



Real time intraoperative functional brain mapping using a RGB camera

C. Caredda, L. Mahieu-Williame, R. Sablong, M Sdika, J. Guyotat, B. Montcel

► To cite this version:

C. Caredda, L. Mahieu-Williame, R. Sablong, M Sdika, J. Guyotat, et al.. Real time intraoperative functional brain mapping using a RGB camera. Colloque RITS, May 2019, Tours, France. hal-02142491

HAL Id: hal-02142491

<https://hal.science/hal-02142491>

Submitted on 28 May 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Real-time intraoperative functional brain mapping using a RGB camera

C. Caredda¹, L. Mahieu-Williams¹, R. Sablong¹, M. Sdika¹, J. Guyotat² and B. Montcel¹

¹CREATIS; CNRS (UMR 5220); INSERM (U1206); INSA Lyon; Université de Lyon, France.

²SERVICE DE NEUROCHIRURGIE D ; HOSPICES CIVILS DE LYON ; Bron, France.

Introduction

Context: Non invasive functional brain mapping is an imaging technique used before brain tumor resection to localize the functional areas of the patient brain. f-MRI and electrical brain stimulation are two complementary clinical tests realized before neurosurgery.

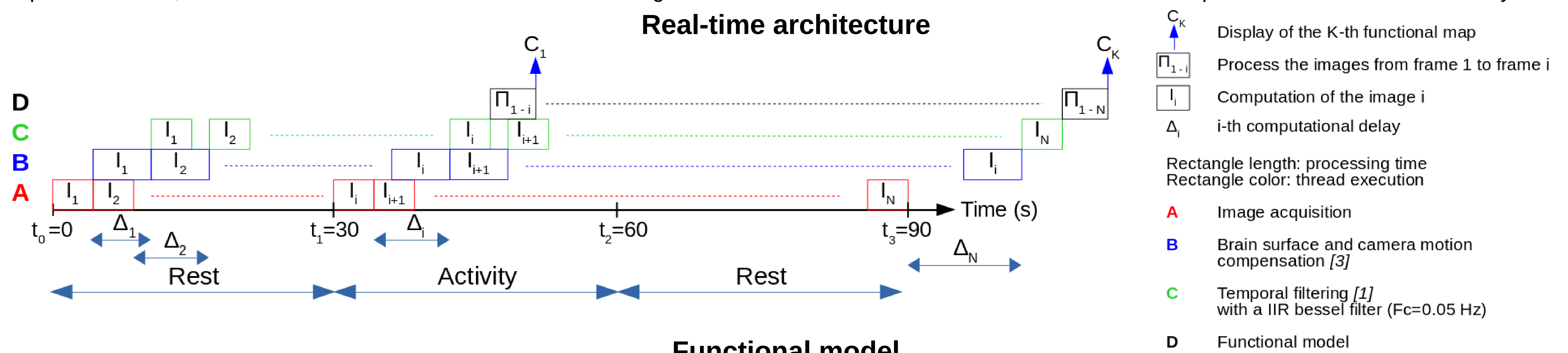
f-MRI tests are realized before the patient craniotomy. Electrical brain stimulation tests are realized once the patient cortex is exposed.

Background: Optical imaging can be used to monitor the brain activity [1] with the measure of hemoglobin concentration changes ($\Delta[\text{HbO}_2]$ and $\Delta[\text{Hb}]$). A device consisting of a continuous wave white light illumination and a RGB camera is a suitable approach [2].

Objectives: We propose to realize a real time intraoperative localization of brain functional areas using a RGB camera with the analysis of $\Delta[\text{HbO}_2]$ and $\Delta[\text{Hb}]$ time courses which is closely linked with the Bold contrast in f-MRI studies.

Material & methods

Experimental paradigm: After the patient craniotomy and before the brain tumor resection surgery, the patient was awakened and functional tests have been realized. The stimulation of the motor cortex was achieved through a repetitive and alternative hand opening and closing at $\approx 1\text{Hz}$. The paradigm consisted of 3 steps : 30s of rest, 30s of stimulation and 30s of rest. The neurosurgeon realized electrical brain stimulations to localize the patient brain motor and sensory areas.



1 - Correction of the collected intensity slope

The slow drift of the collected intensity (cortical dessication) was corrected through a linear regression subtracted to the original data.

2 - Modified Beer-Lambert law [4]

$$\begin{bmatrix} \Delta A_R(t) \\ \Delta A_G(t) \\ \Delta A_B(t) \end{bmatrix} = \begin{bmatrix} E_{R,Hb} & E_{R,HbO_2} \\ E_{G,Hb} & E_{G,HbO_2} \\ E_{B,Hb} & E_{B,HbO_2} \end{bmatrix} \times \begin{bmatrix} \Delta[Hb](t) \\ \Delta[HbO_2](t) \end{bmatrix}$$

$$\text{with } E_{i,n} = \int \epsilon_n(\lambda) \times D_i(\lambda) \times S(\lambda) \times L(\lambda) d\lambda.$$

A global mean path length L is calculated with Monte-Carlo simulations [5].

D_i : spectral sensitivity of the camera detector i (R,G,B). S: light source spectrum

ϵ_n : chromophore n (Hb, HbO_2) molar absorption coefficient ($\text{L. Mol}^{-1}.\text{cm}^{-1}$)

3 - Selection of activated areas

For each camera pixel, the Hb or HbO_2 concentration changes time courses are obtained by matrix inversion. The time courses which best fit the expected patient hemodynamic response [6] are considered (the Pearson correlation coefficient threshold is set to 0,5).

4 - Functional quantitative maps

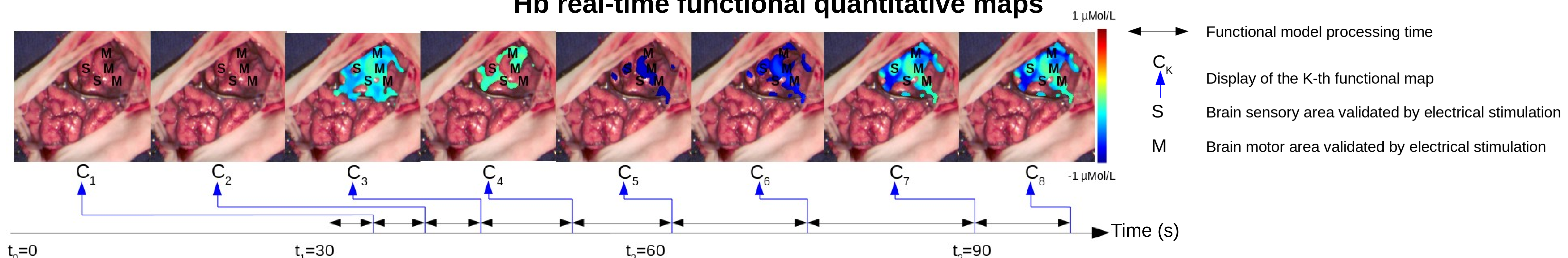
Hb or HbO_2 concentration changes are averaged over the duration of the patient cortical activity.

$$QMap_C(x, y) = \frac{\sum_{t=t_1}^{t_2} \Delta C(t, x, y)}{t_2 - t_1}$$

C represents either [Hb] or $[\text{HbO}_2]$. (x,y) is the position of an image point.

Results

Hb real-time functional quantitative maps



✓ The Hb functional quantitative maps correspond to the motor and sensory areas validated by the neurosurgeon.

✓ Relevance of the functional quantitative maps as soon as the patient activity is established.

Discussion & conclusion

↗ A global mean path length is calculated for all camera pixels. A pixel-wise computation of the mean path length is required.

↗ The correction of the collected intensity slope is not optimal for the first maps (from C_1 to C_6). This problem will be investigated in a future work.

↗ The functional quantitative maps processing time depends on the amount of pixels contained in the region of interest. CPU and GPU optimization code is required.

References

- [1] Chance B. et al. Proceedings of the National Academy of Sciences 90, 3770–3774 (1993).
- [2] Malonek D. et al. Science 272, 551–4 (1996).
- [3] Sdika M. et al. Medical Image Analysis 53, 1–10 (2019).
- [4] Kohl-Bareis M. et al. Apparatus for measuring blood parameters (2012).
- [5] Fang Q. et al. Optics express 17, 20178–20190 (2009).
- [6] Veldsman M. et al. Human Brain Mapping 36, 1620–1636 (2015).

