New Fully Decoupled Manipulator with Three Translational Motion for Pick and Place Applications

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***Abstract*—A new three degree of freedom 3-DOF manipulator with fully decoupled translational motion is proposed in this paper. The conceptual design of the proposed manipulator is based on the pantograph mechanism which provide the decoupling motion. Parallelogram mechanisms are added to the pantograph to obtain the fixed orientation of the end-effector in XYZ directions. The proposed manipulator not only has the same characteristics of parallel manipulators as high stiffness, high accuracy and small power consumption, but also has large workspace compared to its volume as serial manipulators. Thus, the advantages of both parallel and serial manipulators are offered in the proposed manipulator. Moreover, it possess unique characteristic over decoupled parallel manipulator counterparts in terms of workspace to size ratio. Besides, this manipulator moves with high speed as the Pantopteron manipulator and many-times faster than the other decoupled parallel manipulators based on the magnification factor of the pantograph mechanism. The mobility, kinematic analysis and workspace of the proposed manipulator are studied in details. The simulation results are carried out using ADAMS software to validate the feasibility of the conceptual design.**

Keywords-decoupled mations; translational maniplatours; constant orientation; workspace; pick and place

I. INTRODUCTION

Parallel manipulators provide compact structure, high stiffness, and lower moving inertia, high load to weight ratio, high dynamic performance, and high accuracy [1]. So, it has attracted significant attention amongst researchers and industry in the past decade. As a result, many industrial parallel robots are developed as Delta robot and Tsai robot [2], [3]. These robots provide translational motion with constant orientation to cover a wide applications as pick-and-place, parallel kinematic machines, and medical devices. In contrast, parallel manipulators suffer from disadvantages such as the small workspace and coupling of kinematics and dynamics. Since, such kind of these robots needs a 3-DOF to position the end-effector in a specific location. This means one should control three actuators to produce just the motion of the end effector due to the coupling between the joints. This problem, predictably associated with nonlinearity, high coupled kinematics, singularities and a complex shaped workspace [4]. Hence, the decoupling motion between the robot actuators and positioning the end effector with fixed orientation are important issues for many industrial applications as pick and place operations. In order to solve this problem, in the last few years, a large family of decoupled 3-DOF translation parallel mechanism was developed to solve such kind problem. Gosselin and Kong [5] have presented their patent about simple 3-DOF translational parallel robot, with fully-decoupled input-output equations. Then, many researchers proposed series of decoupled 3-DOF translational parallel mechanisms, all covered by the above-mentioned patent [6]-[10]. A new family of decoupled motion called Tripteron was presented in details in many works [11]-[14]. Hence, many researchers try to solve the proposed problem of coupling motion with different structures as the Quadrupteron [15], Isoglide4 [16] and Pantopteron [17]. The mechanism of Quadrupteron or Isoglide4, which are very similar, consists of four identical leg with PRRU type attached to a common platform. These robots are a 4-DOF parallel mechanism capable of producing the Schönflies motions consist of three translations plus one rotation about a given fixed direction. Besides, the linear actuators are employed and the displacements of three of them are directly proportional to the translational displacements of the mobile platform along a given Cartesian axis. The Pantopteron manipulator is similar to the Tripteron Cartesian parallel manipulator, but due to the use of three pantograph linkages, an amplification of the actuator displacements is achieved. Therefore, equipped with the same actuators, the mobile platform of the Pantopteron moves many times faster than that of the Tripteron. This amplification is defined by the magnification factor of the pantograph linkages. This paper introduces new 3-DOF translational manipulator with fully decoupled motion based on pantograph mechanism [18]. The advantages of parallel and serial manipulator are offered in this manipulator. Besides, the proposed manipulator has a unique advantage in terms of workspace/size ratio and velocity compared to other decoupled parallel manipulators.

This paper is organized as follows: Section II introduces a mechanism description and mobility analysis of the proposed manipulator. Then, Section III represents kinematics analysis. Section IV presents the workspace determination. Then, the system simulation results are carried out by ADAMS software in Section V. Finally, the conclusions are presented in Section VI.

978-1-4673-9859-6/16/$31.00 ©2016 IEEE