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DEVELOPMENT OF ARTIFICIAL NEURAL NETWORK BASED EGG SELECTIVITY CONTROL MODEL FOR EGG HATCHERY

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Abstract:

This research work is based on selectivity control model for egg hatchery/incubator using artificial neural network. The nature of hatching process takes 21days with a temperature of 99-102°F or 37to 38.9°C, with proper humidity level and the egg moved several times with time for optimum performance .The system developed was based on the principle of selectivity, which was derivation of selecting good eggs for incubation/hatchery for derivative of good eggs. The system allowed an entry of a desired number of eggs in a prescribed range, at a steady-state temperature error. This being done using the artificial intelligent neural network system. The system allowed for low energy consumption when applied and a low time, to give a viable hatching of the eggs. This allowed for viable production of chicks at appropriate temperature. It allows for perfect training which gives the regression value of 1 (showing that ANN has learnt well enough); and it reveals a good match meaning the ANN has done well in predicting the number of good eggs under investigation in relation to the temperature. This work finds application in the egg hatchery system in the poultry industry.

Keywords **—Selectivity Control, Hatchery/Incubator, Eggs, Artificial Neural Network.**

1.INTRODUCTION

Artificial Neural network (ANN) is a computer based program that somewhat behaves like the natural brain in man. Millions of neurons are in a biological brainwork together in parallel, each trying to solve a small part of a complex problem. Based on this natural problem solving methods in man, this type of problems solving (divide and conquer) seems to be very efficient to recognize speech and image data, to make decisions based on past experiences and to associate and apply the acquired knowledge to new situation. Neural networks learn by examples to train a neural network under supervision for a specific problem, it needs to have good examples, with known inputs and outputs. The ANN presents knots or processing units, with each unit connected to other units, which receive and send signals. Each unit has a local memory.

Most poultry species have an optimum incubation temperature of 37 to 38^{o}C and small deviations from this optimum can have a major impact on hatching success and embryo development (Wilson, 1991). The vast majority of poultry hatching eggs are artificially incubated in incubators that must be designed to accurately control the temperature of the developing embryo which does not deviate from this optimum. The aim of this work is to develop an artificial neural network based selectivity control model for the hatching/incubation of eggs. This will be able to achieve perfect training with regression value of 1 and also predicting the number of good eggs under investigation.

The prediction/selectivity based on the temperature experienced by the developing embryo is dependent on three factors:

1. The incubator temperature
2. The ability of heat to pass between the incubator and the embryo itself
3. The metabolic heat production of the embryo itself

2.1Review in Literature

In daily life, human being's activities requires stable temperature both for their comfort in their activities and for their work as in poultry hatching cultivation which has to be heeded in term of successful process, even more for local chicken eggs. Hatching eggs has two ways; 1) incubated by the chicken hen directly and 2) through egg hatching machine with the system to control the temperature of the radiation of heating lamp. According to the field survey on egg hatchery, this shows that:1)the suitable temperature of incubation is at 37^{o}C; 2) span of the egg-laying period is approximately21days; 3) the characteristics of incubator's design and egg. Stability of hatchery room temperature should always be maintained in order to obtain maximum result.

Environment temperature instability can influence the temperature of the hatchery (forces air).Moreover, the working system is still On/Off with the outages of the heating lamp which cause wear-worn components. Besides, while the system is still not precise, there is a big error which has a relatively long settling time to reach the next set point due to the instability of the radiation beam temperature. The idea to control the temperature of the incubator appears in order to reduce error level, wear out on components and keep the system working for a more stable temperature.

ANNs are characterized by learning through examples. For a certain data set, the learning algorithm must be responsible for adapting the network parameters to allow, in a finite number of algorithm interactions, convergence for a solution. The convergence criterion varies according to the algorithm and the learning paradigm. A neural network typically consists of a set of processing units, which compose the input layer, one or more hidden layers, and the output layer. The input signal is propagated forward through the network, layer by layer (Haykin, 2001).Poultry production is the most technologically advanced activity in Brazilian poultry production (Furtado et al., 2006). The state of Santa Catharina is outstanding in this scenario, hosting important poultry companies, particularly in the west. The poultry industry heavily invests in equipment, technology, innovations, management, and health (Denardin, 2006).

The artificial neural network (ANN), an artificial intelligence technique, is a potential tool for modeling data in poultry production. (Roush et al., 1997). This uses an ANN to make a probabilistic prediction of ascetics in broilers, with no need of post-mortem examinations or other procedures. In the ANN methodology to estimate production parameters of developing broiler breeders, this allowed the simulation of the consequences of management decisions, determining the contribution of each variable to the studied phenomenon. During embryo development, the nutrients, energy, and water used by the embryo are inside the egg. Embryo development also requires egg heating, proper air oxygen, steam, and carbon dioxide transport rates, which are necessary for cell metabolism during different incubation steps. Temperature and humidity are the main factors involved in embryo survival during incubation (Boleli, 2003). Low relative humidity levels increase the incubation period (Muraroli and Mendes, 2003) and embryo late mortality (Decuypere et al., 2003). A mere increase of 0.2 ºC during incubation may also reduce the incubation period and affect embryo livability. The biggest problem in artificial incubation is to control all these factors, as many are not well-known, and others are difficult to control. During artificial incubations, egg hatchability is a measure of embryo livability, and it is directly related to the combined action of a large number of factors.

2.2 Related Work

Joseph, Okeke & Taiwo (2021) in their work, modelled and designed an egg incubator system that is able to incubate various types of egg within the temperature range of 35 – 40 ^{o}C. Adaptive Network based Fussy Inference Systems (ANFIS) was used in modelling and identification of numerous systems and successful results achieved. The development of the temperature control model was executed using Neuro-fuzzy controller, which entails the combination of neural network that predict the functionality of the egg hatchery system and fuzzy logic that act as an actuator for the system.

Yin et al., (2003) employs the neural model implementation of multilayer artificial neural network, with a back propagation training algorithm and 11 neurons in the input layer, was used. In this type of network, network inputs are represented in the first layer, which distributes input information to the intermediate layer. The following inputs were used: egg storage time, air temperature, air relative humidity, and molar internal concentrations of carbon dioxide and oxygen, all with their respective standard deviations. The last layer is the output layer, where the solution for the problem is obtained.

Haykin (2001) used input signal which was propagated forward through the network, layer by layer, called multi-layer perceptron. The general architecture of the neural system used here consisted of a multi-layer perceptron network. The back propagation learning algorithm was applied, and network neuron weight fit and learning rate depended only of the gradient signals of the error function. The objective of this algorithm is to find in the error surface values for the synaptic weights that minimize network errors.In this work, neural network enables the selectivity of good eggs via training and prediction.

3.1Design of Model

The following neural network algorithm is developed for this work:

i. Input determination
ii. Output determination
iii. Target
iv. Step Size
v. Training

3.2 Simulation Software

MATLAB R2007a edition environment was used to carry out the simulation of this work.

3.3 Design of the Neural Network Controller

Neural network helps us to predict or forecast the performance in the egg incubator. Neural experts described neural network as characterized by learning through samples and/or imprecision of practical systems. The design of a neural network controller is in a three stages. It comprises of input, summer or comparator and the output; these have got a lot of advantages compared to the classical controllers such as the simplicity of control, low cost and the possibility to design without knowing the exact mathematical model of the process. Neural network is one of the successful applications of neural set in which the variables are linguistic rather than the numeric variables.

The neural network controller is created directly based on the neural network identifier. Its design has fully incorporated the learning strategy into the trained identifier. The weights of the neural network identifier are constantly verified against the actual plant output. This ensures that the weights allow the neural network identifier to properly predict actual plant output. The neural network identifier is used as means to back propagate the performance error to get the equivalent error at the output of the neural network controller. The accuracy of the plant model is critical in ensuring that the controller is accurate as well. The error between the plant output and the identifier output is also checked for the accuracy level of the identifier. This error is used to back propagate adjust the weights of the identifier to provide the most accurate plant representation.

3.3.1 Input Data Training

The input and target data supplied to ANN model developed are presented in table 1 and 2.The input data consider between 50 eggs and 100 eggs.

Tables 1 and 2 were supplied to the neural network model, which is a four layer model and it was trained using back propagation algorithm.

Table 2 forecast between 95 good eggs and 100 good eggs and this is our target data, show the step sizes for the eggs.

Table 1: The input data to the ANN for Training

50.0000 50.5010 51.0020 51.5030 52.0040 52.5050
53.0060 53.5070 58.0160 58.5170;

59.0180 59.5190 60.0200 60.5210 61.0220 61.5230
62.0240 62.5250 63.0260 63.5270;

64.0280 64.5290 65.0300 65.5310 66.0320 66.5330
67.0340 67.5350 68.0360 68.5370;

69.0380 69.5390 70.0400 70.5410 71.0420 71.5430
72.0440 72.5450 73.0460 73.5470;

74.0480 74.5490 75.0500 75.5510 76.0520 76.5530
77.0540 77.5550 78.0560 78.5570;

74.0480 74.5490 75.0500 75.5510 76.0520 76.5530
77.0540 77.5550 78.0560 78.5570;

79.0580 79.5590 80.0600 80.5610 81.0620 81.5630
82.0640 82.5650 83.0660 83.5670;

84.0680 84.5690 85.0700 85.5710 86.0720 86.5730
87.0740 87.5750 88.0760 88.5770;

89.0780 89.5790 90.0800 90.5810 91.0820 91.5830
92.0840 92.5850 93.0860 93.5870;

94.0880 94.5890 95.0900 95.5910 96.0920 96.5930
97.0940 97.5950 98.0960 98.5970

Table 2: Target data supplied to ANN for Training

95.0000 95.0500 95.1000 95.1500 95.2000 95.2500
95.3000 95.3500 95.4000 95.4500;

95.5000 95.5500 95.6000 95.6500 95.7000 95.7500
95.8000 95.8500 95.9000 95.9500;

96.0000 96.0500 96.1000 96.1500 96.2000 96.2500
96.3000 96.3500 96.4000 96.4500;

96.5000 96.5500 96.6000 96.6500 96.7000 96.7500
96.8000 96.8500 96.9000 96.9500;

96.5000 96.5500 96.6000 96.6500 96.7000 96.7500
96.8000 96.8500 96.9000 96.9500;

97.0000 97.0500 97.1000 97.1500 97.2000 97.2500
97.3000 97.3500 97.4000 97.4500;

98.0000 98.0500 98.1000 98.1500 98.2000 98.2500
98.3000 98.3500 98.4000 98.4500;

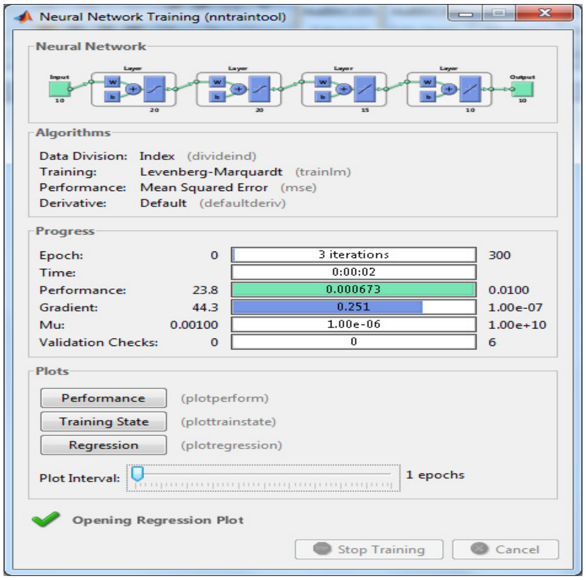
98.5000 98.5500 98.6000 98.6500 98.7000 98.7500 98.8000 98.8500 98.9000 98.9500;

99.0000 99.0500 99.1000 99.1500 99.2000 99.2500 99.3000 99.3500 99.4000 99.4500;

99.5000 99.5500 99.6000 99.6500 99.7000 99.7500 99.8000 99.8500 99.9000 100.0000

3.2Neural Network Inference System (nntrraintool)

As stated in the algorithms for this work under section 3.1, neural network inference system is set up hereunder:



Data Division: Index (divideind)
Training: Levenberg-Marquardt (trainlm)
Performance: Mean Squared Error (mse)
Derivative: Default (defaultderiv)

Epoch:	0	3 iterations	300
Time:		0:00:02	
Performance:	23.8	0.000673	0.0100
Gradient:	44.3	0.251	1.00e-07
Mu:	0.00100	1.00e-06	1.00e+10
Validation Checks:	0	0	6

(plotperform)
(plottrainstate)
(plotregression)
Plot Interval: 1 epochs

Opening Regression Plot

Figure 1: Neural Network Training Tool

Neural networks works well with a range of 0 and 1.Therefore, any value above 1 is normalized to have the corresponding output values above 1 as well.

The Network was run and gave the output as contained in Table 3 as shown in the result section.

The definition of terms as contained in Figure 1 is as analyzed:

Epoch: One complete presentation of data set to the iterative learning algorithm of the ANN.

Time: Duration for the iterative learning algorithm

Performance: Translation of the input/output of the iterative learning algorithm.

Gradient: The graph of the input/output data for the iterative learning algorithm.

Mu: The momentum update that makes the convergence of training faster.

nntraintool: Neural Network Inference System training tool which comprises the following structure; Input, Layers (four in number) and the Output.

4.1 Presentation of Results

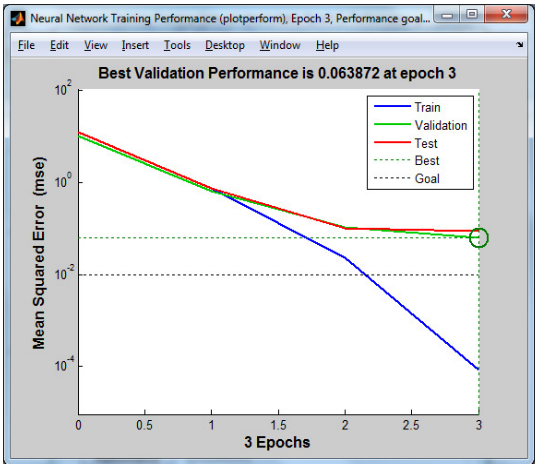


Figure 2: Neural Network Performance (Plot perform)

Figure 2 shows the difference between the target data Table versus ANN output data Table.

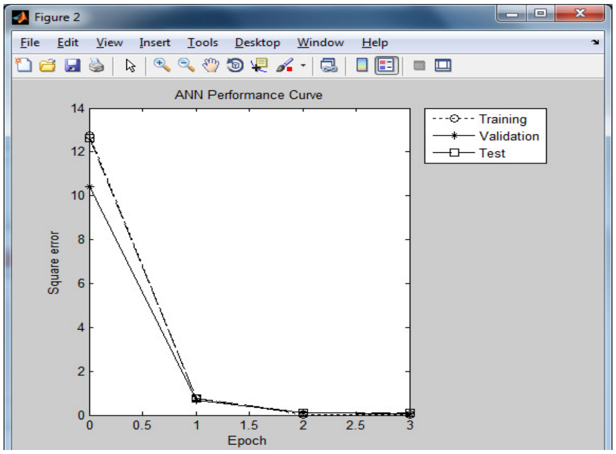


Figure 3: ANN Performance Curve

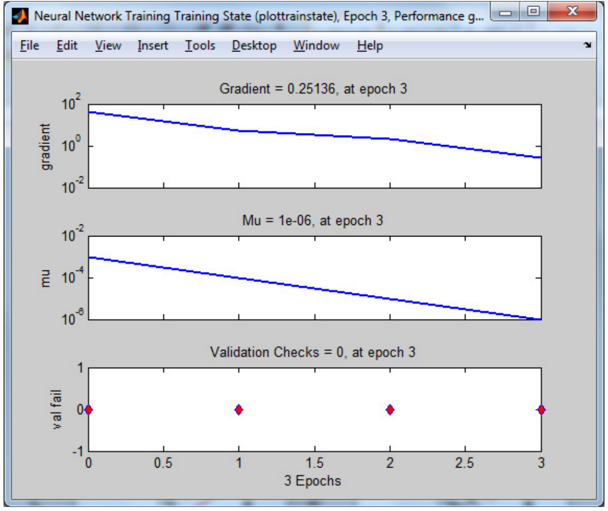


Figure 4: Performance Gradient, Momentum and Validation checks.

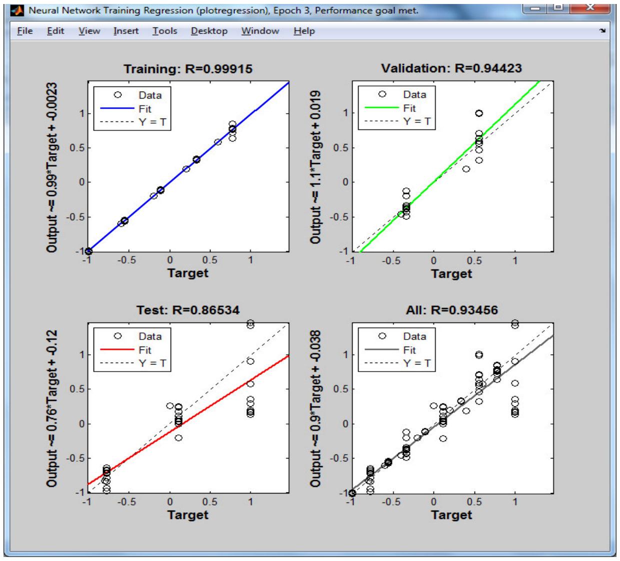


Figure 5: Performance Goal

Table 3: The Artificial Neural Network (ANN) Output/Results

94.9994	95.0374	95.1000	95.1499	95.2006
95.2657	95.3006	95.3680	95.4001	95.5454
95.5012	95.5712	95.5990	95.6157	95.6981
95.7818	95.7980	95.8298	95.9024	95.7644
96.0018	96.0649	96.1006	96.1277	96.1990
96.2501	96.2989	96.3583	96.3994	96.2705
96.5017	96.5483	96.5996	96.6410	96.6985
96.7792	96.7985	96.8507	96.8960	96.9283
96.5029	96.5809	96.6031	96.6297	96.6994
96.7314	96.8003	96.9478	96.9149	96.7908
97.0014	97.0631	97.1012	97.1389	97.2008
97.2421	97.2996	97.3837	97.3982	97.2617
98.0018	98.0745	98.1023	98.1451	98.2015
98.2253	98.3011	98.4511	98.4163	98.3564
98.4986	98.5048	98.5976	98.6808	98.6982
98.7334	98.7978	98.7970	98.8690	98.8063
98.9988	99.0149	99.0997	99.1979	99.1992
99.1783	99.3002	99.3850	99.3883	99.2564
99.5010	99.5434	99.6005	99.6356	99.7001
99.8143	99.7993	99.7980	99.8955	100.1166

Table 3 shows the artificial neural network output result that is the input data is well predicted.

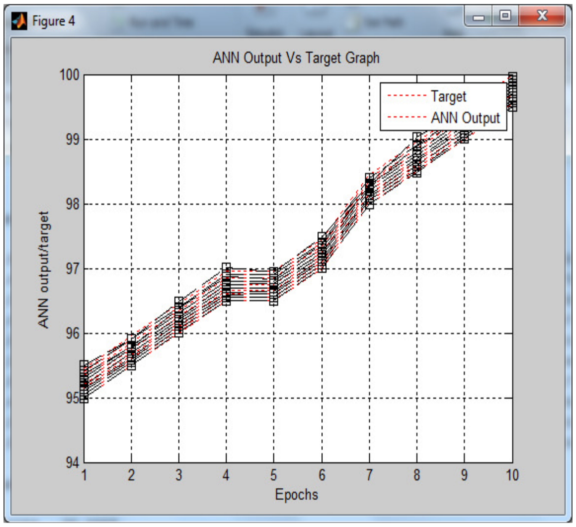


Figure 6: ANN Output versus Target Graph

4.2 Discussion of Results

Figure 2 shows the neural network training performance goal with best validation performance of 0.063872. The comparison shows that the ANN is well predicted and it helps the incubator to select good eggs of at least 95 out of 100 eggs.

Figure 3 shows ANN performance curve in terms of the square error and epoch. The convergence of the training parameters was achieved at epoch 3. That is training, testing and validation, all with a common agreement. Therefore, the ANN has fully learnt what it wanted to learn and can therefore predict accurately.

Figure 4 shows the neural network training state performance gradient of 0.25136, Mu of 1e-06 and validation checks of 0. It shows the training regression curves where the performance was met and should be understood. At epoch 3 where convergence occurred, gradient is the maximum error encountered during training, followed by Momentum at epoch 3 and the validation checks at 0.

Figure 5 shows the neural network training regression and performance goal met with the following, Training: R=0.99915; Validation: R=0.94423; Test: R=0.86534 and in combination (All): R=0.93456. This shows a perfect training which gives the regression value to be 1.and the result shows that ANN has learnt well enough.

Figure 6 shows the ANN output versus target data as contained in Tables 2 and 3, with the main combinational output graph. It is also depicted in Table 4. The ANN output is compared to the target data. It reveals a good match meaning the ANN has done well in forecasting/predicting the number of good eggs under investigation.

5.1 Conclusion

This work develops a model, design and simulation of a prediction/selectivity control of a smart egg hatchery/incubator system for various types of eggs. This shows a perfect training which gives the regression value to be 1 (showing that ANN has learnt well enough); and it reveals a good match meaning the ANN has done well in predicting and/or selecting the number of good eggs under investigation.

5.2 Recommendation

This work clearly shows ANN system in use, which gives an improve performance in the egg production. This ANN system could also be incorporated with the likes of Proportional-Integral-Derivative (PID), Fuzzy Logic Controller for optimal performance and autonomous operation for appropriate egg hatching.

5.3 Contribution to Knowledge

The major contribution to knowledge of this research work is as summarized;

The development of an Artificial Neural Network based temperature control model with the ANN learning well enough and done well in predicting the number of good eggs under investigation.

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