Chapter 17

Smart Jacket Design for Improving Comfort of Neonatal Monitoring

Wei Chen
Eindhoven University of Technology, The Netherlands

Sibrecht Bouwstra
Eindhoven University of Technology, The Netherlands

ABSTRACT

Health monitoring is crucial for the survival of ill and premature infants admitted at the neonatal intensive care unit (NICU) in a hospital. The reliability and comfort of monitoring systems will impact on the quality of life and long-term health prospects of the neonates. This chapter presents the ongoing design work of a smart jacket for improving comfort of neonatal monitoring. Textile sensors, a reflectance pulse oximeter, and a wearable temperature sensor are developed to be embedded into the smart jacket. The authors also report a power supply and wireless communication system developed for the smart jacket. Sensor locations, materials, and appearance are designed to optimize the functionality, patient comfort and the possibilities for aesthetic features. Prototypes are presented for demonstrating the design concept, and experimental results for functional performance are shown from the tests on premature babies at the NICU of Máxima Medical Centre (MMC) in Veldhoven, the Netherlands.

INTRODUCTION

Critically ill and preterm infants (i.e., neonates) are usually admitted at the neonatal intensive care unit (NICU) of a hospital. These neonates are tiny and highly vulnerable to external disturbances.

Continuous monitoring of the neonates at NICU is crucial for early detection of inadverted events and possible complications, and consequently increase the survival rate (Costeloe, Hennessy, Gibson, Marlow, & Wilkinson, 2000). Vital signs for neonatal monitoring include body temperature, electrocardiogram (ECG), respiration, and blood oxygen saturation (Polin & Fox, 1992). Presently,
body temperature is monitored with adhesive thermistors; ECG and respiration are obtained by adhesive skin electrodes. The oxygen saturation of the blood is monitored by a transmissive pulse oximeter with the sensor applied on the foot or palm of the neonate (Murković, Steinberg, & Murković, 2003). Placement and detachment of these adhesive sensors and the presence of all the wires lead to discomfort and even painful stimuli. Moreover, the parent-child interaction is hampered. The disturbance, interruption of sleep, and lack of natural communication with parents all interfere with the babies’ normal growth and development (Als et al., 2003).

The objectives in the application of unobtrusive health monitoring are improving comfort of patients and enhancing social interaction, which involves multi-disciplinary research and collaboration, including sensor technology, medical science, industrial design, electrical engineering, etc. Recent advances in sensor technologies (Tao, 2005; Yang & Yacoub, 2006) and wireless communication technologies (Goldsmith, 2005) enable the creation of a new generation of healthcare monitoring systems with wearable electronics and photonics. Smart textiles have been integrated into a garment for electrocardiogram (ECG) and respiration monitoring with wireless transmission (Catrysse et al., 2004; Paradiso, Loriga, & Taccini, 2005). Reflectance pulse oximeters attached to the forehead (Mendelson, Duckworth, & Comtois, 2006; Somanetics, n.d.) (New OxyAlert™ NIR-Sensors) have been developed. A device to support cardiopulmonary resuscitation of neonates has been reported (Bambang Oetomo, Feijs, Chen, & Andriessen, 2009; Chen, Bambang Oetomo et al., 2010). A user friendly EEG headset has been designed to enhance people’s wellbeing based on bio-feedback (van Aart, Klaver, Bartneck, Feijs, & Peters, 2008). In the neonatal monitoring area, some early efforts and developments have been made. For example, some methodological options for technological integration and early design work of a future incubator have been reported (Rullo, Marti, Grövall, & Pollini, 2006). A biosensor belt is reported for monitoring the heart rate, breathing rate, body movements and temperature of new born baby with embedded sensors (Piccini, Ciani, Grövall, Marti, & Andreoni, 2008). Dedicated design and integration are essential for achieving reliable neonatal monitoring with significantly improved patient comfort and ease of use.

The Eindhoven University of Technology (TU/e) in the Netherlands has started a 10-year project on perinataloty research in cooperation with the Máxima Medical Centre (MMC) in Veldhoven, the Netherlands. The goal of this project is to improve the healthcare of the pregnant woman, and her child before, during and after delivery (Chen, Bambang Oetomo, & Feijs, 2010).

In this chapter, we present the design work of a smart jacket as a neonatal monitoring platform. The smart jacket is designed to provide reliable health monitoring as well as a comfortable clinical environment for neonatal care and parent-child interaction (Bouwstra, Chen, Feijs, & Oetomo, 2009). Design and integration of various sensors for unobtrusive neonatal monitoring are developed and ready to be embedded into the smart jacket, for example textile sensors for ECG monitoring, a wearable temperature sensor (Chen, Dols, Bambang Oetomo, & Feijs, 2010), and a reflectance pulse oximeter for monitoring blood oxygen saturation (Chen, Ayoola, Bambang Oetomo, & Feijs, 2010). In the previous chapter entitled “Smart Textiles in Neonatal monitoring - enabling unobtrusive monitoring at the NICU,” smart textiles for ECG monitoring of neonates is introduced. In this chapter we present the smart jacket design as a platform and the other monitoring functions including temperature and blood oxygen saturation monitoring. Besides the design for vital sign monitoring, a power supply based on contactless energy transfer (Chen, Sonntag, Boesten, Oetomo, & Feijs, 2008, 2009) and a wireless communication system (Chen et al., 2011; Chen, Nguyen, Coops, Bambang
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