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Data-driven PID tuning for liquid slosh-free motion using memory-based SPSA algorithm

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Abstract. This study proposes a data-driven PID tuning for liquid slosh suppression based on enhanced stochastic approximation. In particular, a new version of Simultaneous Perturbation Stochastic Approximation (SPSA) based on memory type function is introduced. This memory-based SPSA (M-SPSA) algorithm has a capability to obtain better optimization accuracy than the conventional SPSA, since it is able to keep the best design parameter during the tuning process. The effectiveness of this algorithm is tested to data-driven PID tuning for liquid slosh problem. The achievement of the M-SPSA based algorithm is assessed in terms of trajectory tracking of trolley position, slosh angle reduction and also computation time. The outcome of this study shows that the PID-tuned M-SPSA is able to provide better control performance accuracy than the other variant of SPSA based method.

Keywords: Data-driven control, PID controller, Stochastic approximation.

1 Introduction

Recently, liquid slosh problems have become attractive research topics due to their safety issue in vehicle transportations and numerous number of applications in various industries. Nevertheless, there are still a lot of challenges that need to be considered in controlling such systems. The control strategies for liquid slosh reduction can be cluster into two main parts, which are mechanical design part and control design part. In mechanical design part, the researchers are interested to improve the whole mechanical structure of tank or vehicle to reduce liquid slosh motion. For example, they may propose different shape of tank or introduce some kinds of damper inside the tank. Meanwhile, in the control design part, they are interested in developing an efficient control algorithm to suppress the slosh. For such a case, they must clearly observe the slosh behaviour through available sensors to detect the slosh. Perhaps, the sensor design for detecting slosh also became very interesting topics to be discovered.

Research on improving the mechanical design of tank or carrier has started earlier than the controller design part. It is started from 1960 by Budiansky [1], which is the