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Optimal control of hydraulically driven parallel robot platform based on firefly algorithm

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Abstract A new cascade load force control design for a parallel robot platform is proposed. A parameter search for a proposed cascade controller is difficult because there is no methodology to set the parameters and the search space is broad. A parameter search based on firefly algorithm (FA) is suggested to effectively search the parameters of the cascade controller. We used unified mathematical model of hydraulic actuator of parallel robot platform. These equations are readily applicable to various types of proportional valves, and they unify the cases of critical center, overlapped and underlapped valves. These unified model equations are useful for nonlinear controller design. The optimal results are compared to those obtained from other metaheuristic algorithms: GA, PSO and CS. A comparative study is also made between proposed optimal tuned cascade control using FA and well-tuned PID controller. Simulation results show the advantages of the proposed optimal tuned cascade controller using FA to solve a formulated tracking problem.

Keywords Optimal control · Cascade control · Hydraulically control systems · Firefly algorithm · Parallel robot platform

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1 Introduction

A 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. Parallel linkage enables the payload distribution and averaging of the positioning error. The payload and positioning errors would be accumulated without parallel linkage. Accordingly, these types of parallel robot platforms are attractive for certain applications, such as flight simulators, machine tools and force–torque sensors.

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 all legs are well controlled. Bearing this in mind, the control strategy of the parallel robot platform rather is based on the legspace coordinates. A linear control techniques do not always guarantee the desired high-performance of a parallel robot plat-