Abstract

Parallel manipulators are widely used for a variety of tasks where increased accuracy and large load carrying capacities are required. In this work, we propose a Monte Carlo based method to represent and quantify the workspace of the manipulator and demonstrate the use of gradient based optimization techniques to synthesize the manipulator for a required workspace.

First, we define the \well-conditioned workspace" of the manipulator and show how the Monte Carlo method in conjunction with techniques from computational geometry can be used to represent and quantify the workspace of the manipulator. We also discuss the advantages and limitations of this method over the current state-of-the-art. Next, we demonstrate the technique through two examples of obtaining the workspaces of multi fingered hands. In the first example, we propose a six degrees of freedom approximation of the human three fingered grasp and obtain the workspace of the same. We conduct experiments with human subjects and show that our formulation can obtain envelopes of the actual human hand workspaces with a maximum error of 2 cm. Additionally, we show that the human hand workspace is the largest when the cross-section area of the grasped object is roughly equal to the palm area and the hand workspace is always larger when rolling is allowed at the object-finger contact point. In the second example, we obtain the workspace of the well-known Stanford-JPL hand.

In the second part of the work, we show that the Monte Carlo method in conjunction with gradient based optimization techniques can be effectively used for optimal design of parallel manipulators for a required well-conditioned workspace. We demonstrate this by two examples in the first example, we consider a planar 2 degrees of freedom 5 bar manipulator and discuss 4 different shapes of the manipulator workspace due to different constraints on the link dimensions and how the choice of constraints affects the problem of optimal design for a prescribed workspace. In the second problem, we discuss the optimal synthesis of a Stewart platform in a special configuration defined by 6 geometric parameters. We consider two assembly modes of the manipulator and compare the workspaces obtained in each case. For both of the examples, we obtain the optimal manipulator dimensions for a given workspace and discuss the sensitivity of the manipulator workspace to perturbations in the design constraints.