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Modelling and Optimization of Nonlinear Proportional Integral Controller

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ABSTRACT

The NPIC (Nonlinear proportional integral Controller) has been studied in this research, and a genetic method has been used to find the smallest possible error. Integral absolute error was used to develop the objective function (IAE)A nonlinear component is included in this controller, making it one of a kind in its mix of proportional and integral control. For non-linear robotic manipulators, this means that the controller may be far more effective than a linear controller, which has historically been difficult to operate. Consequently, this controller offers a nonlinear controller for manipulators. Programming controller parameters to achieve high trajectory tracking has always been a difficult and time-consuming task for engineers, thus developing a system that can handle non-linearity and complexity has become more difficult in the next year. An intelligent controller is needed to meet today's demands It is the goal of this review article to provide an in-depth analysis of different controllers and control approaches as well as optimization strategies.

Keywords: *Modelling; Objective Function; Optimization; Absolute Error; Integral Absolute Error.*

1.0 Introduction

Robots, as we are all aware, are becoming increasingly important in today's world as we move toward automation and robotization. With robots, we can produce high-quality products in shorter periods of time while also alleviating the shortage of skilled workers. We can also handle the increased pressure to increase production rates in order to compete in the market. However, in order to manipulate a system that could be adaptive and robust to design such control systems, various controllers and control techniques are used, which also took us towards inter-disciplinary fields. For example, suppose we're talking about controlling a robotic manipulator so the first thing we need is the physical model of the robot that's needed to design such control systems that can be adaptive and robust to control. As a clever hybrid of artificial intelligence and control engineering, fuzzy controllers have found success in commercial settings thanks to their ability to deal with almost any non-linearity. Fuzzy logic, with its shorter rising time and higher overshoot, gives researchers more latitude in their design choices since the parameters aren't only limited to true or false. When a situation resides halfway between truth and untrue, fuzzy logic may help. Fuzzy logic provides flexibility so that we can manage a break if a person or another vehicle unexpectedly comes into our path as an example of driving an autonomous automobile. It's being hailed as one of the best techniques among controllers because its results and performance are superior to traditional controllers, and as the year progresses, various controllers are designed in combination with various

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controlling techniques, such as fuzzy, neural network, and many more, for more precise and accurate tuning. It is being tested using a genetic algorithm to see how it performs, and varied findings are emerging. Robots need a controller to prevent them from becoming a catastrophe on their own. Robotic manipulator is the phrase used to describe the arm of a robot. In order to control and operate the manipulator, there are several controllers and procedures.

2.0 Literature Review

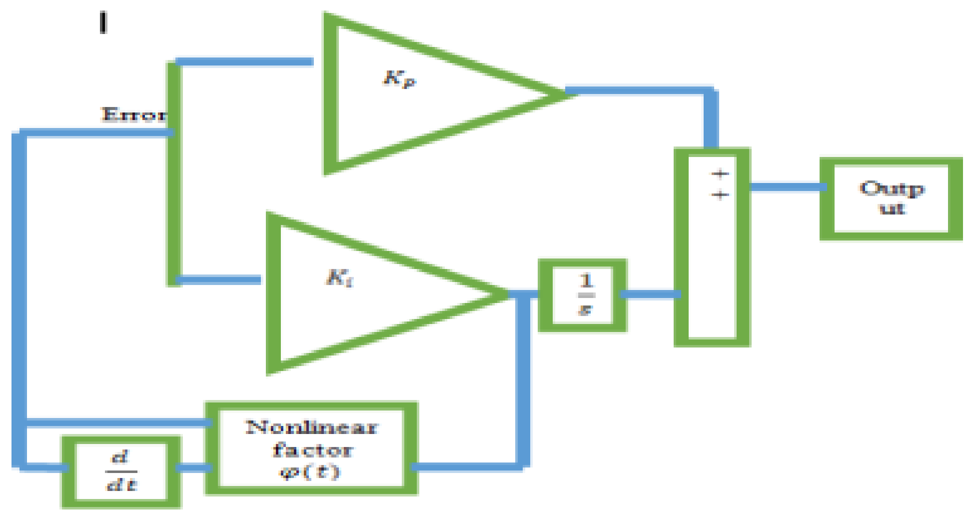
Until 1950, controlling nonlinear and complex manipulator systems was a difficult task for engineers. PID's simple structure and imprecise implementation made it a good candidate for development to handle this new class of nonlinear and complicated manipulator systems. This controller is relatively cost-effective [1-4], however it was unable to manage nonlinearities and uncertainty well enough to solve these problems. In 1960, a new approach called "classic adaptive control technique" was developed. allThese methods heavily depend on the manipulator system's dynamic model.The greatest approach to cope with nonlinearities and complexity [5-7-] is via them.It's been said that "nothing is flawless," and therefore there were some downsides to the system. [8]One drawback of these control systems is that they demand a precise mathematical model in order to produce a faultless outcome, and gain scheduling design finds it difficult to deal with the a broad area of action[9,10]. So, in order to deal with systems that have inadequate dynamic analysis, artificial intelligence (AI) was examined as a potential solution.The standard control techniques[11] were integrated with these fuzzy logic controllers to make the system more intelligent and adaptable.Neurofuzzy approach combines the (FLC) and artificial neural network, as well as their respective fusions to provide excellent results in enhancing thethe SMC's capabilities[12,13].zadeh presented a fuzzy logic controller that offers almost correct outcomes for uncertain systems.Although not limited to true or false, fuzzy logic may assist us cope with the probability of anything being either false or true.As the years went by, the controller envisioned by mamdani came into being.Together with fuzzy logic, PID and Fuzzy controllers have all their flaws eliminated and their overall benefits boosted, making the PID-Fuzzy combo the best of both worlds.that by combining the two strategies, a robust system may be created Fuzzy logic-based control systems are examined in great length by wang.and kwok, as well as their own suggestions, recommend that fuzzy pd and fuzzy I be combined. making a few tweaks to the fuzzy PI controller Li and adding a few more featuresA fuzzy three-term controller was suggested by Gatland.

3.0 Modelling of NPI Controller

For the control of robotic manipulators, linear controllers are becoming more used. it is possible that just a few number of nonlinear controllers will be developed An entirely new technique to dealing with the nonlinear model is provided by this controller, which handles slow time variable errors and numerous unknown parameters quite effectively, as well.

The PI controller combination helps to remove the steady state error completely, has good transient response, and is robust enough to handle nonlinearities. It also provides better system stability than traditional controllers. This proposed controller is faster, more accurate, and provides better system stability than traditional controllers. As an integral gain is added to the nonlinear controller in order to adjust for any uncertainty that may arise throughout the course of a run, the controller's nonlinear factor (t) is multiplied by the integral gain. It was created using a mathematical formula. The input may accept a sine wave. MATLAB/SIMULINK can conduct further simulations on this waveform, making it ideal for trajectory tracking planning for manipulators whose paths are similar to those of sine waves.

Figure 1: Block Diagram of NPI Controller



4.0 Simulation of NPI Controller

Integral absolute error was used as the objective function in the graphs below, with the x axis representing the fitness value, and the y axis representing generations (the number of times the genetic algorithm has run). The fitness value for best fitness in the first graph is 0.04438; this is the highest error value among the graphs. There is a table below that shows the comparison between the values of error and we can state that we have finally achieved the lowest value of error by optimising the controller using genetic algorithm.

Figure 2: Graph Representing Error Value in First Run

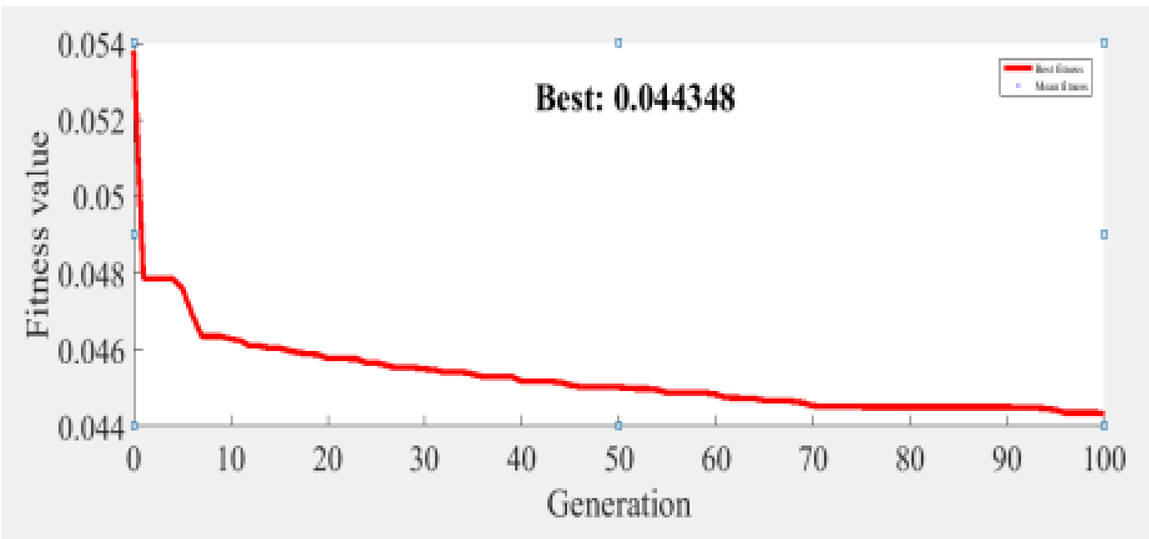


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Figure 3: Graph Representing Error Value in Second Run

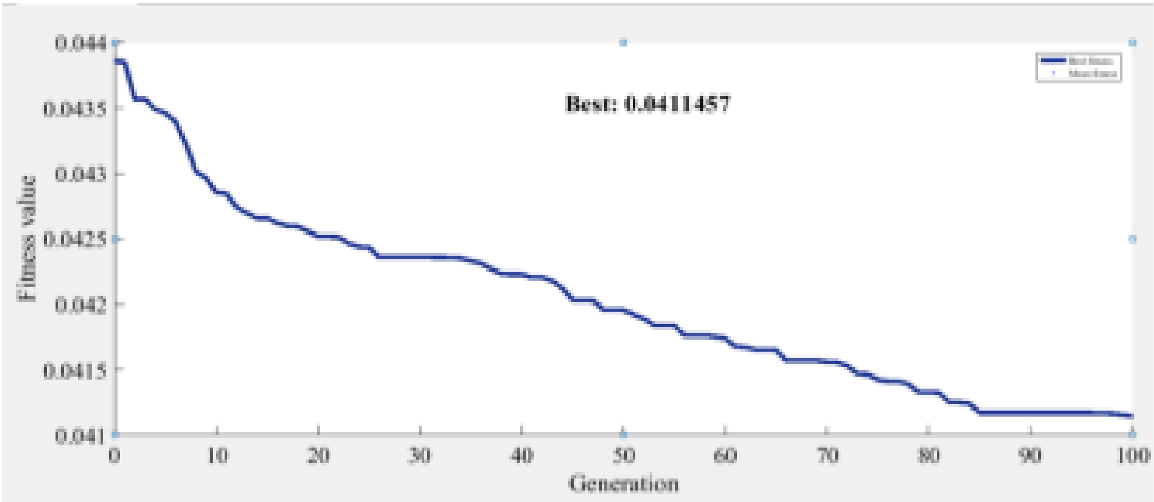


Fig 4: Graph Representing Error Value in Third Run

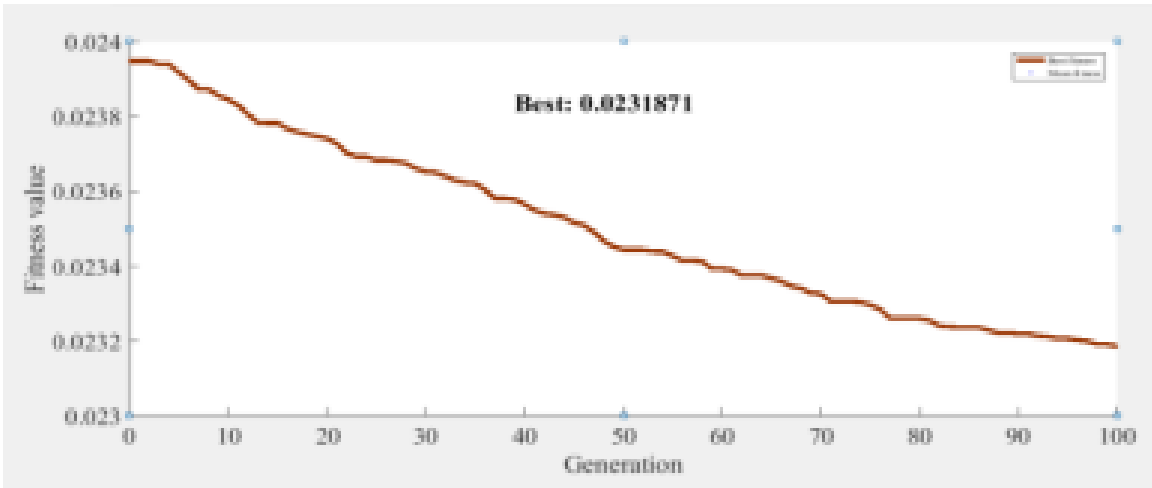
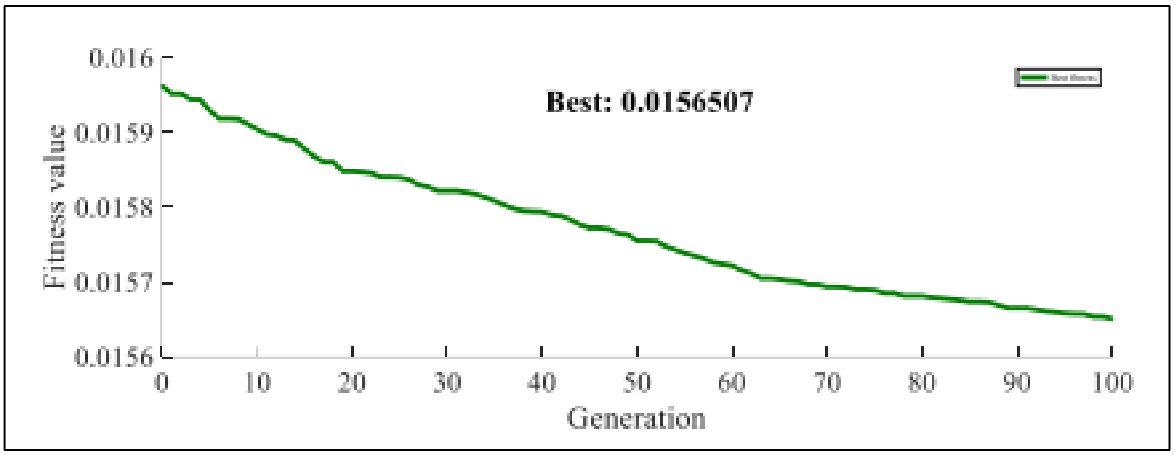


Fig 5: Graph Representing Error Value in Fourth Run



5.0 Conclusion

In this research, we show that optimising the nonlinear proportional integral controller and obtaining the lowest error value may be accomplished by watching the gains value after each generation and applying the new gains value in the form of lower and upper bounds. There are several uses for NPIC controllers, including controlling. As a result of the inherent stability provided by integral controller absolute error, the Y axis represents the number of generations number of times genetic algorithm has been run that have been taken into consideration as an objective function.

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