International Journal of Computing and Artificial Intelligence

E-ISSN: 2707-658X
P-ISSN: 2707-6571
IJCAI 2021; 2(1): 57-61
Received: 21-11-2020
Accepted: 24-12-2020

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Measure of disturbance rejection for a Neonate Monitoring System using adapted Neuro-Fuzzy inference system

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DOI: https://doi.org/10.33545/27076571.2021.v2.i1a.27

Abstract
Temperature is a critical component of the environment since it significantly impacts human life, property, and product quality. A pleasant temperature is necessary for pleasant living. As a result, it is critical to monitor the temperature of humans, particularly newborn newborns less than 30 days, due to their low thermal stability. The temperature monitoring system for newborns enables the monitoring and regulation of neonatal heat levels. Adequate ambient warmth is critical for child care to sustain body heat. The typical Proportional Integral Derivative (PID) temperature controller, which is often employed, is well suited for stable systems.
Additionally, there are issues with the extended settling period, the huge time constant, overshoot, and the difficulty in obtaining an appropriate mathematical model. The purpose of this project is to create a neural fuzzy-PID controller for monitoring neonatal temperature. A typical fuzzy proportional integral derivative (PID) controller was integrated with artificial neurons in the heating and cooling system design to manage the Neonate's temperature.

Keywords: Disturbance, Inference, Monitoring, Neonate, Neuro-fuzzy and System

1. Introduction

Accurate body temperature monitoring is critical in newborns as a measure of thermal balance and thermoregulation. Neonates are newborn infants under the age of 28 days. Because newborns have poor thermal stability due to excessive heat loss and are particularly susceptible to body temperature changes [1-2], it is necessary to monitor and manage their temperature to the babies' normal body temperature to protect them from hypothermia. This may be accomplished by the development of a heating system for neonates. Though several heating techniques have been used in the past for newborns, including heating the room with a bright bulb or lantern, covering their bodies with clothing, and others that need human interaction, a more modern technique uses the PID control scheme [3]. The proportional integral derivative (PID) controller is one of the first control algorithms and techniques utilized in control engineering. PID controllers were invented in 1940 and have been extensively employed in industries ever since. PID controllers are used in businesses to regulate variables such as fluid flow, pressure, level, temperature, consistency, and density. The controller maintains a constant level of process output so that the difference between the process variable and the setpoint is as little as possible [4-5].

The conventional PID controller is frequently used for temperature control because it has a good control effect for a steady-state system and can generate an accurate mathematical model. However, due to the complexity of the actual temperature control system, varied parameters, large inertia, and large delay, the conventional PID controller has difficulty controlling its high precision [6]. The disadvantages of temperature control in a room heating system include repetitive ON/OFF switching, a longer settling time, a large time constant, and overshoot.

To address these shortcomings, a system combining PID algorithms, trained inputs, and fuzzy control will be developed that does not require a precise mathematical model of the controlled object and instead relies on experience and knowledge to monitor the Neonate's temperature and prevent it from falling or rising above the normal room temperature. As a result, a neuro-fuzzy adaptive PID temperature controller will be created that utilizes fuzzy reasoning techniques to auto-tune PID settings. This system will be suited for a time-varying, non-linear delay system.

1.1. Tuning Method for Minimum Error Integral Criteria

Tuning for the 1/4 decay ratio often results in oscillatory responses, and this criterion also takes just two points of the closed-loop response into account (the first two peaks). Alternatively, you may construct a controller design relationship based on a performance metric that takes the full closed-loop response into account. Several of these indices are listed below.1) Integral of the absolute value of the error (IAE) [7].

$$IAE = \int_0^{\alpha} | e(t) | .dt \quad \text{equ (1)}$$

2) Integral of the square value of the error (ISE)

$$ISE = \int_0^{\alpha} e^2 (t).dt \quad \text{equ (2)}$$

3) Integral of the time-weighted absolute value of the error (ITAE)

$$ITAE = \int_0^{\alpha} t \; | e(t) | .dt \quad \text{equ (3)}$$

4) Integral of the time-weighted square of the error (ITSE)

$$ITSE = \int_0^{\alpha} t.e^2 (t) | .dt \quad \text{equ (4)}$$

1.2. Fuzzy sets

[8] Considered fuzzy sets to be an extension of classical or crisp sets. Classical sets and their operations are especially advantageous for expressing classical logic since they lead to Boolean logic and its applications in digital systems. On the other hand, fuzzy sets and fuzzy operations are valuable for expressing fuzzy logic concepts, resulting in applications such as fuzzy controllers. A fuzzy set is a set that allows for degrees of membership between 1 and 0. Because fuzzy sets allow for partial membership, they may more accurately represent the way clever people think. For instance, an intelligent individual will not categorize others as friends or foes; there is a spectrum between these two extremes.

1.3. Related Works

To manage the Draw-Texturing Yarn (dti) machine, [9] designed an automatic PID temperature control system. A thermodynamic model has been put up, followed by a minimal phase control system for the Self-Tuning Proportional Integral Derivative (ST-PID). A forgetting factor searching (ANN-FFS) approach was developed to improve system parameter identification. ST-PID has enhanced the identification of the parameter by utilizing ANN-FFS and increases the check precision almost three times compared to the fluid pid approach.

Do [10] build a fuzzy PID controller for tracking the distinguished robot path? The model was based on the dynamic method from Lagrange for a differentially driven robot and a MATLAB/Simulink test of the route tracking of the mobile robot. Regarding fast responses, high stability, tracking precision and strong anti-interference, the fuzzy-PID controller has greater performance than the traditional PID controller. The FUZZY-PID controller is suitable for path tracking the differential drive control of mobile robots. The boiler drum level regulations utilizing the fuzzy-PID are suggested by [11]. Liquid level control difficulties can develop in power plants in a boiler drum. Compared with traditional PID, fuser-PID control is a better reaction than conventional PID, comparing the time-domain features and the simulation results.

To optimize the PID parameters of the three tank levels procedure [12], the Differential Evolution (DE) method was used. The DE-based PID controller's responsiveness is better than the standard PID response. The precise demands for humidity in a range of situations were addressed by [9]. The design of a moisture fugues control system was carried out using a fugitive control algorithm. The method provided is very accurate, has a minimal overlay, excellent stability and intelligent moisture management.

PID and Fuzzy Controller for the smart greenhouse [8-9] have been used to regulate various greenhouse parameters. The control activities are done based on the merger of many factors to optimize energy usage and room utilization. The PID controller was created for moisture and temperature while the fuzzy carbon dioxide enrichment inferencing system was built. The PIDA controller for the electric furnace temperature control has been developed by [2]. In the search for optimum PIDA parameters, the Flower Pollinating algorithm (FPA) was used. A restricted optimization issue is examined in the suggested PIDA framework based on FPA. The FPA-based PIDA controller system responses were compared with those of the PID controller. The PIDA was obtained that the electrofurnace temperature control system gave a very acceptable monitoring and regulating response.

2.0. Materials and Method

P, I, and D (D). When P relies on the present error, I on the accumulation of previous mistakes, and D is calculated as a forecast of future mistakes based on the current rate of change. The values of these parameters are understood in terms of time. Figure 3.2 illustrates how the P, I, and D inputs are combined to generate the PID controller output.

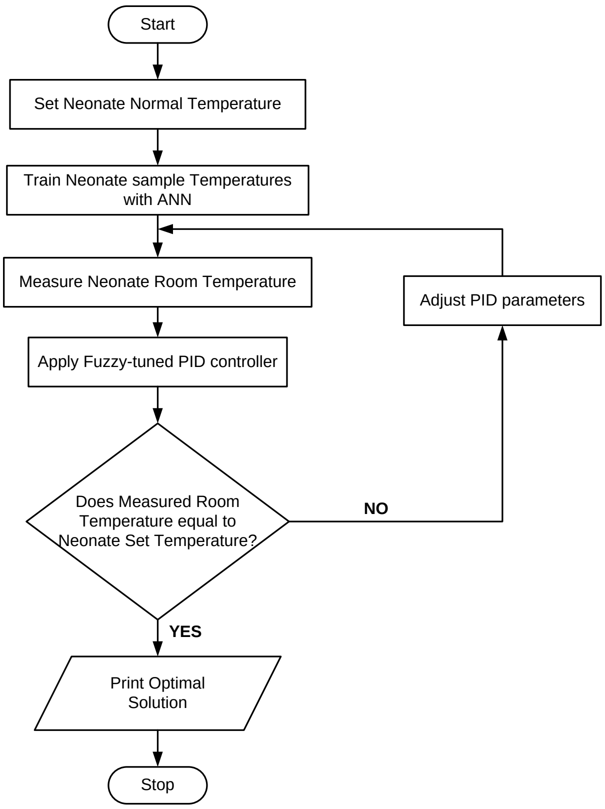

Fig 1: Flow chart of the proposed system

The model of the temperature control system is given below:
Let's assume that:
T_{in} = inner wall temperature of the neonates
T_i= air temperature of the neonate room
T_{amb} = outside air
h = coefficient of convection of heat transmission, Then

- Heat exchange between the indoor air and the inner wall temperature is given as

$$\frac{dQ_1}{dt} = h_1 A_1 (T_{in} - T_i) \qquad (1)$$

Where A = Cross-sectional area

$$\frac{Q_1}{A_1} = h_1 (T_{in} - T_i) \qquad (2)$$

Note that $\frac{Q_1}{A_1} = q$ = heat transfer per unit area/heat flux

- Heat exchange between the outer wall temperature and outside air is given as

$$\frac{dQ_2}{dt} = h_2 A_2 (T_{out} - T_{amb}) \qquad (3)$$

$$\frac{Q_2}{A_2} = h_2 (T_{out} - T_{amb}) \qquad (4)$$

- Transmission by conduction between the inner wall and the outside wall is given as

$$\frac{dQ_3}{dt} = \frac{kA(T_{out} - T_{in})}{l} \qquad (5)$$

$$\frac{Q_3}{A} = \frac{kAdT}{dl} \qquad (6)$$

Where $\frac{Q_3}{A} = q$

K = coefficient of thermal conductivity
A = cross-sectional Area of the wall
l = Path length

- The heat generated by the heater is given as

$$\frac{dQ_{heating}}{dt} = \eta\rho(t) \qquad (7)$$

Where

$\eta = \frac{\text{Power delivered}}{\text{Power consumed}}$ and

$\rho(t)$ Represents the power consumed

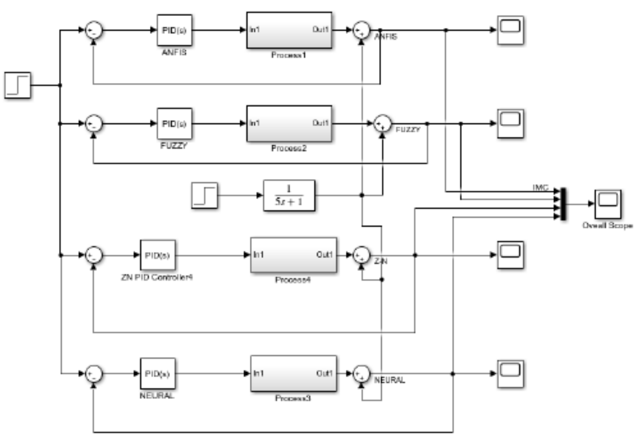

Fig 2: Simulink model for the response of PID controller comparing ANFIS tuning with FUZZY, ZN and NEURAL.

3.0. Result and Discussion

Temperature control in Neonate is crucial for maximizing productivity in Room Heating. The better the temperature regulation, the longer the Neonate will live. As a consequence, this study endeavour included neonate temperature control. The Neonate temperature was controlled in this study effort using a simple, adaptable, and adaptable hybrid Fuzzy-PID control system. The required temperature was set using the potentiometer, and the temperature sensor device's output signal was compared to the target temperature. The temperature sensor and the humidity sensor determine the Neonate's current temperature and relative humidity. The controller has been tasked with interpreting and simulating the sensor data streams. When the room temperature increased, the controlled signal activated the heater, and when the temperature decreased, the controlled signal activated the cooler. Consequently, the process was able to achieve a preset fixed point in the shortest amount of time with the least amount of overshoot.

3.1. Disturbance Rejection

Starting at roughly 34 degrees, space was heated to a fixed point of 88 degrees or 44 degrees. During the heating phase, the cold chamber was placed in the centre on the 500th iteration. ANFIS performed well in this area as well.

Disturbance Rejection

PID	34.25
Neural Network	45.21
Fuzzy	60.27
Fuzzy-Pid	69.25
Neural-Pid	62.89
Anfis	78.91

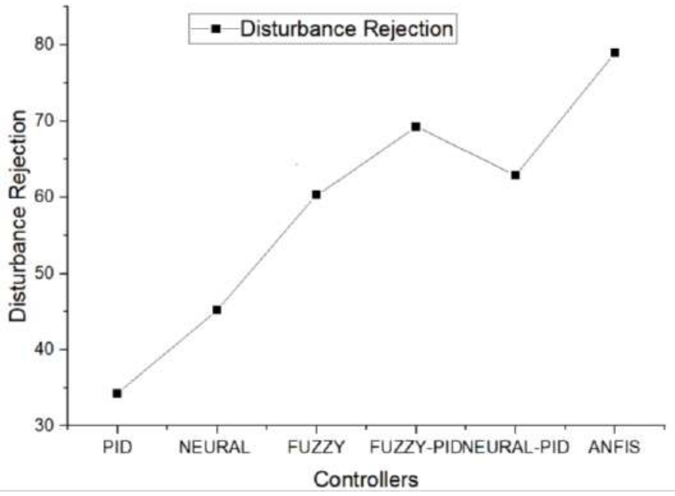

Fig 4.10: Disturbance Rejection

Controllers	Mean Square Error	Setpoint Tracking	Disturbance Rej
Pid	4.67	32.18	34.25
Neural Network	3.56	55.45	45.21
Fuzzy	2.89	72.67	60.27
Fuzzy-Pid	2.01	91.54	69.25
Neural-Pid	3.01	99.67	62.89
Anfis	1.25	105.23	78.91

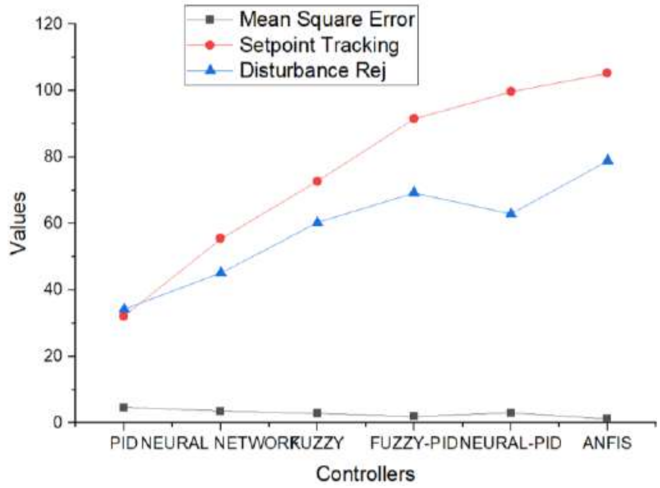

Fig 4.11: Comparative Analysis of Different Parameters

4.0. Conclusion and Recommendation

This study contributes to the solution of the issue of inadequate neonatal temperature management. The results indicated that the ANFIS tuned PID controller step response crossed the steady-state level earlier than the other tuning methods at 2 seconds, reached stability earlier at 5 seconds, and produced the fastest rise time at 0.5 seconds, the fastest settling time at 1.7 seconds, and the lowest overshoot level at 1%. Additionally, it is recognized that the shorter the settling time, rising time, and overshoot, the quicker the system will respond and attain its intended aim. It is now established that the ANFIS-tuned PID controller provided optimal responsiveness and stability. As a result, it is stated that ANFIS is the superior approach of controller tuning among the four. The quickest rising time and settling time were obtained in the input disturbance rejection and output disturbance rejection modes, respectively, while maintaining an equal % overrun.

Reference

1. Guanda Lu, Qiuyue Zhang, Qihui Feng and Tongtong Qie. The fuzzy control algorithm of One Kind moisture test device, IOP Series Conference Materials Science and Technology 2019;470:87-92. High-precision humidity control research.
2. Kaushal Kapadnis & Chandle JO, Manish Pathil. DC Motor, International Journal of E-communication, Electronics and Data Control, Special edition 2015;201-220. Fuzzy-PID Design and Simulation
3. Shahrokhi Mohammad & Zomorrhodi Alirezza. Comparison of PID Controller Tuning methods, Chemical and Petroleum Engineering Department, Technical University of Sharif 2013, 156-200.
4. Ikhlas Septiani, Ike Bayusari, Caroline, Bhakti Yudho Suprapto, Triya Haiyunnis, Triya Suprapto. Stirred Tank Heater Process Temperature Control Logic, International Conference on Electrical Engineering and Computer Science (ICECOSS) 2017, 178-198 Optimization for Pid control parameters Plus Fuzzy Logic.
5. The City of Poland. Poongodi. The Temperature Process Implementation is utilizing Soft Computing Techniques, World Engineering Congress 2016, 382–398.

6. Kayalvaši B, & Ramji B & Kayalvaši V. Boiler Drum Control Level by Use of the Hybrid Controllers, Fourth ICTS'18', St. Xaviers Catholique College of Engineering, Nagercoil, Tamil Nadu, India 2018, 235-287. Drum control by Use of Hybrid PID.
7. Gao Zhiwei, Xlao Peng Shi Dequan & Gao Guili. Application of the Fuzzy PID Method for Heating Oven Tempain Control (IWIWW), Elsevier Ltd., IWIWW International Workshop 2012, 90-101.
8. Sivaji & Seagull. Stop and Go Manoeuvres, International Engineering Research Journal (IJERA), 2013;3(4):2453-2456. Adaptive Cruise Control Systems for Vegetable Modeling.
9. Ravi Mishra and Smiriti Rao. Comparative P, PI and PID speed control studies for the VSI motors, International Engineering Development and Research Journal 2014;2(2):2321-9939.
10. Copripio Smith. Automatic process control principles and practices, Sons and John Wiley 1985, 154-165.
11. Campelid, DC Chadee, Y Honda, Q Liu, JM Olaw B Revich and R Sauerborn A. Woodward, Campbeliz-Lendrum AC. Human health: effects, adjustments and benefits. In: 2014: Impacts, adaptation and vulnerability in climate change. Part A: Aspects of the global and sector. Working Group II's Contribution to the Intergovernmental Climate Change Panel Fifth Assessment Report 2014, 214-220.
12. Patrick & Patrick K Mittal Sneha. The Heating Control System Design for Fuzzy PID, Electronics and Instrumentation Engines, International Journal of Advanced Research 2017;6(6):2320-3765.