Nonlinear Sliding Mode Control Based on Backstepping Approach Applied for 2DoF Planar Parallel Manipulator Biglide Type

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***Abstract*—This work presents the control of a two-degree of freedom parallel manipulator using nonlinear sliding mode based on Backstepping approach. The aim is to achieve a robust control for trajectory tracking, dynamic equations of motion for a two-degree of freedom parallel robot manipulator including structured and unstructured uncertainties are considered. The application of control technique for trajectory tracking in presence of parameter uncertainties in mass variation is studied. The advantage of control technique is that it imposes the desired properties of stability by fixing initially the candidate Lyapunov functions, then by calculating the other functions in a recursive way. Simulation results are presented in order to evaluate the tracking performance and the global stability of the closed loop system. Obtained results show the effectiveness of the proposed controller for a two-degree of freedom parallel robot Biglide type.**

Keywords—Parallel robot; Nonlinear control; stability; sliding mode control; Tracking.

I. INTRODUCTION

PArallel robots are closed-loop mechanisms where all of the links are connected to the ground and the moving platform at the same time. They have high rigidity, load capacity, precision and especially structural stiffness, since the end effectors is linked to the movable platform at several points [1], [2], [3], [4], and [5]. Despite of their advantages, parallel manipulators have also some drawbacks, such as limited workspace and complex kinematic issues caused by the presence of multiple closed loop chains and singularities.

Two categories of parallel manipulators exist, spatial and planar robot. The first category composes of the spatial parallel robots that can translate and rotate in the three dimensional space. Gough-Stewart platform one of the most popular spatial manipulator, is extensively preferred in flight simulators [6], [7]. Therefore, they attracted a lots of researchers interests in recent decades [8] and [9].The planar parallel robot which comprises of second category, translates along the x and y axes, and rotates around the z axis, only. The planar parallel manipulators are increasingly being used in industry for many tasks such as a micro or nano positioning applications [10], and in industrial high speed applications [11]. In this paper, we will discuss the motion control of a planar parallel robot known as Biglide with two degrees of freedom (DoF) [12], [27], [13] and [14]. This type of parallel robot is used in the manufacturing industry of electronic products, as pick and place applications [12], [27]. A dynamical analysis of parallel robot is very complex because the existence of multiple close-loop chains. In addition, due to uncertainties such as not modeled errors of dynamic parameters, measurement noise and external disturbances. Many researchers worked on the dynamic modeling of parallel robots as in [15], [16] and [17]. The Conventional control methods of parallel manipulators have attracted many researchers in studying their performances. A proportional derivative (PD) controller [18], a nonlinear PD controller [19] and an adaptive switching learning PD control method [20], [21] were proposed for the motion control of parallel manipulators. It is also noted in [22] that all of these controllers are simple and easy to implement but they are not robust in presence of uncertainties or when the robot supports different payloads. Some other advanced controllers were proposed, such as the computed torque controller [12] [22], and the adaptive controller [24]. These approaches are based on a full knowledge dynamic model and require a computational power. However, it is complicated to obtain a precise dynamic model of the parallel manipulators, due to the aforementioned drawback [21]. In recent years many researchers are worked on the modern control methods for nonlinear mechanical systems [25],[28] such as adaptive control [26] and [25], TS disruptor [12], Sliding mode control [27] and computed torque control and neural network optimized [23]. These types of controller work very well when all dynamic and physical parameters are known, but when the manipulator has variation in dynamic parameters, the controller has no acceptable performance [12]. Sliding mode control, which is a method, can be a solution, but some bounds on system uncertainties must be pre estimated [27],[29].

In this paper, a new contribution of sliding mode control based on backstepping approach is proposed to control planar parallel robot in the cartesian space. This approach is based on the nonlinear direct dynamic model and sliding mode surfaces. The theories of sliding mode control and backstepping approach have been successfully applied to control planar