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OPTIMAL TUNING OF PID CONTROLLERS FOR A HYDRAULICALLY DRIVEN PARALLEL ROBOT PLATFORM BASED ON FIREFLY ALGORITHM

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Abstract: The positions of moving platform are changed by extension or shortening of the six pneumatic cylinders. A PID control technique has been applied in practice for control of a 6-DOF parallel robot platform. A parameter search based on Firefly Algorithm (FA) is suggested to effectively search the parameters of PID controllers. Simulation results show the advantages of the proposed optimal tuned PID controllers to solve the formulated tracking problem in relation to the classical tuned PID controllers.

Key words: optimal control, hydraulically control systems, firefly algorithm, parallel robot platform

INTRODUCTION

The hydraulically driven parallel robot platform is obtained through a generalization of the mechanism proposed by Stewart [1] as a flight simulator. As shown in Fig.1, this spatial platform mechanism consists of a fixed base platform and an upper moving platform. The six extendable legs connect these platforms. Besides greater stiffness and accuracy, these robot platforms have high payload-weight ratio due to parallel linkage. The payload and positioning errors would be accumulated without parallel linkage.

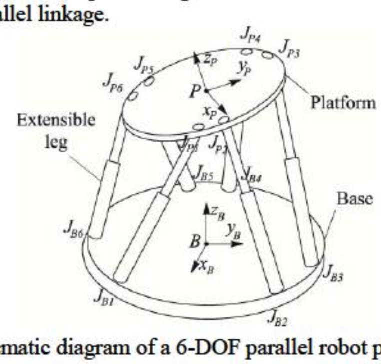

Fig.1. Schematic diagram of a 6-DOF parallel robot platform

However, the upper moving platform of a parallel platform can move with the six desired degrees of freedom (DOF) if the lengths of the all legs are well controlled. A classical PID control technique has been applied in practice for a control of a 6-DOF parallel robot platforms.

An approach to optimal tuning the parameters of the PID controllers is presented. Namely, the PID controller is often poorly tuned owing to highly changing dynamics of parallel robot platform caused by large nonlinearities and changes of parameters during motion. Due to a change of the system parameters, the PID controllers result in suboptimal corrective actions and hence require retuning. In control design of continuous processes, the tuning of controller parameters could be done with traditional methodology. The models of such processes can be linearized in an equilibrium point. However, there are the systems that cannot be linearized around an equilibrium point, because there is no equilibrium point. If a linear approximation is found, the resulting model will be valid only for a small region around the linearization point. Therefore, it is necessary to use non classical tuning methods to achieve the best overall control strategy for the entire operating envelope of the given system. As an alternative, metaheuristic algorithms are applied for the quality controller tuning. Authors use Firefly Algorithm (FA) to tuning the parameters of PID controllers. FA represents a new metaheuristic algorithm which is nature-inspired. The FA was developed by Yang [2-3], and it was based on the idealized behaviour of the flashing characteristics of fireflies.

A MODEL OF PARALLEL ROBOT PLATFORM

A spherical joint is employed to connect the upper part of each leg by the upper moving platform while its lower part is connected to the base platform by an universal joint. A prismatic joint is employed for translational motion of the actuator. Well controlled lengths of six actuators make the upper moving platform follow the desired trajectory [5].

KINEMATICS ANALYSIS

As shown in Fig.1, the legspace frame (x_B, y_B, z_B) is located at the center of the base platform, and the workspace frame (x_P, y_P, z_P) is located at the center of the moving platfrom. The angle between the fixed x_B axis of the base platform and the line of the joint J_{Bi} is denoted by α_i, as shown in Fig. 2a. In the same manner, an angle β_i is defined between the local x_P axis of the moving platform and the line of the joint J_{Pi}, as shown in Fig.2b.

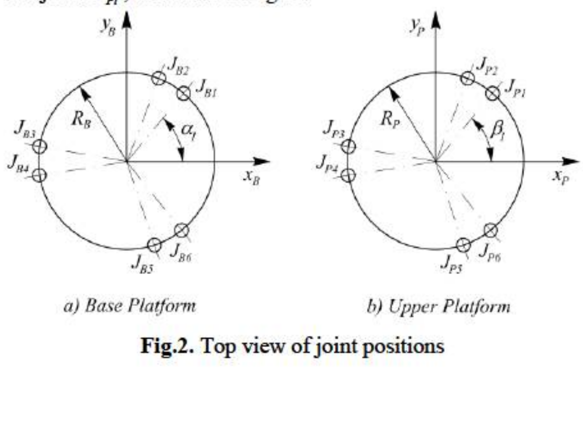

Fig.2. Top view of joint positions