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Temperature Control System in Closed House for Broilers Based on ANFIS

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Abstrak

Indonesia adalah negara tropis dengan suhu lingkungan yang tinggi bagi ayam broiler karena suhu harian mencapai rata-rata 36^{0}C (maksimum) dan 32^0 C (minimum). Kondisi suhu optimal untuk ayam broiler adalah sekitar 28-30^{0}C. Itulah sebabnya banyak industri peternakan ayam berupaya mendayagunakan sistem kendali untuk mempertahankan suhu kandang ayam broiler (broiler house) pada suhu yang mendekati optimal. Oleh karena itu, peran sistem kendali untuk pengendalian lingkungan, tidak saja suhu, namun juga meliputi RH, pencahayaan dan kadar amonia di dalam kandang ayam broiler menjadi sangat kritis dan relevan untuk peningkatan kapasitas dan kualitas produksi ayam broiler. Penelitian ini bertujuan untuk merancang suatu sistem kendali ANFIS untuk mengendalikan suhu di dalam kandang tertutup (closed house) untuk ayam broiler. Pengambilan data dilakukan pada tiga periode yang berbeda yaitu masa awal (5 hari): 29.5^{0}C-30.90^{0}C, masa tengah 25 hari adalah 29.^{0}C-34.2^{0}C, dan masa akhir 30 hari adalah 29^{0}C-33.2^{0}C. Simulasi kendali suhu menggunakan setpoint yang sama 29^{0}C untuk masa awal, tengah dan akhir. Hasil simulasi menunjukkan suhu output dalam closed house berfluktuasi di sekitar setpoint yaitu 29^{0}C-34^{0}C.

Kata kunci: *ANFIS, Sistem Kontrol, Suhu, Closed Broiler House, Produksi Broiler.*

Abstract

Indonesia is a tropical country with high ambient temperatures for broilers since daily temperature reaches an average daily temperature of 36^{0}C (maximum) and 32^0 C (minimum); whereas the optiml temperature for broilers is in the range of 28-30^{0}C. Thefefore, midle or large scale broiler industries have been using a control system to maintain the optimal temperature within a broiler house. Therefore, the role of a control system for regulating environmental parameters, not only temperature but also humidity, light intensity, and amonia content level, is very critical and relevant for better broiler production. This study aims to design an ANFIS control system for controlling the temperature inside a broiler house (closed house) for broiler. Data is collected at three different periods of the starter period (5 days): 29.5^{0}C-30.90^{0}C, a period of 25 days is a grower-29.^{0}C 34.2^{0}C, and the finisher of 30 days is obtained 33.2^{0}C. Set point control simulation using the same temperature 29^{0}C for starter, grower and finisher period. The simulation results show the output in a closed house temperature fluctuates around set point the 29^{0}C-34^{0}C.

Keywords: *ANFIS, Control System, Temperature, Closed Broiler House, Broiler Production*

1. Introduction

The contribution to heat exchange of surfaces whose temperature is close to the environmental temperature is small, whereas the surface whose temperature is constantly greater or lesser than the environmental temperature contributes significantly to heat exchange. Thus, in calculations of sensible heat transfer of different surface parts (of a bird) surface temperature measurement is a key element [1]-[3].

Introducing architecture and learning procedure for the FIS that uses a neural network learning algorithm for constructing a set of fuzzy if-then rules with appropriate membership functions (MFs) from the specified input–output pairs [3]. This procedure of developing a FIS using the framework of adaptive neural networks is called an adaptive neuro-fuzzy inference system (ANFIS) [3, 7]. There are two methods that ANFIS learning employs for updating

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membership function parameters: 1) backpropagation for all parameters (a steepest descent method), and a hybrid method consisting of backpropagation for the parameters associated with the input membership and least squares estimation for the parameters associated with the output membership functions. As a result, the training error decreases, at least locally, throughout the learning process. Therefore, the more the initial membership functions resemble the optimal ones, the easier it will be for the model parameter training to converge.

Human expertise about the target system to be modeled may aid in setting up these initial membership function parameters in the FIS structure. In this research we use Adaftive Neuro Fuzzy Inference Systems (ANFIS) [4]-[17]. Poultry are homeotherms that attempt to maintain deep body temperatures around 41^0C. The body temperature of poultry is usually greater than the ambient temperature, so heat will be countinually lost to the environment. Poultry can alter their sensible heat losses to control their body temperature.

The best temperature to keep fully feathered poultry is difficult to estimate. Temperatures between 18^0C and 24^0C are generally preferred, but this depends on the relative prices of feed, broilers and the cost of providing housing and heating. Indonesia has the ambient temperature high enough to maintain the broilers with an average daily temperature of 30.96^0C (maximum) and 22.4 ^{0}C (minimum). Optimun temperature for broilers ranged between 18 and 22 ^{0}C or exactly 21 ^{0}C to old chicks for five weeks [18]. Food consumption and growth declines in daily fluctuations between $18.3\text{-}23.9^0$C but the conversion of food had not changed. Homeotermik chickens as animals have the ability to maintain relatively stable body temperature at a wide temperature range [19]. In cold conditions the animals homeotermik require large amounts of food used as fuel to generate heat to offset heat loss from the body, and in hot conditions will require lots of water to help the process of heat dissipation from the body so that an increase in body temperature excessive.

Hot ambient temperature is very real (P <0.01) lower consumption of broiler rations of 4.2% in the fifth week and 16.7% at six weeks compared with the temperature comfortable. Hot ambient temperature is very real (P <0.01) lowering effect of weight loss 17.65% in week five and 21:13% at six weeks compared with the temperature comfortable. Conversion broiler rations being kept in a very real heat (P <0.01) increase in the amount of 5% to 16.7% fifth week and 8% at six weeks compared with the temperature comfortable. Discussed based on previous research based control ON-OFF and simulation study of the behavior of broiler in closed house so that reason and the application of control ANFIS model in closed houses for broiler chickens as a novelty.This research aims to design an adaptive control system for temperature in a closed broiler house. ANFIS approach modeling is used for simulation and control of broiler closed house temperature.

2. Research Method

2.1. Material Research

The material used consisted of 20,000 broilers tail, closed housewith a closed system house in the study area Cikabayan IPB with length x width x height width is 120 mx 12 mx 2.5 m. high, chicken feed, drinking water, using the software matlab version 7.1 with ANFIS Controlling simulation. Tools used include: microcontroller, kestrel 3000 temperature sensor, A set of computers and peripherals, weather station, one set of with insulation systems, Exhaust fan 8 units, Cooling Pad as much as 2 units, Heater as much as 2 units, Temtron as much as 2 units, place water, place chicken feed. The experiment was conducted three times that of the maintenance period the age of 5 days, 25, days, 30 days with room temperature measurements in 2009.

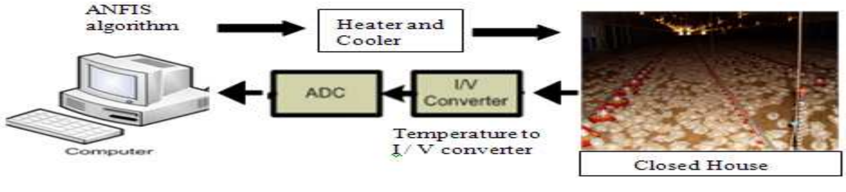

Figure 1. Closed house system for broilers (Cikabayan Unit University of farm IPB, 2009)

2.2. Modeling of Temperature Closed House For Broilers

Dynamic model of energy and mass balance of stable air are indicated by model the heat and cold on boiler house. In the model the heat ventilation (heating) and cold (cooling) can be obtained defrensial equation, which in practical effect and the heat stored *(latent heat),* the same as the volume of water in balance [20]-[22]. Dynamic equations are as follows:

$$\rho C_p V_T \frac{dT_{in}(t)}{dt} = Q_{an} + Q_{heater} - Q_v - Q_c - Q_c - Q_{fog} \qquad (1)$$

where:
ρ = air density (1.2 gm $^{-3)}$
C_p = air heating (1006 J (kg K) $^{-1)}$
T_{in} = temperature of air in closed house (^{0}C)
Q_{an} = heat production in broiler (kW)
Q_{heater} = heat that comes from the floor (kW)
Q_v = Best temporary ventilation (kW)
Q_c = heat conductor of the walls, roof and floor (kW)
Q_{fog} = heat caused fog system (kW)
V_T = Volume of house (m$^{3)}$

A brief description of the zone of mixed volume ventilation, hot temperature and humidity with special features significantly volume. Mixing to calculate the total volume constant ventilation approximately amount 60-70%. This means that the temperature and humidity inside the uniform may not be comprehensive in the room. In addition, the model only one variable, ie temperature, heat capacity is assumed to be effective must be greater than the determination of air volume, which comprises several heat capacities of construction materials. In the same way, the volume of moisture may be effective for smaller or larger than large geometric, depending on the degree of mixing and other effects, such as air and moisture loss.

Heat production of broiler (Q_{an}) and vapor liquid livestock production (W_{an}) is a general, non-linear function of air temperature inside (T_{in}), the class of livestock (N_{an}), and the mass of air (M_{an}) that can be described in the formula:

$$Q_{an} = g_1(T_{in}, N_{an}, M_{an}),\ W_{an} = g_2(T_{in}, N_{an}, M_{an}) \qquad (2)$$

The time limit on the ventilation heat loss

$$Q_v = \rho V_R C_p (T_{in} - T_{out}) \qquad (3)$$

$$T_{in} = Qv/ \rho V R C p + T_{out} \qquad (4)$$

Formulation of temperature on broiler house : $T_{in} = Qv/ \rho V R C_p + T_{out}$

2.3. Modeling Approach with ANFIS

An adaptive neuro-fuzzy inference system (ANFIS) is a fuzzy inference system formulated as a feed forward neural network. The ANFIS architecture is shown Figure 2. The circular nodes represent nodes that are fixed whereas the square nodes are nodes that have parameters to be learnt.

A Two Rule Sugeno ANFIS has rules of the form:

$$If\ x\ is\ A_1\ and\ y\ is\ B_1\quad THEN\ f_1 = p_1x + q_1y + r_1 \qquad (5)$$

$$If\ x\ is\ A_2\ and\ y\ is\ B_2\quad THEN\ f_2 = p_2x + q_2y + r_2 \qquad (6)$$

For the training of the network, there is a forward pass and a backward pass. We now look at each layer in turn for the forward pass. The forward pass propagates the input vector through the network layer by layer. In the backward pass, the error is sent back through the network in a similar manner to backpropagation.

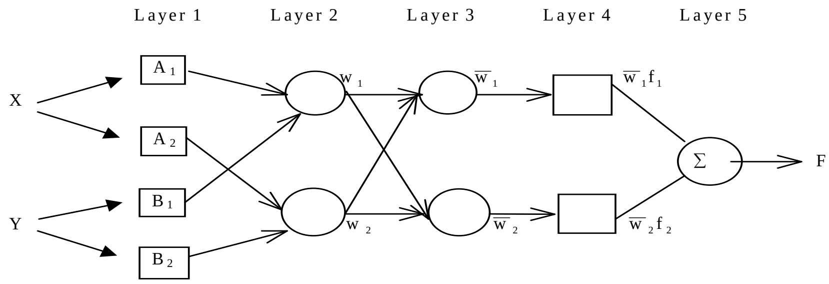

Figure 2. A first order Sugeno type fuzzy inference system

Layer 1 The output of each node is:

$$O_{1,i} = \mu_{A_i}(x) \qquad for \;\; i = 1,2 \tag{7}$$

$$O_{1,i} = \mu_{B_{i-2}}(y) \qquad for \; i = 3,4 \tag{8}$$

So, the $O_{1,i}(x)$ is essentially the membership grade for x and y. The membership functions could be anything but for illustration purposes we will use the bell shaped function given by:

$$\mu_A(x) = \frac{1}{1 + \left| \frac{x - c_i}{a_i} \right|^{2b_i}} \tag{9}$$

where a_i, b_i, c_i are parameters to be learnt. These are the premise parameters.

Layer 2 Every node in this layer is fixed. This is where the t-norm is used to 'AND' the membership grades - for example the product:

$$O_{2,i} = w_i = \mu_{A_i}(x)\mu_{B_i}(y), \quad i = 1,2 \tag{10}$$

Layer 3 contains fixed nodes which calculates the ratio of the firing strengths of the rules

$$O_{3,i} = \overline{w}_i = \frac{w_i}{w_1 + w_2} \tag{11}$$

Layer 4. The nodes in this layer are adaptive and perform the consequent of the rules:

$$O_{4,i} = \overline{w_i} f_i = \overline{w_i}(p_i x + q_i y + r_i) \tag{12}$$

The parameters in this layer (p_i, q_i, r_i) are to be determined and are referred to as the consequent parameters.

Layer 5. There is a single node here that computes the overall output:

$$O_{5,i} = \sum_i \overline{w_i} f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \tag{13}$$

2.4. ANFIS Based Control

Due to the adaptive capability of ANFIS, its application to adaptive and learning control is immediate. The most common design techniques for ANFIS controllers are derived directly from neural networks counterpart's methodologies. However certain design techniques apply exclusively to ANFIS [4].

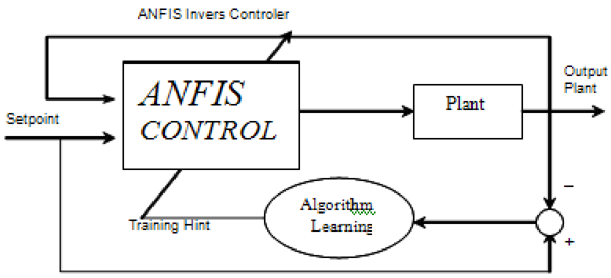

Figure 3. Block diagram control of ANFIS

When the plant exhibits time variable dynamics, direct invers control does not guaranty satisfactory response characteristics and steady state errors exist. Many of these problems can be overcome using one-line invers learning strategy. The overall control structure is illustrated in figure 4. One-line learning of ANFIS inverse model occurs at each time step to fine-tune the membership function parameters of ANFIS controller. This controller strategy could be applied directly by assuming random premise and consequent parameters or allow for initial learning in open loop mode and then close the loop once the parameter estimates have assumed some reasonable values. The simplest approach for controller design is a completely open loop control strategy, in which the controller is the inverse of the process. This method seems straight forward and only one learning task is needed to find the inverse model of the plant. It assumes the existence of the inverse plant, which is not valid in general. Also minimization of the network error (e_u) does not guarantee minimization of the overall system error.

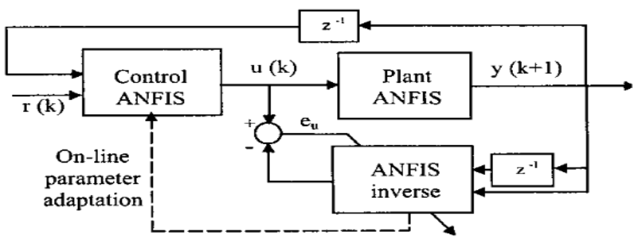

Figure 4. Block diagram control of ANFIS on closed house for broilers

3. Results and Analysis

The implementation of control system (Figure 1) is simulated by using the adaptive neuro-fuzzy inference system (ANFIS) as shown in Figure 4. These techniques provide a method for the fuzzy modeling procedure to learn information about a data set, in order to compute the membership function parameters on equation 9 that best allow the associated fuzzy inference system to track the given input/output data. This learning method works similarly to that of neural networks. The Fuzzy Logic Toolbox function that accomplishes this membership function parameter adjustment is called ANFIS. The anfis function can be accessed either from the command line or interconnection node wheight.

This allows ANFIS systems to learn from the datas are modeling FIS Structure and parameter adjustment a network-type structure similar to that of a neural network, which maps inputs through input membership functions and associated parameters, and then through output membership functions and associated parameters to outputs, can be used to interpret the input/output map. The parameters associated with the membership functions will change through the learning process. The computation of these parameters (or their adjustment) is facilitated by a gradient vector, which provides a measure of how well the fuzzy inference system is modeling the input/output data for a given set of parameters. Once the gradient vector is obtained, any of several optimization routines could be applied in order to adjust the parameters so as to reduce some error measure (usually defined by the sum of the squared difference between actual and desired outputs). ANFIS uses either back propagation or a combination of least squares estimation and backpropagation for membership function parameter estimation.This is accomplished with the ANFIS Editor GUI using the so-called testing data set, and its use is described in a subsection that follows

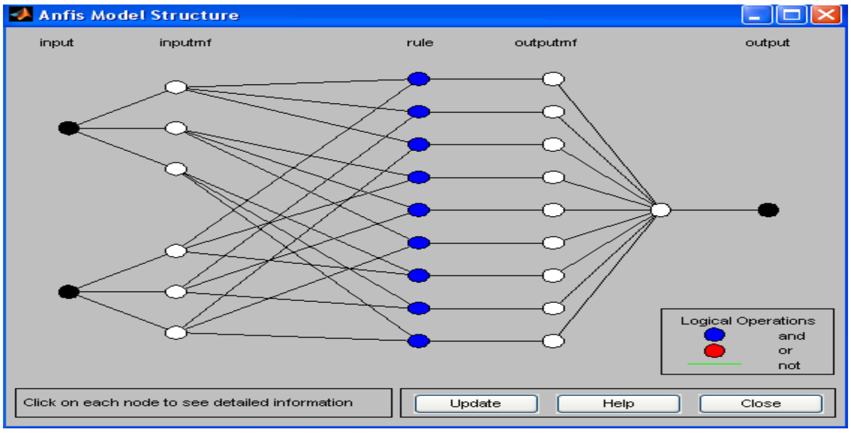

Figure 5. ANFIS Model Structure Temperature of poultry house

3.1. Validation temperature of room on measurement and simulation

The ANFIS model was tested using 5, 25, and 30 days poultry house temperature data and the simulation result is shown in Figure 5. The horizontal axis is marked data set index temeperature and vertical is age of broiler. This index indicates the row from which that input data value was obtained vector because it could be low, midle, long. The measure data appears in the plot in the center of a set of circles (0) is data input temperature and a set of plus sign (+) is simulation of control temperature. Quantities of temperature are 29.5-30.90 ^{0}C to approach set point 27-30 ^{0}C. Average error = 0.18313 from measure and simulation. Result of temperature suistable setpoint it. This data set will be used to train a fuzzy system by adjusting the membership function parameters that best model this data. The next step is to specify an initial fuzzy inference system for anfis to train. Structure of ANFIS use node AND representing a normalization factor for the rules.

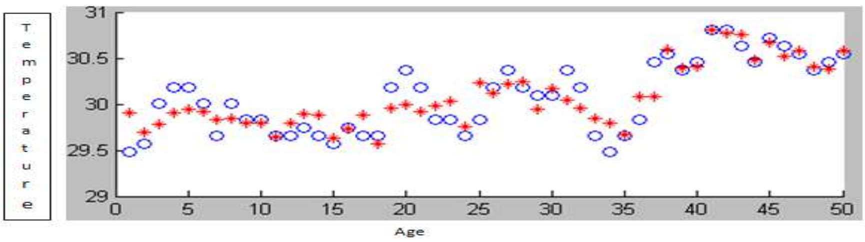

Figure 5. Plot validasi measurement and simulation temperature average 5, 25, dan 30 days

3.2. Training data input Temperature of room

The training data appears in the plot in the center of the GUI as a set of circles (0) is data input temperature and a set of plus sign (+) is optimation temperature. Quantities of temperature are 29-34.2 ^{0}C. Average error = 0.0017909 between input optimation terining. This data set will be used to train a fuzzy system by adjusting the membership function parameters that best model this data Structure of ANFIS use node AND representing a normalization factor for the rules.

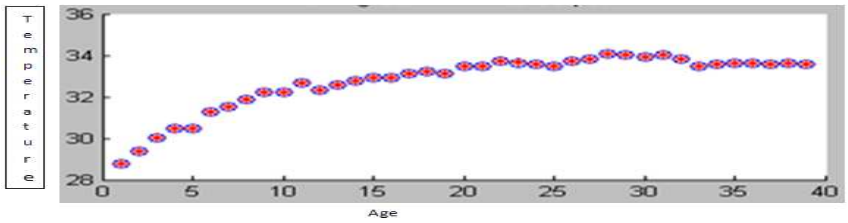

Figure 6. Plot training data temperature of 5, 25, and 30 days

3.3. Testing data input Temperature of room

The testing data appears in the plot in the center of the GUI as a set of circles (0) is data input temperature and a set of plus sign (+) is output of optimation temperature. Quantities of temperature are 29-33.2 ^{0}C. Average testing error = 0.00097861. This data set will be used to train a fuzzy system by adjusting the membership function parameters that best model this data. The next step is to specify an initial fuzzy inference system for anfis to test. Structure of ANFIS use node AND representing a normalization factor for the rules

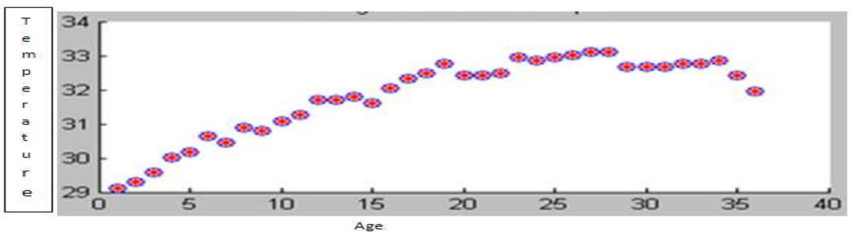

Figure 7. Plot testing data temperature of poultry house is 5, 25 and 30 days

3.4. Temperature Control of poultry house

The plot a set of circles (0) is output control temperature 29-35 ^{0}C and a set of plus sign (+) is set point 28 ^{0}C, error = 3 ^{0}C. The next step is to specify an initial fuzzy inference system for anfis to control. Structure of ANFIS use node AND representing a normalization factor for the rules

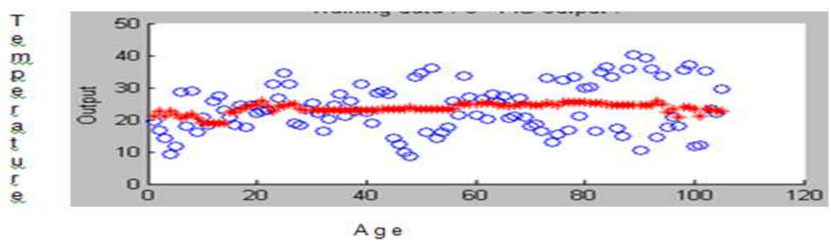

Figure 8. Plot set point and output control on temperature of 5, 25 and 30 days

4. Conclusion

In this experiment conducted three times that of the maintenance period broiler chickens 5 days, 25 days and 30 days. The average room temperature is 29-31 ^{0}C. This control generate ANFIS control system model has been used to represent the temperature measurement and simulation with an error 0.18313 and C. Input temperature fluctuated but there are training and testing the output temperature of the temperature approached 28 ^{0}C with an error setpoin 3 ^{0}C.

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