ICA Applications

Biomedical Applications

1. Analysis of Electrogastrogram (EGG) Signals

A gastric myoelectrical activity measured by several electrodes attached on the abdomen. The purpose of ICA analysis is **to remove the interfering signals other than the gastric activity**. Analysis is done under the assumption that electrical activities of the organs near the electrodes are statistically mutually independent of each other and the EGG data is a convolutive mixture of them[1].

The independent components are directly separated from the ECG signals after ICA iteration. When the number of observed signals are more than that of source signals, either minimal distortion principle(MDP) or inverse minimum distortion principle(IMDP) to eliminate the indeterminacies.

The ICA algorithm to the data in each case that the number of sources is assumed to be 2, 3 and 4. The result suggests that EGG signals seem to be mainly originated from two sources. One of them is most likely to be associated with the stomach's activity while the origin of the other component is unknown at present.

Initially, the gastric electrical activity is recorded after fasting, then again after a small meal is ingested. In a normal stomach muscle, the regular electrical rhythm generates an increased current after a meal. In persons with stomach muscle or nerve irregularities, the post-meal electrical rhythm is irregular or voltage does not increase.

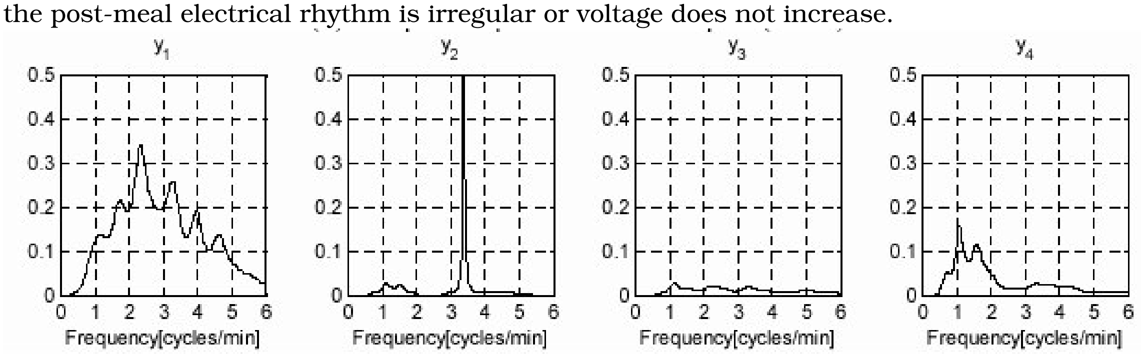

Fig 1: Extraction from 4 channels: Y_2 corresponds to 3 cpm gastric slow wave.

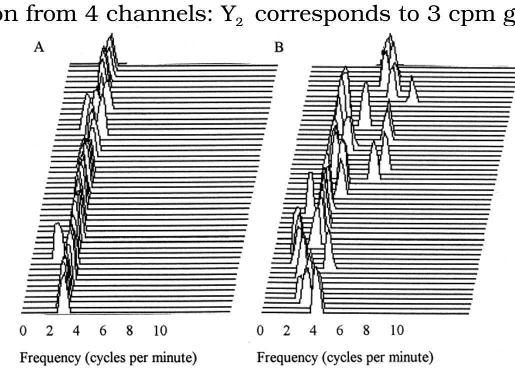

Fig 2: A pseudo–three-dimensional representation of an analyzed EGG in a functional dyspepsia patient A) Before meal B) After Meal

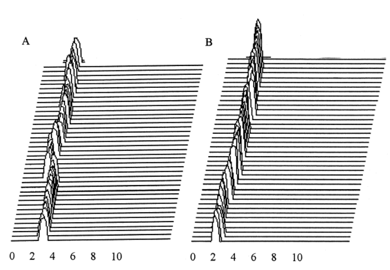

Fig 3: A pseudo–three-dimensional representation of an analyzed EGG in a normal person A) Before meal B) After Meal

2. Extracting Blood Vessel related component

In positron emission tomography (PET),radioisotpe labeled pharmaceutical is administrated to a patient,and its kinetic in a tissue can be measured as a spatial distribution of radioactivity. Dynamic PET images are assumed to be decomposed into independent source maps (pTAC map, plasma Time Activitiy curve, and tTAC map, Tissue TAC),and pTAC is extracted as a column of the estimated mixing matrix using a spatial ICA[2].

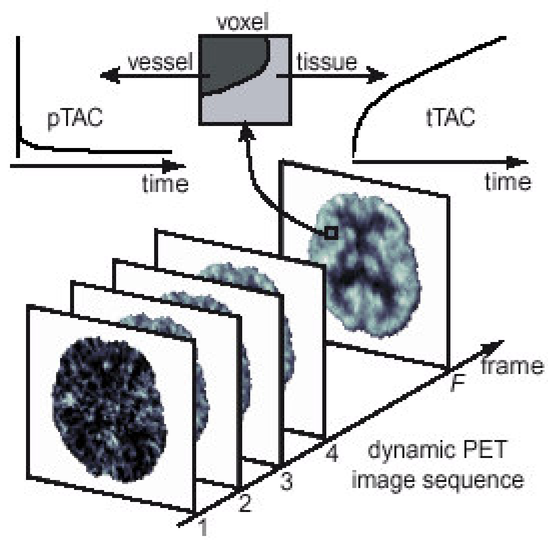

Fig 1. Illustration of human brain FDG−PET image sequence. A voxel of FDG−PET image is a linear combination of pTAC and tTAC[2]

As ICA has an ambiguity in the scale of the estimated component, the scale of pTAC is adjusted using one-point blood sampling by arterial puncture.

Thus ICA analysis separates pTAC and tTAC. These two are required as the input and output functions to fit the compartment models to estimate the physiological parameters.

3. ICA APPLIED TO ATRIAL FIBRILLATION ANALYSIS

ICAsolves the problem of atrial activity (AA) extraction from real electrocardiogram (ECG) recordings of atrial fibrillation (AF). It requires the cancellation of ventricular activity (VA)[3].

The subgaussian model of AA in front of the supergaussian behavior of VA allows the identification of AA using a kurtosis–based reordering after Fast ICA iteration. After reordering, AA is identified by computing Power spectral density for estimated idependent components with subgaussian kurtosis < 0.This procedure consisted of obtaining the modified periodogram from the separated sources using the Welch-WOSA method with a Hamming window of 4096 points length, a 50% overlapping between adjacent windowed sections and a 8192 points length FFT. Later, the spectral content above 20Hz has been discarded due its low contribution. This way, it is possible to observe and compare the spectral content of the separated sources with the accepted spectral content of AF.

4. Applications in analyzing EEG signals [4]

The method consists of two processing stages (see fig. 2). First, the measured EEG signals are decomposed into different spectral bands, by short-time Fourier transformation or wavelet transformation, yielding a complex-valued spectro-temporal representation for each electrode signal. Then, a separate independent component analysis is performed on the complex frequency domain data within each spectral band, producing, for each band, a set of complex independent component activation time courses and corresponding complex scalp maps.

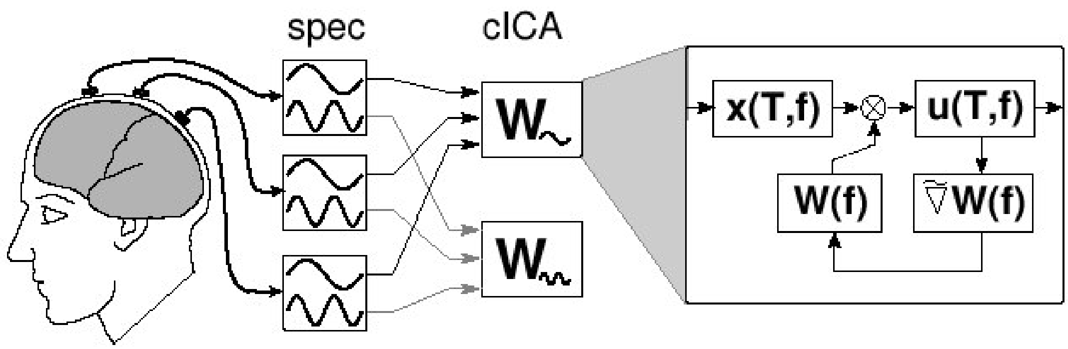

Fig 2. Schematic representation of the processing stages of the complex spectral-domain ICA algorithm. Left (`spec' ): the recorded electrode signals are decomposed into different spectral bands. Center (`cICA'): Complex ICA decomposition is performed within each spectral band. Right: Iteration steps performed by complex ICA for estimation of each separating matrix **W**(f).

Military Applications

1. Artificial Vision

Computer vision systems must include methods that enable applications for detecting objects through scattering environment, in bad weather conditions such as fog, rain, haze, snow, etc.

This needs to associate classical physics (radiative transfer in scattering environment) to signal and image processing techniques as blind source separation[5].

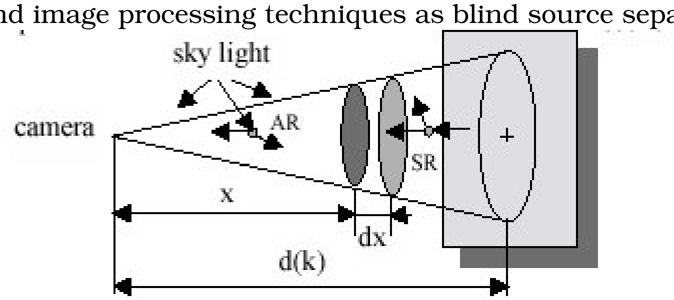

Fig 3. Degradation Model (SR- Surface Radiation effect, AR- Atmospheric radiation effect)

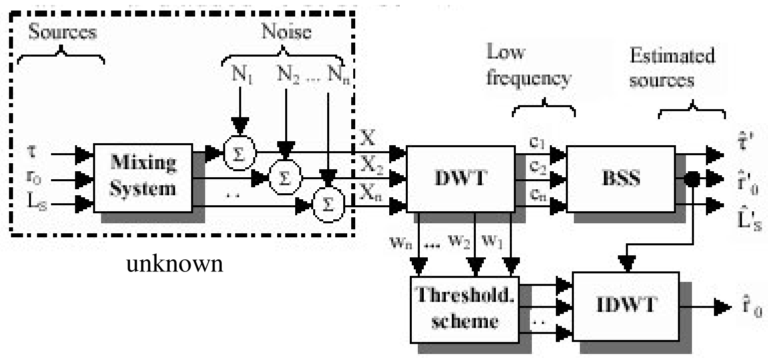

Fig 4. Application of BSS to vision in scattering environment

The proposed method to denoise images has the following steps as shown in fig.4.

1. transform the image into orthogonal domains using Discrete Haar Wavelet Transform (Harr-DWT);
2. apply a BSS method on the average coefficients c_i of low frequencies in order to separate the scattering
environment and the scene;
3. threshold the wavelet coefficients wi of high frequencies;
4. perform the inverse Harr-DWT from the low resolution scene of obtained in 2. and thresholded coefficients obtained in 3. in order to restore the de-noised image.

2. A DIGITAL WATERMARKING SCHEME BASED ON ICA DETECTION

The scheme proposed in this paper combines independent components analysis (ICA) with discrete wavelet transform (DWT) and discrete cosine transform (DCT). Firstly, the original image is decomposed by 2-D DWT and the detail sub-bands are reserved. Then, the approximate image is transformed by DCT and embedded with watermark. The watermark is detected through ICA. The simulation results demonstrate its good performance of the robustness and invisibility. The watermark detection is improved greatly compared to the traditional subtracting detection scheme [6].

Before doing ICA analysis, the watermarked image to be detected is transformed by N-Level DWT.

Other Applications

1. Independent component analysis approach to resolve the multi-source limitation of the nutating rising-sun reticle based optical trackers

2. ICA analysis for synthetic aperture radar(SAR) imagery processing

3. A DIGITAL WATERMARKING SCHEME BASED ON ICA DETECTION

4. Artificial Vision in scattering environment

5. Face Recognition

6. Mutimedia authentication protection using ICA

7. Artefacts separation from interesting asterophysical events

8. Multiple face detection for video surveillance

9.ICA applications in synthetic aperture radar (SAR) imagery processing

10. ICA representation of local color histograms for object recognition

11. Time delay estimation of acoustic emission signals

12. ICA based receivers for block fading DS_CDMA channels

13. ICA Analysis for Detection of Gas leakage

14. .ICA based thermal source extraction and thermal distortion compensation method for a machine tool

15.Machine fault detection

16. Input reduction in Human sensation modeling in Virtual reality

17. Efficient IRIS recognition using ICA

18. Change detection using ICA to track moving targets in scenery

19. Application of ICA to chemical reactions

20.ICA application in Electromagnetic environmental pollution monitoring

21. Vibrational Analysis for fault detection of motor

22.Acoustic arrays

23. ICA analysis of Gene expression data

24. ICA application in identification of explosives using electronic nose

25.ICA application in infrasound separation to identify nuclear explosion.

References

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2. MODIFICATION OF ICA FOR EXTRACTING BLOOD VESSEL-RELATED COMPONENT IN NUCLEAR MEDICINE: CONTRAST FUNCTION AND NONNEGATIVE CONSTRAINTS, Naganawa et al, ICA 2003, pg 65
3. ICA APPLIED TO ATRIAL FIBRILLATION ANALYSIS**,** Rieta et al, ICA 2003, 59
4. COMPLEX SPECTRAL-DOMAIN INDEPENDENT COMPONENT ANALYSIS OF EEG Data, Anemuller et al, UCSD, ICA 2003, pg 47
5. BLIND SEPARATION IN LOW FREQUENCIES USING WAVELET ANALYSIS, APPLICATION TO ARTIFICIAL VISION, Nuzillard et al, Romania, ICA 2003, pg 77
6. A DIGITAL WATERMARKING SCHEME BASED ON ICA DETECTION, Ju Liu, China, ICA 2003, pg 215