Introduction to Neonatal Facial Pain Detection Using Common and Advanced Face Classification Techniques

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Summary. Assessing pain in neonates is a challenging problem. Neonates cannot describe their pain experiences but must rely exclusively on the judgments of others. Studies demonstrate, however, that proper diagnosis of pain is impeded by observer bias. It has therefore been recommended that neonatal pain assessment instruments include evaluations that have bypassed an observer. In this article, we describe the Infant COPE project and our work using face classification to detect pain in a neonate's facial displays. We begin by providing an introduction to face classification that includes an outline of some common and advanced algorithms. We then describe a small database we designed specifically to investigate classifier performance in this problem domain. This is followed by a summary of the experiments we have performed to date, including some preliminary results of current work. We believe these results indicate that the application of face classification to the problem of neonatal pain assessment is a promising area of investigation.

1 Introduction

Pain is an important indicator of medical conditions. It is also the source of suffering. Health professionals are responsible for diagnosing pain, determining when pain intervention is necessary, and developing treatment plans [1]. To accomplish these tasks, health professionals employ a variety of assessment tools for evaluating patient self-reports. In the case of preverbal children, methods have been devised to help them communicate their pain experiences. These children can indicate their pain levels, for example, by pointing to drawings of faces that express increasing levels of discomfort [2]. Neonatal pain assessment, in contrast, depends exclusively on the judgment of others. A growing body of evidence suggests that failing to diagnose and alleviate pain in newborns can have devastating and long-term effects [3]. Developing accurate pain assessment instruments for neonates is thus inherently problematical and yet most crucial.

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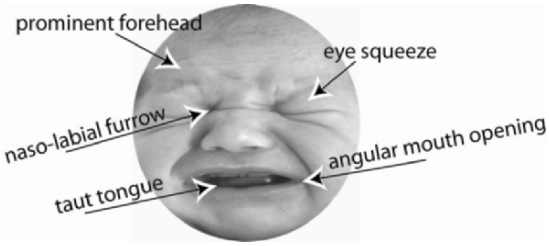

Fig. 1. Characteristics of neonatal facial displays of pain

To diagnose pain in neonates, health professionals draw on physiological and behavioral information. Among the many physiological indicators of pain are changes in heart and respiratory rates, blood pressure, vagal tone, and palmar sweating [4]. Inferring neonatal states from physiological measures is difficult, however. The physiological parameters associated with pain are often indistinguishable from those produced by other stressful events [5], and physiological responses can vary widely from newborn to newborn [6].

Significant behavioral indicators of pain include gross body movement, crying, and facial expressions [6]. The gold standard in infant pain assessment is the face. Facial responses to pain are more specific and consistent than other known behavioral and physiological responses [7]. For this reason, the majority of pain assessment instruments developed for newborns incorporate observations of facial activity. Figure 1 illustrates some of the patterns – prominent forehead, eye squeeze, naso-labial furrow, taut tongue, and an angular opening of the mouth – that characterize neonatal pain displays [8].

Even though facial activity is easier to decipher then physiological measures and other behavioral indicators such as crying, instruments that have relied on facial information have proven unsatisfactory primarily because of problems with observer bias [9]. Bias is defined as the tendency for a person to alter responses to a stimulus over time and when the parameters of the situation change [10]. Several factors influence an observer's propensity toward bias. Some of these include the personality of the observer, perception of the measure, the context, and desensitization due to repeated exposure to patient suffering [1, 11].

One way to reduce bias is to incorporate evaluations that have not been made by an observer. Several researchers have begun investigating machine assessment of common pain indicators. Lindh et al. [12], for instance, have reported some success detecting pain as it relates to heart rate variability, and Petroni et al. [13] have trained neural networks to discriminate differences in neonatal cries, including a cry in response to pain. Developing classification systems using these pain indicators, however, has limited practicality. Given the robust population of most neonatal units, implementing systems that distinguish different types of cries for individual neonates would be difficult to accomplish, and monitoring physiological measures would probably require