AN IMAGE PROCESSING TECHNIQUE FOR MENTAL HEALTH ASSESSMENT FROM ELECTROPHOTONIC IMAGES

JANIFAL BIN ALIPAL

THESIS SUBMITTED IN FULFILLMENT FOR THE DEGREE OF MASTER OF ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITI MALAYSIA SABAH
2019

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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

30 SEPTEMBER 2019

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CERTIFICATION

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ACKNOWLEDGEMENT

This thesis is dedicated to my mom. Wish your soul and spirit rest in Heaven. Thank you for everything and I love you always.

I would like to express my deepest gratitude and appreciation to my supervisor, Dr Razak Mohd Ali Lee for all his advice, guidance and support in this research work that leads to the completion of this thesis.

To my co-supervisor, Dr Mazlina Mamat thanks for the commitment you gave, you are so thoughtful and generous in your work giving for the completion of this thesis.

Our special thanks to the inventor of the EPI technology, Professor Konstantin Korotkov for providing us with access to the Bio-Well archive database.

Also, much appreciation to my family and close friends, especially to Jany, Lily, Acing, Rin, Marc, Tomomei, Diet, Bayu, Lana, Wawa, Muja and Dr Rem. Thank you for the help and make my life happy in so many ways.

Exceptional dedication to the love of my life, David Thompson, for always being very supportive, lift my spirit up and retain until to the finishing line of this study. Thanks for the love you gave me. I love you from the core of my hearts.

As a whole, thank you for everyone who contributes to the completion of this thesis.

I love you all.

Janifal Alipal

30 September 2019

ABSTRACT

Almost every single existing Medical Imaging techniques available nowadays is dealing with captured non-invasive radiations spectrum (NIR) in digital image form to aid the visualization probes for disease diagnosis and treatment process. Electrophotonic Imaging (EPI) is one among them. Through extensive studied literatures, EPI is a current technique used in Integrative Medicine. In correlation to EPI development, this thesis is presenting an engineering approach on how the captured Kirlian effect in an image form indicates the energy level of human biofield. The study is introducing an Enhanced Region-specific algorithm, ERS to extract the captured Kirlian's 'digital signatures' as human radiated energy inside an EPI (Electrophotonic Imaging) image. The prevalence range of radiated energy on the EPI image is calculated based on the extracted significant (morphed-absolute) region of Kirlian effect on image and its most-significant region (the peak signals on the image). By utilizing image morphology transform, ERS is improving the procedure of blob extraction process using absolute arithmetic between the gray-level and binary slice of the image. In addition, ERS analysis deduces energy parameters as the image significant 'digital signature' for energy in Joules. In brief, through these digital parameters, the energy level of different mental health status in 160 images of healthy and mentally ill subjects is quantified. As a result, by using ERS algorithm, the image quality is improved and the extracted region derives the maximum and minimum significant region in the image, subsequently improve the existing extraction process. Through this capability, this study found that the energy of healthy subject based on its EPI images is cumulatively from 1.5 up to 2.5×10^{-27} Joules. Meanwhile above this range are mostly Anxiety, and below this range are confirmed for Acute Psychosis, Hypertension and Retarded. Henceforth, the finding subsequently offers new diagnostic information about captured Kirlian effects through the skin of human's fingertips. At the same time, this study also provides reasoning evidence that the recorded human biofield energy levels inside an EPI image can potentially be used as an alternative approach to aid early stage detection of mental illness and psychological state in future clinical practice.

ABSTRAK

PENDEKATAN KEJURUTERAAN UNTUK MENILAI TAHAP KESIHATAN MANUSIA MELALUI IMEJ ELEKTROPHOTONIK

Hampir setiap kaedah penghasilan imej perubatan yang wujud masa kini berfungsi berdasarkan projeksi gambaran kesan radiasi bukan invasif (NIR) pada badan manusia dalam bentuk digital untuk membantu proses diagnosis penyakit, juga untuk tujuan visualisasi yang lebih baik. Pengimejan Elektrophotonik (EPI) adalah salah satu kaedah pengimejannya. Berdasarkan kajian saintifik masa kini, EPI adalah kaedah pengimejan yang digunapakai secara meluas dalam bidang Perubatan Integratif (gabungan terapi alternatif dan komplimentari. Selari dengan perkembangan EPI terkini, tesis ini merungkai pendekatan kejuruteraan dalam menjelaskan bagaimanakah kesan Kirlian yang diprojeksikan dalam bentuk imej menggambarkan aras tenaga biofield dalam badan manusia. Kajian ini memperkenalkan algoritma yang dikenali sebagai Enhanced Region-specific, ERS bagi proses pengekstrakan identiti-digital untuk kesan Kirlian di dalam imej EPI, yang dikenalpasti sebagai tenaga radiasi dalam badan manusia. Skala-kelaziman untuk tenaga radiasi ini diukur berdasarkan signifikasi gambaran cahaya tertangkap dalam imej setelah diproses, yang dikenali sebagai lapisan morphed-absolute dan juga extrated'. Dengan menggunakan kaedah pengubah-morfologi, algoritma ERS berhasil dalam menambahbaik prosedur blob extraction sedia ada dengan menggunakan kaedah 'absolute' aritmatik di antara proses pembentukan lapisan aras-kelabu dan lapisan binari. Dalam prosedur yang sama, analisis berdasarkan ERS menyimpulkan bahawa parameter tenaga dalam imej EPI adalah 'identiti-digital' yang wujud dalam unit Joule. Ringkasnya, melalui parameter digital ini, aras tenaga dalam imej untuk subjek kajian bagi enam kluster imej EPI untuk pesakit mental dapat dikenalpasti; Healthy, Stress, Anxiety, Hypertension, Retarded dan Acute Psychosis. Keputusan juga mendapati bahawa tenaga GDV untuk subjek yang sihat, secara komulatifnya adalah diparas 1.5 *sehingga* 2.5×10^{-27} *Joules. Manakala di atas jeda tenaga ini mejoritinya dimilkili oleh imej subjek Stress dan Anxiety. Di bawah daripada paras tenaga ni pula dimiliki oleh subjek Acute Psychosis, Hypertension dan Retarded. Oleh itu, kajian ini secara konseptualnya membuka ruang diagnosis baru dalam memberi informasi tenaga biofield pada kulit melalui rangsangan voltan pada hujung jari manusia. Pada masa yang sama, analisa penaakulan dapat dibuat berdasarkan imej yang tertangkap melalui teknik EPI (rangsangan voltan berkapasiti tinggi yang diberi pada hujung jari manusia) sebagai gambaran visual aras tenaga biofield pada badan manusia. Ia dilihat berpotensi tinggi untuk digunakan sebagai indikator dalam mengukur tahap kesihatan mental manusia, sekaligus menjanjikan EPI sebagai pengimejan alternatif yang berkesan.*

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LIST OF ABBREVIATIONS

EPI	-	Electrophotonic Imaging
GDV	-	Gas Discharge Visualization
EPC	-	Electrophotonic Camera
EMF	-	Electromagnetic Field
BME	-	Biomedical Engineering
ROI	-	Region of Interest
EDA	-	Electrodermal Activity
ERS	-	Enhanced-region Specific
IoT	-	Internet of Things
DSP	-	Digital Signal Processing
MRI	-	Magnetic Resonance Image
IAEA	-	International Atomic Energy Agency
PACS	-	Picture Archiving and Communication System
RIS	-	Radiology Information System
CT	-	Computed Tomography
TCO	-	Total Cost of Ownership
ANN	-	Artificial Neural Network
TENS	-	Transcutanel Electrical Neuro Stimulation
MET	-	Microcurrent Electrical Therapy
FDA	-	Food & Drug Administration
CES	-	Cranial Electrotherapy Simulation
ASD	-	Autism Spectrum Disorder
ESL	-	English as a Second Language
ATP	-	Adenosine Triphosphate
NIH	-	National Institutes of Health
CCD	-	Charge-coupled Device
ROC	-	Receiver Operating Characteristics
MLP	-	Multi-Layer Perceptron
FB	-	Fasting Blood Sugar
AC	-	Activation Coefficient
IA	-	Integral Area
IE	-	Integral Entropy
IYP	-	Integrative Yoga Practice
CAM	-	Complementary and Alternative Medicine
ANS	-	Autonomic Nervous System

LIST OF SYMBOLS

A_B	-	Size Of The Blob
I_C	-	Number Of The Closed Isolines
F	-	Form Coefficient
$F_{Dev.}$	-	Form Deviation
$g(f)$	-	Gradient Operator
G_{TH}	-	Top-Hat Operator
G_{BH}	-	Bottom-Hat Operator
G_{abs}	-	Absolute Coefficient

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CHAPTER 1

INTRODUCTION

1.1 Overview

New techniques based on digital analysis and more precise visualisation in monitoring of individual health status can improve the accessibility and reliability of healthcare services. An innovation in capturing a human biofield and its energy level using Electrophotonic Imaging (EPI) is seen as a breakthrough approach to the current alternative medicine and healthcare service (Mândrea, Curta, & Marosy, 2018). As a digital non-invasive imaging approach, EPI produces an image known as the Kirlian image in digital form (known as EPI image) to aid visualization and probe for disease identification and organs energetic state (Korotkov, 2018b). The diagnosis and treatment process are fast, reproducible and cost-effective (Kushwah, Srinivasan, Nagendra, & Ilavarasu, 2016). The EPI technique is based on computational models of the human health state commonly before and after a course of treatment or meditation. The reliability and efficacy of EPI are validated by the physician's perceptions using biomedical measurements (Yakovleva & Korotkov, 2013). At the same time, the algorithms developed by engineers embedded in the imaging system have advanced gradually (Korobka, Yakovleva, Korotkov, Belonosov, & Kolesnichenko, 2018) with the help of clinical data from physicians (Yakovleva & Korotkov, 2013). Overall, this research simplifies the procedure of blob extraction for EPI image digitally using the absolute arithmetic in-between transformation of grey-level and binary image. The algorithm will thoroughly explain the process of calculating the captured energy inside an EPI Images, which subsequently depict the energy level of the healthy subject are differ from the mentally ill.

1.2 Research Background

One of the chapters titled as 'Psychomagnetobiology' in Applied Biological Engineering book written by Chiapas (2012) discuss the existing technologies that use electricity and magnetism for diagnosis and therapy and its applications. Gas discharge visualisation (GDV) or electrophotonic camera (EPC) recognised as one of the electrotherapy techniques used in recent medical diagnostic. GDV technology is a machine and system consisting of hardware and software (known as Bio-well) to processes the captured images of coronal discharge from human fingertips (recorded through EPC optic sensor) and together this application of technology named as Electrophotonic Imaging (EPI). Figure 1.1 depicted various current technologies used to measure electromagnetic fields in human beings. GDV/EPC which nowadays known as Electrophotonic Imaging, EPI categorised as a technique functioned by electrical stimulation attached to the subject fingertips for diagnosing health status of human's body through biofield (Chiapas, 2012).

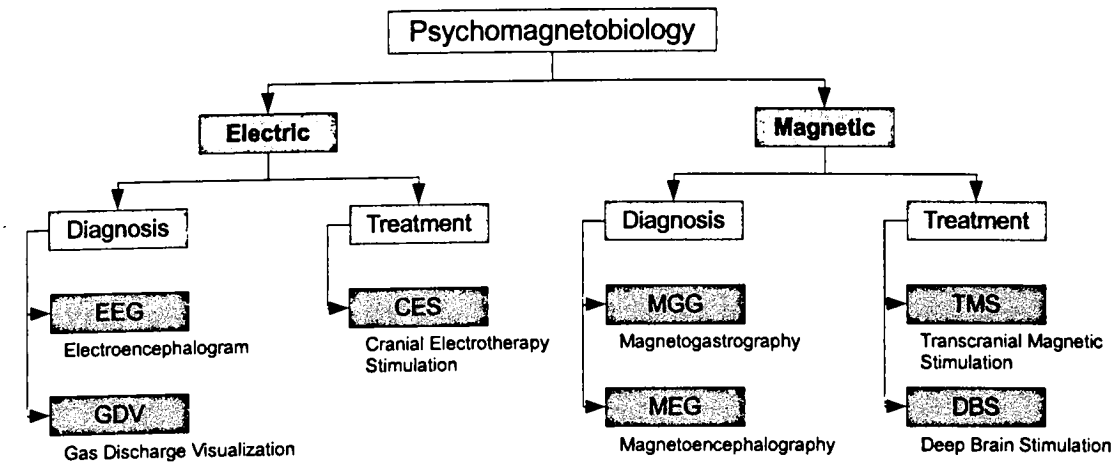

Figure 1.1 : Overview of magnetism and electricity in diagnosis and treatment in both medicine and psychology inside Psychomagnetobiology principle (interdisciplinary research that includes psychology, medicine, biological engineering, and physics)

Source : Chiapas, 2012

An exhaustive study done by Zhou and Uesaka (2006) about the interdisciplinary subject of bioelectrodynamic in the living organism scrutinizes the intrinsic roles of electromagnetic fields in biomedical imaging and its advances events. Since the 18th century, our knowledge of the usability of electromagnetic in biomedicine is well established, but premature developments into those ideas and techniques nowadays did not flourish as much as the digital advancement i.e. evolve rapidly to improve future quality of human life (Ignatov, Mosin, & Stoyanov, 2014). In the scope of electromagnetic study leads by Ignatov (Ignatov, 2014; Ignatov & Mosin, 2014; Ignatov et al., 2014) are accomplished to recognize various types of non-ionizing radiation (NIR) wave emitted from the human body in the electromagnetic range; Corona discharge spectrum is one of them. As study by Chiapas (2012) stated that the link between electromagnetic fields and the behaviors of the living organism in psychomagnetobiology principle is elucidated the separations of electric and magnetic spectrum for disease diagnosis and treatment, where's the Gas Discharge Visualization (GDV) and its electrophotonic camera (EPC) is the current technique used to collecting signals from the living organism using electrical digital stimulation.

After more than a decade, a series of studies on details explanation about the usability of the Kirlian image, especially on its texture analysis for medical imaging and applications are still not well developed. For example, the GDV as stated in (Chiapas, 2012) is still couldn't explain exactly how the imaging method amplifies the body's natural electromagnetic field, or how the patient's energy state is measured from an image. Above all well-established entropies on the Kirlian image captured by GDV as reviewed by Kushwah et al. (2016) and Kostyuk et al. (2010), an intrinsic image processing analysis for Kirlian effect and the state of its radiated energy, calibration system and algorithm developments are the emerging research field which offer promise to being develop; especially in the early stage of disease detection on living organism. The stressed-signaling induced by the infection of the disease will reflect the characteristics of living biofield; which then possible to detect the signaling response through a digitized signal using electrophotonic imaging (EPI). This concept of analysis becomes the principle of the study. In most conducted research about EPI,

the glowing picture known as an 'aura image' is also recognized as a medical biometric of a person in the basis of automatic response from skin, which then scientifically verified as human electrodermal activity, EDA (Priyadarsini, Thangam, & Gunasekaran, 2014).

In addition, from the view of image processing, the EPI image will be treated as a data consist of digital patterns corresponding to the coronal discharge energy spectrum, which can be extracted as feature elements that could be useful for any further dedicated machine learning and computer vision. For that reason, this research promotes a study to elevate the digital image processing technique in analysing the captured energy of Kirlian effects digitally by implementing proposed algorithm; features segmentation and extraction process on the region of interest (ROI) using mathematical morphology model. The technique employed in this research is a fundamental process to control the uncertainty characters of captured optoelectronic emission from fingers into specific digital features, based on its pixel's intensity.

1.3 Problem Statements

Suspicion arose when Chiapas (2012) faltered on deliberating more about EPI in how the imaging method amplifies the body's electromagnetic field and how the patient's information is collected from the captured image. Chiapas (2012) concluded that the EPI as an established 'entropy' of medical diagnostic in medicine and psychology with outstanding results. Hence, through research observation on the current published paper i.e. in Mândrea et al. (2018) also in Baldwin & Trent (2017), most of the existing research focus on examining the capability of EPI in diagnosing disease and the state of human psychology but the fundamental explanations on how the recorded image digitally depicts the energy levels of human body's electromagnetic field in principle of digital processing is left behind.

To close the gap between engineering and medicine, the field of research known as 'Biomedical Engineering' (BME) has been established to merge engineering principles with medicine in order to advance diagnosis, treatment, and monitoring,

which will in turn improves the quality of life of mankind (Kostyuk et al., 2010). Through this research, an engineering approach is used to study on how the captured image indicates the energy level of the human biofield. This research introduces an Enhanced-region Specific algorithm, ERS as a pre-processing procedure to extract the texture of Kirlian effects inside an EPI image. In this research, ERS treats that the EPI image indicates the radiation energy level based on its significant and most significant glow (region of interest, ROI) and is used for biomarker in biometrics of human psychological state.

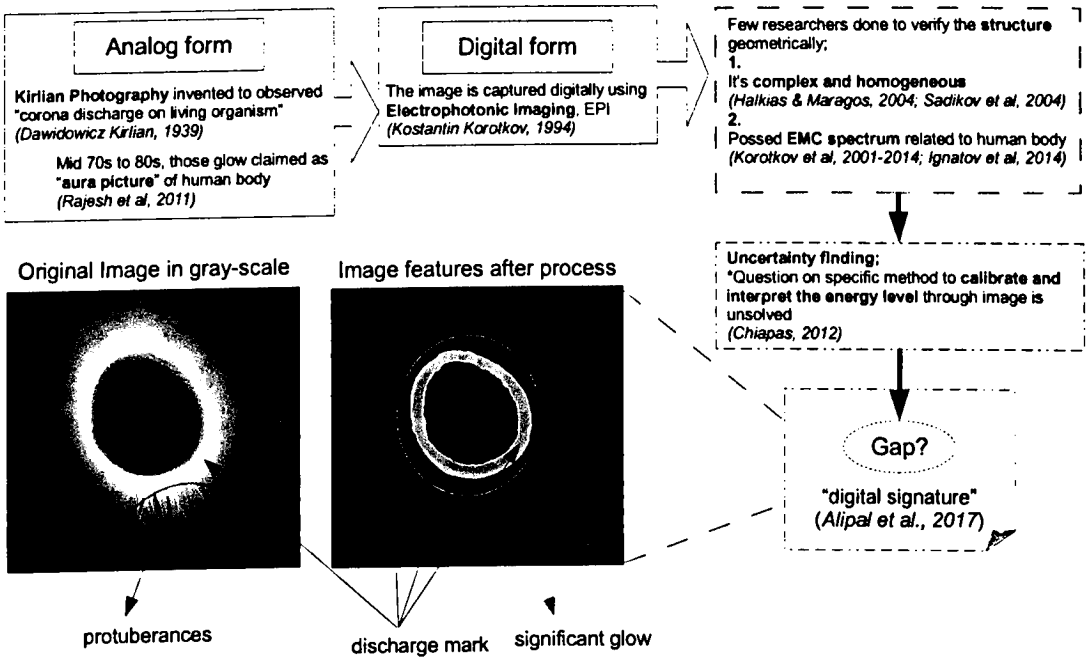

Figure 1.2 : The digital signature is proposed as the gap of research based on the brief of the history of research on Kirlian effect in image processing

Figure 1.2 explains the current paradigm of EPI technology. It is observed that the captured Kirlian images were acquired in an analogue form until, at the early of the 90s, EPI technology processing techniques upgrades the analysis into digital form. The previous study confirmed that the Kirlian images are complex and homogenous (Halkias & Maragos, 2004; Ignatov, 2014; Ignatov & Mosin, 2014;

Ignatov et al., 2014; Korotkov, 2014). However, there are no explanations of how the captured energy being processed or calculated digitally. Although its possessed EMC spectrum, (which related to the human body) the question of how the digital processing calculates that captured radiation in an image form is still undiscovered. Thus, this research proposed an image processing technique as an algorithm to deliberate the answer on how to calculate the energy level in the images, and this will be the further problem to be discovered in the discussion. Throughout the proposed process, significant parameters are being analysed as the image 'digital signature', which answer the unexplained 'gap' of previous research about the energy level inside an EPI image (Figure 1.2). Through the introduced parameters (morphed-absolute and extracted), the energy level of human biofield from fingertips is being verified with the Bio-well analysis, subsequently conclude its potential as an alternative approach in health assessment for future clinical practice, especially in differentiating the healthy and mentally ill subject (IAEA, 2015).

Henceforth in engineering perspective, an exploration on method of EPI technique amplifies measurement of patient's energy state in terms of "image processing" is overlooked. If the image processed digitally, means there must be an algorithm involved. Thus, a control parameter on the image features should be discussed. Then, this research is principled to analyse an insight correlation of the Kirlian effects (coronal discharge) and it's captured radiated energy inside an EPI image (taken from human' fingertips; retrieved from Bio-Well archive). The research concern is on the image digital parameterization ('digital signature' – refer Figure 1.1) to delineate the energy recorded on the captured image by modelling the analysis numerically on Scilab, which then generate the corresponding features of Kirlian effect to represents the energy of body's electromagnetic field. Moreover, this principle of research is suggested as the close possible answer for two research questions; first, how the digital form of Kirlian effect amplifies body's energy state; and the second is how the captured corona discharge in an image being process, subsequently indicates subject health status. To verify the introduced parameter capability, a comparative study is conducted between the simulated data from Bio-Well Analysis with the processed image using Enhanced-region Specific, ERS Algorithm to classify subject health status.

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