**Video-Based Actigraphy for Monitoring Wake and Sleep in Healthy Infants: A Laboratory Study -2019**

**Summary** - Prolonged monitoring of infant sleep is paramount for parents and healthcare professionals

for interpreting and evaluating infants’ sleep quality. Wake-sleep patterns are often studied toassess this. This paper, we propose a method using motion data detected from infrared video frames (video-based actigraphy) to identify wake and sleep states. The motion, mostly caused by infant body movement, is known to be substantially associated with infant wake and sleep states. Two features were calculated from the video-based actigraphy, and a Bayesian-based linear discriminant classification model was employed to classify the two states. Leave-one-subject-out cross validation was performed to validate our proposed wake and sleep classification model. From a total of 11.6 h of infrared video recordings of 10 healthy term infants in a laboratory pilot study, we achieved a reliable classification performance with a Cohen’s kappa coefficient of 0.733 ± 0.204 (mean ±standard deviation) and an overall accuracy of 92.0% ±4.6%.

Feature Extraction and Classification-mACT and pSLP

Validation- statistical analysis (Mann–Whitney U test)

Video based Actigraphy- IR videos

Data collection- 10 infants

**Block diagram of the proposed system**

**References**

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**Infants’ Pain Recognition Based on Facial Expression: Dynamic**

**Hybrid Descriptions-2018**

**Summary -**The accurate assessment of infants’ pain is important for understanding their medical conditions and developing suitable treatment. This paper proposes a new set of pain facial activity features to describe the infants’ facial expression of pain. Both dynamic facial texture feature and dynamic geometric feature are extracted 0from video sequences and utilized to classify facial expression of infantsas pain or no pain. For the dynamic analysis of facial expression, we constructspatiotemporal domain representation for texture features and timeseries representation (i.e. time series of frame-level features) for geometricfeatures. Multiple facial features are combined through both feature fusionand decision fusion schemes to evaluate their effectiveness in infants’ painassessment. Experiments are conducted on the video acquired from NICUinfants, and the best accuracy of the proposed pain assessment approachesis 95.6%. Moreover, we find that although decision fusion does not perform better than that of feature fusion, the False Negative Rate of decisionfusion (6.2%) is much lower than that of feature fusion (25%).

Temporal Geometric Feature Representation

Data collection- Video from NICU

Fusion and Classification

Infants video frames, facial landmarks

Temporal Appearance Feature Representation

Correlation of Facial Features to Pain

**Block diagram of proposed system**

**References**

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**Automatic Infants’ Pain Assessment by Dynamic Facial Representation: Effects of Profile View,Gestational Age, Gender, and Race-2018**

**Summary**-Facial expression is the most specific pain indicator, which has been effectively employed for automatic pain recognition. In this paper, dynamic pain facial expression representation and fusion scheme for automatic pain assessment in infants is proposed by combining temporal appearance facial features and temporal geometric facial features. The effects of various factors that influence pain reactivity in infants, such as individual variables of gestational age, gender, and race. Different automatic infant pain assessment models are constructed, depending on influence factors as well as facial profile view, which affect the model ability of pain recognition. It can be concluded that the profile-based infant pain assessment is feasible, as its performance holds good to the whole face. Gestational age is the most influencing factor for pain assessment, and it is necessary to construct specific models depending on it. This is mainly because of a lack of behavioral communication ability in infants with low gestational age, due to limited neurological development.

Classification and Decision Fusion

Frame-Level Hybrid Facial Representation

Preprocessing- Video segmentation

Data Acquisition- 31 infants

**Block diagram of proposed system**

**Reference**

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premature infants. Egypt. Pediatr. Assoc. Gaz. **2016**, 64, 74–80.

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Johnston, C.; et al. Determining behavioural and physiological responses to pain in infants at risk forneurological impairment. Pain **2007**, 127, 94–102.

**A Novel Approach on Infant Facial Pain Classification using Multi Stage Classifier and Geometrical-Textural Features Combination - 2017**

**Summary** - Infants are unable to communicate pain, they cry to express their pain. In this paper we describe the most effective feature for infant facial pain classification. The image dataset was classified by medical doctors and nurses based on cortisol hormone difference and FLACC (Face, Legs, Activity, Cry, Consolability) measurement. This paper investigates a number of features based on Action Unit (AU) for infant facial pain classification and discovers that the best features are combination between geometrical and textural features. Active Shape Model (ASM) is trained and extracted the geometrical features based on landmarkpointsfound by our ASM. The textural features are extracted using Local Binary Patterns (LBP) from multiple facial patches. Two stage pain classification preceded by a cry detection system is examined, and concluded that this scenario combined with geometrical and textural feature produce a very high F1 score for infant facial pain classification.

Geometrical Feature Extraction

Data acquisition-Hanindito dataset consist of 46 videos from

23 infants

Performance Measurement

SVM classification

Face detection using ASM

**Block diagram of proposed system**

**REFERENCES**

[1] K. M. Prkachin, N. A. Currie, and K. D. Craig, “Judging nonverbalexpressions of pain.,” Canadian Journal of Behavioural Science/Revuecanadienne des sciences du comportement, vol. 15, no. 4, p. 409, 1983.

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**Emotional Facial Expression and Tears Simulation:An Analysis & Comparison of Current Approaches-2015**

**Summary–** This research reviews and compares two major techniques for generating extreme expression in 3D facial animation, the facial action coding system is employed to describe and create facial expressions. It breaks down facial actions into minor units known an action units (AU’s). Emotion facial expressions generated are based on Facial animation as media of emotion expression. MPEG-4, FACS and facial animation techniques have used. Graphic designing tool is used to design various facial expressions based on Facial action coding system.

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**Categorization and understanding of facial expressions in 4-month-old infants-2014**

**Summary**-The present study investigated whether 4-month-olds could perceptually categorize happy and angry faces, and respond to those facial expressions appropriately. Regarding the ability to categorize happy and angry faces perceptually, the results indicated that 4-montholds do have this ability. That is, 4-month-olds who were habituated to three happy faces looked longer at an angry face posed by a fourth model than at another happy face during the test phase. Similarly, those who saw angry faces during the habituation phase showed longer looking times at a happy face than at another angry face in the test phase. The present research thus confirmed that 4-montholds perceptually categorize facial expressions.

Statistical analysis- ANOVA test

Data collection-Forty healthy, full term 4 months old

Stimulus -10 colored pictures of facial expressions were used as stimuli consisting of two facial expressions, happiness and anger

Habituation phase behavior coding

**Block diagram of proposed system**

**References**

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**Analysis of the First Cry of the Newborns in Case of Vaginal Delivery and Caesarean Section- 2012**

**Summary**-Nearly all of the newborns are coming into the world with crying. The first cry carries significant information about the baby’s wellbeing, about his successful adaptation to the extra uterine life. The quality of first cry is a part of the Apgar score system which is used to assess the condition of newborns after delivery. The powerful first cry can carry the message for parents about the arrival of a healthy baby or the feeble cry immediately arises anxiety. In many countries the number of caesarean section has been increasing. The differences in the first cry can represent a subtle parameter which can reflect the start of life in a different way. The first cry samples of 10 vaginally born babies and 10 babies born by caesarean section were analysed. The analysis took place by subjective test with the participation of infant care specialists and with objective measurements based on signal analysis. The groups of cry samples showed definite differences besides that the cry samples in both groups were in the normal range. The results can contribute to the decision making process about the way of delivery knowing that the events in the perinatal period create the base for the later physical, mental, emotional development.

Comparison between Vaginal delivery babies and caesarean delivery by calculating average values.

Subjective tests- record composed by digital editing at a sampling rate of 22050/s.

Cry signals divided into 25 cry signal subsections and assessment was done by 32 specialists in newborn care

Comparison by calculating average values of RT, F0, F1, F2, D parameters

Data recording First cry samples from new born babies (10 vaginally born babies and 10 babies born by caesarean section were analysed

Objective measurements done by signal processing using Wave surfer software

Speech signal processing carried out using Hamming window by 2048 samples, pre-emphasis value 0.9

**Block diagram of proposed system**

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**A longitudinal analysis of the development of infant facial expressions in response to acute pain: Immediate and regulatory expressions-2012**

**Summary-**Facial expressions during infancy are important to examine, as infants do not have the language skills todescribe their experiences. This is particularly vital in the context of pain, where infants depend solely on their caregivers for relief. The objective of the current study was to investigate the development of negative infant facial expressions in response to immunization pain over the first year of life. Infant facial expressions were examined longitudinally using a subsample of 100 infants that were each videotaped during their 2-, 4-, 6-, and 12-month routine immunization appointments. Facial expressions were coded using BabyFACS (facial action coding system) for the first minute after a painful needle prick. Facial expressions were examined with a catalogue of the most commonly occurring facial expressions. Results demonstrated that clear differences were seen over ages. Infants display a variety of facial expressions with some of the components of adult pain expressions immediately after the needle and they abate shortly after. Infants displayed a variety of generalized pain and distress faces aimed at gaining caregiver aid. The development of nonverbal communication in infants, particularly facial expressions, remains an important area of inquiry.

Analyses are described according to each facial expression (i.e., color label)

Participants- 100 infants selected during 4 separate routine immunization appointments

Statistical analysis is done using related-samples Friedman’s 2-way analysis of variance by ranks for each facial expression.

Facial coding measurefacial expressions were coded for 1 minute after the last immunization needle using BabyFACS

**Block diagram of proposed system**

**References**

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**Event-related potentials elicited in mothers by their own and unfamiliar infants’ faces with crying and smiling expression-2012**

**Summary-**Crying by an infant signals an urgent desire for care and protection. Because of the special relationship between a mother and her infant and the signal value of her crying, it is possible to suggest that the maternal brain efficiently processes crying by infants. The present study, examines this hypothesis by measuring event-related potentials in mothers while they observed crying or smiling by their own or unfamiliar infants embedded within a train of neutral expressions. It is found that the amplitude of the face-specific N170 component was enlarged for crying regardless of familiarity. The P300 component, which reflects a later cognitive evaluation stage of stimulus processing, was decomposed into functionally distinct components by temporal principal component analysis. The amplitude of the third temporal factor, which corresponds to the earliest portion of the P300, was larger when a mother observed her own infant crying than for the other conditions. Moreover, onset latency of P300 was shortest when mothers observed their own infant crying. These results indicate that mothers process their own infant’s crying more efficiently than smiling by their own infant or crying by an unfamiliar infant.

Peak amplitude and latency analysis, Principal component analysis

Correlation between behavioral results and ERP results

EEG Preprocessing raw data filtered with a 0.1-Hz high-pass filter and a 30-Hz low-pass filter

Behavioral results-Reaction times (RTs),Stimulus ratings.

Stimulus Evaluation – Ratings given by participants for the given stimulus

EEG recording was done when the participant is being subjected to visual stimulus

Participants- 16 mothers with infants aged approx. 12 months

**Block diagram of proposed system**

**References**

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**Behavioral State Detection of Newborns Based on Facial Expression Analysis-2009**

Summary-Prematurely born infants are observed at a Neonatal Intensive Care Unit (NICU) for medical treatment. Whereas vital body functions are continuously monitored, their incubator is covered by a blanket for medical reasons. This prevents visual observation of the newborns during most time of the day, while it is known that the facial expression can give valuable information about the presence of discomfort. The proposed algorithm automatically segments the face from the background and localizes the eye, eyebrow and mouth regions. Based upon measurements in these regions, a hierarchical classifier is employed to discriminate between the behavioral states sleep, awake and cry. Tests on three healthy newborns show that the prototype system can be used for determination of the states of the above-mentioned facial components with an acceptable accuracy (approximately 88.2%).

Classification- hierarchical classifier (kNN, SVM and neural networks)

Feature extraction-Eye region, eyebrow region, mouth region

ROI detection-eyes, eyebrows and mouth

Pre-processing Face segmentation, light adaptation

Image acquisition- 3 new born infants at NICU

**Block diagram of proposed system**

**References**

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**AN INFANT FACIAL EXPRESSION RECOGNITION SYSTEM-2008**

**Summary-**This paper presents a vision-based infant facial expression recognition system, which can be applied to infant monitoring systems to reduce the take-care load of the caregivers. In this study, a video camera positioned above the infant's crib captures video. The proposed system consists of two stages: infant face detection and infant facial expression classification. An improved Locus model is applied to detect the infant skin color for infant face detection. The proposed face detection method can be applied to different infants or various lighting environments. Moreover, a principal component analysis method is used to extract the features for the infant facial classification. In this study, the infant facial expression is classified into seven classes, including sleeping, dazing, crying, laughing, yawning, sneezing and vomiting. The experimental results show that the proposed method is robust and efficient.

Feature extraction using Principle component analysis

Database- Feature vectors stored in database.

Database training phasethe skin color areas and face is located

Input images from video recorded from infant’s crib

**Database construction stage**

Skin color areas are detected, the infant face is located and the face region is sub-sampled.

Feature vectors are compared with database images

Result- Detection of infant’s expresssion

Testing input image sequence

**Facial expression recognition**

**Block diagram of the proposed system**

**Reference**

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**EMOTION DETECTION FROM INFANT FACIAL EXPRESSIONS AND CRIES-2006**

**Summary-**The system is designed to analyze the facial image and sound of the crying infant to derive the reason why the infant is crying. The image and the sound represent the same cry event. The image processing module determines the state of certain facial features, certain combinations of which determine the reason for crying. The sound processing module analyzes the data for the fundamental frequency and the first two formants and uses k-means clustering to determine the reason of the cry. The decisions from the image and sound processing modules are then fused using a decision level fusion system. The overall accuracy of the image and sound processing modules are 64% and 74.2%, respectively, and that of the fused decision is 75.2%.

Cry signal

Decision Fusion

Sound processing module- extraction and analysis of F0, F1, F2 and F3, of infant vocalization

Image processing module- input images from open sources on internet

**Block diagram of proposed system**

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**A NEONATAL FACIAL IMAGE SCORING SYSTEM**

**(NFISS) FOR PAIN RESPONSE STUDIES-2005**

**Summary -** The aim of this study was to establish a scoring system, Neonatal Facial Image Scoring System (NFISS), for investigating the pain responses in neonates during routine venipuncture. During the first phase of this study 1998 facial images from 19 infants were collected and identified twelve features of the facial image: normalized scale for NFISS (scale from 0-15), including brow bulge (0-2), vertical brow furrowing (0-1) and short distance (0-1), brow lowering (0-1), eyes close (0-1), bulging eyes (0-2), eye-eye furrowing (0-1), cheek bulge (0-1), nasal-labial furrowing (0-2), mouth open and stretch (0-1), lip purse (0-1) and taut tongue (0-1). During the second evaluation phase, with 2770 images from 31 newborn infants (average age: 2.85°”.027 days), the pain responses were graded on the NFISS scale. Two peak score values during a time course of baseline-venipuncture-recovery (3-3-10 min) were found with needle piercing and needle withdrawal. The reliability of the score analysis was evaluated using 492 randomly selected images out of the 2770 images. The results for intrascorer (author, one week interval) and inter-scorer (author and one experienced nurse) has correlation coefficients of 0.916 and 0.826, respectively.

Phase 2 formal study -2770 images from 31 newborn infants, pain responses were assessed by physiological and behavioral parameters.

Phase 1 pilot study -Qualitative content analysis based on static images

Input images and physiological parameters are recorded during venipuncture

Data were analyzed with SPSS statistics package using descriptive analysis and graphs.

**Block diagram of proposed system**

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# The Recognition of Facial Expression of Pain in Full-Term Newborns by Parents and Health Professionals-2000

**Summary-** Facial expression of pain represents an effective neonatal communication tool. A cross-sectional study to determine whether adults can recognize neonatal facial expression of pain. 405 adults divided into 2 groups: health and nonhealth professionals at Neonatal intensive care unit, nursery, and out- patient clinic of one university hospital and one private hospital in Sa˜o Paulo, Brazil. The faces of 3 healthy full-term new- borns who needed glucose screening were photo- graphed at rest and during light exposure, heel rubbing, and heel puncture. A series of adults answered a questionnaire on personal and professional data 74% of the health professionals and 86% of the nonhealth professionals indicated correctly the picture with facial expressions of pain in at least 2 of the 3 sets. Regarding which picture was picked out by the interviewee, 94% of the health professionals and 92% of the nonhealth professionals indicated the picture taken during the heel puncture in set 1. The same observation was made by 53% and 54% of the health professional and by 68% and 66% of the nonhealth professional interviewees for sets 2 and 3, respectively. However, the health professional group achieved a lower level of recognition of neonatal facial expressions of pain. Factors related to the personal and professional characteristics of the adults interviewed probably contributed to this result.

Analysis of results from both the group

Response were recorded

Photographs of were shown, questionnaire on those set of images

Participants divided into health and non health professionals

**Block diagram of proposed system**

**References**

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**Machine assessment of neonatal facial expressions of acute pain-2007**

**Summary-** Pain is a major indicator of medical problems and a major source of discomfort. Although the vast majority of patients are capable of describing their pain experiences, other patients, such as neonates, must rely entirely on proxy judgments. At present, the medical assessment of neonatal pain takes into consideration a number of physiological and behavioral factors, with neonatal facial expressions playing a central role in pain assessment. This paper proposes that a machine assessment system of neonatal expressions of pain be developed to assist health professionals in diagnosing pain. Study is designed to investigate machine classification of neonatal facial displays. The facial expressions of 26 neonates between the ages of 18h and 3days old were photographed experiencing the pain of a heel lance and three nonpain inducing stressors: transport from one crib to another, an air stimulus on the nose and friction on the surface of the heel. The neonatal facial images were divided into two categories: (1) pain, which included all the heel lance images, and (2) nonpain, which combined the images of the nonpain inducing stressors. Two advanced classification algorithms, SVM and NNSOA, and two baseline face recognition algorithms, PCA and LDA, performed 26 classification experiments, one for each subject. NNSOA provided the best classification rate of pain versus nonpain (90.20%), followed by SVM with linear kernel (82.35%).

Classification

Input image of infants and different stimulus

Pre-processing

Feature extraction

**Block diagram of proposed system**

**Reference**

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**Video-based facial discomfort analysis for infants-2014**

**Summary-** Prematurely born infants receive special care in the Neonatal Intensive Care Unit (NICU), where various physiological parameters, such as heart rate, oxygen saturation and temperature are continuously monitored. This paper, presents an experimental video monitoring system for automatic discomfort detection in infants’ faces based on the analysis of their facial expressions. The proposed system uses an Active Appearance Model (AAM) to robustly track both the global motion of the newborn’s face, as well as its inner features. The system detects discomfort by employing the AAM representations of the face on a frame-by-frame basis, using a Support Vector Machine (SVM) classifier. Three contributions increase the performance of the system. First, several histogram-based texture descriptors to improve the AAM appearance representations are extracted. Second, the outputs of various individual SVM classifiers, which are trained on features with complementary qualities are fused. Third, the temporal behavior and stability of the discomfort detection is improved by applying an averaging filter to the classification outputs. Additionally, for a higher robustness, the effect of applying different image pre-processing algorithms for correcting illumination conditions and for image enhancement is examined to evaluate possible detection improvements. The proposed system is evaluated in 15 videos of 8 infants, yielding a 0.98 AUC performance. The system also offers monitoring of the infant’s expressions when it is left unattended and it additionally provides objective judgment of discomfort.

Classification using SVM classifier

Feature extraction- AAM based features and histogram based features

AAM model for face tracking

Input video of 10 infants at NICU

**Block diagram of proposed system**

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