An Adaptive Generalized Predictive Control for Temperature and Humidity inside an Incubator

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Abstract— As the problem of birth defects, neonatal jaundice and Infant respiratory syndrome has been increased the design of Incubators came into existence. When the baby is kept inside an Incubator, the temperature and humidity level has to be regulated properly. Attempts were already made in the elimination of cross-coupling between temperature and humidity which resulted in 80% accuracy. With the help of RLS algorithm 95% accuracy can be achieved by controlling temperature and humidity by exploiting an active humidification system. In addition this paper presents an adaptive decoupling strategy in which the performance of LMS (Least-Mean Square) and RLS (Recursive Least Square) filters are compared. Also the development of lungs can be known by measuring the respiration rate of the neonate.

Key words: Cross Coupling, LMS, RLS

I. INTRODUCTION

The problem of prematurity and low birth weight infants is not a new one. Before the Industrial revolution babies were cared at home. As the childbirth has been increased, neonate incubators are nowadays widely used in almost all the hospitals for Intensive care of a premature or preterm infant. Incubators are specially designed in order to maintain and regulate temperature for a neonate by setting ideal conditions. By placing the baby inside the Incubator, infection due to pollution gets reduced such that one can provide a healthy environment for an Infant. Also the Infant has a fair chance of survival. Although these designs have been evolved, problems associated such as cross-coupling, maintaining constant temperature have been increased. One of the best approaches to eliminate cross coupling is the Generalized Predictive Control (GPC) whereas problems associated with strong interactions cannot be eliminated [2, 3]. Attempts were made to introduce the interaction compensators which do not offer satisfactory control because of the improper mismatch in the delay structure [3, 4]. So a practical method was proposed where the decoupling control approach for a neonate Incubator system can be able to achieve an active humidification system with 80% accuracy [1]. In order to make this system more efficient our proposed model achieves humidity level up to 95%. The paper is structured as follows: In Section 2, methodology of the incubator system has been given. Section 3 describes the Adaptive Noise Cancellation technique by using Recursive least square filters (RLS). Section 4 is devoted to present the experimental setup. Section 5, includes experimental result in order to analyze the performance of the incubator system.

II. METHODOLOGY

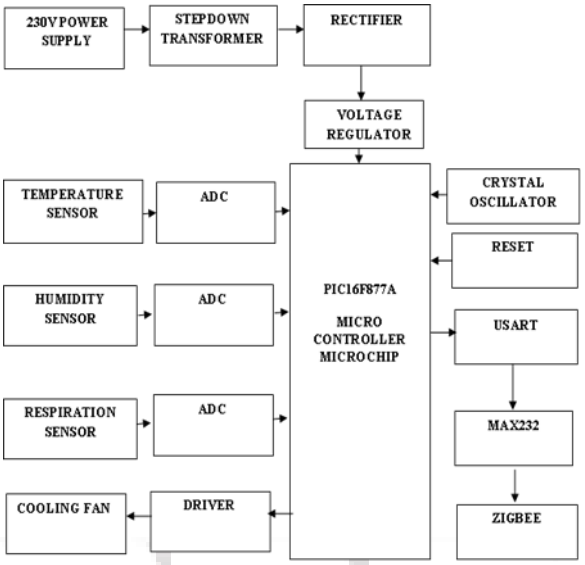

Fig. 1: Block Diagram: Control Section of Neonate Incubator system

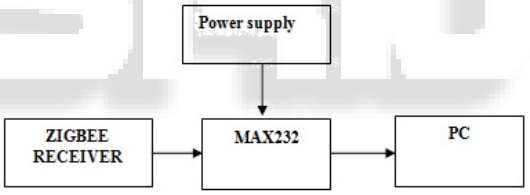

Fig. 2: Block Diagram: Monitoring Section of Neonate Incubator system

A. *Overview:*

The proposed incubator system consists of 230V, 50 HZ power supply unit which consists of a rectifier circuit and a voltage regulator. A separate 12V supply is given to the sensor circuit to sense the temperature change and humidity regulation. Respiration rate is measured by using respiration sensor. All the analog values are converted digitally by an Analog-Digital converter and fed into the Micro-controller PIC16f877a. A separate 8MHZ clock signal is supplied by the crystal oscillator to the controller. From the controller the data is transmitted to the neonatal intensive care unit using Zigbee. If the temperature exceeds a preset value, the cooling fan will be switched on by which temperature and humidity can be regulated properly.

B. *System Design*

The most important parameters which have to be monitored and regulated inside a neonate incubator system are temperature and humidity. LM-35 is used as the temperature sensor because the output voltage is linearly proportional to the centigrade temperature. Also it does not require any external calibration. SY-230 is the humidity sensor used which determines the humidity content of air or relative humidity measurements. It is highly

reliable in converting the relative humidity into output voltage. To measure the breathe rate of the Infant the respiration sensor namely PS-2133 is used which measures breathe rate in one-minute cycles. It has a pressure sensor and an inflatable belt which is placed near the Infants nose. As the Infant breathes the respiration rate and pressure changes can be displayed in a graph on a computer. Similarly the temperature and humidity levels are indicated on the computer.

III. ADAPTIVE NOISE CANCELLATION

The adaptive filters generally used are digital filter. The incubator works on the principle of a closed loop control system in which a part of the output is fed back into the input Therefore the feedback is used to refine the coupling factor inside the neonate incubator system.

Initially the input signal y(n) consists of both noise and information. When the signal passed into the adaptive filter it removes the noise signal e(n). The noise signal e(n) can be removed by using reference signal x(n) which is approximate to the error signal.

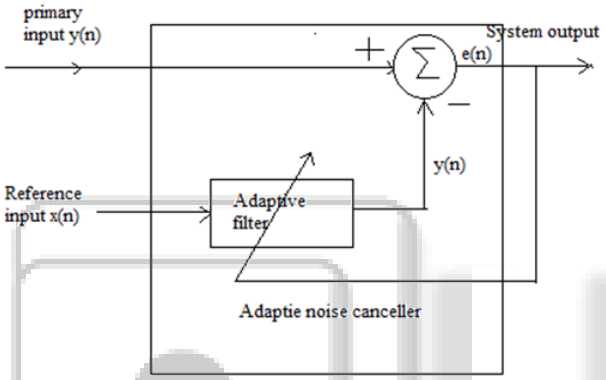

Fig. 3: Adaptive noise cancellation

In RLS algorithm, the performance index or objective function ξ(n) to be minimized in the sense of least square is defined as

$$\xi(n) = {}_{i=1}\sum^{n} \lambda^{n-i} |e(i)|^2$$

After convergence, the primary noise estimate, that is, the output of adaptive filter,

$$Y(n) = \dot{w}^{T}(n-1)r(n)$$

In previous methods the performance was analyzed by using LMS filter but it has many disadvantages like slow convergence and gradient factor .So RLS filter can be used to filter the error in which the input statics is time variant. The performance is also good when compared to LMS filter because it has good compromise between faster and slow convergence. RLS filter used in many real time application due to noise cancellation process when compare to LMS filter. An important feature of the RLS algorithm is utilizes the information from the input signal and extends back to the instant of time when the algorithm was started.

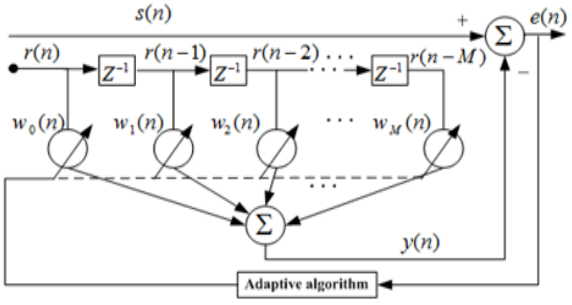

Fig. 4: Recursive Least Square filter

IV. EXPERIMENTAL SETUP

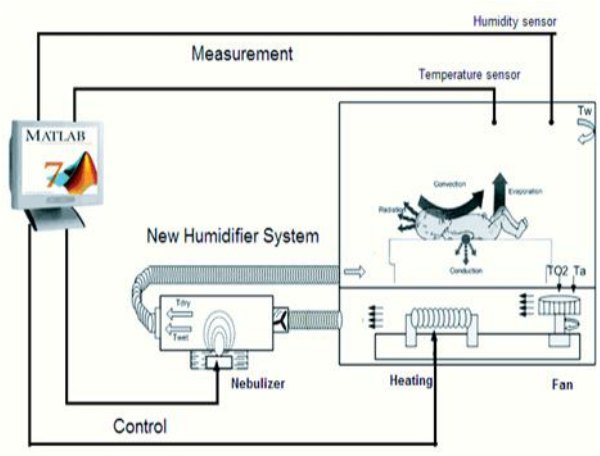

Fig. 5: Proposed Neonate Incubator system

An incubator is usually a small cabinet with transparent walls so that the baby can be easily observed [1]. The device includes an AC powered heater, a fan to regulate the air, a container for water to add humidity and access ports for nursing care. In this set up, the passive humidifier is replaced by an ultrasonic nebulizer system which converts the liquid into a fine spray. By using this system humidity level can be achieved up to 80% [1]. In order to achieve 95% humidity regulation, the proposed model utilizes, Adaptive noise cancellation using Recursive least mean square filters.

V. RESULT

This paper has implemented a systematic design for development of Generalized Predictive Control using Recursive least square filter by which 95% humidification has been achieved. This system works satisfactorily for recording the variables such as temperature, humidity, respiration rate and transmitting it to the nursing station by using Zigbee.

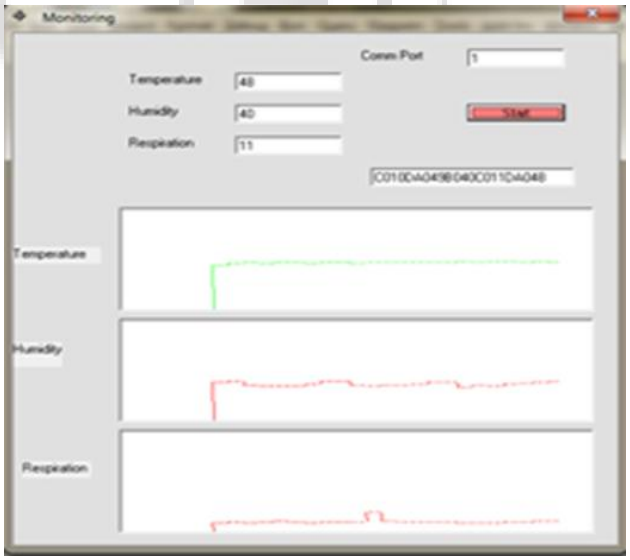

Fig. 6: Visual basic output of Temperature, Humidity and Respiration.

VI. CONCLUSION

This paper has developed an Adaptive decoupling strategy for controlling temperature and humidity inside a neonate incubator by using Adaptive noise cancellation technique. Several decoupling methods have been demonstrated but the RLS algorithm is more general and a practical approach. It is capable of giving satisfactory performance than other systems by exploiting active humidification.

VII. REFERENCE

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