimisation takes dynamic environment changes into account.
citations

To be able to generate collision free trajectory we need to have a representation of the environment. One common approach is to represent environment with geomertic primitives such as bounding boxes or spheres. These representations are often combined into hierarhical trees, such as octatree, to make calculations more efficient. Such representations are memory effective and offer simple and computationally undemanding distance calculation and collision detection. These representations are widely used in computer simulations and games, however they can be suboptimal for , where sensor measurements arent always accurate and contain only part of the surrounding space. This can lead to approximation errors, which are additionally probelmatic when we are dealing with irregular shaped objects.

Point-cloud representation captures the environment by directly using a collection of points obtained from sensors like LiDAR, providing a more precise depiction of space than bounding boxes or spheres. This method can more accurately represent the complex and irregular shapes of real-world objects, although it typically requires more memory and computational power to process, which can make it chllenging fore real-time representation.

Voxel grid representation, on the other hand, divides the space into a regular grid of volumetric elements, or voxels, which can be used to create a more manageable approximation of the environment. While this approach offers a balance between detail and computational efficiency, it can still introduce discretization errors, particularly when modeling objects with smooth surfaces or intricate details. The fidelity of the representation is dependent on the size of the voxels: smaller voxels can capture more detail but require more memory and computation, while larger voxels result

in coarser approximations but are more memory-efficient, adaptive voxel grids have been explored, where the voxel size can vary throughout the space to provide higher resolution in regions of interest while conserving resources in less critical areas. Voxel grids can incorporate probabilistic information, such as in occupancy grid maps, where each voxel holds a probability indicating the chance of an obstacle's presence. The occupancy probability of a voxel can be updated dynamically using sensor measurements and Bayesian updating methods. As new sensor data is collected, the probabilities are revised to reflect the increased or decreased likelihood of the presence of an obstacle in the voxel space.

Additionally, techniques such as ESDF and TSDF can be utilized in conjunction with voxel grids to encode distance information, thereby enhancing the grid's utility for navigation and path planning by providing gradient information for obstacle avoidance and facilitating smoother trajectories

Gradient based voxel field methods. Voxel fields including distance information.

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A. Headings, etc

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B. Figures and Tables

Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation Fig. 1 , even at the beginning of a sentence.

TABLE I

AN EXAMPLE OF A TABLE

One	Two
Three	Four

We suggest that you use a text box to insert a graphic (which is ideally a 300 dpi TIFF or EPS file, with all fonts embedded) because, in an document, this method is somewhat more stable than directly inserting a picture.

Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity Magnetization , or Magnetization, M , not just M . If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write Magnetization (A/m) or Magnetization A[m(1)] , not just A/m . Do not label axes with a ratio of quantities and units. For example, write Temperature (K) , not Temperature/K.

III. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes should appear before the acknowledgment.

ACKNOWLEDGMENT

References are important to the reader; therefore, each citation must be complete and correct. If at all possible, references should be commonly available publications.

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