# PASME–Parallel Robots

**Lecture – Project** **January 30, 2025**

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## 1 Introduction

The ROPAH practical work is evaluated with a final project that is conducted by groups of two students. Projects are suggested by the instructor. A final report is due at the end of the practical work. Three project subjects are described thereafter.

Each group of two students should choose one the three projects. For each project,

1. The design problem should be formulated as an optimization problem based on the given specifications;
2. A list of manipulators should be synthesized
3. A good candidate amongst the obtained manipulator architectures should be selected for detailed design and CAD modeling with CATIA or SolidWorks software;
4. A animation of the final design should be made;

## 2 Project 1: Design of a three degrees of freedom translational parallel manipulator

The subject of Project 1 is about the design of a three degrees of freedom translational parallel manipulator. Here are the specifications:

1. The manipulator should have a cubic regular workspace of size 500 mm $\times$ 500 mm $\times$ 500 mm.
2. The inverse condition number of the normalize kinematic Jacobian matrix should be larger than 0.1 throughout the regular workspace.
3. The manipulator should be compact, i.e., the overall size of the manipulator should be as small as possible.
4. For any force of magnitude 10 N applied on the moving-platform in the plane of motion, the point-displacement of the moving-platform should be lower than 0.1 mm throughout the regular workspace.

# 3 Project 2: Design of a parallel Schönflies motion generator

The subject of Project 2 is about the design of a parallel Schönflies Motion Generator (SMG). The parallel Schönflies motion generator should be designed for pick-and-place operations based on the path defined to test the performance of SCARA robots, as depicted in Fig. 1. Moreover, one of the objectives of the project is to realize a parallel system that outperforms

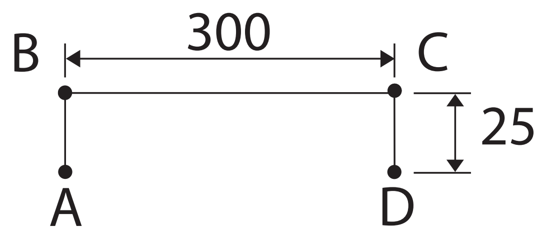


Figure 1: Path adopted for the manipulator design

both serial SCARA systems and the parallel robots currently available for Schönflies motion generation, i.e., the McGill SMG [5], the H4 [8], the T3-R1 [7], and the fully isotropic parallel mechanisms developed by [6]. To this end, the design specifications for the good under design are given below:

- The robot must be capable of producing a test cycle that is commonly accepted for SCARA systems, in at most 500 ms. The test cycle consists of:
  - 25-mm vertical displacement up
  - 300-mm horizontal displacement with a concomitant 90° turn
  - 25-mm vertical displacement down
  - 25-mm vertical displacement up
  - 300-mm horizontal displacement with a reversed 90° turn
  - 25-mm vertical displacement down
- The system should be capable of attaining a configuration where kinetostatic robustness is achieved. As a matter of fact, from kinetostatics, the SMG is maximally accurate and robust when its normalized forward and inverse Jacobians are maximally invertible, i.e., when their *condition number* $\kappa$ is as small as possible, i.e.,$\kappa < 10$ .
- The mechanism should not be too bulky.

The dimensions of the SMG are mainly determined by the isotropy conditions derived in the kinetostatic design, the geometric considerations, and the moveability of the end-effector to achieve the 180° rotation of the test cycle.

# 4 Project 3: Design of a cable-driven parallel manipulator for painting large parts

The subject of Project 3 is about the design of a cable-driven parallel robot for painting large parts:

1. The manipulator should cover a workspace of size 40 m $\times$ 20 m $\times$ 10 m.
2. The manipulator should have a payload capacity equal to 200 kg.
3. The manipulator should be able to paint a horizontal cylinder of diameter equal to 4 m and length equal to 30 m while avoiding
   (a) the collisions beween the cables and the part to be painted;
   (b) cable/cable collision type;
   (c) cable/moving-platform collision type.

# References


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