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# Controlling of Manipulator for Welding Advanced Metals

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**ABSTRACT**

*Welding processes may become more efficient and precise if the robot arm is controlled properly. Welding characteristics such as temperature, Welding speed and vibration at the end effector may affect the location and velocity of the manipulator, hence a control system calibrated with these factors must be used to manage its movement. This work uses SIMULINK to manage a two-link stiff robotic manipulator system. SIMULINK was used to develop a FUZZY-PID controller whose output serves as an input to the plant in order to simulate the dynamic behaviour of the manipulator. The controller is getting an upgrade thanks to the Genetic Algorithm (GA). According to simulation findings, FUZZY PID had the lowest integral absolute error compared to the other three models (FUZZY PI, FUZZY PD, and PID Controller) (IAE). An updated dynamic PID model called FUZZY may be used to precisely position the robot arm along a predetermined pathway. An arc welding, casting, and load-bearing manipulator controller may benefit from this controller.*

***Keywords:*** *Fuzzy PI; Fuzzy PD; IAE; Tracking; Error; Values.*

## 1.0 Introduction

Managing a stiff robotic manipulator with several connections and a payload is difficult for control engineers since most practical systems are nonlinear and complex. Artificial Intelligence (AI) in conjunction with conventional control systems may improve the efficiency of today's industrial organisations. Because of its nonlinear complexity, a fuzzy PID controller is used to operate the manipulator with two links. One of the finest controllers for robustness, uncertainty and noise rejection, according to Sharma et al. in [1-3] is the fractional order fuzzy PID controller. Using a fractional order fuzzy PD+I controller, J.Kumar et al. in [4] operated an electrically driven robotic manipulator and discovered that the FOFPD+FOI Controller was better than all others. Genetic algorithms, for example, have been extensively studied as a control and optimization tool. GA optimization of ant colonies [5] Six of the PSOs a firefly algorithm is only one of many such examples. [6,7] A search approach reminiscent to a cuckoo clock and optimised like a bat Using a cuckoo search method provides a variety of benefits, including the fact that it needs fewer starting parameters, has longer step durations, and does not rely on parameter values for its convergence. With this search algorithm, the traditional PID controller also helps to eliminate

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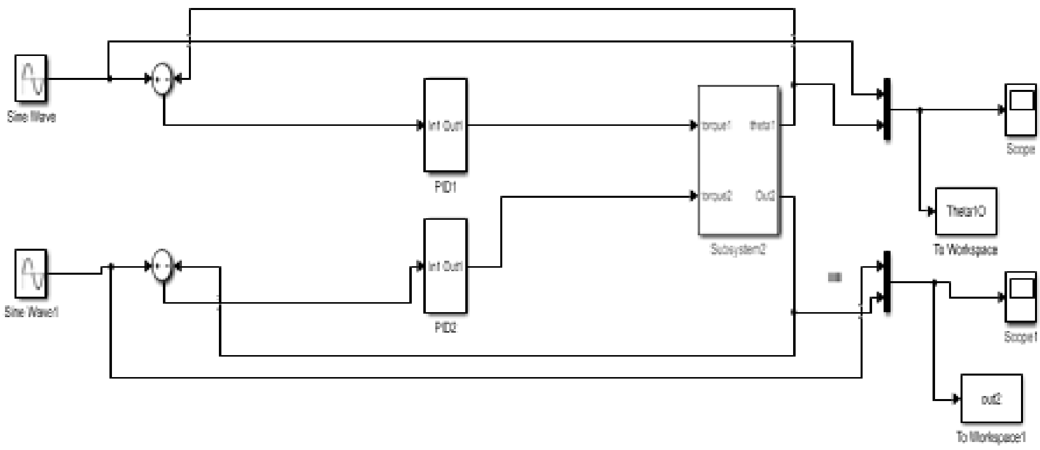
steady-state error This controller is incapable of successfully controlling nonlinearities and uncertainty. To deal with nonlinearities, a fuzzy logic controller has a short rise time and low overshoot. Using a stiff robotic manipulator with two linkages, the researchers found that the C-FOPID-FOFLC control scheme outperformed the other three. A genetic algorithm will be used to pick the optimal controller from among FUZZY PID, PI, and PID. Arc welding is a typical contemporary technique for joining metal plates. There must be advanced welding robot design in order to achieve excellent weld quality. The welding industry is increasingly turning to visual welding robots to connect thin plates. For GMA and GTA welding, when gas metal arc and gas tungsten arc are used, a CCD camera may serve as an effective visual sensor. Grooves are cut into the margins of the thick boards and the gap is prepared before the boards are linked. Additional heating is achieved by using an oscillating welding torch in a groove to heat thick slabs of metal. To keep an eye on the weld pool, you'll need an oscillating flame and a synchronised CCD camera shutter. In practise, it's difficult to use the weld pool method described for thin-plate welding. GMA welding is used to reduce welding gaps in order to improve productivity. Depending on how well the first layer's welding is done, following layers will be of lower quality. If the weaving width is equal to the gap, the arc crawls up the electrode wire. Because the arc discharges to the groove's upper side, it does not melt the metal's root edge. The wide-back bead is not for sale.. The weaving gap is less than the gap. If the groove angle is larger than a certain value (such as 16°), the arc cannot creep up the electrode wire. If the angle of the electrode wire is too small, the arc may crawl up the wire.

## 2.0 Controller Design

### 2.1 PID controller modelling

The dynamic model of a robotic manipulator with two connections is controlled by a PID controller using the mathematical equations previously stated, and an input sine wave is used to determine whether or not the output is tracking the reference wave. Self-tuning is conducted here since the gains are manually tweaked. There are two PID controllers utilized for each link of the manipulator arm and the plant, one for the first link and the other for the second link of the manipulator plant, respectively. Similarly, theta 1 and out 2 indicate the outputs of links 1 and 2, respectively. A graph may be created by using scope.

**Figure 1: Block Diagram of PID Controller**



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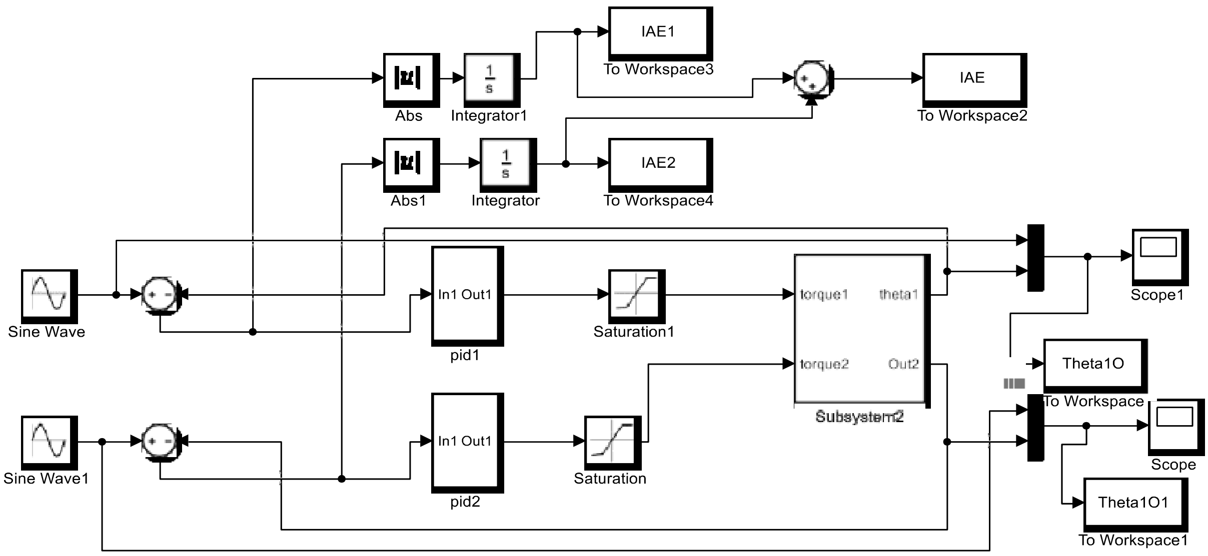
## 2.2 Optimized PID controller design

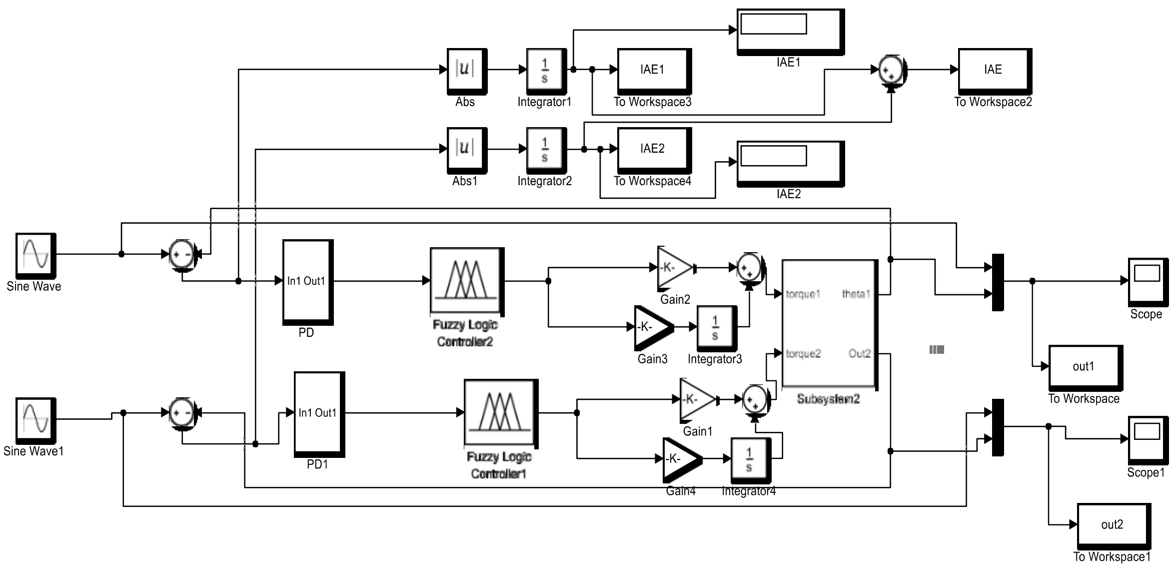
The controller has been optimized utilizing GA in this design (Genetic Algorithm). When it comes to finding the best way to survive, a genetic algorithm is one of the most effective methods. We are utilizing genetic algorithm to reduce the error value, which is a primary goal of the genetic algorithm. In this case, we utilized IAE (INTEGRAL OF ABSOLUTE ERROR) as an objective function to determine the fitness value since it integrates the absolute mistake without adding any weight to the error. Integral Absolute Error is linked to the inputs of PID controllers 1 and 2, respectively. An integrator is coupled to the absolute block, and the integrator's output is IAE. We'll use the Genetic algorithm in the optimization tool and input all of its parameters to produce an optimum outcome.

**Figure 2: Optimized PID Controller Design**




## 3.0 Optimized Fuzzy PID Controller Design

**Figure 3: Optimized Fuzzy PID Controller Design**



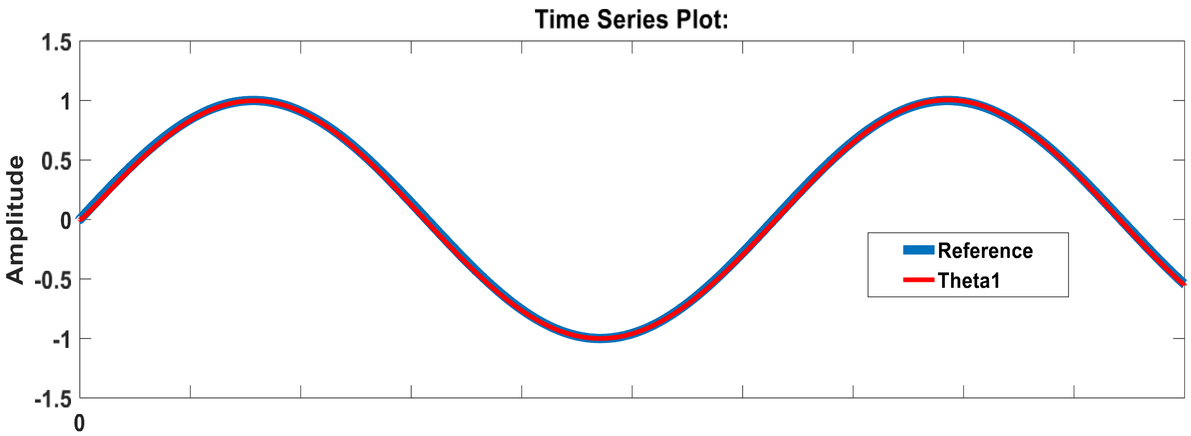
Many industrial issues may be solved more effectively with the use of unique. Fuzzy controllers are currently widely used in a wide variety of power system applications. As a model-free control design method, fuzzy logic is a viable option for today's complex and dynamic power systems. To acquire the best results, we employ a PD controller, which sends its output to a fuzzy logic controller, which in turn is incorporated into a FUZZY PID controller, which feeds the plant and uses a genetic algorithm to optimize the outcomes.

## 4.0 Results

### 4.1 PID controller result

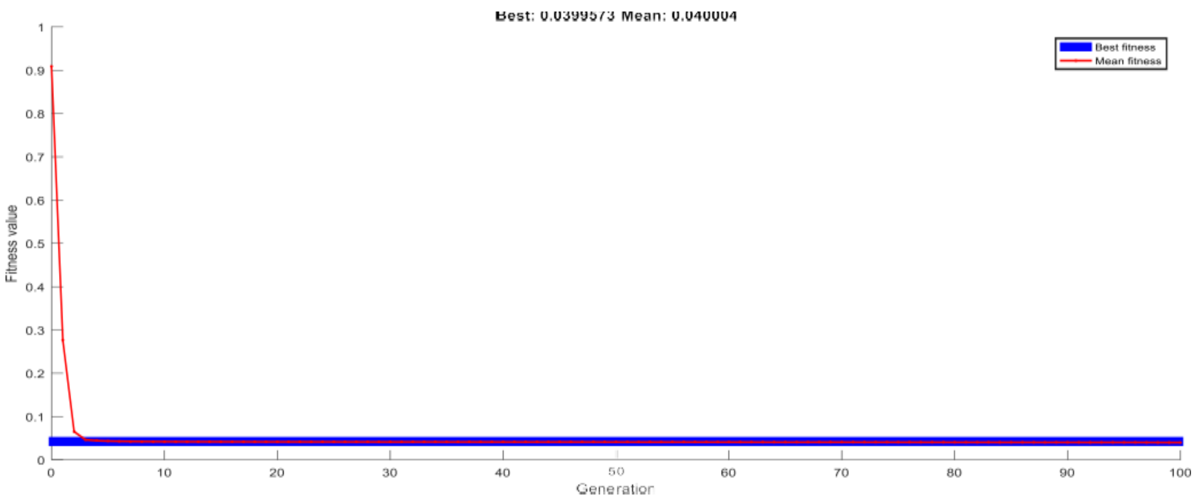
Because the output of the manipulator arm for the two links properly tracks the sine wave for welding purposes, we can state that by using a PID controller, the output is able to follow the input. At order to weld in the right place, precise monitoring is needed. Using a PID Controller, this is the outcome. The sine wave we've provided as a reference is perfectly tracked in the graphic shown above. Self-tuning is possible in this instance since the gains may be adjusted in value.

**Figure 4: Error Tracking Result**




### 4.2 Fuzzy PID controller result

**Figure 5: Fuzzy PID Controller Result**



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GA optimization yields a fitness value of 0.0399573 after 100 iterations. Until now, this is the lowest value of error we've found. They're less expensive to build and can handle a broad variety of operational conditions. The PID controller warms up quickly. Using this controller, we are able to accomplish precision welding by controlling the temperature at which we weld.

## 5.0 Conclusion

A basic PID controller is presented here, and we can achieve a perfect tracking of the reference and the real route, which might assist us to precisely weld at the correct spot. Non-linearities and vibration at the end effector during welding are being addressed by designing an arc welding controller with a rapid rise time and reduced overshoot, which will allow for more accurate arc welding. We're able to acquire the lowest possible error value thanks to the genetic algorithm optimization approach we utilized here. Between the fitness value and the first 100 generations, we are able to acquire the lowest value of integral absolute error. The lower the amount of error, the more accurate the route tracking may be. In order to achieve high-quality one-side multi-layer welding, a robust back bead in the first layer is essential. An experimental finding that serves as the basis for a linear differential equation model is first used to create the model. Also developed for two controllable variables (bead height and arc position) is the digital controller. The digital controller's validity is tested using numerical simulations with the gap varied.

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