International Journal of Soft Computing 1(4): 308-312 , 2006

The Statistical Analysis to Extract the Activity Beyond Technic Bold of Irmf

K. EL Kourd
Institut d'Electronique, Université Med Kheider Biskra

Abstract: Our project entitled: " The statistical analysis to extract the activity beyond technic BOLD of IRMf". The goal of this theme is to study and to explore the technique of BOLD (Blood Oxygenation Level Dependent) of IRMf type, this technique is the most used for the detection's variations of oxygenation and blood fluxes bound to the activity neuronal *in vivo*. The functional magnetic imaging IRM (IRMf) is used by the Neurologists, Physicists and Mathematicians who work on the brain activation card. For the treatment of the IRMf data several methods, algorithms mathematical have been elaborated for the calculation's regions of cerebral activations that demand complex software tools and powerful computer platforms, either in the medical clinics or in the centers of research on the IRMf due to the complexity and to the volume of the data treated. Among these tools in the research domain we can found The SPM Toolbox (Matlab environment), a tool of research pioneer in the analysis of both PET and IRMf data. After the pre-treatment of data bus where we use the spm , we applied an analyse statistic with student t-test to explore the activity and inject it on the talairach glass.

Key words: IRM, IRMf, BOLD, PET, SPM, neuronal activity

INTRODUCTION

The IRM became the instrument privilege's survey *in vivo* for anatomy normal and pathological brain. Otherwise, the survey of the cerebral drip permits to get some information on the working of the brain and on its viability. Some recent developments showed that the IRM permits to study the cortical organization of the cerebral functions, while detecting the local variations of drip associated to the neuronal activity (functional IRM, IRMf). Indeed, it is known that every motor, sensory, or cognitive function, can be assigned to one or several cerebral anatomical regions[1,2].

IRMf present multiple advantages for the survey of the functions cerebral *in vivo* among the patients and the normal subjects. Indeed, it doesn't require injection of radioactive tracer, present a temporal and spatial resolution until now unequaled and is extensively available on the clinical sites. Otherwise, whereas in TEP, the middle of several topics is often necessary to get a report signal on noise being sufficient, the IRMf is especially suitable to an individual's survey, what makes the first tool of functional imagery of it comfortably usable in clinic[1-4].

The fMRI has been developed in the beginning of the years 1990 when some more and more powerful computers were coupled to the devices of IRM. The time of registration can be as short as 40 milliseconds and the resolution of the order of the millimeter is the best of all functional imagery techniques. The last scanners of fMRI

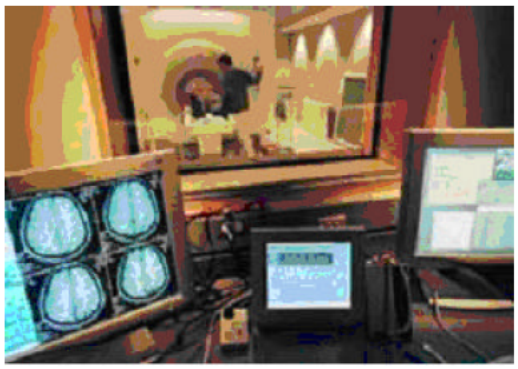

Fig. 1: Picture of: Jeff miller. Source: The science of Emotions, research at the University of Wisconsin-Madison[1-4].

can produce four images per second of the brain, what permits to follow the displacement of the neuronal activity during a complex task.

IMAGERY BY FUNCTIONAL MAGNETIC RESONANCE (IRMF)

To the difference of the magnetic resonance that permits to visualize the anatomy of the cerebral structures, the Imagery by Functional Magnetic resonance (IRMf) informs us on the activity of the different cerebral regions. The equipment that surrounds the patient and the working of basis is appreciably the same that with the

IRMf, but the computers that analyze the signal differ (Fig. 1)[2,5-8].

PRINCIPLES AND MECHANISMS OF THE IRMF

Cerebral drip and activation

Cerebral drip: The word "drip" makes reference to the local contribution of elements useful to the life of the cells (oxygen, nutriments, hormones, chemical mediators...) and to the evacuation of the products's catabolism or synthesis (CO2, NO, hormones, mediators...). The exchanges between blood and texture don't take place that to the level of the capillary network.

The brain at the man receives a debit of blood of 50 to 60 mL^{-1} 100 g^{-1} min (either to the total 750 mL^{-1} min). The consumption of oxygen is essentially the fact of the gray substance (40 to 45 mL^{-1} min of oxygen). The increase of the CO2 entails a cerebral vasodilatation, whereas the hypocapnie entails a cerebral vasoconstriction on the contrary, the hypoxia being a weaker stimulus of the cerebral vasoreactivity[2].

Techniques of functional IRM: The metabolic answers and hemodynamics in relation with a cerebral activity being localized remarkably, it is possible to get a cartography of drip that either a precise reflection of the cerebral functional zones.

The methods of survey of the drip by IRM used principles developed in nuclear medicine as the use of tracers initially. But these techniques are relatively difficult to put in work and don't offer a sufficient temporal resolution to follow " in real time" the neuronal activity. Some techniques in development measure the variations of flux regardless's blood oxygenation while using methods of magnetic marking's protons of the circulating blood. But currently, the technique of IRMf the more used detects the variations of oxygenation and a blood flux bound to the neuronal activity and has been called BOLD (Blood Oxygenation Level Dependent)[2,15,9,8,10].

INSTALLATION OF THE PATIENT

The patient must be installed comfortably, because the immobility of the head is essential (holds of mosses, elastic bandaging, masks in plastic thermoformables...), the technique being based on a comparison of the pictures acquired sequentially during the test.

Protocol of activation and acquirement of the pictures: The technical IRMf-BOLD being based on the comparison of pictures acquired during two different functional states (activity vs rest, or activity vs references), all sequence of activation in IRMf must include these two different states, that are alternated according to one precise fashion (paradigm of activation) (Fig. 2). For example, in a survey of the primary motor cortex of the hand, one asks the patient initially to remain immobile, then to move the fingers of the hand and this cycle is repeated several times. During the whole length of the paradigm, some pictures are acquired to a fast cadence (all 3 to 10 seconds according to the cases), always the same in order to be able to compare their signal during rest (or the state of reference) and the activation. To the total, one acquires fluently between 500 and 2000 pictures by IRMf set.

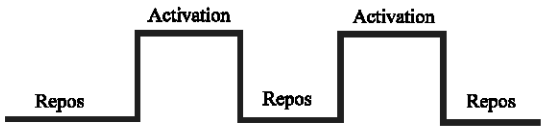

Fig. 2: Classic paradigm of activation for the survey in BOLD. An alternation of phases of activation and rest (or reference) is used[2].

The very big variety of the neurological functions capable to be tested in IRMf explains that innumerable paradigms of activation can be finalized according to the calm question. These paradigms sometimes require particular facilities (all non magnetic in order to can be placed in the room of the imager): video projector adapted and reflecting mirror to present to the patient of the stimuli on a screen placed to its feet at the end of the tunnel, bound joystick to a computer to record the answers of the topic, special helmet with earphones in case of auditory stimuli, etc... In any case, one is careful to avoid the movements of the patient's head, what even obliges to test the language in a silent way, in order to avoid the movements of the face[2,8,].

ANALYSE STATISTIC

Diagrams synoptic: The objective of the treatment of the data in IRMf is to detect and to localize the zones activated from sets of pictures. The variations of signal bound to the activation are not very visible to the naked œil and require a statistical treatment of the pictures with the help of specialized software. This study takes place in several stages: pre-treatment, treatment, presentation of the results, either directly to the console with software constructors and either on workstations. Many software have been developed by the laboratories of recherche. Fig. 3.

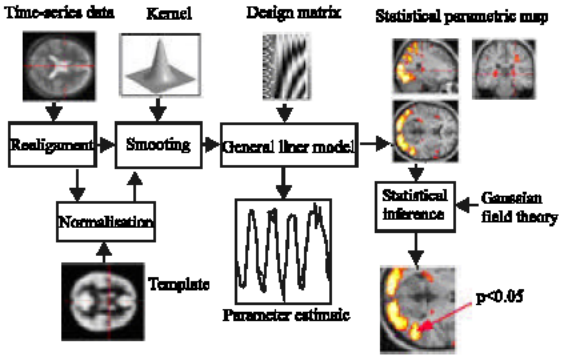

Fig. 3: General working of the treatment of the pictures of IRMf[11,12,13].

- Pre-treatment[12,13]
- Detection and correction of the artifacts of movements (Recalage of the pictures)
- Correction of geometric distortions. Filterings...

Normalization in the space of Talairach

- Treatment (statistical test Choices)[12,13]
- Subtraction
- Parametric cartography (Z, t, ANOVA) or non parametric
- Analysis of interrelationship
- Multiple linear regression
- Regrouping of data (Dated clustering)
- Presentation of the results[13,2,14]
- Superposition to an anatomical picture 2D
- Superposition to an anatomical picture 3D (returned surfacique)
- Coordinated of Talairach

The contrasts of time hemodynamic(t-test): For calculate t-test it is necessary know that:

- To every position in the brain, one l module activity during the time by a set of function that represents that that we know function (paradigm or noise).
- One adjusts by least squares the weight of each of these functions to adjust to best the data (to minimize the variance of the residues). One gets valued parameters. (The weights of these functions), of the adjusted data and of the residues-One test then these weights (One test then these weights (them): Creation " contrast" and one calculates a statistical (equation (1))

$$t = \frac{\text{contrast of estimated parameter}}{\sqrt{\text{variance estimate}}} = \frac{C' \cdot \beta}{\sqrt{\hat{\sigma}^2 \cdot C' \cdot (x^T \cdot x)^+ \cdot C^2 \cdot}} \quad (1)$$

$$\hat{\sigma}^2 = \frac{\varepsilon^T \varepsilon}{M - p} \quad (2)$$

with

$\hat{\sigma}^2$: Estimated of σ, M : The time and P: A parameter .

If we think that 1 regressor in our matrix of the drawing (for example $\beta 1$) could lead to an interesting activation, we calculate:

$$1\beta 1 + 0\beta 2 + 0\beta 3 + 0\beta 4 \qquad (C' = 1\ 0\ 0\ 0)$$

One gets a statistical card in t. to test the simultaneous influence of several columns of the experimental drawing matrix, one uses a F. test[12,13].

Presentation of our results
Algorithme:

- Extraction of the IRMf data (temporal Set in a specific Voxel)
- Definition of the experimental protocol: Auditory stimulation based on words bi syllabic to a report of 60 per minute.-Evaluation of the general linear Model
- Definition of contrasts them
- Execution of t-test

Data of IRMf: The IRMf data are pictures of the brain in format ANALYZES acquired by the functional imagery technique (BOLD/EPI) with a scanner (Siemens MAGNETOM Vision system) of which the magnetic field equal to 2T.

The experience is executed on only one topic in only one session. The protocol consists to scanner one volume of (64x64x 64 3mm x 3mm x 3mm voxels) every 7 second (TR = 7). Therefore we got 96 acquirements after have suppress the first four pictures due to the undesirable effects of T1 fashion. We have only one condition (auditory Stimulation) executed in successive alternation separated by equal rest times formed of block of 6 acquirements.

Example 1 of a voxel(x,y,z) for one section the bus of data: fM00223: One studied only one point(voxel)of section « Fig. 4 », one has find the matrix of drawing that contains the protocol proposed the regressor equal to a more then the bruits « Fig. 5 ».

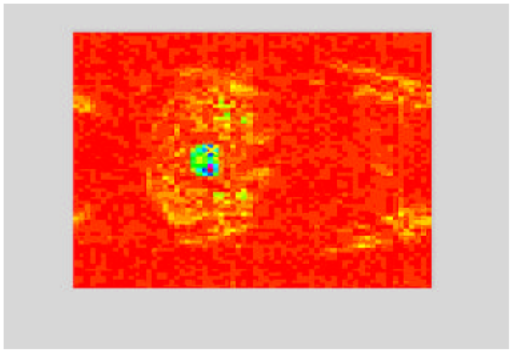

Fig. 4: Voxel chosen for data bus and: fM00223

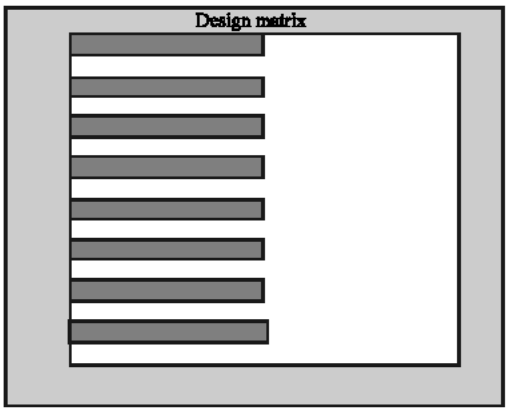

Fig. 5: The protocol chosen for design Matrix with: andTR=7s and, le box car=6 bloc

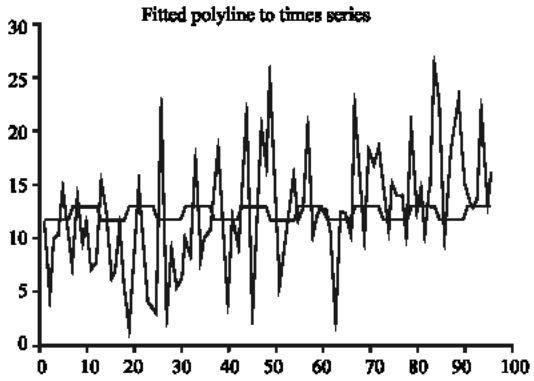

Fig. 6: and Time series and the fitted (mean)

- To adjust the signal by the temporal set, one needs the drawing matrix more the general linear model (Fig. 5):

For every voxel:
Temporel serie(Y) = design matrix(β) × parameters(X) + vector of error(ϵ)

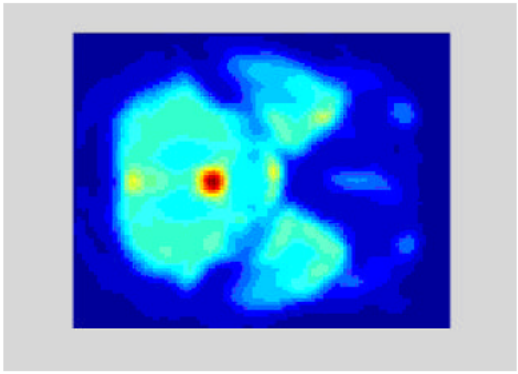

Fig. 7: section of image chosen (number 20)

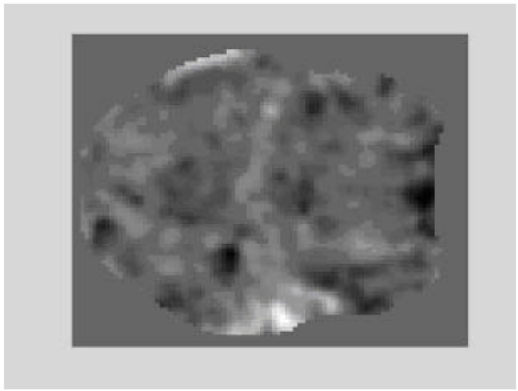

Fig. 8: Execution of t-test for all the section

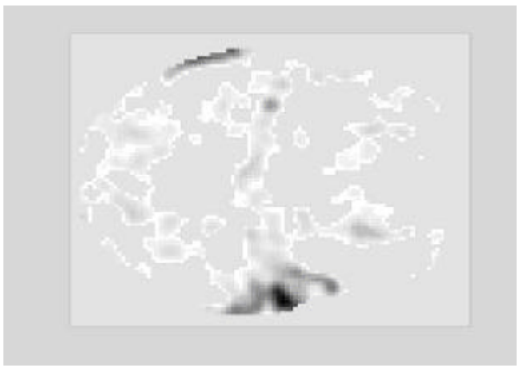

Fig. 9: Image masked to extract the Activity for t-test inf (to 0.05)

Execution of program:
workdir =c:\matlabR12\work\data new IRMf\MoAEpilot\fM00223
Dimensions are:

- Width = 64
- Height= 64
- Slice = 64

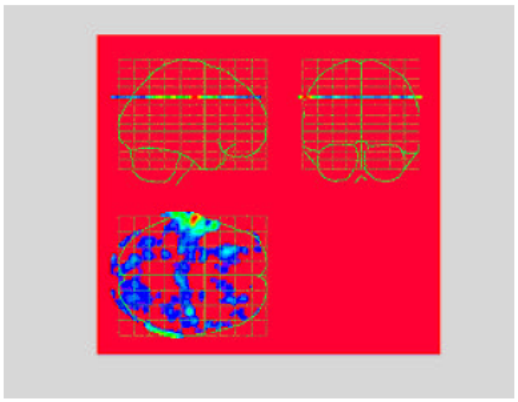

Fig. 10: Project the precedent figure on 'glass ' of talairach

voxel(x,y,z):
X = 25.2419
Y = 29.9854
First TD analysis: t-test = 1.04s
elapsed_time =14.83s

Example 2: Survey the section20 of data bus snrfM00223:
elapsed_time =572.8700s

Note: We can't inject our safe result only if we normalized a bus of data in the beginning of analysis, to be on that our result becomes to apply correctly on the glass talairach.

CONCLUSION

We have explored after pre-treatment the activity by student-t statistics analyse then project it on talairach glass. The character non invasif of the cerebral functional IRM and his/her/its very good spatial and temporal resolution explain the big interest of the researchers and clinicians for this technic. IT makes, the exploding progress of the technique since its discovery, there are only of years, let foretell a very fast growth of its clinical indications[1,9].

REFERENCE S

1. Michel Dojat, I : « L'Imagerie par Résonance Magnétique Anatomique et Fonctionnelle-Rappel des Principes de base et Artéfacts» U594.Université Joseph Fourier. Grenoble I.
2. Verdun, F.R. and A.G. Marshall, 1995. «Transformée de fourier»: Application en RMN et IRM.Masson Paris,1995.
3. Line Garnero, «andImagerie cérébrale fonctionnelle: Techniques et applications and» Laboratoire de Neurosciences Cognitives and Imagerie Cérébrale, CNRS UPR640, Centre de Magnétoencéphalographie
4. «Voir dans le cerveau»,La recherche, N^0 289 de Juillet-Août 1996.
5. André Alaux« L'image, 1994. Par Résonance Magnétique» imprimé en Espagne: Dépôt légale 1er trimestre.
6. Siugna Horizon, L.X., 1997. «Ecran Scan Timing (Temps de Répétition (TR)): Chapitre 12-Acquisition temps d'acquisition)Manuel de référence2148088-101 Rev 1,(6/97).
7. Ackerman, J.J.H. and T.H. Grove, D.G. Gadian and G.K. Radda, 1890. Mapping of metabolites in whole animals by 31P NMR using surface coils. Nature.183 and: 167-170.
8. Bottomley, PA., HR. Hart WA. Edelsteim *et al*., 1984. Anatomy and metabolism of the normal human brain studied by magnétic resonance at 1.5 Tesla Radiology 150: 441-446.
9. Bradley, W.G., 1985. Fundamentals of NMR image interpretation. In: Bradley WG, Adey WR, Hasso, head and neck: A text atlas. Rockville, Md.: Apsen.
10. Callen, H.B. and T.A. Welton, 1951. Irreversibility and generalized noise. Phy. Rev., 83: 34-40.
11. Kaufman, L. and D. Shosa, 1981. Quantitative characterization of signal to noise ratio in diagnostic imaging instrumentation. In: Progress in Nuclear Medicine, Neuro-Nuclear, Juge O, Donath A, Editors. Basel. Switzerland: S.Karger AG.
12. Traitement des données KH sous spm, coriandre vilain, 6 juillet, 2004.
13. Etat de Spm Parallel, Gerald vétoi, 5/10/2001.