Motivation

A detailed probe arm study is required before designing a collision-free planning algorithm.

Introduction

The Mid-resolution Infrared Astronomical Spectrograph (MIRADAS) is a near-infrared multi-object spectrograph for the Gran Telescopio Canarias (GTC).

- It can simultaneously select up to 20 targets using 20 deployable cryogenic robotic arms with pickoff mirror optics.
- The bases of the arms are fixed to the same side of a circular platform (MXS plate) and arranged in a circle around the focal plane.
- There is minimum separation between mechanical elements in the MXS Plate.

The instrument was selected in 2010 by GTC and successfully passed PDR in November 2012.

Probe arm description

It is a 2 degree-of-freedom (DoF) mechanism that produces a planar motion over the plane formed by the MXS plate.

The mechanism, seen in fig. 1 and 2, consists of:

- Two tubes (L1 and L3) and a bar (L2).
- Four joints:
  - J1, J2 and J3 are revolute joints.
  - J1 rotates about a shaft perpendicular to the view in fig. 1 and slides over L3.

Figure 1: The full-scale MXS probe prototype P2a shown from an aerial view.

Figure 2: The arm model is a close-loop kinematic chain. Joint J1 must be always between stop positions s1 and s2. The 2 DoF of the mechanism are represented by θ1 and θ2, where θ1 ∈ [0, π] and θ2 ∈ [0, 2π].

Probe arm behaviour

Only a reduced set of (θ1, θ2) pairs satisfy the arm mechanical constraints. Each of these pairs forms the arm configuration space.

Some tip positions can be reached by two configurations (different J1 pos.) as can be appreciated in the 3D workspace.

Patrolling strategies

- Workspace: Each arm patrols the points of its workspace that are in the instrument field-of-view (FoV); see fig. 5.
- Slice-of-Pie (SoP): FoV is divided into 20 identical areas or SoPs. Each SoP is a subset of the arm workspace. A given SoP is patrolled by only one arm and each arm patrols always the same SoP.

Figure 3: (Left) The arm envelope in gray and the 2D workspace in purple. The upper (center) and lower workspaces (right) are the projections of the upper and lower sides of the 3D workspace onto the (X, Y) plane.

Figure 5: (Left) envelopes for arm1 in blue, arm2 in green and arm10 in red; (right) each colored area of the arm envelope specifies the max. number of collisions it can experiment when passing through that zone.

Conclusion

- The arm can work with only configurations belonging to the upper workspace, as their patrol almost the total area of the 2D workspace.
- The workspace patrolling is the approach that enables future planning algorithm to obtain better solutions; however, it can require the use of heuristics for fast convergence to an optimal solution.
- The options for a proper SoP are drastically reduced, since the restrictions in trajectories imposed by the motor controllers of the prototype. Although this strategy is still usable, it does not ensure that all points of the FoV can be observed.