

The use of EEG-based inverse models for both BCI design and brain activity visualization in VR

F. Lotte, M. Congedo, A. Lécuyer, C. Arrouet, F.
Lamarche, J.-E. Marvie, B. Arnaldi
fabien.lotte@irisa.fr

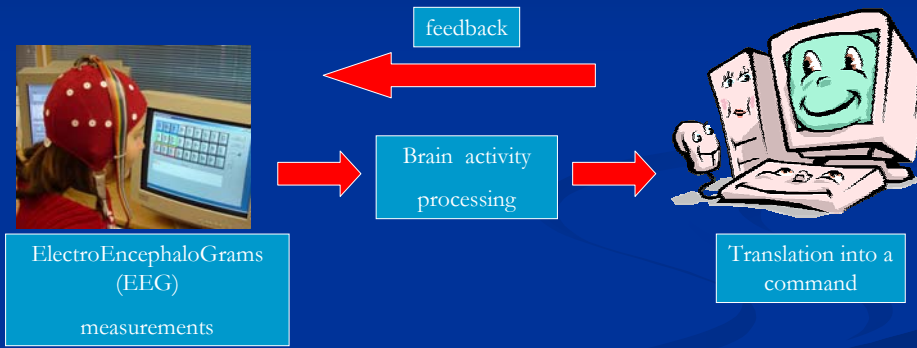
1



Open-ViBE

- Open-ViBE: An open-source software for Brain-Computer Interfaces (BCI) and Virtual Reality (VR)
- French national Project
- Duration: 3 years
- Beginning: December 15th 2005
- 4 Partners: INRIA/IRISA (VR, computer science), INSERM (medical/neurophysiology), France Télécom (signal processing, HCI), AFM (disabled people)
- Objective: develop an open-source software with innovative techniques for more efficient BCI
- Coordinator: Anatole Lécuyer (anatole.lecuyer@irisa.fr)

Brain-Computer Interfaces (BCI)



Outline

- Introduction
- Inverse model and sources localization
- Brain activity visualization in Virtual Reality
- BCI design using an inverse model
- Conclusion

Outline

- Introduction
- Inverse model and sources localization
- Brain activity visualization in Virtual Reality
- BCI design using an inverse model
- Conclusion

Inverse models and sources localization

- Problem
 - EEG are the **scalp measurements m** resulting from the mixing **A** of several unknown **sources s**
- $$m = As$$
- Inverse models
 - Reconstruct the **sources s** from the **scalp measurements m**
- $$s = Tm$$
- Ex: LORETA [Pascual-Marqui94]
- Advantage
 - Enable the localization of active sources in the brain, using EEG

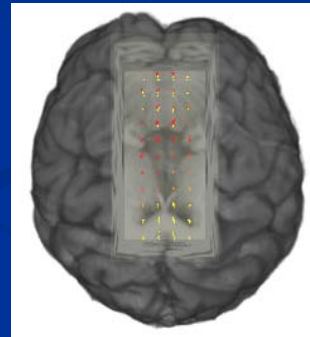
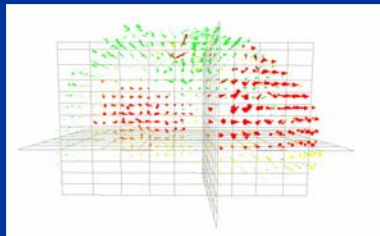


Outline

- Introduction
- Inverse model and sources localization
- Brain activity visualization in Virtual Reality
- BCI design using an inverse model
- Conclusion

3D visualization in VR

- Representation of the current density reconstructed in the brain volume (2394 points)
 - Use of the LORETA inverse model [Pascual-Marqui94]
 - Real-time representation



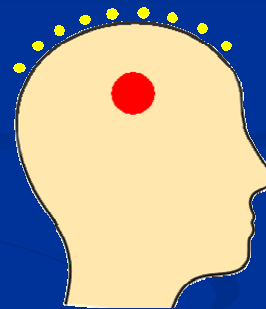
(Arrouet et al., Journal of Neurotherapy, 2005)

Outline

- Introduction
- Inverse model and sources localization
- Brain activity visualization in Virtual Reality
- BCI design using an inverse model
- Conclusion

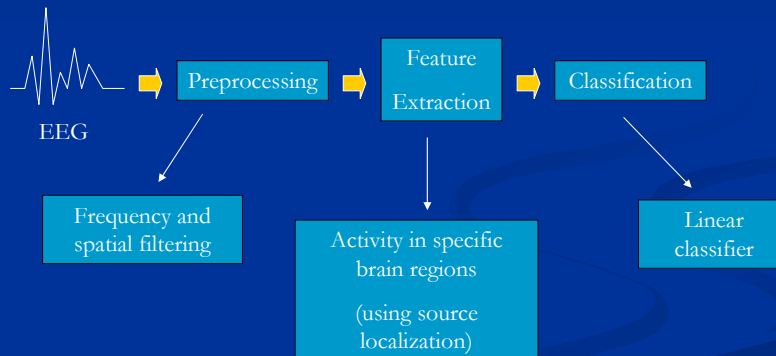
BCI and 3D localization of sources

- Context: most EEG-based BCI only use **surface** information
- Idea: reconstruct, from EEG, the **volume** information
- How: use a source localization method
- Advantage: knowing **where** the activity is implies knowing **what** the activity is



General principle

- How identifying the “brain activity pattern” ?



Experimental Validation

- Data set IV of the « BCI competition 2003 » [Blankertz *et al*, 04]
 - Protocol: left/right finger movement intention
 - 2 Classes: left/right
 - Two data sets
 - Training set
 - Test set
 - Objective of the competition: obtain the highest recognition rate on the test set
 - Winner's score: 84% [Wang *et al*, 04]

Sources localization

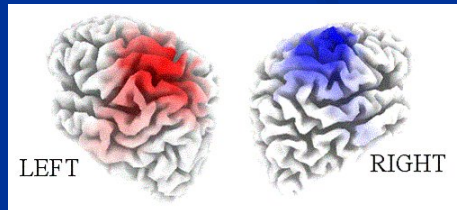
- Method: sLORETA [Pascual-Marqui02]
- Principle: computation of the current density γ_λ in the region or voxel λ , using measurements v_t at instant t

$$\gamma_\lambda = v_t^T R_\lambda v_t$$

- Advantage: perfect localization

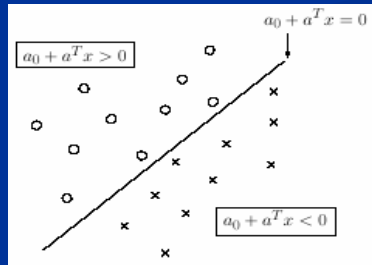
Identifying the Regions Of Interest (ROI)

- Method
 - Statistical analysis [Holmes *et al*, 96]
- Principle
 - Determine the region which activity makes it possible to discriminate the two classes
 - Obtention of two ROI (left and right motor area)



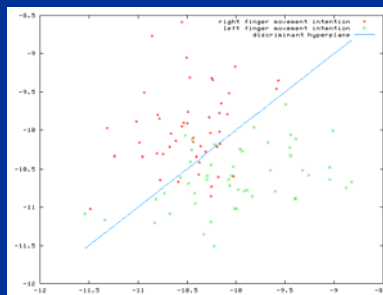
Identifying the « brain pattern »

- Feature extraction
 - Two features (one per ROI):
 - Activity in the **left** ROI, averaged over time
 - Activity in the **right** ROI, averaged over time
- Classification
 - Linear classifier [Duda *et al*, 01]



Results

- Test set classification
 - Using a linear classifier: 84 % (same score as the winners)



- Shows the interest of the method (Congedo, Lotte and Lécuyer, Physics in Medicine and Biology, 2006)

Conclusion

- Two approaches using inverse models
 - Brain activity visualization in VR
 - Brain-Computer Interface design
- Novelty and efficiency of the methods
 - Arrouet et al., Journal of Neurotherapy, 2005
 - Congedo, Lotte and Lécuyer, Physics in Medicine and Biology, 2006
- Research is going on
 - the Open-ViBE project

Questions ?



Fabien Lotte
fabien.lotte@irisa.fr