VIDEO-BASED DISCOMFORT MONITORING FOR PREMATURE INFANTS IN NICU

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ABSTRACT

Premature infants are particularly vulnerable to discomfort, which can lead to abnormal brain development. In this study, we propose a video-based method for automated monitoring of their discomfort by analyzing motion trajectories and applying a support vector machine (SVM) classifier. On a clinical dataset collected in the hospital for 11 premature infants, our approach achieved an area under the receiver operating characteristic curve (AUC) of 0.94 and an accuracy of 0.86.

1. INTRODUCTION

In the Neonatal Intensive Care Unit (NICU), continuous discomfort assessment for premature infants is highly desired, since it helps caregivers to understand the severity of infant situation and develop appropriate treatments. Therefore, we propose a video-based automated system for detecting their discomfort moments.

2. DATA AND METHOD

The study was conducted with videos recorded at the Maxima Medical Center in Veldhoven, The Netherlands, by a fixed-position camera filming the infant face and upper body. The recording started 10 minutes prior to the heel lance procedure, which is typically a well-known pain stimulus. Once the heel lance procedure was finished, the video recording continued for an observation time of returning to baseline (10 minutes).

In order to detect the body motion of infants, we employ optical flow to estimate pixel motion vectors, which is followed by feature extraction for discomfort/comfort classification. Motion vectors are first calculated for each video frame using the optical flow proposed by Farnebäck *et al.* [1]. We accumulate the magnitude values of all motion vectors for each frame and further take the first derivative to estimate the motion acceleration rate. For each video segment, features are extracted from the one-dimensional signal of motion acceleration rate. We calculate 18 features: mean, median, root mean square, 3 peak-height- and location-based features from the autocorrelation to capture motion intensity and periodicity, and 12 spectrum features based on the height and location of the 6 highest peaks in the derived spectrum to analyze movement from the perspective of different frequencies. Finally, a linear SVM classifier is adopted on video segments to recognize the infant status of comfort or discomfort using the 18 extracted features.

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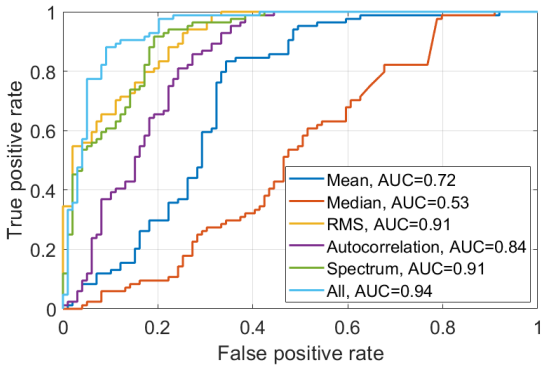

Fig. 1. ROC curves for classification using each individual category of features, and combining all features together.

3. EXPERIMENTAL RESULTS AND CONCLUSIONS

The method was evaluated using 183 video segments (2,738-second discomfort and 3,429-second comfort moments in total) for 11 infants from 17 heel prick events. When all features are combined, the average accuracy for all infants is 0.86 and the AUC for the detection of discomfort is 0.94 (Fig. 1) using leave-one-infant-out cross-validation.

With an AUC of 0.94, our system is promising for clinical practice to detection discomfort related motion. When achieving a high sensitivity of 85%, our system detects false positives of 10%. A majority of these false positives are segments with irregular comfortable movements. For further work, we may add features extracted from the monitored vital signs to improve the system.

4. REFERENCES

[1] Gunnar Farnebäck, "Two-frame motion estimation based on polynomial expansion," in *Scandinavian conference on Image analysis*. Springer, 2003, pp. 363–370.