Wireless Oral Feeding Monitor for Premature Infants with Flex Sensor for Respiration

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Abstract— Premature infants have poor feeding skills which leads to oral feeding disorders. This is because prematurity disrupts the normal growth and neurodevelopment, especially a neural circuit called suck central pattern generator. This involves three motor patterns such as sucking, respiration and swallowing that have to co-ordinate with each other for a normal feeding to occur. Moreover preterm infants have immature lungs which lead to the improper coordination of respiration pattern with the other two. Monitoring of all those three motor patterns in preterm infants is quite challenging and no monitoring system for this purpose exists so far. The proposed system monitors the motor patterns of sucking, swallowing and respiration. Sucking is measured using a pressure sensor, swallowing with the help of microphone and respiration with EMG electrodes. To evaluate those patterns a detection algorithm based on fractal dimension is also proposed that has less computational complexity. The result obtained has proved the efficiency of the proposed system.

Key words: Fractal dimension, oral feeding disorder, premature infants, respiration patterns, sucking, swallowing

I. INTRODUCTION

Preterm infants are now-a-days subjected to severe oral feeding disorders which is life threatening. It includes aspiration, oxygen desaturation, choking, apnea disorders and bradycardia [1]. From the time of birth the infant does not receive any nutrition from the mother through umbilical cord and it starts feed orally [2, 3]. Nutrition is very much essential for the further development of the infant i.e. for growth and brain development [4]. This is achieved by nutritive sucking which involves the actions of sucking, swallowing and respiration. As preterm infants have immature lungs and suck central pattern generator they find it difficult to coordinate the patterns of sucking, swallowing and respiration. This may lead to the death of the infant. Thus continuous monitoring of those events becomes essential.

II. LITERATURE SURVEY

Many studies have been carried out regarding oral feeding disorders. E.C. Goldfield stated that swallowing is not a random process and it occurs only at particular locations [5]. A. Van Deer Meer proposed that swallowing takes place during breathing in and breathing out and before the onset of next sucking [6]. M.E.R Macies showed that nutritive sucking happens by the sequential process of sucking swallowing and respiration [7]. Many comparative studies were made between bottle feeding and breast feeding.

Monitoring of those three motor patterns was carried out in many ways. Initially respiration was measured with the help of foam filled capsules that is placed over the abdominal region [8]. Then this was replaced by the use of accelerometers [9]. But the disadvantage of using accelerometers was that the respiratory movement of the infant will be too low to be measured by the accelerometer. Later EMG electrodes were used which caused irritation to the skin and also dislocation of the electrodes may occur [10, 11]. No sensing devices were available for recording the patterns of sucking and swallowing.

III. SYSTEM DESIGN

A. Biosignal Acquisition Module:

The basic block diagram of the system is shown in Fig. 1. It consists of a pressure sensor for measuring the sucking pressure of the feeding infant, a microphone for measuring the swallowing sound and flux sensor for recording the respiration pattern. All the three parameters tapped from the preterm infants will be given to the acquisition module where it is amplified, filtered and then the processed signals will be transmitted to the host system with the help of Bluetooth module. The host system will be programmed for receiving and monitoring those biosignals.

Fig. 1: Block diagram of wireless oral feeding monitor.

B. Pressure Sensor:

The pressure sensor used here is MPX2010DP MEMS pressure sensor with 5-7 psi. The sensor has two ports, one is meant for vacuum and the other is for positive pressure. The ports are connected with transparent rubber tubes. The terminal of the rubber tube is placed at the front end of the feeding bottle. As the baby sucks the milk the pressure sensor senses the pressure and gives it to the amplifying unit [12].

C. Microphone:

The microphone used to measure swallowing sound is a condenser microphone. It is placed near the throat of the infant [13]. The amplification rate of the microphone varies from 20- 500 Hz. This is again given to the amplifying unit.
D. Respiration Sensor:
In this system, a Flex sensor is used as the respiration sensor. It has a Piezoelectric crystal which is highly sensitive to the respiratory movements. This sensor can be placed over the chest near the abdomen. This causes less irritation to the baby's skin when compared to the EMG electrodes.

E. Hardware Description:
All the three signals recorded are given to the amplifying unit of gain of 100 dB. The amplified signals are given to the controller unit. The microcontroller with in-built ADC is used. Here the signals are digitized and given to the host system through Bluetooth module with V2.0 + EDR specification. The system operates with 3 V DC supply.

F. Host System:

Fig. 2: Operating procedure of the host system

Fig 2 shows the basic block diagram of the process involved in the host system. The system is programmed with ‘C’ codes for monitoring the motor patterns of sucking, swallowing and respiration. The system is paired with the Bluetooth module to receive those signals. The processed signals will be displayed whose parameters can be varied using graphical user interface. The signals are analyzed based on fractal dimension method [14, 15]. The noise components are removed by adaptive noise cancellation technique. Based on the threshold value and the sequential actions of sucking, swallowing and respiration the coordination of the oral feeding actions is determined.

IV. EXPERIMENTATION AND RESULTS
The baby was allowed to feed through a polypropylene bottle. Each motor pattern was recorded over 2-3 minutes. The normal and abnormal patterns of sucking, swallowing and respiration were determined with the help of 7-10 recordings.

The system was tested to preterm infants and the result obtained was highly reliable. The difference between event frequencies of various ages were analyzed. Fig 3 shows the analysis results.

V. CONCLUSION

Wireless oral feeding monitor with high efficient flex sensor, pressure sensor and microphone was designed and the results obtained were reliable and accurate. The proposed non-invasive method of measuring the feeding pattern reveals the coordination of respiration, sucking and swallowing. The respiration pattern was found to be slower during continuous phase and faster during intermittent phase. The infant learns to coordinate those motor patterns with maturity.

VI. FUTURE SCOPE

Usage of wireless sensors makes the system more efficient since artifacts that occur due to infants' motion can be resolved.

REFERENCES


