2013 3rd International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering (ICICI-BME)
Bandung, November 7-8, 2013

Facial Feature Extraction on Pre and Post-operative Infant With NFCS and nCRF

Mira C. Kirana[1,2], I Ketut E. Purnama[1], Yoyon K. Suprapto[1], Mochamad Hariadi[1], Mauridhi H. Purnomo[1]
[1]Department of Electrical Engineering, Faculty of Industrial Technology,
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
(Tel : +62-31-594-7302; E-mail : ketut@ee.its.ac.id, yoyonsuprapto@ee.its.ac.id, mochar@ee.its.ac.id, hery@ee.its.ac.id)
[2]Department of Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia
(Tel : +62-778-469-856; E-mail : mira@polibatam.ac.id)

Abstract--Infant Mortality Rate (IMR) is the predominant problem in medical, especially in developing countries like Indonesia. One cause of IMR increasing is diagnosis mistake of infant pain. Baby's communication have not perfect, it is leading to high risk of diagnosis mistake when the baby feels pain, such as post-surgery conditions. This problem encourages research on the pain identification of infant facial expressions. The purpose of this study is to analyze change or difference in infant facial expressions. This research is expected to provide the appropriate parameters in order to contribute the accuracy of infant diagnosis.

The alteration of infant's facial expressions is analyzed using several methods as appropriate, facial feature detection and extraction take advantages of Ganglion Cells working principles, which nCRF (non-Classical Receptive Field) mechanism and inhibition and disinhibition are complementary in weak feature detection. There are several ways of infant pain identification in medical, Neonate Facial Coding System (NFCS) is one which focuses in face. With several points of NFCS scale is expected to get more accuracy in the pain identification. This study is a combination of image processing and medical methods that can be more flexible in future development.

Keywords : ***Pain, Infant, Ganglion Cells, non-Classical Receptive Field(nCRF), NFCS***

I. INTRODUCTION

Infant Mortality Rate (IMR) is the probability of infants dying before reaching one year of age per thousand births. The highest IMR was in West Nusa Tenggara province, 43.51, while the lowest IMR in Jakarta there are only 10.95 [1]. Indonesia in 2012, ranks 73th world with 26.99 points [2]. Preventing diagnosis mistake of infant pain is one of any efforts to reduce the infant mortality rate. Pain gives uncomfortable conditions. Crying for pain condition is natural thing for babies, nevertheless babies cry for others such as hungry or uncomfortable things else. It often leads to misinterpretation in providing medical treatment related. So that, the diagnosis of a crying baby who is suffering from pain require accuracy.

Pain is sensation that accepted by human neurons. It is caused of external stimuli that is gained by sensory receptors in part of body. Pain sensory neuron generates uncomfortable and suffering circumstances. This reaction stated in any actions, such as face expression, voice and another limb movement. Crying and changing of face expression significantly are common infant's reactions of pain. Most infants and babies express their pain by crying due to have not abilities in communicating as adults. The difference of infant's face expression in pain is able to be identified not only by seeing and watching, but also assessing any characteristic parameters. Previous research (medical research) about pain analysis on infant's immunized using three indications of pain. Purpose of this study to determine reliability, validity and practicality from three measures of acute pain in infant, Modified Behavioural Pain Scale (MBPS), Neonatal Infant Pain Scale (NIPS) and Face Legs Activity Cry Consolability Scale (FLACC). However, it is focused on infant's immunized for pain identification. The identification requires the analysis of the changes rate that indicated by patient. Infant's face is the form that must be early identified, afterwards the assessment of the parameter value should be performed. Based on previous studies on pain in infants, of the three methods above, FLACC, NIPS and MBPS also carry out an assessment of facial expressions with different values scale, with the result that the parameters will be analyzed to distinguish infants in pain. This research analyzes the changes of infant's facial expression in pain to provide the proper information in order to assisst in the diagnosis and treatment [3].

Infants can not express the pain, as normally children or adult, use verbal communication. The disparity of communication lead to various allegations that have the possibility of diagnosis mistake obtained as of the treatment is not appropriate or even impact.The main purpose of this research is to identify the pain from the change of infant face expression with nCRF that approach the working principal of human visual system and NFCS that have validity from medical field in infant's pain assessment. Contribution of this research is to provide the appropriate parameters that are generated from image processing (nCRF) and pain scale measurement from medical site (NFCS) with expectation in greater assisst of infant's diagnosis and treatment.

II. METHODOLOGY

Initial data retrieval is performed in Hospital on pre and post-operative infant by the Anesthetist. First step is take video recording of infant's face expression in before and after surgery. Next, the file will be convert to be image sequence in order to be able to be processed and analyzed. This processing implements feature extraction based on non-Classical Receptive Field (nCRF). This method utilize the working principal of Ganglion Cells that assist human visual to receive the external stimuli and process the information from visible object [4]. Image from the video consist of many information to be processed. Adopt the working principle of the system, expected to obtain the appropriate result from the important information. The methods used in this study are the stages that must be implemented to obtain the expected results.

FLACC (Face. Leg, Activity, Cry and Consolability) scale is a behavior that has been recognized scale for the assessment of postoperative pain in children between the ages of 2 months and 7 years. After observing children for one to five minutes, the pain scores obtained by studying the behavior description and determine the most appropriate score with the observed behavior [5]. Figure 1 shows the FLACC scale with five categories, each of which has a score of 0-2, so that the total score between 0 and 10. FLACC scale developed by Sandra Merkel, MS, RN, Terri Voepel-Lewis, MS, RN, and the Shobha Malviya, MD, at Children's Hospital CSMott, University of Michigan Health System in Ann Arbor, MI. [6] Poin pair position determination of face area is performed by NFCS (Neonatal Facial Coding System), as show in Figure 2. NFCS is the only tool that analyze post-operative infant face.

Categories	Scoring 0	1	2
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested	Frequent to constant quivering chin, clenched jaw
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking, or legs drawn up
Activity	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid or jerking
Cry	No cry, (awake or asleep)	Moans or whimpers; occasional complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching hugging or being talked to, distractible	Difficulty to console or comfort

Figure 1. FLACC Behavioral Pain Assessment[6]

Tool name	Features	Suitable for setting:	Suitable for (gestational age): Pre-term neonates	Term neonates
COMFORT		Post-operative and peri-procedural pain		✔
CRIES		Post-operative pain	✔	✔
Neonatal Facial Coding System (NFCS)		Post-operative pain	✔	✔
Nepean NICU Pain Assessment Tool (NNICUPAT)		Peri-procedural pain		✔
Neonatal Infant Pain Scale (NIPS; developed from CHEOPS for neonates)		Post-operative pain	✔	✔
Objective Pain Scale (OPS)		Post-operative pain	✔	✔
Pain Assessment Tool (PAT)		Post-operative pain	✔	✔
Premature Infant Pain Profile (PIPP)		Peri-procedural pain	✔	✔

Figure 2.Guide to selection of pain scales for neonates [7]

NFCS has 10 activities to be observed, i.e. frowning eyebrows, squinted, the depth of nasolabial folds (crease that runs down the sides of the nose to the mouth), the opening of the lips, mouth vertical line, horizontal line of the mouth, tongue tense, chin trembling (high frequency vibration between the chin and lower jaw), pursed lips (the muscles around lips to form the "oo") and tongue protrusion (only occurs in premature newborns) (Grunau and Craig, 1987; Grunau et al., 1990). Indicators derived from the NFCS then applied and analyzed in order to get the parameters that distinguish the pain or not through the alteration of infant facial expressions.

Facial feature assessment by points pair system for measuring motion in pixels, in the area of facial expressions by tracking changes in infant pain between points. Percent of the width of the face is used as a standard unit of measurement to prevent problems in image size and the difference of infant's anthropometry (the science that is related with the measurement of human body dimensions). Face width of each infant was measured and averaged at neutral and reaction, then used to make scale calculations all pixels on the next point. Initial and movement conditions use the same scale. Preceded by calculating the Euclidean distance between the pair of points. Output from the endpoint pair, stated as a percent of the width of the face, is the distance between two test points divided by the scale and multiplied by 100 [8].

$$Pi = \frac{100 * \sqrt{(x_{i1} - x_{i2})^2 + (y_{i1} - y_{i2})^2}}{\sqrt{(x_{s1} - x_{s2})^2 + (y_{s1} - y_{s2})^2}} \quad (1)$$

In equation (1), S is a point scale derived from the calculation of the width of the face. Point pairs are calculated for both conditions, neutral and reaction. Point-pair alteration is the changes that occurred between the two images is computed in equation (2).

$$\Delta Pi = P_i^R - P_i^B \quad (2)$$

Where P_i^R is poin pair value for reaction image and P_i^B poin pair value for neutral image [8].

(a) (b)

Figure 3. Point Pair Placement Sample of (a)neutral face and (b)reacted face. [8]

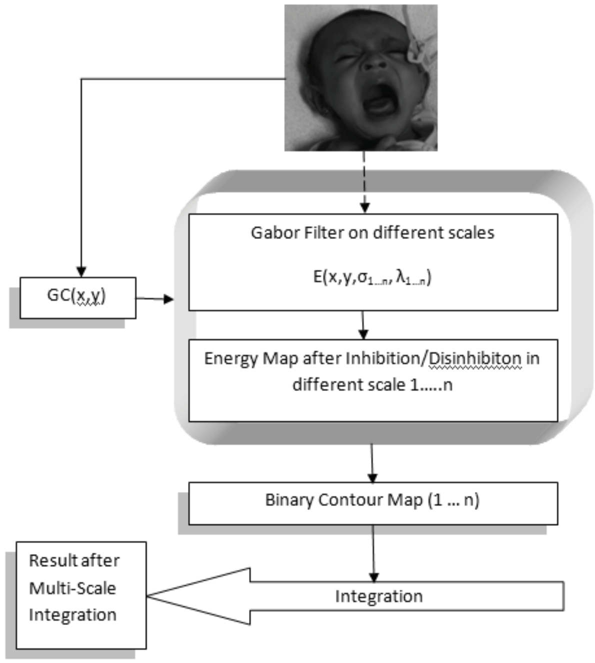

Figure 4. Multi Scale Integration Algorithm [9]

Sample of the point pair system implementation can be viewed in Figure 3, there are two images with different conditions, neutral and react. Multi-scale representation of the image obtained from the pre-processing is filtered using Gabor and then inhibited or disinhibited in different spatial locations at different scales to obtain the final response, the flow diagram shown by Figure 4. Because the contour information obtained with different scales are not same, the optimally production of information smooth and continuous contours needed to be superimposed and integrated.

Multi-scale integration was initiated using Gabor filtering, which is one form of feature extraction techniques. Gabor was first introduced by Dennis Gabor to detect the signal in the noise. Gabor is known for varied incorporating in different opinions, but in principle have the same goal. Image processing use Gabor to evoke specific characteristics of the image that has been in the kernel convolution. The speed of the process, both the image and the convolution is influenced by processes occurring in the frequency field. Gabor has the same form with the receptive fields of simple cells (simple cells) in the primary visual cortex, i.e. multi-scale and multi-oriental kernel. This filter shows the quantum principle which is used for information. Signal ID in the form of a combined frequency domain and time needs to be improved in order to occupy less than the minimum area specified in it. However there is an exchange between time and frequency resolution.

The ability of the human visual system to distinguish textures based on the capability of identifying a variety of frequencies and spatial orientation of the textures were observed. Gabor filter is a filter that is able to simulate the characteristics of the human visual system to isolate a particular frequency and orientation of the image. These characteristics make it suitable for applications texture recognition in computer vision. Spatially, a Gabor function is a sinusoid modulated by a Gaussian function.

$$g(x,y,\lambda,\theta,\sigma,\varphi,\gamma) = \exp\left(-\frac{\tilde{x}^2+\gamma^2\tilde{y}^2}{2\sigma^2}\cos\left(2\pi\frac{\tilde{x}}{\lambda}+\varphi\right)\right) \quad (3)$$

Equation (3) is a 2D Gabor function, where $\tilde{x} = x\cos\theta + y\sin\theta$ and $\tilde{y} = -x\sin\theta + y\cos\theta$, γ is a constant that represents the ratio of major and minor axes for RF oval, λ is the wavelength, $1/\lambda$ is the spatial frequency of the cosine function, σ/λ is the bandwidth of the spatial frequency and φ is the phase parameter. NCRFs inhibitory characteristics can be used as a basic biological methods for edge detection. They can detect the boundaries and contours isolated. The inhibition showed a dynamic feedback and forward input to cortical neurons via inhibitory inter neurons. Weight inhibitory function models developed by Grigorescu modified such that it only works in certain areas (areas on the two sides of the RF) [13]. Distance weight function (W_d) is used to define the inhibitory area shown in equation (4) and (5)

$$W_{in(x,y)} = Wd_{(x,y;\sigma,Ain)} W_{o(x,y)} \quad (4)$$

$$W_{o(x,y)} = \begin{cases} 1 & \\ 0 & \beta < \theta \end{cases} \quad (5)$$

Function of RF response intensity:

$$E(x,y) = \iint E_{Center}(x,y)dxdy - \iint W_{in}(x,y) * E_{in(x,y)}dxdy + \iint W_{disin(x,y)} * E_{disin(x,y)}dxdy \quad (6)$$

W_{in} and W_{disin} is a Weight function of inhibitory and disinhibitory region. Equation (6) shows that the final response intensity of the RF are determined by the intensity of the response to CRF stimulation coincide with the intensity of inhibitory and disinhibitory nCRF. GCs with the same RFs size to obtain multi-scale representation of the physical scene, the distance from the eye to the object must always changing. However, the distance change is unrealistic and impossible in the biological sense. In daily life, we know that the shape of the tree can be recognized on the coarse scale, while the leaves have to be considered on a small scale. Objects with sizes smaller than the trees and larger than the leaves recognized on a medium scale. The most important issue of scale-space theory is how to effectively build a projection corresponding to the same physical views at different scales. For this purpose, the brain has developed GCs with different RF sizes. Because the scene images obtained with different RF sizes according to the images obtained by a single RF at different distances, the image information that is received by the brain is a multi-scale representation of the vision.

II.1. Pain Identification

Generally, the design of software systems face detection in image sequences as shown in Figure 5. The proposed method in this research is using a Multi-scale Integration based on nCRF, implemented to image sequences to detect the face features from image. Concisely, pain identification system is:

- Digital video files obtained from a specialist
- The video file will be sliced to be several frames.
- Initialize RF (pre-processing by GCs) in the image sequence will be performed as a first stage to be able to determine the region of the face as an object of observation.
- The process of multi-scale integration uses Gabor filters and inhibition/disinhibition of nCRF, afterwards integrate the results of binary contour map, so the boundary between object observation and background become more obvious.
- Analyze changes in parameter using point pair calculation based on NFCS scale obtained from the face detected for identification of pain.

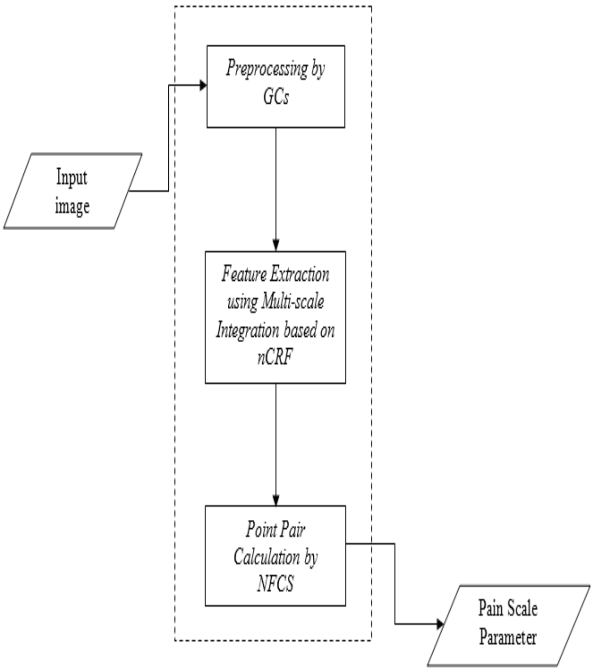

Figure 5. System Design

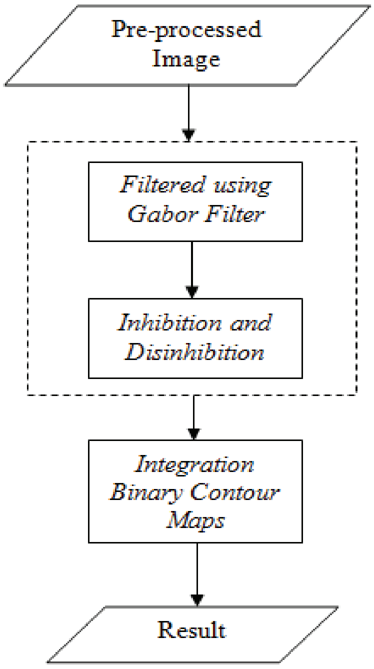

Figure 6. Multi-scale Integration

II.2. Face Feature Extraction and Detection

Utilizing multi-scale integration method to determine the final contour of the target object. This model does not only include simple and complex cell mechanism, but also introduce pre-processing of external information by GCs in the early stages. Multi-scale integration begins with the image pre-processing results are filtered using Gabor filters and then inhibited or disinhibited in different spatial locations at different scales to obtain the final response. The flow diagram can be seen in Figure 6.

II.3. Point Pair Analisys

Using NFCS scale that refers to the face score assessment, measured in pixels movement of the pain face expression by tracking of changes between the coordinates of the image that has been recognized as a face.

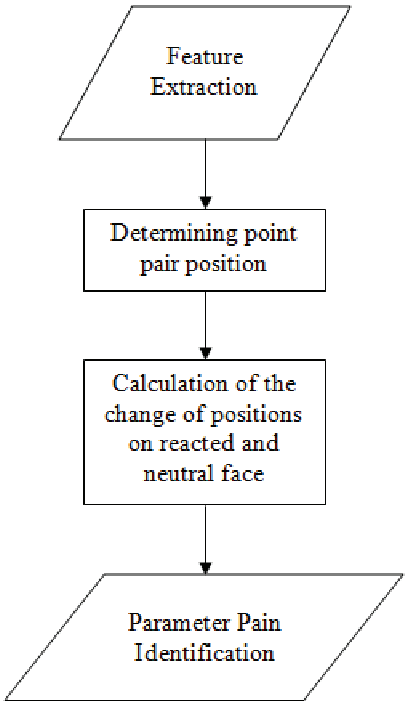

Figure 7. Point Pair Analysis

Figure 7. shows the point pair analysis of the image feature extraction results, hereafter determine the parameters to be analyzed for comparison based movements or facial expressions on two conditions, neutral and react.

III. PRELIMINARY RESULT

The expected result from this research the object of observation will be in the feature extraction with higher accuracy so that the information provided be able to be used for further processing in medical imaging. As preliminary result from this proposed method is RF size determining that is shown on Figure 8.

Figure 8. RF size determining

Table 1. Values Of *A1, A2 and A3 When S = 150 Cm,* Values Of d*S1, dS2 and dS3*

d1	d2	d3	dS1	dS2	dS3	A1	A2	A3
0.3333	1	1	5.4745e-04	0.0097	0.0011	900	100	50
0.6667	2	2	0.0078	0.0626	0.0070	225	25	12.5000
1	3	3	0.0347	0.1409	0.0157	100	11.1111	5.5556
1.3333	4	4	0.0840	0.2506	0.0278	56.2500	6.2500	3.1250
1.6667	5	5	0.1420	0.3915	0.0435	36.0000	4	2
2	6	6	0.2069	0.5638	0.0626	25	2.7778	1.3889
2.3333	7	7	0.2818	0.7674	0.0853	18.3673	2.0408	1.0204
2.6667	8	8	0.3682	1.0023	0.1114	14.0625	1.5625	0.7813

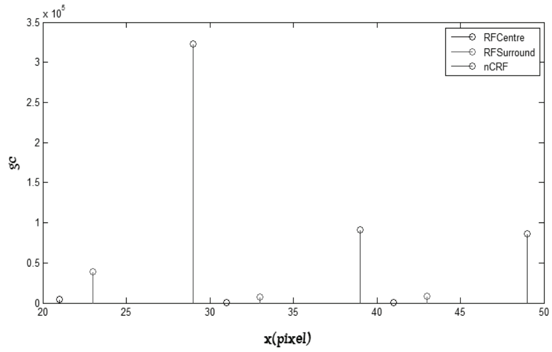

Figure 9. GC output versus stimulus radius (pixel)

This size is calculated to get any parameters that is shown in Table 1. As for the Weight1 are obtained for centre area that calculated with the brightness to produce GC respond. Figure 9 illustrates the graph of GC output and stimulus area in pixel. This step is initially to adjust RF size in order to get GC array, it will be further processed to obtain facial features.

REFERENCES

[1] Proyeksi Penduduk Indonesia per Provinsi 2005-2015, BPS.
[2] CIA World Factbook 2012.
[3] Anna Taddioa, Mary-Ellen Hogana, Paul Moyera, Angela Girgisa, Sandra Gergesa, Evaluation of the reliability, validity and practicality of 3 measures of acute pain in infants undergoing immunization injections, Vaccine 29 (2011) 1390–1394.
[4] Hui Wei, Xiao-Mei Wang, and Loi Lei Lai, Compact Image Representation Model Based on Both nCRF and Reverse Control Mechanisms, IEEE Transactions on Neural Networks and Learning Systems, Vol. 23, No. 1, January 2012
[5] Guide to Physical Therapist Practice. 2nd ed. Phys Ther.2001 ;81:9–744.
[6] Barry D. Dickinson PhD, Pain Assessment in Infants and Children, American Medical Association, Original Release: 2003; Revised 2007 and 2010; Updated: April 2013 Expiration Date: March 31, 2016
[7] The recognition and assessment of acute pain in children, clinical practice guidelines. Royal College of Nursing, September 2009
[8] M. Schiavenato and P. Scovanner, A computer method "point-pair system" for measuring movement in facial expression based on video from a natural/clinical context, Proceedings of Measuring Behavior 2008 (Maastricht, The Netherlands, August 26-29, 2008)
[9] Hui Wei, Bo Lang, Qingsong Zuo,Contour detection model with multi-scale integration based on non-classical receptive field, Neurocomputing 103 (2013) 247–262