

MECHATRONICS BOOK SERIES
SELECTED PAPERS FROM
ICOM'01, ICOM'05 AND
ICOM'08

Editors

Asan G. A. Muthalif
Amir A. Shafie
Momoh J.E. Salami



IIUM Pres

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011
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Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

ISBN: 978-967-0225-68-5

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN. BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

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A study of Independent Component Analysis Applicability to Fetal Heart Rate Detection Using Photoethismogalph

H. Malek¹, Othman O. Khalifa¹ and M. A. Mohd Ali²

¹Department of Electrical Engineering
International Islamic University Malaysia, Jalan Gombak, 53100 Kuala Lumpur, Malaysia
malyk19@yahoo.com

²Department of Electrical and Computer Engineering
National University of Malaysia

ABSTRACT

Photoplethysmograph (PPG) is an optoelectronic technique for measuring and recording changes in the volume of body parts. These changes are associated with each heart beat and acquired by pulse oximetry. Fetal heart rate (FHR) monitoring using PPG is a challenging task since the acquired signals present the pattern of both fetal and maternal hearts. The effect of maternal component, noise and artifacts on fetal component makes the separation of FHR is very difficult. In this paper, we study the applicability of independent component analysis (ICA) to FHR detection using PPG. The study was conducted using emulated signals to mimic the pulsation nature of both maternal and fetal hearts. The outcome of this experiment shows encouraging results in terms of ICA extraction ability which can well-perform even when fetal-to-maternal SNR (S_F/N_M) drops to -276 dB.

1. INTRODUCTION

Pulse oximetry is a non-invasive method for measuring and recording the changes in the volume of body parts such as fingers, earlobes, toes and etc. caused by the changes in volume of the arterial oxygenated blood, associated with cardiac contraction [1]. The acquired signal is called a photoplethysmographic (PPG) signal. PPG signal is based on the absorption properties of vascular tissue when it is transilluminated by light. The emitted light, which is made to traverse the skin, is reflected, absorbed and scattered in the tissues and blood. The emerged light, which is modulated by the pulsation nature of blood flow, is measured using a suitable photodetector. Depending on the extremity properties, photodetector can be placed either opposite (transmitted mode PPG) or beside (reflected mode PPG) the light source. The waveform in the received light allows the absorbance effect of the arterial blood to be identified from those of non-pulsatile venous blood and other tissues. The variations in the photodetector current are assumed to be related to the blood volume changes underneath the probe, which are electronically amplified and recorded as a voltage signal [2].

The last two decades has seen a renewed interest in PPG monitoring techniques; its application has been extended to ante-partum and intra-partum monitoring of fetal well-being, which can give information about FHR as well as arterial blood oxygenation (SaO_2) [3]. However, previously fetal pulse oximetry (FPO) was conducted by placing the probe through the birth canal onto a part of the fetus which is considered as an invasive monitoring. In addition, some problems were faced when dealing with this placement, namely the applicable time (during labor) and probe requirements (a cervical dilation of 2 cm and ruptured membranes) [4]. Alternatively, the reflectance probe of trans-abdominal FPO offers the non-invasivity as well as time applicability [5].

In this paper, an evaluation of ICA separation ability to FHR using trans-abdominal FPO is conducted. The advantage of using ICA is allowing the detection of FHR even though the signal-to-noise ratio is very low. In addition, the algorithm has a fast convergence and easy separation procedure. However, the major defect was faced is the sensitivity of ICA against motion artifact which will be discussed in a further research.