Chapter 14
Neonatal Monitoring Based on Facial Expression Analysis

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ABSTRACT

Prematurely born infants are observed in a Neonatal Intensive Care Unit (NICU) for medical treatment. These infants are nursed in an incubator, where their vital body functions such as heart rate, respiration, blood pressure, oxygen saturation, and temperature are continuously monitored. However, the existing monitoring system is lack of the measurement for visual expression of the neonatal. Therefore, valuable information about the well being of the patient (e.g., pain and discomfort) may pass unnoticed. This chapter aims at designing a prototype of an automated video monitoring system for the detection of discomfort in newborns by analyzing their facial expression. The system consists of several algorithmic components, ranging from the face detection, ROI determination, facial feature extraction, to behavior stage classification. To further adapt this system to the real hospital environment, the authors also intend to address the problem of locating the face regions under varying lighting conditions. To this end, an adaptive face detection technique based on gamut mapping is presented. The authors have evaluated the prototype system on recordings of a healthy newborn with different conditions, and we show that our algorithm can operate with approximately 88% accuracy.

INTRODUCTION

In a neonatal intensive care unit (NICU), premature infants receive specialized care. Many infants are born without having reached full gestational age. As a consequence, their physiological development is immature and their bodily processes cannot sustain autonomous operation. To survive, these neonates, thus, rely on various ways of adequate support. This support is provided at the NICU by medical attention, treatment and the presence of a multitude of machinery.

Examples of support machinery are ventilators to provide the underdeveloped lungs with

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Figure 1. The incubator and its setting at a NICU

oxygen, external heaters to regulate body temperature. More specifically, infants are placed inside a transparent confined space known as an incubator (see Figure 1 for an example), so that the environment surrounding the infant can be controlled and stabilized. Apart from providing this ideal environment, NICU also continuously monitors several vital physiological parameters of the neonatal, such as heart rate, oxygen saturation, and temperature. The monitoring system sounds alarms when values exceed normal physiological ranges. Such systems are very important to keep the neonatal safely. Unfortunately, the currently available monitoring systems did not enable to automatically observe the visual expression of the infant. As a result, valuable information about the well being of the patient (e.g., pain and discomfort) may be lost or remain unnoticed for a long time because an infant is not able to self-report discomfort. The awareness that early treatment of pain and discomfort is important for the future development is presently growing and this eventually motivates us to design a prototype for an automated video observation system that can detect discomfort in newborn babies.

As mentioned, vision-based facial-expression analysis on newborns with discomfort detection as an objective is not yet applied in the real hospital situation. Therefore, we explore the route to such a system, and propose a pilot system, which is able to analyze several important facial regions: eyes, eyebrows and mouth in an automatic way. Whereas the hospital environment is too challenging to start, we use own recordings that approach this environment, while taking the following constraints into account: the system should be as viewpoint and lighting-condition independent as possible and should be able to handle partial occlusions of facial components. Based on these constraints, we design an experimental framework, and evaluate in how far this framework can be applied for automatic facial expression analysis under various conditions. The results also indicate on which aspects we should further improve the system in order to use it in the reality.

BACKGROUND

1. Neonatal Monitoring Technique

In the last decades the advances in sensor technologies and wireless communications technologies have resulted in the possibility to develop intelligent systems for monitoring neonatal vital parameters. The basic vital parameters include