Chapter 3

Smart Textiles in Neonatal Monitoring:
Enabling Unobtrusive Monitoring at the NICU

Fernando Seoane
University of Borås, and Royal Institute of Technology, Sweden

Juan Carlos Marquez
University of Borås, and Royal Institute of Technology, Sweden

Sibrecht Bouwstra
Eindhoven University of Technology, The Netherlands

Johan Löfhede
University of Borås, Sweden

Kaj Lindecrantz
Royal Institute of Technology, Sweden

ABSTRACT

Prematurely born and critically ill babies admitted to the Neonatal Intensive Care Unit require round-the-clock monitoring of vital signs and in special cases additional parameters such as brain functioning monitoring. Although close monitoring is fundamental for a good developmental outcome, the monitor systems are obtrusive, causing stress for the baby and hampering parent-child contact. New developments in textile and electronics offer opportunity in greatly improving the comfort and appearance of the monitoring systems for ECG as well as EEG monitoring by replacing the adhesive electrodes with textile electrodes. The authors present the designs of a neonatal jacket containing textile electrodes for ECG monitoring and textile electrodes intended to be integrated in a cap for brain functioning monitoring. The initial results presented show good prospect for further development. Accuracy and reliability are challenges specific for the medical application of smart textiles such as in neonatal monitoring. Furthermore, the mass-production of smart textiles requires improvement before smart garments can be introduced to the practice of neonatal care.

INTRODUCTION

The perinatal period, the time around birth, is a time in life associated with particular risks. The delivery could be complicated in various ways leading to reduced blood gas exchange for the fetus. The fetus can be growth retarded or it can have congenital malformations or the baby could be born prematurely, all of which can lead to problems for the baby to adapt to the extrauterine life. In many cases these problems lead to critically ill and vulnerable neonates with respiratory and circulatory problems, and with a significant risk of neurological damage. These babies therefore require special monitoring and intensive care involving treatment in an incubator at a Neonatal Intensive Care Unit (NICU). Traditionally vital signs such as ECG, oxygen saturation, respiration and temperature have been routinely monitored at the NICU (Nicklin, Wickramasinghe, & Andrew Spencer, 2004; STELLA Newsletter, 2010) and brain function monitoring is currently becoming a clinical practice (Lavery, Randal, 2008; Toet & Lemmers, 2009).

This round-the-clock health monitoring, allows taking medical actions based on timely detection thus increasing the survival rate and resulting in a better developmental outcome. With appropriate monitoring and medical care at the NICU, neonates born after 25 weeks of pregnancy may survive and live a normal healthy life (Costeloe, Hennessy, Gibson, Marlow, & Wilkinson, 2000; de Kleine et al., 2007). Therefore, close monitoring is fundamental at the NICU.

However, a calm environment suitable for the development of the neonate and parent-child bonding is also of importance. A monitoring system for neonates at the NICU must therefore comply with a diverse set of requirements, such as accuracy and efficiency, but also comfort. Advances in electronics and communication technologies allow for the monitoring instrumentation to be smaller. The advances are mainly electronic miniaturization and the integration of wireless communication eliminating the need for wires and communication busses. Miniaturization has offered new design opportunities in creating efficient and attractive designs. The development in the field of textile technologies and functional smart textiles has enabled the implementation of sensors for minimally intrusive neonatal monitoring systems.

BACKGROUND

Clinical Relevancy

The premature neonates with an immature central nervous system have to develop in an extra uterine environment. The incubator at the NICU environment is full of sources of discomfort and intrusion that interfere with the normal growth and development of neonates (Als et al., 2003; STELLA Newsletter, 2010). One of the major causes of discomfort in the incubator is the monitoring systems. Examples of discomfort are: pain at removal of the adhesive electrodes, false alarms at accidental disconnection and restriction in movement. Since close monitoring is fundamental for early detection of medical problems (e.g., apnea, arrhythmias and hypoxemia) and potential complications (e.g., convulsions) but at the same time cause discomfort, the intrusiveness of the current neonatal monitoring systems must be reduced, while maintaining the signal quality and reliability.

Smart Textiles

Textile technology has gone through a remarkable development in the field of Smart Textiles, which are materials or garments that due to their structure and/or composition can sense and react to stimuli imposed by their surroundings. Not all Smart Textiles are considered equally 'intelligent'. A truly Smart Textile can sense or even adapt based on context, however electronic components

Related Content

Computer-Aided Fetal Cardiac Scanning using 2D Ultrasound: Perspectives of Fetal Heart Biometry
N. Sriraam, S. Vijayalakshmiand S. Suresh (2012). *International Journal of Biomedical and Clinical Engineering (pp. 1-13).*
www.irma-international.org/article/computer-aided-fetal-cardiac-scanning/73690

Bioinformatics-Inspired Algorithms for 2D-Image Analysis--—Application to Medical Images Part II: Images in Circular Format
Perambur S. Neelakanta, Edward M. Bertotand Deepti Pappusetty (2012). *International Journal of Biomedical and Clinical Engineering (pp. 49-58).*
www.irma-international.org/article/bioinformatics-inspired-algorithms-image-analysis/73693

ePortfolios in Graduate Medical Education
Jorge G. Ruiz, Maria H. van Zuilen, Alan Katz, Marcos Milanezand Richard G. Tiberius (2009). *Medical Informatics: Concepts, Methodologies, Tools, and Applications (pp. 1016-1023).*
www.irma-international.org/chapter/eportfolios-graduate-medical-education/26277

Breast Cancer Lesion Detection From Cranial-Caudal View of Mammogram Images Using Statistical and Texture Features Extraction
Kavya N, Sriraam N, Usha N, Bharathi Hiremath, Anusha Suresh, Sharath D, Venkatraman Band Menaka M (2020). *International Journal of Biomedical and Clinical Engineering (pp. 16-32).*
www.irma-international.org/article/breast-cancer-lesion-detection-from-cranial-caudal-view-of-mammogram-images-using-statistical-and-texture-features-extraction/240743

Motion Perception in Healthy Humans and Cognitive Disorders
Takao Yamasakiand Shozo Tobimatsu (2011). *Early Detection and Rehabilitation Technologies for Dementia: Neuroscience and Biomedical Applications (pp. 156-161).*
www.irma-international.org/chapter/motion-perception-healthy-humans-cognitive/53434