

Modeling of Self Tuned Fuzzy Proportional Integral Derivative Controller

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ABSTRACT

As the number of connections and the complexity of the manipulator system rose, it became more difficult for the control engineers to manage such a manipulator system, requiring the employment of a separate control system to govern the manipulator's position and velocity. Using different mathematical equations, this work investigates a self-tuned fuzzy PID (STFPID) controller that is capable of following trajectories and suppressing noise. A dynamic model for a two-link stiff robotic manipulator has been built in Simulink and used to drive the plant, and the STFPID controller is being used to do so. Genetic Algorithm is being used to tune the controller and we are using IAE (integral absolute errors) as an objective function in order to obtain the least amount of error and we have determined that STFPID has the least value of error as compared to the other three controllers. A fuzzy logic controller's ability to manage uncertainty is facilitated by its ability to climb in time quickly and to minimize overshoot.

Keywords: *Self Tunned Controller; Objective Function; Integral Absolute Error; Dynamic Modelling; Genetic Algorithm.*

1.0 Introduction

As a result, it is challenging for control engineers to operate stiff robotic manipulators with numerous connections and payloads. Using a combination of artificial intelligence and traditional control systems, industrial companies in the modern world may be able to function more effectively. The manipulator with two connections is controlled by a fuzzy PID controller because of its nonlinear complexity. A study by Sharma et al. [1] indicated that the fractional order fuzzy PID controller beat the other three controllers in terms of robustness, uncertainty, and noise suppression. Fuzzy P+ Fuzzy I + Fuzzy D exhibit self-tuning for nonlinear and uncertain systems, according to studies by V.Kumar et al.in [2]. One of his designs for a two-link manipulator system proved to be more flexible in terms of design and trajectory tracking. According to J.Kumar et al. in [4], using a fractional order fuzzy PD+I controller, the FOFPD+FOI Controller outperformed all others. The Genetic algorithm is one of several optimization and control methods that have been studied recently. GA Several methods, such as firefly, may be used to optimise an ant colony. cuckoo clock-inspired cuckoo clock-inspired search method and optimization employing bats In order to minimise steady-state error, the basic PID controller utilises well-known characteristics, such as 1) fewer starting parameters needed, 2) longer step lengths, and 3) convergence rates that are independent of parameters. Nonlinearities and uncertainty render this controller useless. Fuzzy logic

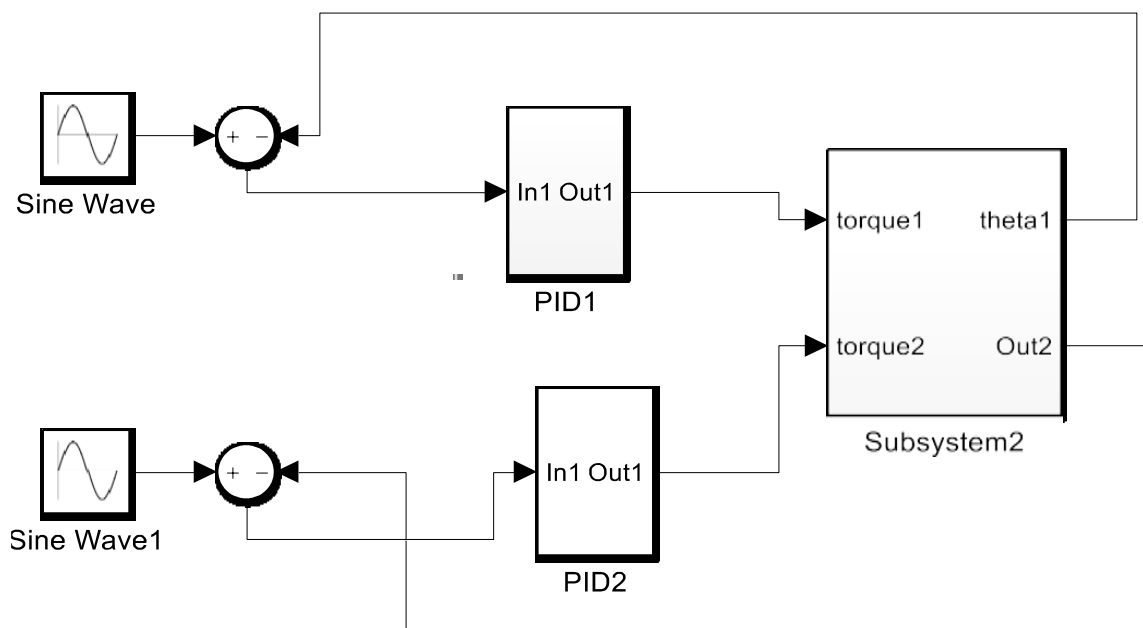
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controllers have a fast rising time and little overshoot to manage nonlinearities. [11] [12] Controls for fractional order proportional integral derivatives and fuzzy logic controllers have been developed by Sharma and others . Because of its two-link manipulator, C-FOPID has been found to outperform the other three controllers. In order to identify the optimum controller out of a vast number of options, genetic optimization is applied.

2.0 Designing of Controllers

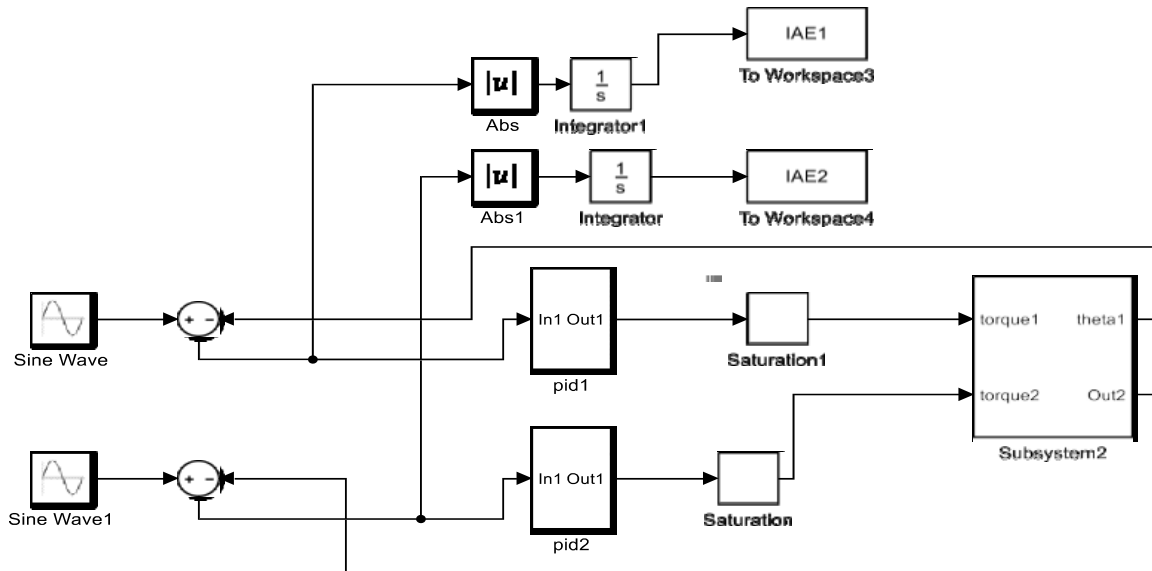
Two PID controllers have been used for Link 1 and Link 2 in the first structure. SIMULINK was used to construct this controller. PID stands for proportional Integral and Derivative Control. By using a proportional controller, it is possible to lower the steady-state error and so make the system more stable. With the help of an integrator, we were able to construct an integral error signal, which is directly proportional to the output of the integrative controller. The output of a derivative controller is directly proportional to the error signal's derivative. A proportional, integral, and derivative controller are all included in a PID system. controller's input is a sine wave, and controller's output is linked to a plant as a reference wave. A dynamic model of a two-link stiff robotic manipulator was created using the mathematical formulae described above. This Dynamic model is described in terms of plants. By reducing this plant output from the real value and subtracting the planned value from this value, we hope to reduce the inaccuracy and achieve perfect tracking between the input and output wave. We have the power to affect change. Gains are being manually tuned in this instance in an attempt to reduce the likelihood of error. As a result, our evolutionary algorithm will automatically and adaptively update the gain amount depending on the error value, while in this design the gains are being manually altered based on stimulation results and error values. To make certain that the waves at the input and output are identical. In order to reduce the amount of inaccuracy, gains may be manually set here. We've also utilised this design to manually tweak gain values depending on stimulation results and error numbers in addition to the genetic method.

Figure 1: Block Diagram of Controller



2.1 Optimized controller structure

Figure 2: Block diagram of Controller in SIMULINK

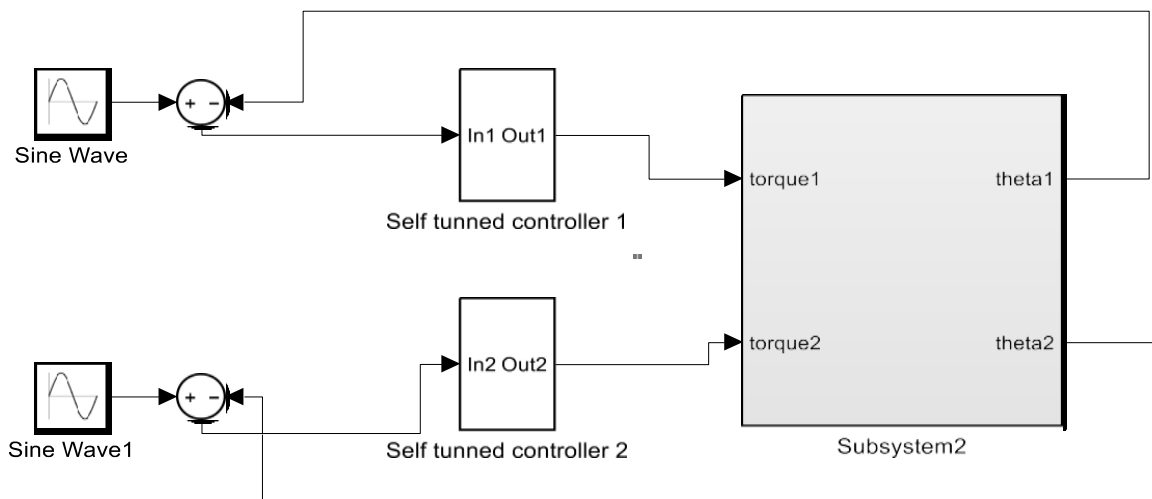


IAE (integrator/absolute block) is coupled to the input of the PID control model for use in the Genetic Algorithm. As an objective function in the Genetic Algorithm, we combined the absolute block with the integrator and attached these two blocks together to create this IAE.

3.0 Self Tunned Controller

The IAE (integrator/absolute block) is connected to the PID control model's input for the Genetic Algorithm. We created this IAE by connecting the integrator and the absolute block as an objective function in the Genetic Algorithm.

Figure 3: Block Diagram of Self-Tunned Controller in SIMULINK



4.0 Results

Because sine waves are fed into their inputs, all of the controllers have great tracking, as can be seen in the graphs. When looking at the graph, we can observe that a sinusoidal signal (blue line) closely follows the output signal (red line). We can see from this graph that our controller is able to handle all of the system's non-linearities and disturbances, even if they are there. It's possible for the controller to employ fuzzy logic's quick rise time, reduced overshoot, and ease with non-linearities to achieve faultless tracking. Since the world is increasingly heading toward automation, we employed Genetic Algorithm (GA) to optimise the controller for the lowest possible error value utilising integral absolute error as our goal function. As a consequence, in today's environment, automated controller tuning is favoured over human controller tuning. Absolute mistakes in system responsiveness are not weighted by IAE when integrating over time. This goal function was created using command-line tools like assignin and sim. It's possible to reduce the steady state error, stabilise the system, and improve transience of the system by using a single Simulink simulation output object that contains all of the results of the Self-Tuned FUZZY PID controller's stimulation output and the third represents all results of fitness values for all of the controllers under one graph. Robotic manipulators can now do repetitive tasks at a pace and precision that much exceeds those of human operators thanks to this controller. Controllers like this are often used in spot welding and painting, two common manufacturing processes. There has been a great deal of thought put into designing these controllers so that they provide the finest potential outcomes in a variety of industries.

Figure 4: Waves Representing Precise Tracking

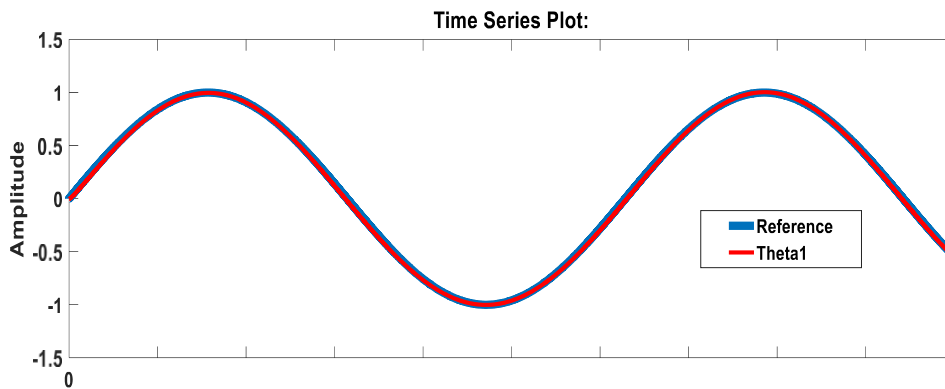
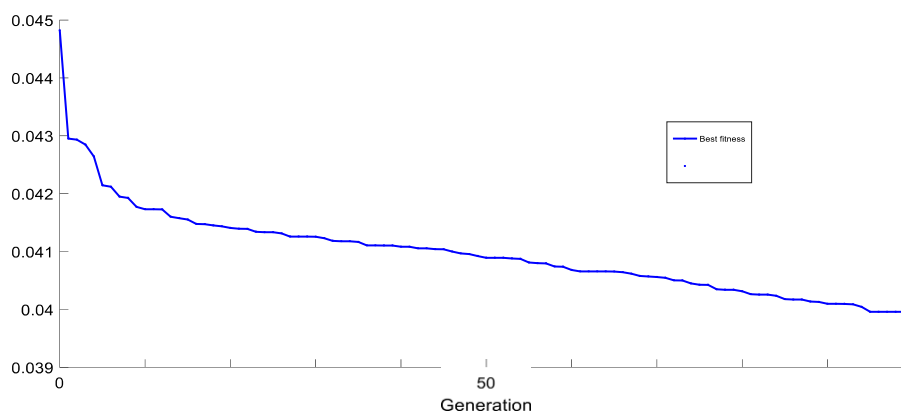


Figure 5: Graph Representing Error Values



5.0 Conclusion

All of the controllers' tracking is excellent since sine waves are supplied into their inputs, as can be seen in the graphs. We can see from the graph that the output signal is closely followed by a sinusoidal signal (blue line) (red line). Even if the system's non-linearities and disturbances are present, our controller is equipped to deal with them. Faultless tracking may be achieved by using fuzzy logic's short rising time, decreased overshoot, and ease with non-linearities. We used a Genetic Algorithm (GA) to optimise the controller for the lowest feasible error value using integral absolute error as our objective function since the world is moving toward automation. As a result, automated controller tuning is preferred over human controller tuning in today's environment. For the sake of long-term integration, IAE gives no consideration to errors in system responsiveness that can never be corrected. Assignin and sim command-line tools were used to develop this objective function. Simulink simulation output objects that include all of the results of the Self-Tuned FUZZY PID controller's stimulation output and all of the results of fitness values for each controller under one graph may minimise steady state error, stabilise the system, and increase transience. Thanks to this controller, robot manipulators can now do repeated operations at a rate and accuracy far above those of human operators. Spot welding and painting are two popular production procedures that employ controllers like these. These controllers have been meticulously crafted to provide the best possible results across a wide range of industries.

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