CLASSIFICATION OF THE AGITATION LEVEL BASED ON FACIAL VARIATION FOR ICU PATIENTS IN HOSPITALS

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By

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LIST OF SYMBOLS, ABBREVIATIONS & NOMENCLATURE

AM	Area mouth
ALE	Area left eye
ARE	Area right eye
Cm	Centimeter
DLE	Distance left eye
DM	Distance mouth
DPF	Dark pixel filter
DRE	Distance right eye
FCF	Face-circle fitting
FCM	Fuzzy C-Means
FDT	Face detection technology
FFT	Fast fourier transform
FIS	Fuzzy inference system
F-KNN	Fuzzy k-NN
GUI	Graphical user interface
HCI	Human computer interface
HIS	Hue, intensity and saturation
HMDs	Head mounted displays
HSV	Hue, saturation, value
ICU	Intensive care unit
IPL	Inner plexiform layer
IR	Infra red
K-NN	K-Nearest Neighborhood
LDA	Linear discriminant analysis
LEDs	Light-emitting diode
Lux	unit of illuminance
NCC	Normalized cross correlation
NN	Neural network
NTSC	National television system committee
OPL	Outer plexiform layer

PC	Personal computer
PCA	Principle component analysis
PROTECT	Patient Monitoring Motion Detection
RGB	Red, green, blue
ROI	Region of interest
RPMS	Remote patient monitoring systems
SAS	Sedation-agitation scale
SJTU	Shanghai Jiao Tong University Library
SQI	Self quotient image
SVM `	Support vector machine
YCbCr	Yellow, chromium blue, chromium red
°	Degree
k	Number of pixel in face
k	Number of neighbors
m	A positive real number called fuzzifier
n	Ratio of the average chromium red
x_1, y_1	Top coordinate of the eye/mouth contour
x_2, y_2	Bottom coordinate of the eye/mouth contour
d	Distances for every eye and mouth
M_{00}	Moment
A	Area for every eye and mouth
I	(x, y) is the image pixel
μ	Membership function for each class
m	Distance is weighted
$\vec{x}$	Features, attributes, variables or measurements
T	Threshold
Σ	Covariance
$\vec{w}$	Eigenvector of covariance
x	Input data
$f(x)$	Activation function
Z_j	Hidden layer neuron
Y_K	Output layer neuron

δ_k	Error for each output neuron.
δ_j	Error for each hidden neuron.
●	Awake
▲	Half awake
■	Sleep condition
%	Percentage

KLASIFIKASI TAHAP GETARAN BERDASARKAN PERUBAHAN MIMIK MUKA PESAKIT DALAM UNIT RAWATAN RAPI DI HOSPITAL.

ABSTRAK

Koma adalah keadaan dimana tubuh tidak sedarkan diri. Seseorang individu yang koma masih hidup tetapi tidak dapat bergerak atau bereraksi dengan keadaan sekeliling. Walupun pesakit kehilangan fungsi otak, sistem pernafasan dan peredaran darah masih berjalan lancar. Walau bagaimanapun gerakan spontan mungkin berlaku dan mata mungkin terbuka kerana rangsangan berlaku apabila ada tindak balas dari luar. Keadaan ini dikenali sebagai eksperisi mimik muka, pegawai kesihatan menganggap eksperisi mimik muka sebagai pengukur yang betul untuk keamatan pergerakan. Oleh itu penjelasan mengenai getaran muka pesakit dan hubungan dengan pergerakan adalah perkara asas dalam menjalankan kajian sistem automasi pergerakan. Teknik pengimejan komputer dapat digunakan untuk menilai pergerakan pesakit dalam unit rawatan rapi (ICU). Teknik yang khusus dapat digunakan untuk mengukur tahap pergerakan pesakit. Dalam kes pesakit yang lumpuh dan koma, pergerakan tidak berlaku pada seluruh tubuh, maka pemantauan seluruh tubuh tidak wajar dilakukan. Sejajar dengan itu empat klasifikasi cerdik buatan (AI) digunakan untuk mengukur keberkesanan sistem ini. Antara empat klasifikasi tersebut adalah Jiran Terdekat K (k-NN), Fuzi Jiran Terdekat K (Fuzzy k-NN), Pembezaan Analisis Lurus (LDA) dan Rangkaian Neural (NN). Tiga eksperimen dengan menggunakan kadar sudut, jarak dan keamatan cahaya yang berbeza telah dijalankan pada semua klasifikasi tersebut. Ketepatan lebih 90.00% telah dicapai. Grafik pengguna antara muka (GUI) telah dibangunkan untuk memudahkan tugas kakitangan perubatan.

CLASSIFICATION OF THE AGITATION LEVEL BASED ON FACIAL VARIATION FOR ICU PATIENTS IN HOSPITALS.

ABSTRACT

A coma *is a profound or deep state of unconsciousness. An individual in a state of coma is alive but unable to move or respond to his or her environment. Even though those patients in a persistent vegetative state lose their higher brain functions, when other key functions such as breathing and circulation remain relatively intact. However, spontaneous facial movements and expressions may occur in response to external stimuli. Clinicians regard the patient's facial expression as a valid indicator for motion intensity. Hence, correct interpretation of the facial agitation of the patient and its correlation with motion is a fundamental step in designing an automated motion assessment system. Computer vision techniques can be used to quantify agitation in sedated Intensive Care Unit (ICU) patients. In particular, such techniques can be used to develop objective agitation measurements from patient motion. In the case of paraplegic and coma patients, whole body movement is not available, and hence, monitoring the whole body motion is not a viable solution. Hence in this case, measuring head motion and facial grimacing quantify facial patient agitation based on K-Nearest Neighborhood (k-NN), Fuzzy k-NN (f-kNN), Linear Discriminate Analysis (LDA) and Neural Network (NN). Using the proposed classifiers, some experimental results for different angle, distances and illumination levels have been obtained. It is found that the classification accuracy is higher than 90.00% for the proposed features and classification techniques. Finally, Graphical User Interface (GUI) Layout Editor is developed to minimize the tedious work of medical staff.*

CHAPTER 1

INTRODUCTION

1.1 Project Background

A coma is a profound or deep state of unconsciousness. An individual in a state of coma is alive but unable to respond to his or her environment. Coma may occur as a complication of an underlying illness or as a result of injuries, such as head trauma. A persistent vegetative state (commonly, but incorrectly, referred to as "brain-death") sometimes follows a coma. Individuals in such a state can lose their thinking abilities and awareness of their surroundings, but retain non-cognitive functions and normal low agitation patterns. Even though those patients in a persistent vegetative state lose their higher brain functions, other key functions such as breathing remains relatively intact. Spontaneous movements may occur and the eyes may open in response to external stimuli. They may even occasionally grimace, cry or laugh. Although individuals in a persistent vegetative state may appear somewhat normal, they do not speak and they are unable to respond to commands. Such a patient is shown in Figure 1.1.

Figure 1.1: A Coma Patient in Intensive Care Unit

Recent advances in vision technology offer new ways to present information about coma patients in intensive care unit (ICU). Some research focuses on identifying information that needs to be conveyed and has led to configural graphic displays that show relations between sensed measures and physiological functions by Tinker et al., (1989). Other research focuses on improving information delivery to the clinician. For example, head mounted displays (HMDs) present monitored information directly to the anesthesiologist's field of view and may be a more effective way of monitoring patients. Alternatively, sonification, a nonspatialized auditory display that represents data as relations between the dimensions of sound, may serve a similar purpose (Penelope Sanderson et al., 2005).

In order to assess the patient images, a range of remote patient monitoring systems (RPMS) are being developed to care for patients at home rather than in the costly hospital environment. These systems allow remote monitoring by health professionals with minimum medical intervention to take place. However, they are still not as effective as one-on-one human interaction. The face and its features can convey patient's cognitive and emotional states faster than electrical signals and facial expression can be considered as one of the most powerful features of RPMS (Gholam Hosseini et al., 2004).

Patient cognitive and emotional represent pain and agitation. Some reviewed of pain assessment in patients who are unable to verbally communicate with medical staff is a challenging problem in patient care taking. The fundamental limitations in sedation and pain assessment in ICU stem from subjective assessment criteria rather than quantifiable and measurable data for ICU sedation and analgesia. This often results in poor quality measure and inconsistent treatment of patient agitation and pain from nurse to nurse. Recent advancements in pattern recognition techniques using a relevance vector machine algorithm can assist medical staff in assessing sedation and pain by constantly monitoring the patient and providing the clinician with quantifiable data for ICU sedation. The pain intensity assessment given by a computer classifier has a strong correlation with the pain intensity assessed by expert and non-expert human examiners Behnood Gholami (2006).

An objective agitation measurement from patient motion that is sensed using digital video image processing was approached by Geoffrey Chase (2004). A fuzzy inference system (FIS) is developed to classify levels of motion that correlate with observed patient agitation, while accounting for motion due to medical staff working on the patient. Clinical tests for five ICU patients have been performed to verify the validity of this approach in comparison with agitation graded by nursing staff using the modified

Riker Sedation-Agitation Scale (SAS). All trials were performed in the Christchurch Hospital Department of Intensive Care, with ethics approval from the Canterbury Ethics Committee. Results have shown good correlation with medical staff assessment with no false positive results during calm periods.

An agitation sensors based on heart rate and blood pressure variability and on overall whole body motion was builds on previous work by Pierrick Becouze (2007). In this research, the focus is on real-time measurement of high-resolution facial changes that are observed to occur in agitation. An algorithm is developed that measures the degree of facial grimacing from a single digital camera. The method is demonstrated on simulated patient facial motion to prove the concept. A consistent measure is obtained that is robust to significant random head movements and compares well against visual observation of different levels of grimacing. The method provides a basis for clinical validation.

It is a well-known that, the vision technology for all these advances is increasingly affordable and customizable for the end-user, but the ideas behind them are only starting to be rigorously evaluated, to emerge that hitherto we have been unaware of, as previously all the patients conditions. Perhaps what applies to the system responses applies also to psychological responses to acute life threatening illness. There can be grave psychological responses to serious illness and recovery as suggested by the unexpectedly high incidence after serious surgery. Clearly, coming out of psychological stress after surgery and recovery is likely to be a field for fruitful research. The fact that psychological problems occur in ICU suggests that directors of such units have to establish psychiatric support services as well as all the other vision system for other observations. Such an important problem of patient observation in ICU to reduce any possible psychological stress is undertaken in this research.

1.2 Problem Statement

There are two primary delimitations to this study due to the research problem. First, when it comes to intensive care units (ICU), difficulties increase due to high cost of equipments necessary to proceed with an efficient monitoring. As these equipment functionalities get broader, their cost raise exponentially, making it hard for hospitals with fewer resources to use them.

There is, therefore, a demand for lowering the monitoring cost, as the only way to guarantee most hospitals survival. Every hospital has presentable monitoring equipments, which, in most cases, do not allow remote monitoring. This problem could be solved by adding this functionality to these equipments without having to acquire new ones.

Another problem in most ICU equipments is to monitor the vital signals only. Most of standardized monitors do not keep records of data; normally, the monitoring record is done with one hour intervals and mostly manually. The doctor may lose information between these intervals. This functionality could be added to existing equipments. The proposed research provides these functionalities, concerning ICU patient remote monitoring and the amount of information available for the health professionals involved and, most importantly, at an extremely low cost. The problem of real time monitoring the face of an ICU patient and its variations in color, texture and other features is most important. Remote monitoring of these functions is vital to continuous observation on patient improvements physical and psychologist aspects.

Additionally, there are challenges that impede the development of effective solutions to the face tracking and recognition problem. They include poor image quality, obscuration, deformations, clutter, texture, extrinsic and intrinsic variations. Variation in images of faces due to external factors, such as lighting and occlusions, is called extrinsic while variation in these same images due to internal factors, such as deformations of the facial surface from expression, is called intrinsic.

1.3 Objective

The objective of this research is as follows.

1) To monitor the patients treated in an ICU around the clock.
2) To discuss the relative merits of configurable graphics, and imaging in supporting the medical work.
3) To design and develop a motion and color image processing software, associated with a camera interface as well as a signal generating system to a computer.
4) To observe some suitable classifiers model such as integration of image acquisition, processing and detection for motion association based on different lighting levels, angles and distances condition.

1.4 Scope

There is a lack of commercial technologies under the generic topic of monitoring a patient in Intensive Care Unit (ICU). This answers too many of the misjudged problems. In this research, one approach to Human Computer Interface (HCI) for monitoring patient is presented. In this dissertation, the design and development of intelligent monitoring system for facial expression analysis of patients in ICU is proudly presented. The ICU patients can be in coma or the patients may be under sedation due to surgery. The facial movements need to be monitored by the nurses at selected intervals and reported to doctors for possible further treatments. Detection of facial changes is very crucial for further treatment. In this research, our study only limit on the eyes and mouth motions. A study is also made on varied illumination levels on the face of patient. The monitoring scheme is to be robust within selected levels of illumination on the face of patient.

1.5 Expected Output

The main contribution of this dissertation is on the design and development of monitoring system for a patient who is in ICU. This includes the development of an observation center. The observation centre has a camera, and its image processing ability which monitors facial changes, in particular changes in mouth and eye areas. There can be one observation centre to each of the ICU patient. The facial changes are monitored outside the ICU from the observation centre. Various motions of mouth and eyes are observed against various camera distances, head angles and illumination levels.

The research outcome is that of a newly developed software package for monitoring changes in face especially mouth and eye.

1.6 Dissertation Outline

The chapter of this dissertation largely follows the order in which the work was done, the scope and objective of the work is presented in this chapter. Second chapter is a literature review encompassing most of the history of image processing techniques. This chapter also describes some existing applications that have been developed using some of the most common techniques and a critical analysis has been made on them. In addition, some new performance evaluation methods are introduced to clarify how these methods are quantified amongst the different approaches using the most commonly used benchmarks. Third chapter presents the experimental setup of design, development and testing of the proposed system for the (HCI). In Chapter Four the software design and development of the system, are briefly discussed. Fifth chapter encompasses the outcome of experimental analysis. In the final chapter, chapter Sixth conclusions on performing experiments and acquiring the results are derived. Conclusions are made in terms of advantages, disadvantages, limitations, dependencies and affecting factors. This chapter also recommends future problems for advancements in this work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The processing of face images receives more and more interest in the field of image analysis. The task of facial image analysis includes the face localization, the recognition of human faces and the analysis of mimics or facial expressions. Face localization is needed as a preprocessing step for many applications such as object-orientated image coding, security control, expression recognition and intelligent man-machine interaction. Various methods for face detection have been documented in the past by Kirby & Sirovich (1990); Turk & Pentland (1991). The methods can roughly be divided into four classes, according to Yang et al. (2002).

a) Knowledge-Based Methods are rule-based approaches which try to model intuitive knowledge of facial features. In general, these facial features have to be extracted first by a preprocessing step.

b) Feature Invariant Methods utilize invariant (scale, orientation, and lighting) features for face detection. One of the most frequently used features for this purpose is skin color.

c) Template Matching Methods use manually defined patterns of the whole face or the facial features which are matched against the input image.

d) Appearance Based Methods try to find the relevant characteristics of face images by machine learning from a training set. Often, face tracking systems exploit a single localization technique to locate and track the users' face. While a modality is able to track a user face under optimal conditions, it may suffer from typical failures in unconstrained conditions.

To arrive at more robust face detection under a number of constraints such as out of plane rotation, presence or absence of structural components, facial expressions, occlusion and illumination level, indicate a difficult research effort. Many researches have documented their outcome in terms of certain constraints applied in face detection methods. However, no one has considered the above constraints all at a time, in face detection (Kirby & Sirovich, 1990; Turk & Pentland, 1991). Here, a brief survey on face detection in various ways including localization of mouth and eyes is presented in this chapter.

A complete chart for a particular project on studies of the patient monitoring is presented in Figure 2.1, in accordance to keywords and the number of hits for each key word. The project focuses on the analysis of the eye and mouth detection from the face candidate in the image. Variations in images of faces due to external factors (extrinsic), such as lighting and occlusions, and variations in these same images due to internal factors (intrinsic), such as deformations of the facial surface from expression are discussed in section 2.4.