A Powerful Signal Extraction Method to Improve the Clarity of Medical and Other Digital Images

Tech ID: 22237 / UC Case 2011-255-0

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OTHER INFORMATION

KEYWORDS

independent component analysis, dynamic images, mutual information, polar coordinates, optimization, PET, CT, MRI, digital images

CATEGORIZED AS

- **Medical**
  - Diagnostics

RELATED CASES

2011-255-0

BACKGROUND

Independent component analysis (ICA) is a mathematical method for temporal and spatial signal extraction, where a data set of digitally recorded mixed signals is transformed into a new set of unmixed source signals. It plays an important role in signal and image processing analysis. A variety of prior methods have been used to estimate the source signals: some methods require *a priori* model probability density functions (pdfs) to approximate the source signal pdfs, other methods involve the optimization of a cost function, such as the mutual information (MI) between the estimated source signals. A method that does not require model pdfs and can perform a global search of the optimum solution over the entire range of angular parameters can greatly simplify the application and the robustness of ICA on a wide variety of signal and image extraction applications.

TECHNOLOGY DESCRIPTION

A UC San Diego researcher has developed a signal/image processing method for extraction/separation of least-dependent signal components without prior model information; it consists of:

Direct minimization of mutual information (MI) criteria between each proposed signal component.
Optimization of proposed signal components using polar coordinates.Visualized behavior of MI criteria with various parameters:

- Histogram bin size
- Over the full range of angular values
- Potential effects of data interpolation
- Number of data vectors analyze

APPLICATIONS

The method has been demonstrated to separate physiologic signals on dynamic medical-image data to obtain images with improved demarcations. Furthermore, the principles of the invention can be applied, in general, to extract/separate signal sources from a variety of digital signal mixtures found in typical applications of spacial and temporal independent component analysis (ICA). The potential applications include, but are not limited to, extraction of source signal of multispectral image, sensor array signal/data, and digitized audio signals.

ADVANTAGES

It does not require a model or prior information on the underlying source signal, which in many cases may be unknown.

- It performs minimization simultaneously in multiple angular parameters.
- For computational speed, the algorithm has been implemented to automatically setup look-up tables and array indices tables for the Givens rotations, based on the number of angular parameters of the optimization; and it is only limited by the computational hardware memory size.
- It reveals regions of local minima, which need to be avoided in finding the optimum solution for signal separation, in polar plots of the mutual information.
- The method allows visual check for proper convergence on the global minimum (best solution) by displaying a plot of the cost function graphically over the full range of angular parameters (0-180°).

INTELLECTUAL PROPERTY INFO

Patent is pending.

STATE OF DEVELOPMENT

Software of the working version of the algorithm has been implemented in Interactive Data Language (IDL, purchased from www.ittvis.com, Boulder, CO) and applied to the processing of dynamic medical images in spatial-independent component analysis for digital phantom data and dynamic positron emission tomography (PET) data. The next stages of development will expand its application to the processing of temporal signals (temporal independent component analysis).

RELATED MATERIALS

- Hoh C. (2010) Independent Component Analysis Minimizing the Mutual Information Criteria in Polar Coordinates. Proceedings of International Multi-conference on Complexity, Informatics and Cybernetics (IMCIC) online publication.

A PowerPoint presentation is available upon request.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,940,546	04/10/2018	2011-255

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