University of the Witwatersrand

Masters Dissertation

Nature-Inspired Meta-Heuristic Algorithms in PID Controller Tuning for Gimbal Stabilization

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Abstract

Engineering and the Built Environment
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Nature-Inspired Meta-Heuristic Algorithms in PID Controller Tuning for Gimbal Stabilization

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Inertial stabilization systems are essential in ensuring that the optical system tracks the target of interest and rejects any disturbance. The work presented in this dissertation focuses on optimizing the Proportional-Integral-Derivative (PID) controller in order to ensure that the gimbal used in the chosen inertial stabilization system follows the Line-of-Sight (LOS) rate command input (which represents the target velocity) and rejects disturbance. The main objective of this research was to compare which optimization methods for tuning the PID controller work best for the one-axis gimbal stabilization system. The methods compared are three nature-inspired meta-heuristic algorithms; the Teaching Learning Based Optimization (TLBO) algorithm, the Flower Pollination Algorithm (FPA) and the Genetic Algorithm (GA). This research also involved tuning the parameters of the algorithms themselves in order for the algorithms to optimize the controller. This work also encompasses tuning the common algorithm parameters including the population size and search space bounds, tuning algorithm-specific parameters for each algorithm that requires this, and comparing whether dynamic or static parameters are better suited for the problem instances presented. These parameters were optimized for three different problem instances, which represent different target motions and additional disturbances in the system. It was found that different parameters work best for different problem instances and that this research favoured the TLBO when comparing the algorithm performances overall.