A Data-driven Sigmoid-based Secretion Rate of Neuroendocrine-PID Control for TRMS System

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***Abstract*—This paper investigated the implementation of data-driven sigmoid-based secretion rate of neuroendocrine-PID (SbSR-NEPID) within a twin-rotor MIMO system (TRMS), based on the adaptive safe experimentation dynamics (ASED) algorithm. In essence, SbSR-NEPID is developed as a human body-inspired mechanism that promotes accurate and efficient controller structure. The ASED approach was then employed for parameter tuning of the proposed controller, following its role as the data-driven control scheme that tracks error and input control performances. Fundamentally, such a game-theoretic approach would seek optimal parameters through random perturbations of several elements from its controller's parameters. Its application in tracking both performance and computational interval has also gained vast explorations above statistical ground. As such, results obtained from the simulation has demonstrated data-driven SbSR-NEPID control based on the ASED method as a capable approach in tracking the assigned trajectory missions, while yielding exceptional control accuracy beyond the requirement of theoretical assumptions on the plant dynamics.**

***Index Terms*—Data-driven control, neuroendocrine-PID, optimization, control system, TRMS**

I. Introduction

Nowadays, complex nonlinear systems have gained vast applications within the industrial sectors as the mechanism that enables operational precision. Attention is particularly directed to the twin rotor MIMO system (TRMS) succeeding its excellent coupling effect via the pitch and yaw angle, as attained through a helicopter-based dynamics and heightened non-linearity. The requirement for a compelling controller structure is further acknowledged, so as to pinpoint the preferred position upon compatibility of the control signals. In achieving this purpose, mechanisms including the PID controller [1]–[3], $H\infty$ controller [4], Linear Quadratic (LQ) controller [5], Fuzzy controller [6], Fuzzy-PD controller [7], sliding mode control [8], fuzzy sliding mode controller [9] etc. have, nonetheless, been short-listed.

Additional efforts were also allocated towards the development of phenomenon-based controllers like the neuroendocrine-PID (NEPID), which has been specially inspired by the surrounding biological nature [10]–[12]. However, the preliminary findings seem to suggest that the constant hormone secretion rate of existing NEPID is still insufficient in producing better control accuracy due to unable to interact directly between secretion rate and control variable error. Thus, this could affect the strength of neuroendocrine in producing the efficient output of neuroendocrine. Moreover, interaction between the secretion rate and control variable error could also contribute to producing an unregulated control response of neuroendocrine. Thus, this influenced the cooperation between neuroendocrine and PID in the NEPID controller structure, which could limit the controller capability. In seek of resolution, the sigmoid-based secretion rate neuroendocrine-PID (SbSR-NEPID) controller had, thus, been introduced by [15] which capitalizes on an adaptable hormone secretion rate. Improved upon the existing NEPID, a sigmoid function for the MIMO container gantry crane system is adopted for the new controller structure towards enabling varying secretion of neuroendocrine in accordance to fluctuations of the control variable error.

Considering improved robustness of the fore-mentioned controller, the current study hereby proposed implementation of a data-driven SbSR-NEPID controller for the TRMS system. Adaptive safe experimentation dynamics (ASED) algorithm (ASED) was further employed in acquiring the optimum parameters. The decision was made on the ground of convergence stability and improved accuracy, which are both achievable through the algorithm's ability to withhold the best value for the optimized parameters, with lesser coefficients that ensure effective implementation under relative ease. Essentially, updated mechanism of the ASED algorithm possesses adaptive potential upon variable objective function; thereby, offering an added perturbation towards aligning both the design parameter and its latest objective function [12]. Evaluated through minimizing tracking errors of the system's angles on both the horizontal and vertical planes, presented circumstances would expect improved performance of the controller structure.

In general, this paper is operationalized through six main sections, as follows: An introduction on the subject matter has been presented via the first section of this paper. The second section follows with an explanation on the investigated TRMS system. Problem formulation concerning employment of the SbSR-NEPID controller for a TRMS system is then highlighted in the third section. The fourth section further outlined an illustrated design of the SbSR-NEPID controller,