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Intelligent Cascade Control of Hydraulically Driven Parallel Robot Platform

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***Abstract* – This paper presents an optimal tuning of cascade load force controllers for hydraulically driven parallel robot platform. A PID control technique is usually applied in practice for control of a 6-DOF parallel robot platform. The proposed parameter search scheme is based on a Cuckoo Search (CS) algorithm, which has received a lot of attention recently in the evolutionary computation area due to its superiority in solving various non-convex problems. Simulation results show the advantages of proposed optimal tuned cascade controllers to solve the formulated tracking problem in relation to the classical PID controllers.**

***Key words:* parallel robot platform, controller tuning, hydraulically control systems, cuckoo search algorithm**

I. INTRODUCTION

The hydraulically driven parallel robot platform is obtained through a generalization of the mechanism proposed by Stewart as a flight simulator [1]. 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.

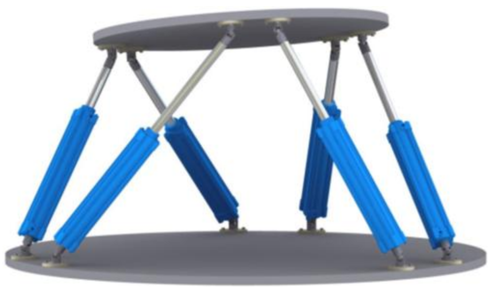

Fig.1. A 3D model of a 6-DOF parallel robot platform

The parallel robot control strategy may be designed from two frameworks. One is to design a controller based on the legspace coordinates and the other is based on the workspace coordinates. The control strategy based on the workspace coordinates has a limitation to the real-time application due to difficulty in obtaining information on the upper moving 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. Bearing this in mind, the control strategy study of the parallel robot platform rather is based on the legspace coordinates [2].

Since dynamics of the hydraulically driven 6-DOF parallel robot platform consist of two parts, the designed controller should take into account not only the mechanical dynamics, but also the hydraulic dynamics by using the cascade control method [2].

However, the PID controllers in inner control loops of the proposed cascade controllers, are 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 conventional PID controllers result in sub-optimal 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. Nonlinearity, in conjunction with the increased complexity due to the mutual influence between the system's variables imposes difficulties to the task of optimization with the use of classical optimization techniques.

Therefore, it is necessary to use non classical tuning methods to achieve the best overall control strategy. As an alternative, metaheuristic algorithms are applied for the quality controller tuning. Authors use Cuckoo Search (CS) to tuning the controller parameters. CS represents a new metaheuristic algorithm which is nature-inspired by some species of a bird family called cuckoo because of their special lifestyle and aggressive reproduction strategy. This algorithm is developed by Yang and Deb [3] and their studies have shown better efficiency of the CS algorithm in finding a global optimum. This artificial technology can obtain the optimal parameters, especially for plants with time variance, time delay, nonlinearity and coupling. The main advantage of these algorithms over the others traditionally used in controller design is that they do not require gradients and convexity of the problem and they will find a global optimum [4].

It is demonstrated by simulation results from MATLAB model that the proposed approach is considerably simple and convenient to use.