

ProSeqqo: Open-source Solver for Robotic Task Sequencing

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MOTIVATION

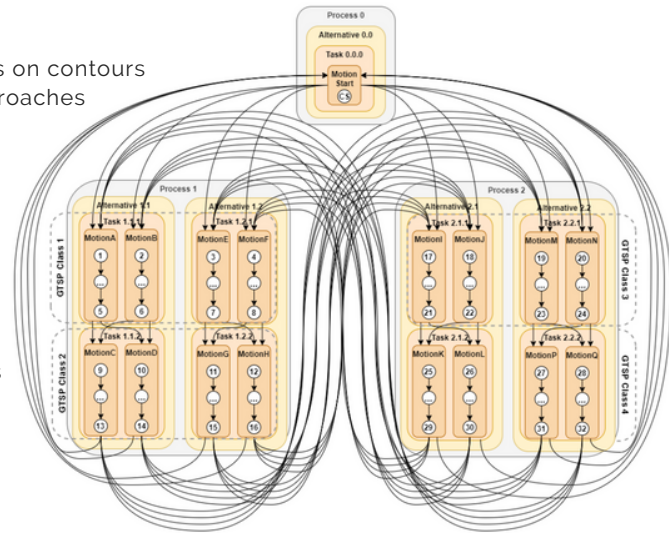
- Task sequencing is a common problem in industrial robotics
- Yet, it arises in slightly different ways in each application
- Sequencing is often coupled with different decisions, e.g., on the IK solutions, the directions of motions, or the entry/exit points on contours
- Hence, literature and industrial practice are dominated by dedicated approaches
- We propose a common model, description language, and efficient solver for typical robotic task sequencing problems

GENERIC MODEL AND DESCRIPTION LANGUAGE

- The robotic task sequencing problem can be formulated using a hierarchical representation
- Five-level hierarchical representation: process, alternative, task, motion and configuration
- Precedence constraints on two levels, capturing conditional precedences
- Pre-defined cost functions, resource change costs and penalties

SOLUTION APPROACH

- Conversion to GTSP with precedence constraints
- Alternative encodings, including one with pre-computed shortest paths
- Initial heuristics and local search from the Google OR-tools VRP library
- Initial solution via MILP in case of conditional precedence constraints



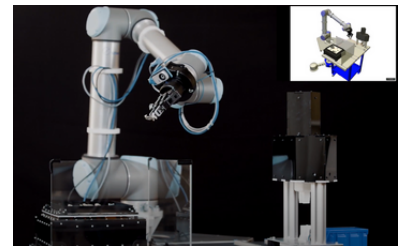
SOME APPLICATIONS

CAMERA-BASED PICK-AND-PLACE

- Goal: pick and place the 3 -30 parts lying in random poses
- Problem: sequencing the parts, selection of IK solutions
- Distance function: trapezoid time profile over 6D configurations
- Result: suitable for online planning, 30 parts in 0.2 second

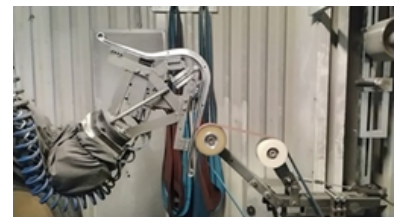


YouTube
Pick and Place



GRINDING AND POLISHING OF FURNITURE

- Goal: rough grinding, fine grinding, and polishing
- Problem: task sequencing, choosing directions
- Distance function: individual cost matrix based on collision-free path length
- Result: 24% lower transition time than human expert, offline planning



ROBOTIC DRAWING

- Goal: cartoon drawing by robot arm
- Problem: sequencing the lines, selection of directions
- Distance function: Euclidian distance of 2D coordinates and penalties for discontinuity
- Result: suitable for online planning, solution in 1 sec, local minimum in 1-7 sec



YouTube
Robotic Drawing



REFERENCES

Video: <https://youtu.be/vK53AcCoVT8>

Open-source software: github.com/sztaki-hu/ProSeqqo

Journal paper:

Zahorán, L.; Kovács, A.: ProSeqqo: A generic solver for process planning and sequencing in industrial robotics. Robotics and Computer-Integrated Manufacturing, 78:102387, 2022.

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