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Pain Detection in Children using Image Processing

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Abstract: Pain is a qualitative character which is very difficult to assess and manage. In younger children it is not possible to measure pain by self report. Behavioral scientists say that pain can be measured by using the facial indicators. The existing approach for assessing pain in children requires the services of a skilled staff. The output thus obtained may not be accurate enough and has a subjective bias also. Here we have suggested a method for assessing the pain in children using image processing techniques by considering facial indicators. Using Viola Jones algorithm the image of the face is segmented and the features are extracted. The classification is done with the help of multi SVM classifier. We obtained a reliability of 0.97 for our system by interrator method, which is very high. This technique is very useful for assessing the pain in children in post operative wards, Intensive Care Units etc.

Keywords*:* Pain, children, pain assessment, image processing, Viola Jones, Multi SVM.

1. INTRODUCTION

Pain is a widely discussed, but least understood problem. It is a subjective and highly individualized experience. No two persons experience pain in the same way and no two painful events elicit similar responses.

Pain is the most common reason for seeking medical help. The concept of pain by its nature is an emotionally laden term. The International Association of the study of pain defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage".

Pain is a subjective experience and can be effectively assessed only from the patient's point of view. The patient's self report of the occurrence and intensity of pain and distress experienced is the most useful measure of pain. Several assessment instruments are available for pain measurement. The scales commonly used are Oucher scale, the Analog Chromatic Continuous Scale (ACCS), Wong-Baker Faces Pain Rating Scale, Poker Chip Tool, McGrath Affective Faces Scale (MAFS), Simple Descriptive Scale, Numeric Scale, Glass Scale etc.

Children and infants, like the rest of the humanity, can and do perceive and experience pain. Many misconceptions have been held by the health professionals about children's and infants ability to perceive and experience pain. The most fundamentally damaging one was that children and infants were unable to perceive and experience pain. In fact, children and infants have a right to careful consideration and management of their pain and it is the duty of every pediatric nurse to ensure that their experience of illness or injury is as atraumatic as possible. When pain is poorly managed, it may have significant negative sequelae. Pediatric nurses are daily faced with the challenges of assessing and managing pain in children. Unfortunately many children may still be enduring needless suffering because their pain is not recognized and managed effectively.

A variety of approaches are available to assess and mange pain in children. The approach used depends on the child's age and development level. Despite the increased attention that pain management has received, it is unfortunate that a proportionate number of children do not get adequate care corresponding to their pain. This provides a challenge to the pediatric nurse, despite advancement in pain management knowledge and technology.

In this paper, we have proposed a system to assess the pain experienced by children using image processing techniques.

The paper is organized as follows. Section 2 presents an overview of related works. The current scenario is described in section 3. Section 4 explains the proposed system and its implementation. The results are discussed in section 5, and we draw our conclusions in section 6.

2. LITERATURE REVIEW

G. Littlewort et al. [1] presented a systematic comparison of machine learning methods applied to the problem of fully automatic recognition of facial expressions. They explored the recognition of facial actions from the Facial Action Coding System (FACS) as well as recognition of full facial expressions. The system employed video inputs.

The results are reported on a series of experiments comparing recognition engines like Adaboost, SVM, LDA and feature selection techniques. The facial expression system was trained and tested on Cohn and Kanade's DFAT-504 dataset of 100 university students.

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G. C. Littlewort et al. [2] also described about faces of pain. Here 26 participants were videotaped under three experimental conditions: base line, posed pain and real pain. An important issue in medicine is the ability to distinguish real pain from faked pain. Hence they explored the application of a system for automatically detecting facial actions.

A. B. Ashraf et al. [3] proposed a technique for automatic detection of pain in adult patients with rotator cuff injuries. The system employed video input of the patients as they moved their affected and unaffected shoulder. For registering the face, they employed an Active Appearance Model (AAM) to derive a number of alternative representations based on a non-rigid registration of the face.

K. S. Deyo et al. [4] examined the development of sensitivity to evidence of pain from childhood to early adulthood. They noticed that the ability to detect pain expressions increased across the young, middle and older groups of children, but older children did not differ from adults. Increasing age was generally associated with increasing sensitivity to more subtle facial signs of pain.

R. E. Howard et al. [5] described the elements of contemporary pain-management practice in children, with particular emphasis on some of the areas in which there have been recent improvements in understanding or that remain particularly problematic.

3. CURRENT SCENARIO

In the current approach, we have a pain rating scale, and we compare the similarities in the facial expression of the child and the picture in the pain rating scale. Particularly the movement of eyebrow, lips and nose are considered. There are six pictures which are used to rate the pain of children in a 10-point Likert Scale. It is observed that there is a muscular change in the face of child when there is pain. Without a trained staff it is therefore impossible to detect the pain score using this method. Further, there is a subjective bias in the detected pain score which means that the observed pain score may differ from one person to another; and it may not be accurate enough also.

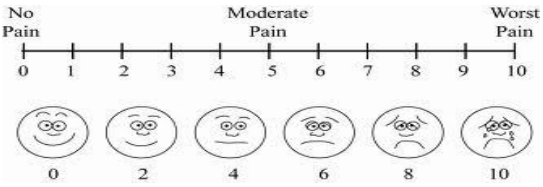

Figure 3.1: Pain Rating Scale (Wong Baker Scale)

Figure 3.1 shows the pain rating scale. It consists of a 10 cm line with two end points representing “no pain” and “the worst pain imaginable”[12]. Patients are asked to rate their pain by placing a mark on the line corresponding to their current level of pain. The distance along the line from the no pain marker is then measured with a ruler giving a pain score out of 10. The score can be used as a baseline assessment of pain with follow-up measures providing an indication of whether pain is reducing. Where pain does not reduce significantly during the first one to five weeks, the practitioner may wish to consider referral to an allied health practitioner. The scores can also be used to evaluate treatment effectiveness.

4. PROPOSED METHOD

The proposed work aims to develop a new system to measure pain score using image processing techniques. The method consists of two phases – training and testing. Training consists of pre-processing, segmentation and feature extraction. Testing consists of pre-processing, segmentation, feature extraction and classification.

4.1. Training

The training phase has three steps – pre-processing, segmentation and feature extraction.

Pre-processing

The pre-processing operation essentially enhances the image and makes it suitable for segmentation. Generally noise filtering, smoothing and normalization are done in this step. Median filtering is used for noise filtering. It is a non linear digital filtering used to remove noise.

Segmentation

The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. We have used Viola Jones algorithm for segmentation. In vision library, there is a function *vision.CascadeObjectDetector()*. The cascade object detector uses the Viola Jones algorithm to detect people’s face, nose, eyes, mouth or upper body. The ultimate aim of using Viola Jones algorithm in our work is to segment the face (figure 4.1) of the child into rectangular portions of eyes, nose and mouth (figure 4.2, figure 4.3, and figure 4.4 respectively)

Feature Extraction

A feature is defined as an interesting part of an image. Once features have been detected, a local image patch around the feature can be extracted. This extraction may involve quite considerable amount of image processing [11].

Figure 4.1 Face Segmentation

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Figure 4.2 Eye segmentation

Figure 4.3: Nose Segmentation

Figure 4.4 Mouth Segmentation

The result is known as feature descriptor or feature vector. Eye pair width, nose width, distance between eye and mouth, and mouth width are the features extracted here. In this work, we have used 20 images for training our system.

Figure 4.5 shows the trained pain score. Pain score (PS = 0) indicates that there is no pain and PS = 9-10 indicate worst pain.

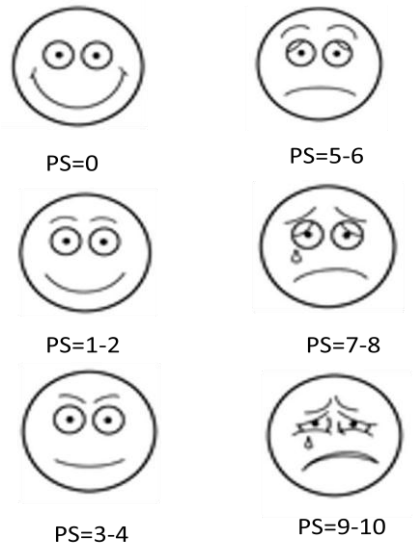

Figure 4.5 Trained Pain Score

4.2 Testing

Testing phase involves pre-processing, segmentation, feature extraction and classification. Out of these, the first three steps are as same as in the training phase.

Classification

Classification is the process of assigning the segments to particular classes. Here, multi SVM is used for classification because of its better performance compared to other classifiers. SVM is a binary classifier i.e the class labels can take only two values; +1 and -1. Many real world problems however have more than two classes. So its better to use multi SVM which has multiple classes and it assigns a point to that class whose confidence value is largest for this point.

5. RESULTS

In this work 20 images are used for training and 10 images are used for testing. It is observed that the proposed system gives an accuracy of 97%. The reliability coefficient (r = 0.97) was obtained by using test and retest method by considering the scores given by an expert in the area of medical field. The accuracy of the system can be improved by increasing the training data set. All the simulations are done using MATLAB R2013a.

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6. CONCLUSION

This paper has proposed an image processing based technique for pain detection in children by using their facial expressions. The system has an accuracy of 97%. This system has wide applications in the post-operative ward because children can't tell if they have pain. It can be very easily applied with less cost. By using digital or mobile camera take a picture of the child and input it into the digitalized system and it gives the pain score. This technique is more efficient than the manual method which we are following today. Apart from pain detection, this method can also be used for the study of psychological characteristics like anxiety, stress and anger in humans.

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