

**UNIVERSITY OF SOUTHERN QUEESLAND**

**ANALYSING EEG BRAIN SIGNALS USING  
INDEPENDENT COMPONENT ANALYSIS TECHNIQUES**

A dissertation submitted by

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## **Dedication**

### **To my mother Gretel Georgia Walters**

a love for education driven her believe in me. Mom you died two years too soon

### **To my family**

who loves me unconditionally and believes in me no matter what.

# Abstract

The use of electroencephalography (EEG) in the medical field is evident in the effect it has on diagnosis and treatment of patients who suffer from some form of brain problem. These signals however once collected are overlaid with artifacts. This thesis considers this problem and seeks to solve using popular methods in the form of Independent Component Analysis (ICA) and Wavelet Transform (WT).

Independent component analysis (ICA) is a popular blind source separation (BSS) technique that has proven to be promising for the analysis of EEG data. There are different estimators to developing these ICAs. Mutual Information is one of the most natural criteria when developing an estimator. Although utilized to some level it has always been difficult to calculate. In this thesis I present a new algorithm which utilizes a contrast function related to Mutual Information based on B-Spline functions. This thesis also investigates the creation of an algorithm which is based on a merger of Independent Component Analysis and Translation Invariant Wavelet Transform and goes on to merger the B-Spline ICA with the Translation Invariant Wavelet Transform. In addition I apply Unscented Kalman Filtering as it does not require any prior signal knowledge. Each algorithm will be examined and compared to ones in literature tackling the same EEG problems; results will be drawn on the base of comparative tests on both synthetic and real.

# Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where acknowledged.



November 24, 2011

Signature of Candidate

Date

ENDORSEMENT

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Signature of Supervisor/s

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Date

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## List of Abbreviations

$\alpha$	Level of Confidence
$\sigma$	Standard Deviation
AL	Average Link
ARMA	Auto-Regressive Moving-Average
BMICA	B-Spline Mutual Information Independent Component Analysis
BMICA-WT	B-Spline Mutual Information Independent Component Analysis – Wavelet Transform
B-Spline	Basis Spline
BSS	Blind Source Separation
CCA	Cuvilinear Component Analysis
CS	Cycle Spinning
CT	Computed Tomography
CTICA	Cycle Spinning Wavelet Transform Independent Component Analysis
CubICA	Cumulant-based Independent Component Analysis
CRB	Cramér-Rao lower bound
CWT	Continuous Wavelet Transform
df	Degree of Freedom
DSS	Dynamic State Space
DWT	Discrete Wavelet Transform
ECG/EKG	Electrooculogram, -graphy
EEG	Electroencephalogram, -graphy
EFICA	Efficient FastICA
EKF	Extended Kalman Filter
EMG	Electromyogram, -graphy
EOG	Electrooculogram, -graphy
FastICA	Fast fixed point Independent Component Analysis



GSR	Galvanic Skin Response
ICA	Independent Component Analysis
IMA	Infusion Motor Artifact
Infomax	Information Maximization
JADE	Joint Approximate Diagonalization Eigen Matrices
KDE	Kernel Density Estimator
KF	Kalman Filter
KL	Kullback Leibler
KNN	K Nearest Neighbour
Matlab	Matrix Laboratory
MEG	Magneto Encephalography
MI	Mutual Information
MILCA	Mutual Information Least-Dependent Component Analysis
ML	Maximum Likelihood
MMI	Minimum Mutual Information
MRI	Magnetic Resonance Imaging
MSE	Mean Square Error
p-value	Probability Value
PCA	Principal Component Analysis
PRD	Percentage Root Mean Square Difference
PSNR	Peak Signal to Noise Ratio
RADICAL	Robust, Accurate, Direct Independent Component Analysis Algorithm
REM	Rapid eye movement
SCCN	Swartz Center for Computational Neuroscience
SDR	Signal to Distortion Ratio
SIR	Signal to Interference Ratio
SNR	Signal to Noise Ratio
SOBI	Second Order Blind Identification

SOS	Second Order Statistics
SWS	Slow wave Sleep
SWT	Stationary Wavelet Transform
TIWT	Translation Invariant Wavelet Transform
TDSEP	Temporal Decorrelation Source Separation
TVAR	Time Varying Parameter Auto Regressive
UKF	Unscented Kalman Filter
UNGM	Univariate Nonstationary Growth Model
UT	Unscented Transformation
WF	Weiner Filter
WT	Wavelet Transform

## List of Publications

### *Journal Papers*

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