

Chapter 19

Silent Alarms for the Neonatal Intensive Care Unit (NICU)

Ivo Stuyfzand

MSc Industrial Design, The Netherlands

ABSTRACT

The goal of this study on silent monitoring alarms is to make the Neonatal Intensive Care Unit (NICU) quieter with the help of a context sensitive clinical monitoring alarm system. A work domain analysis in the NICU of Máxima Medical Centre in Veldhoven, the Netherlands, reveals that more than half of the monitoring alarm events occur when a nurse is treating the infant at the incubator in while the nurse is paying full attention to the infant. This provides an opportunity for silent lighting alarms. The proposed intelligent system detects whether the nurse is treating the infant at the incubator or not and changes alarm modality to light or audio accordingly. This intelligence based on level of attention does not require complex judgments on clinical relevancy of the alarms or optimization algorithms. The results of the work domain research and an experiment show that the proposed solution has potential to improve the alarm system at the NICU, but the success is heavily dependent on the design details, which thus reserve further attention.

INTRODUCTION

The essence of a Neonatal Intensive Care Unit (NICU) or any other ICU is the continuous flow of information in real time about the status of the patient. This allows caregivers to react immedi-

ately to any change in the patient's condition. Information is provided through the monitoring of various biophysical variables. The monitors obtain information from sensors and evaluate them. When a value exceeds a predefined threshold the monitor will produce an acoustic alarm (Bitan et al., 2004).

DOI: 10.4018/978-1-4666-0975-4.ch019

Numerous studies have revealed problems concerning the use of alarms in the ICU. Alarms in ICUs can be unnecessarily loud and cause distress for the patient, who may have a lowered tolerance for noise (Momtahan et al., 1993). This is unnecessary, because a high proportion of alarms is unrelated to emergencies.

In this chapter, we propose an alarm intelligence that can choose to use a silent alarm modality based on *level of attention* of the responsible nurses in the patient room. The level of intelligence required for a product or system to interpreted activities, processes and states of an environment and to adapt to that is described by Ambient Intelligence (AmI) (Aarts & Encarnação, 2006). AmI refers to a developing technology that will increasingly make our everyday environment sensitive and responsive to our presence. In the research presented in this chapter we propose a context sensitive alarm system that can sense if the attention of the nurse is already with the infant related to the alarm event. If so a silent alarm modality, e.g., lighting, can be used to alert and inform the nurse. As a result the environment can become quieter which is a benefit for patient and staff.

BACKGROUND

In an adult ICU more than 70% of all alarms are alarms leading to no action (Chambrin et al., 1999). More than 94% of the alarms have no clinical significance (Lawless, 1994). As a consequence of the high number of false alarms nurses ignore alarms or respond more slowly, known as the cry-wolf phenomenon. Furthermore there is no standardization across manufacturers (Meredith & Edworthy, 1995). As a result there is no respect for harmony and meaning because each device has its own alarm structure and its own alarm sounds.

The current solution to unnecessary alarms is that all devices are equipped with a silencing-knob. Nurses can decide to temporarily suspend

alarms for their own comfort and that of the patient. However the issues related to poor alarm design do not remain unrecognized. The problems are reported in three main fields of research (Freudenthal et al., 2005):

1. Firstly, the field of auditory perception focusing on improving current solutions, for example how to communicate hierarchy in auditory signals (Edworthy, 2005).
2. Secondly, the field of computer science focusing on technical solutions to filter out clinically irrelevant alarms, e.g., filtering by algorithms (Schoenberg et al., 1999). The focus is on the patient's physiology only.
3. Thirdly, alarm research is conducted according to the methods of cognitive systems engineering. For example Bitan et al. (2004) looked at alarms with respect to the whole nursing process and conclude that nurses do not respond immediately when they hear an alarm, but rather register the occurrence, evaluate and adjust their ongoing flow of actions accordingly. In their study Bitan et al. excluded alarms events that occurred while the nurse was treating the infant at the incubator to which the alarm was attached. In the study presented in this chapter we do take these alarm instances into account as they do contribute to the noisy environment and are part of the nursing process.

Freudenthal et al. (2005) aims to break the status quo in alarm design, seeking for a radical different approach. A new alarm hierarchy is proposed according to careful analysis of the nursing process including the 'why' of the nurse's actions to alarms - which is missing in Bitan's work. There is a particular modality for each alarm category; crisis alarms signal with sound, alerting alarms signal with a tactile stimulus, and informing messages with light. Furthermore the system assesses event type according to readings from physiological functions and input from the

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