



UNIVERSITAT POLITÈCNICA  
DE CATALUNYA  
BARCELONATECH

Insight 

# Object Segmentation in Images using EEG Signals

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# Outline

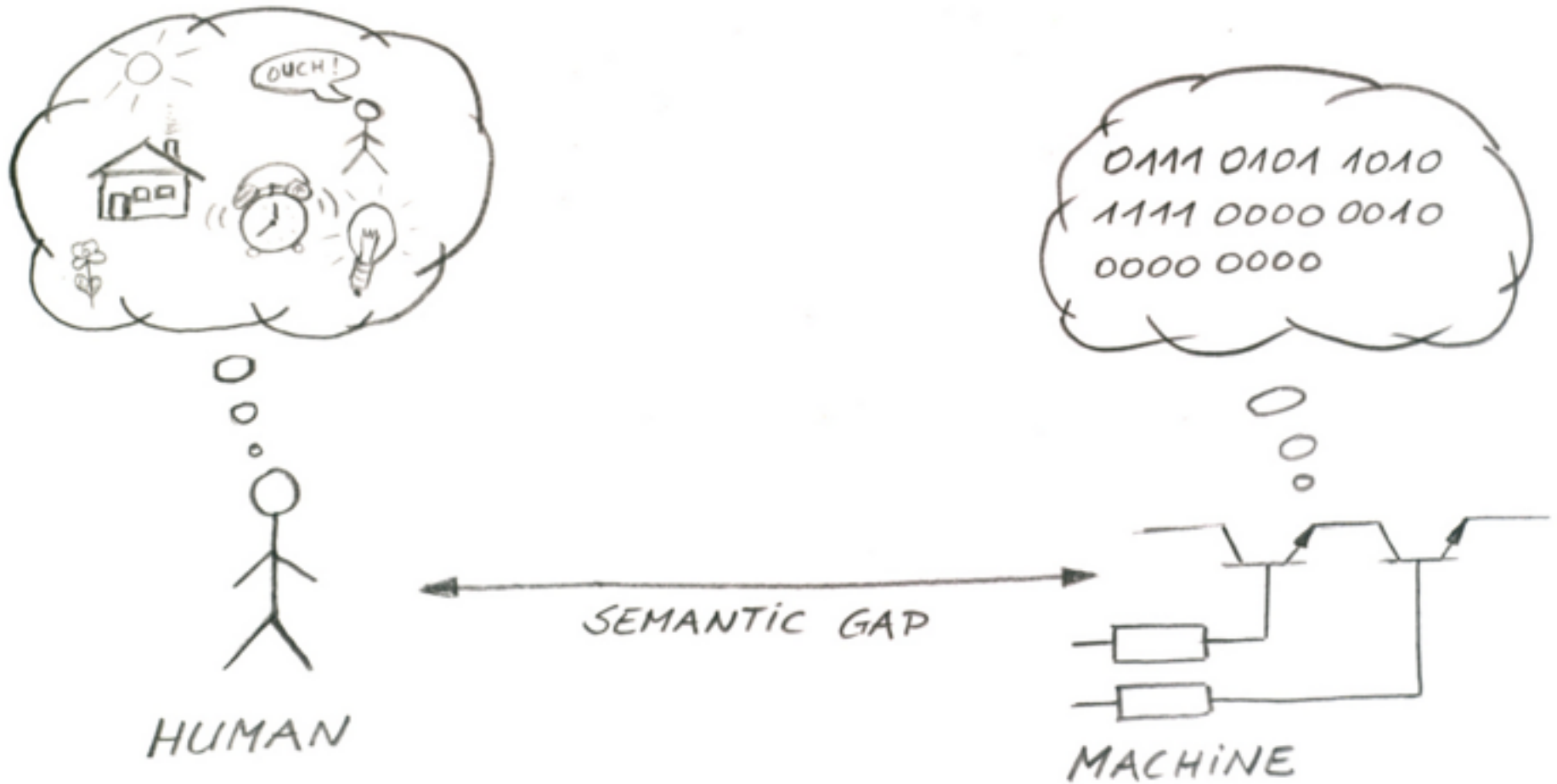
- **Interactive Object Segmentation**
- ACM MultiMedia High Risk High Reward 2014
- Related Work
- System Proposal
- Results
- Conclusions

# Interactive Object Segmentation

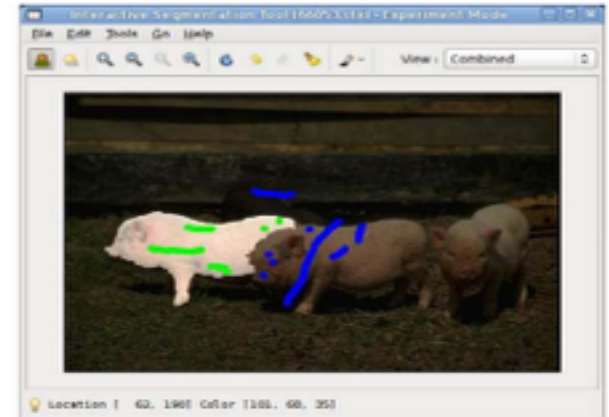
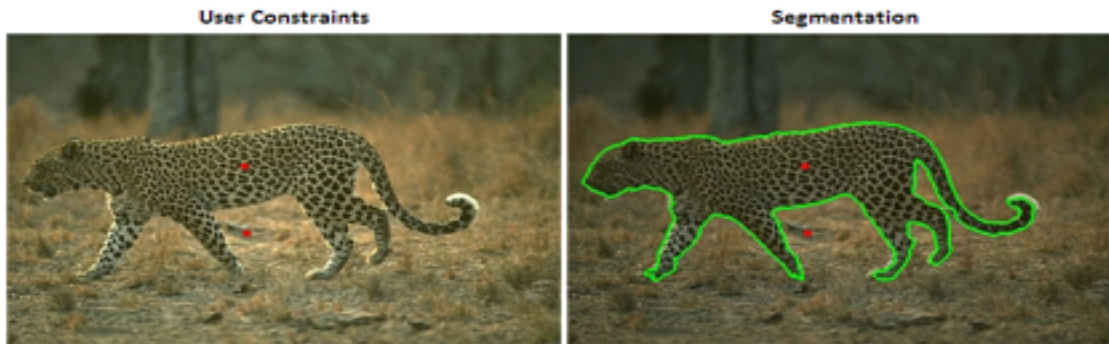
- Object Segmentation



# Interactive Object Segmentation



# Interactive Object Segmentation



1) P. Arbelaez and L. Cohen. Constrained image segmentation from hierarchical boundaries. In CVPR'08, 2008.

2) McGuinness, K., & O'Connor, N. E. (2010). A comparative evaluation of interactive segmentation algorithms. Pattern Recognition, 43(2), 434-444.

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# Brain-Computer Interface (BCI)

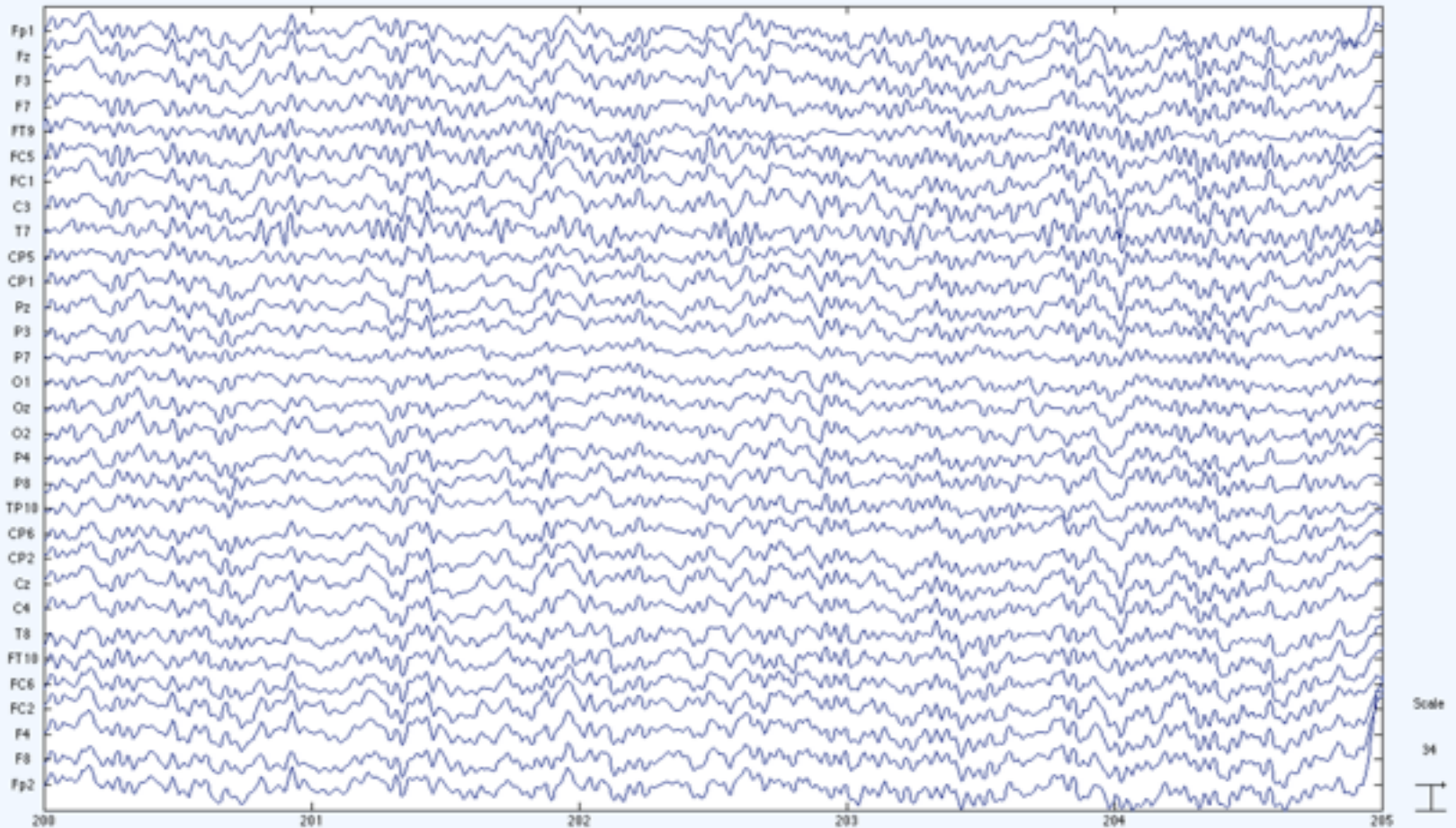
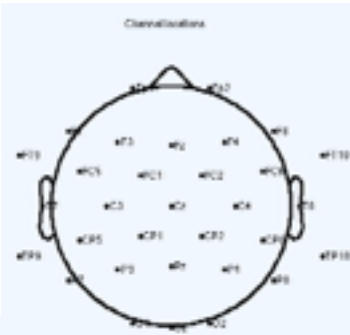


# Brain-Computer Interface (BCI)



# Brain-Computer Interface (BCI)

Electroencephalography (EEG) signals



# Brain-Computer Interface (BCI)

## Strengths



- Non invasive
- Well established tool within clinical practice

# Brain-Computer Interface (BCI)

## Challenges

- Mostly BCI applications remain prototypes not used outside laboratories
- Users need to be trained
- Poor BCI performances
- Low signal-to-noise ratio
- High dimensional data

**HIGH RISK**



# Potentially High Reward

- **Medical applications**

- **Locked in Syndrome (LIS)**
- **Prosthetics control, wheelchairs, spellers**



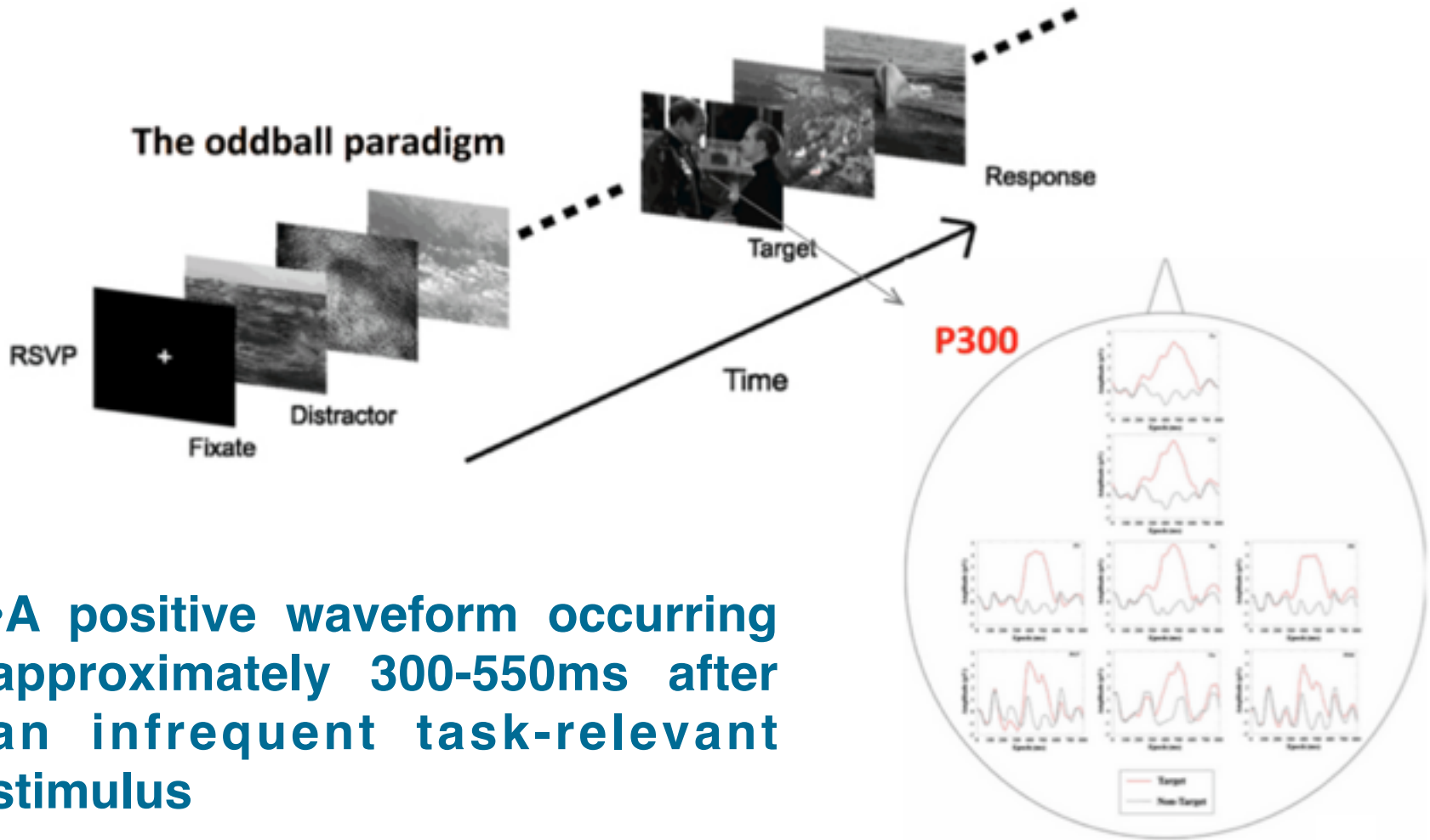
- **Healthy Users**

- **BCI with Virtual Reality technologies**
- **Augmenting gaze control**

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# Related Work: RSVP

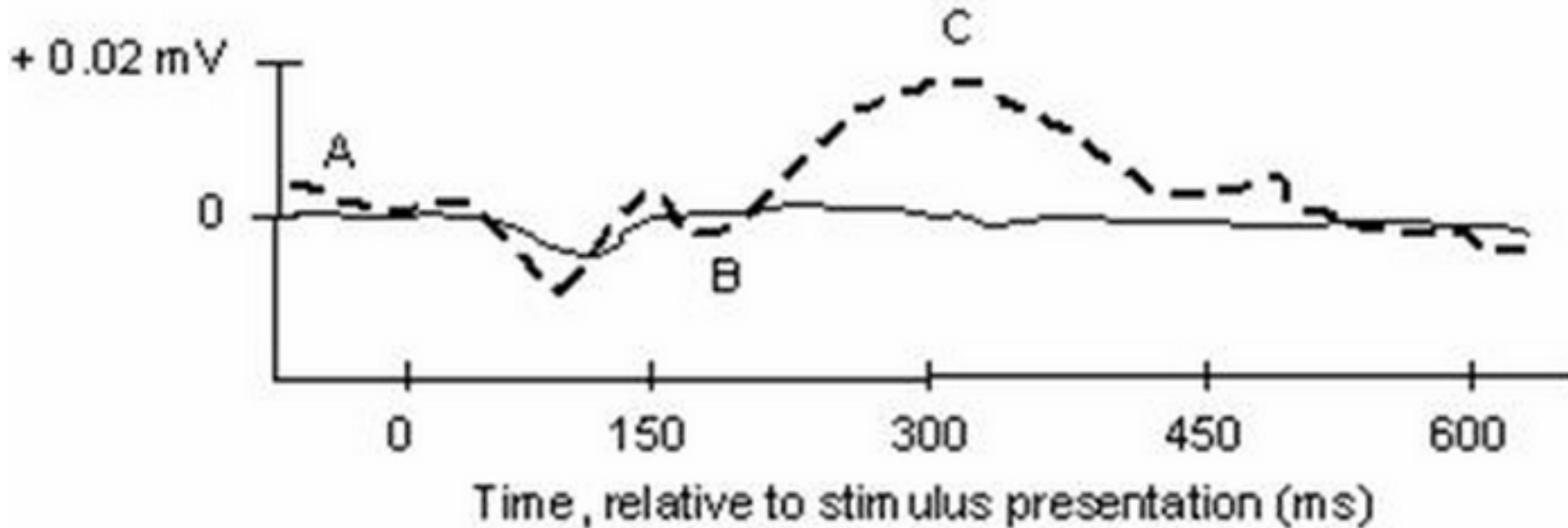


- A positive waveform occurring approximately 300-550ms after an infrequent task-relevant stimulus

# Related Work: RSVP

— Response to frequent stimulus  
- - Response to infrequent stimulus

A: Baseline  
B: N200  
C: P300



# RSVP: Demo

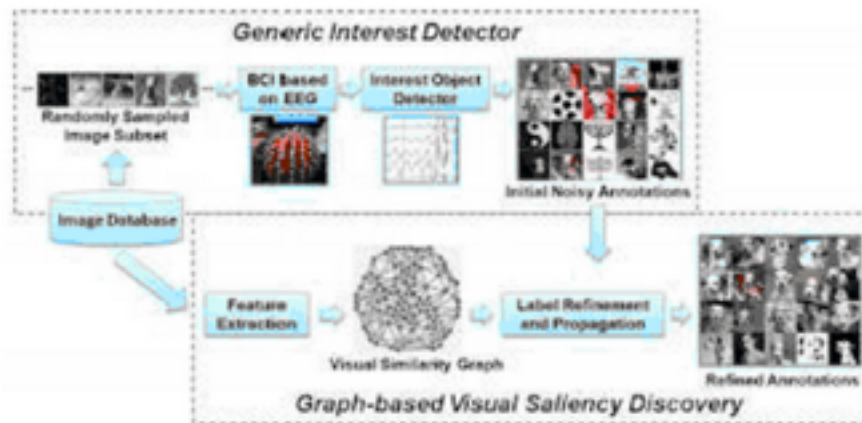


# Related Work

## •Image Retrieval

### 2 - "Brain Computer Decoding for rapid image retrieval". Wang et al (2009)

#### Brain Computer Interface and Visual Pattern Mining (BCI-VPM)



- Caltech101

- 10Hz

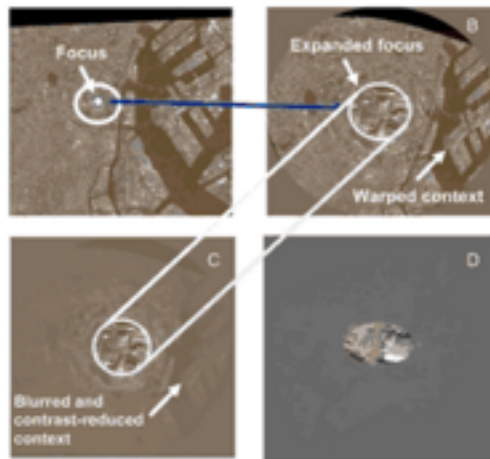
- 4 users

- 64 electrodes recorded at 2048Hz

# Related Work

## •Object Detection

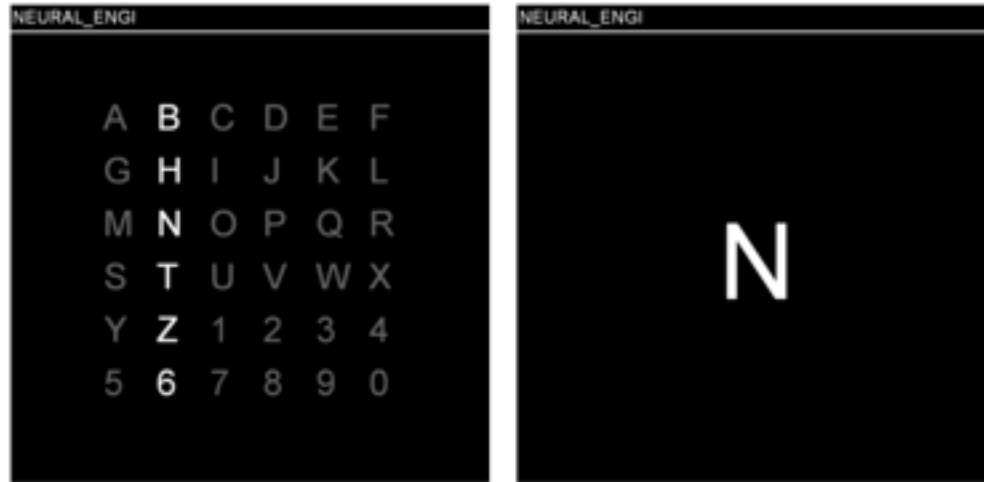
### 3 - "Brain Activity-Based Image Classification from Rapid Serial Visual Presentation" by Bigdelv-Shamlo et al (2008)



- Satellite image from London
- 12 Hz  
(They justify high freq > 2-4Hz to avoid the eye inspection of the image)
- 8 users
- 256 electrodes recorded 256Hz

# Related Work

- BCI speller



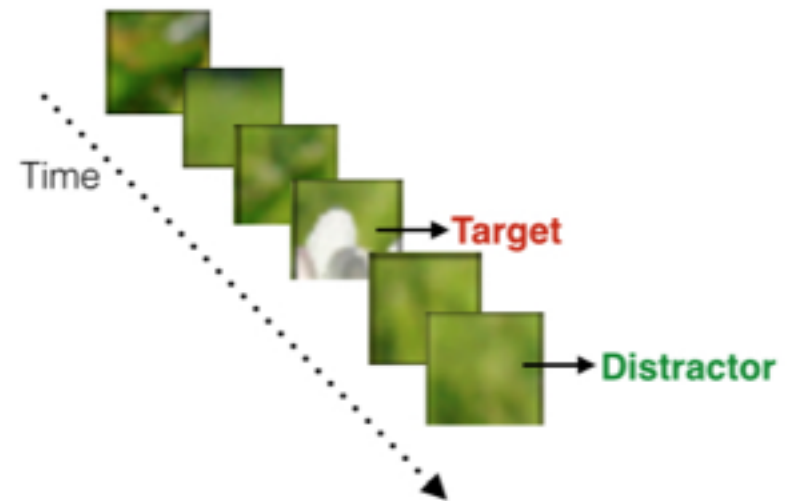
Ref: D. Fernández-Cañellas, [“Modeling temporal dependency of brain responses to rapidly stimuli in ERP based BCIs”](#) (2013)

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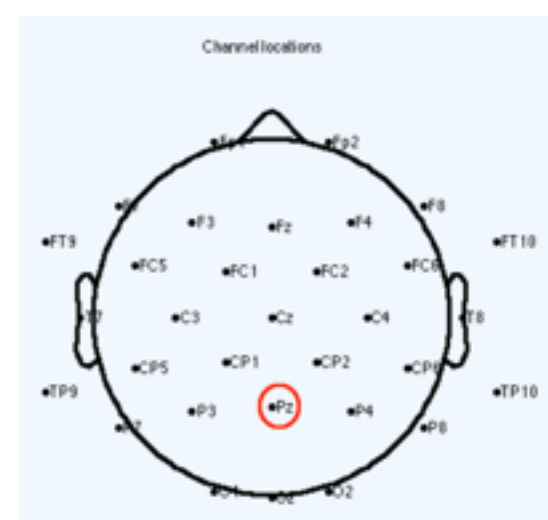
# System Proposal

- Local RSVP (5Hz visualisation windows)

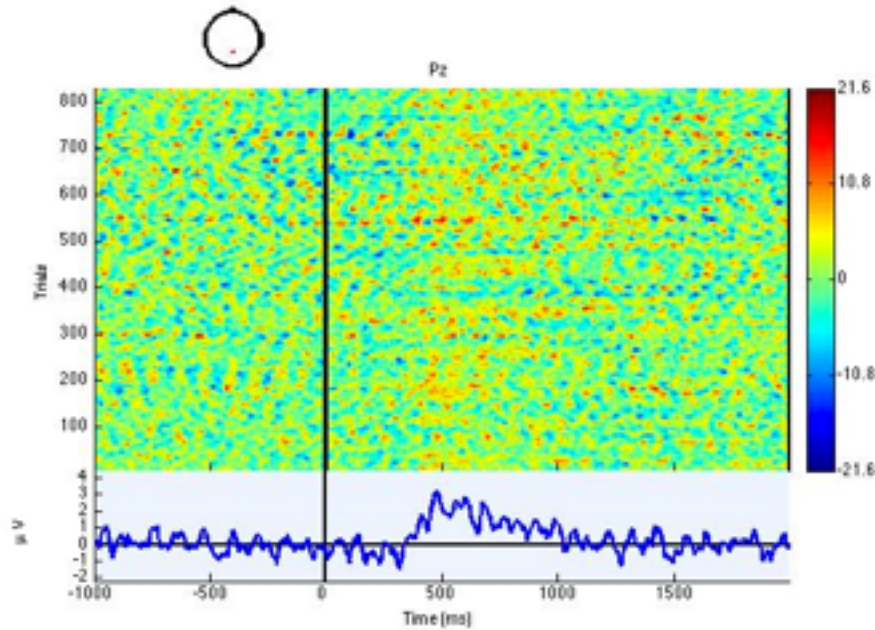


# System Proposal

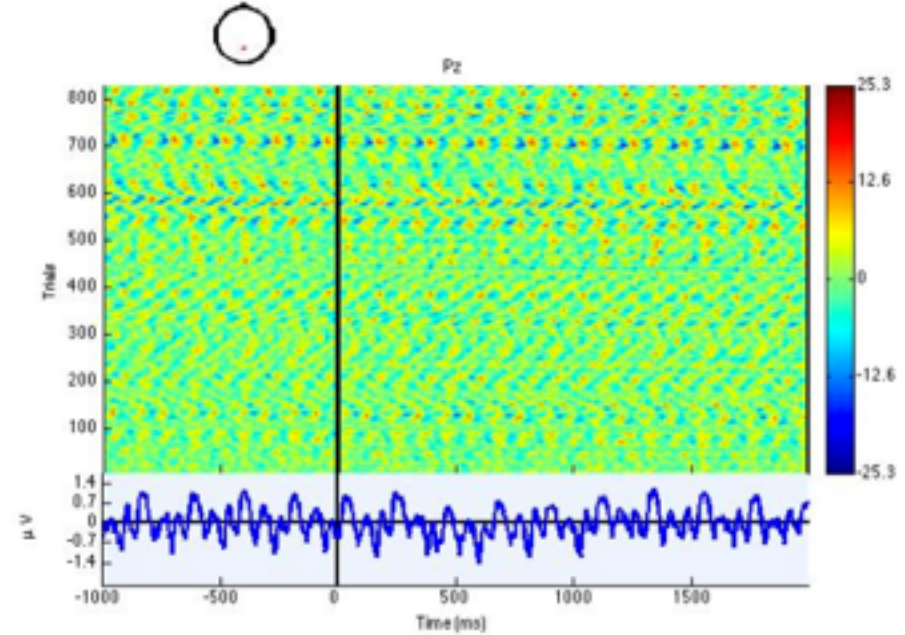
- Different Reaction after seeing a target



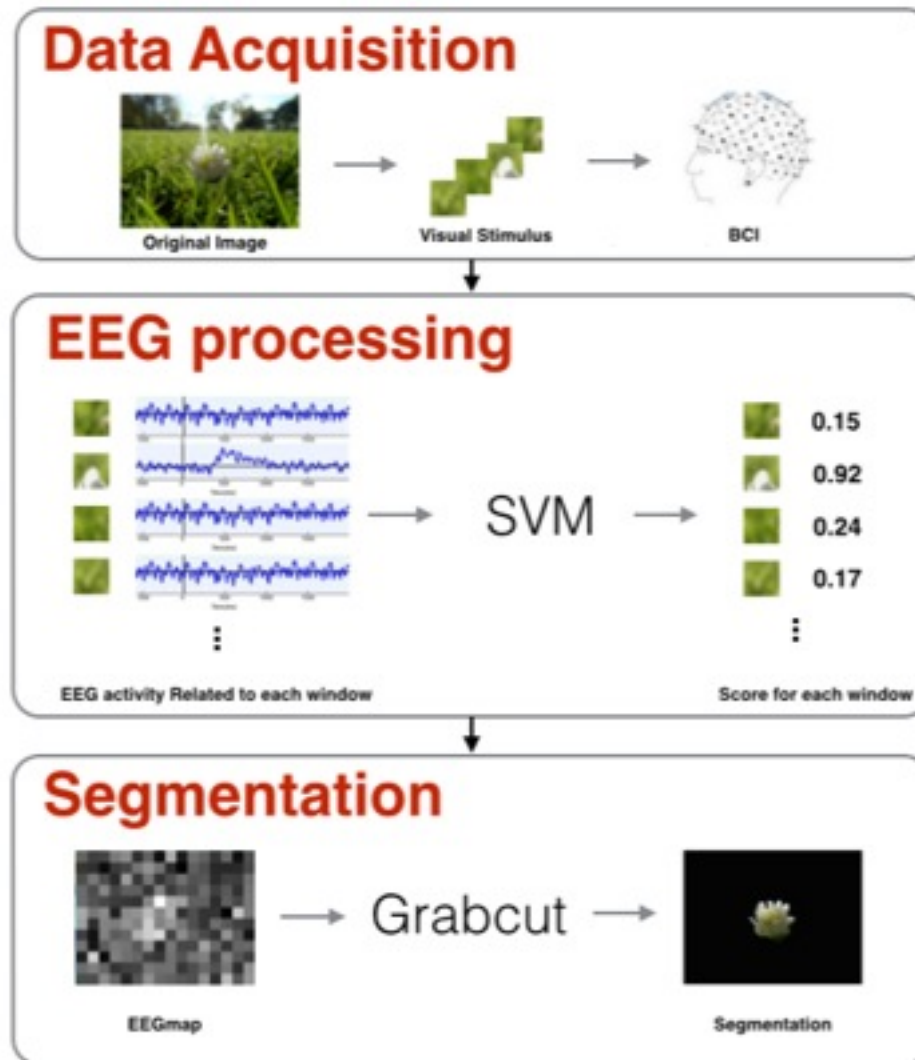
Targets



Distractors



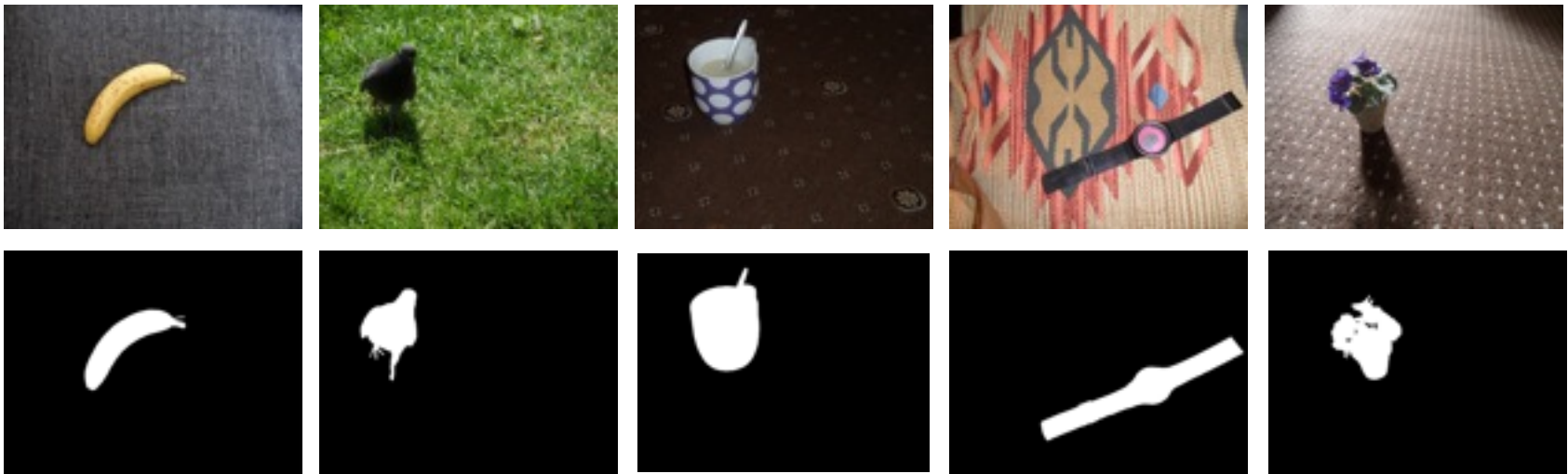
# System Proposal



# System Proposal

## Data Acquisition

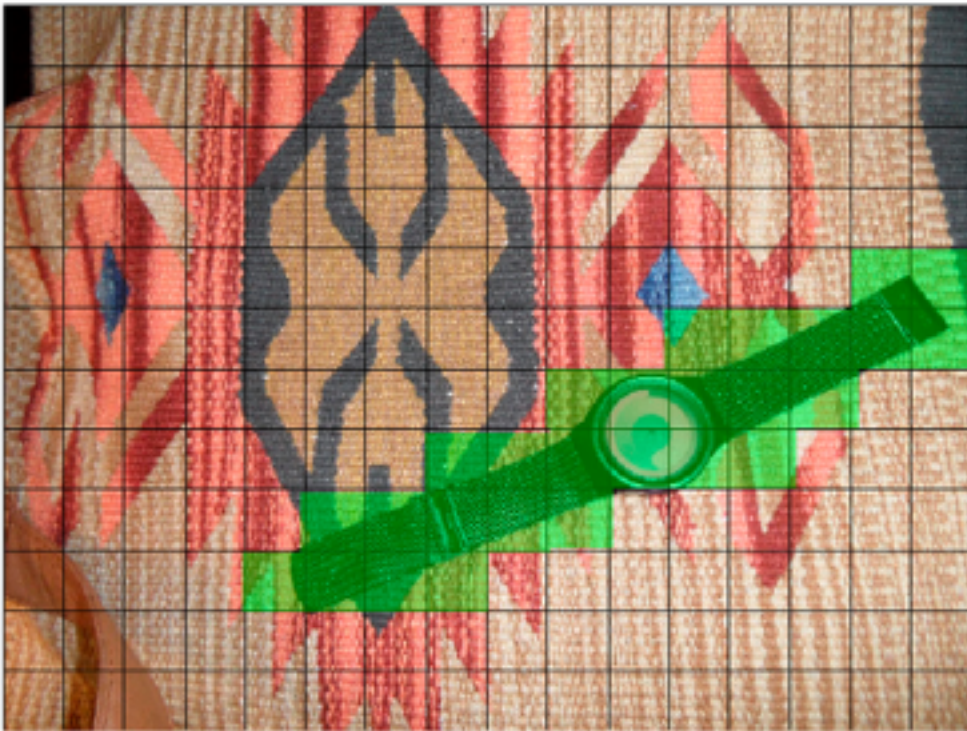
Set of **22 images** with an associated **ground truth mask**



# System Proposal

## Data Acquisition

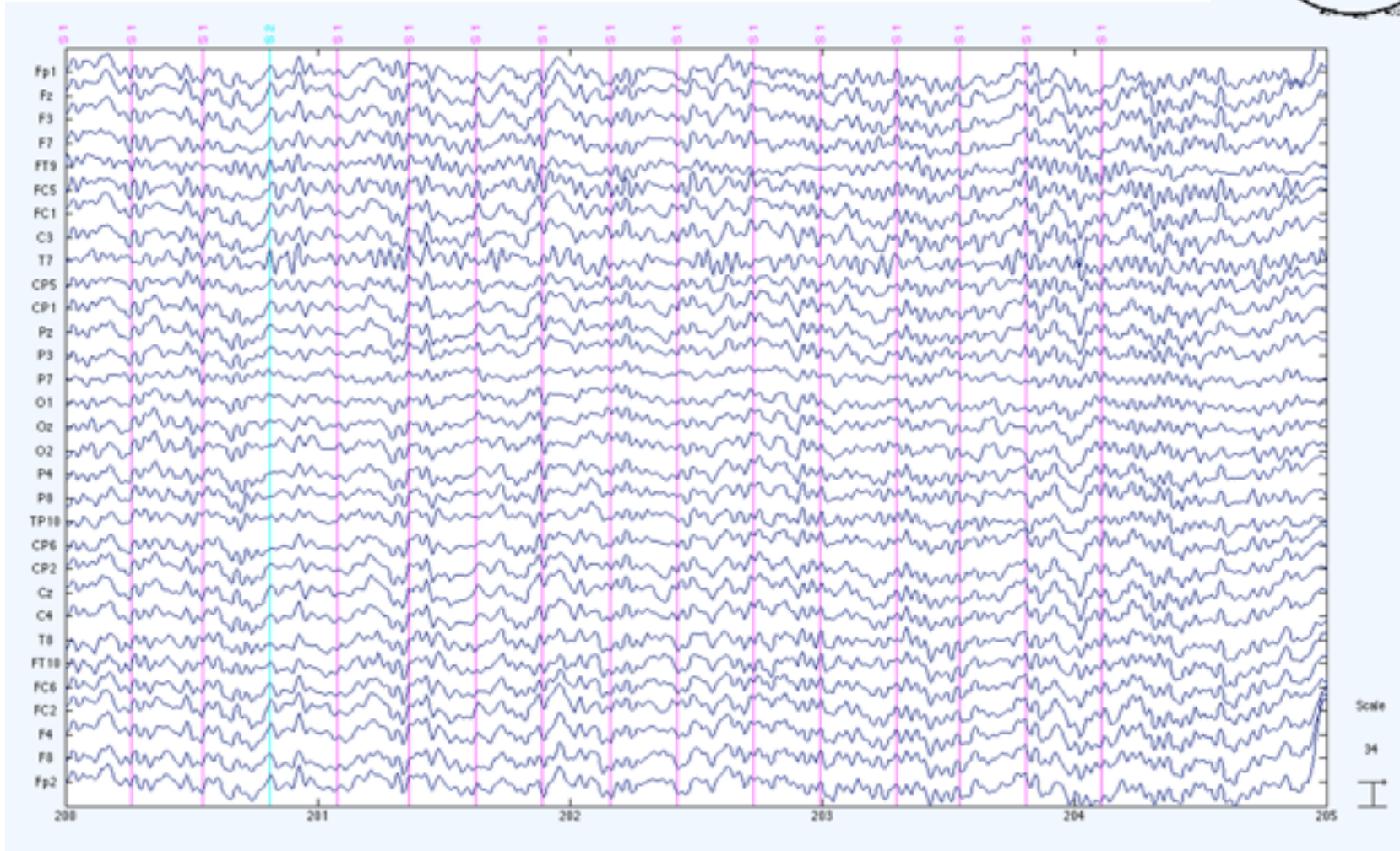
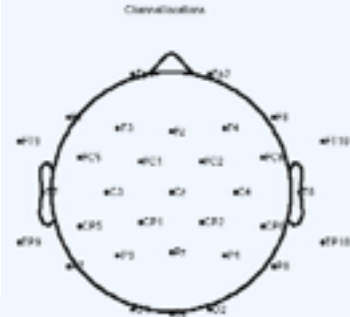
Images were partitioned into 192 non overlapped windows



- 15% Target windows
- RSVP windows at 5Hz
- User asked to count the target windows visualised

# System Proposal

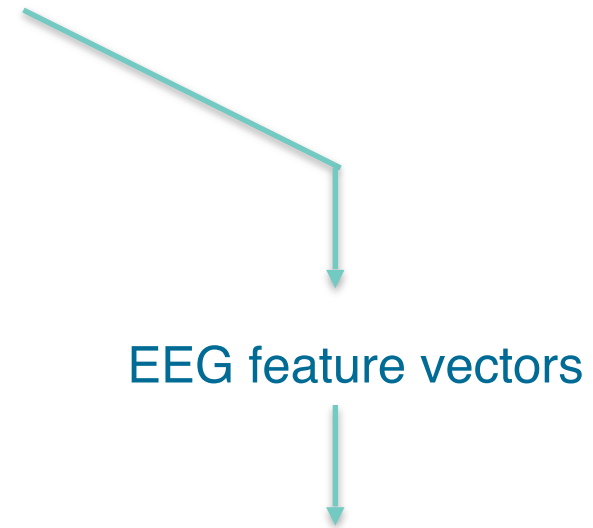
## EEG processing



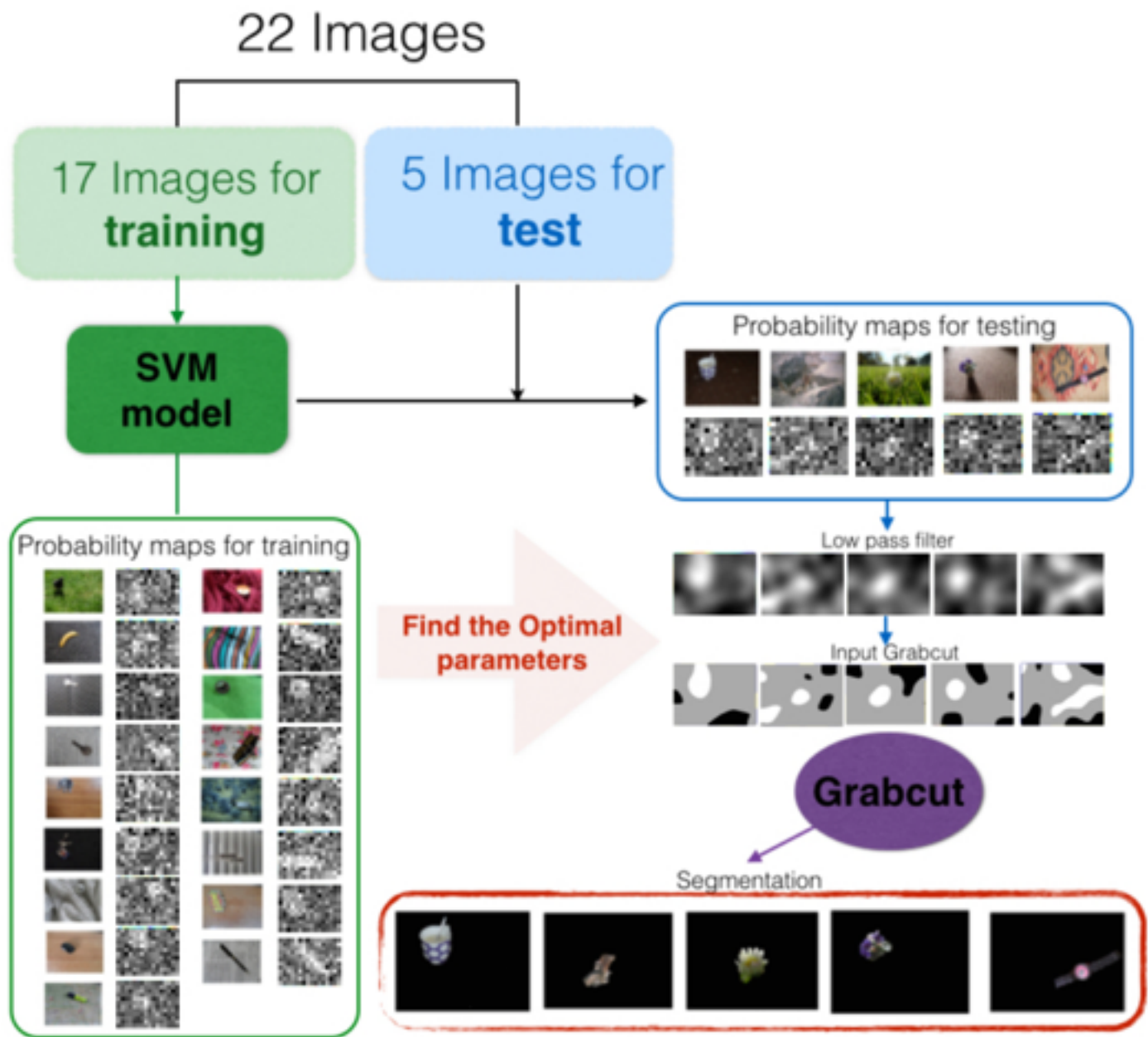
# System Proposal

## EEG processing

- 1) Down sample from 1000Hz to 250Hz
- 2) Bandpass filter 0.1-70 Hz
- 3) Cut EEG activity related to each visual event
- 4) Down sample from 250Hz to 20Hz
- 5) Concatene 31 channels (434D)



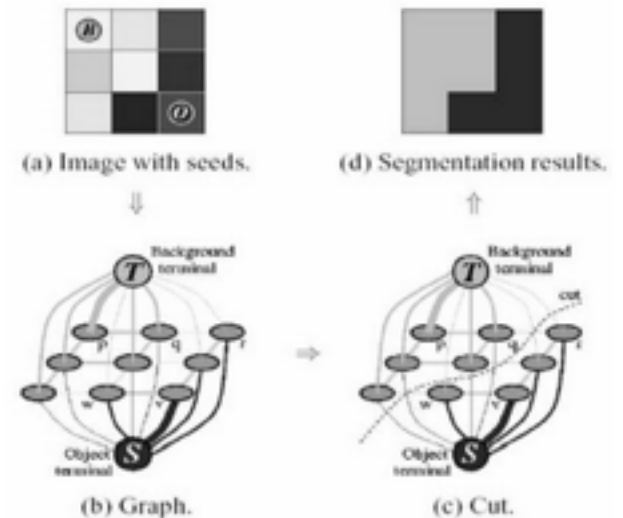
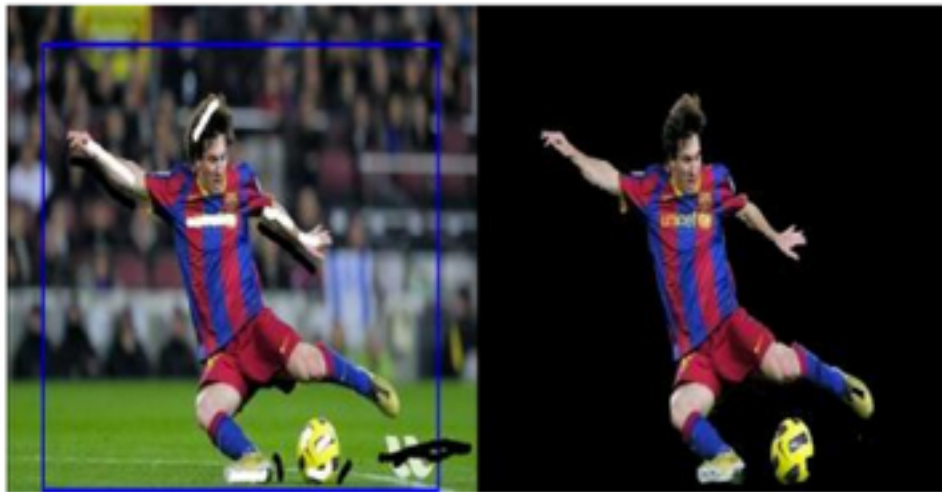
Support Vector Machine Model (SVM)



# System Proposal

## Segmentation

- GrabCut: Interactive Foreground Extraction



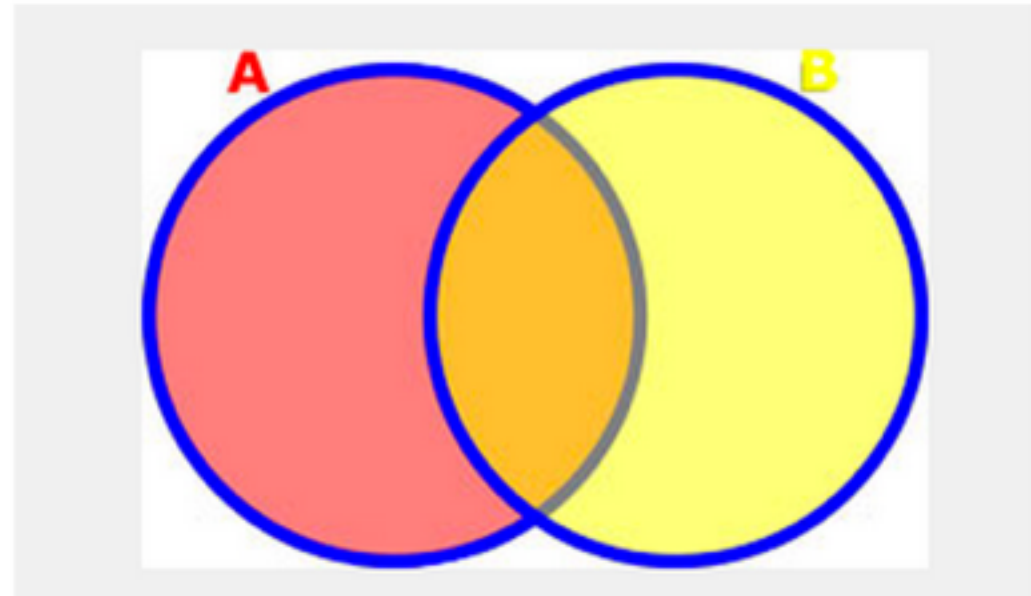
OpenCV's GrabCut Tutorial:

[http://docs.opencv.org/trunk/doc/py\\_tutorials/py\\_imgproc/py\\_grabcut/py\\_grabcut.html](http://docs.opencv.org/trunk/doc/py_tutorials/py_imgproc/py_grabcut/py_grabcut.html)

# System Proposal

Evaluation Metric: **Jaccard Index**

$$J(A, B) = \frac{|A \cap B|}{|A \cup B|}$$



Measure of similarity between the segmentation results and the ground truth mask

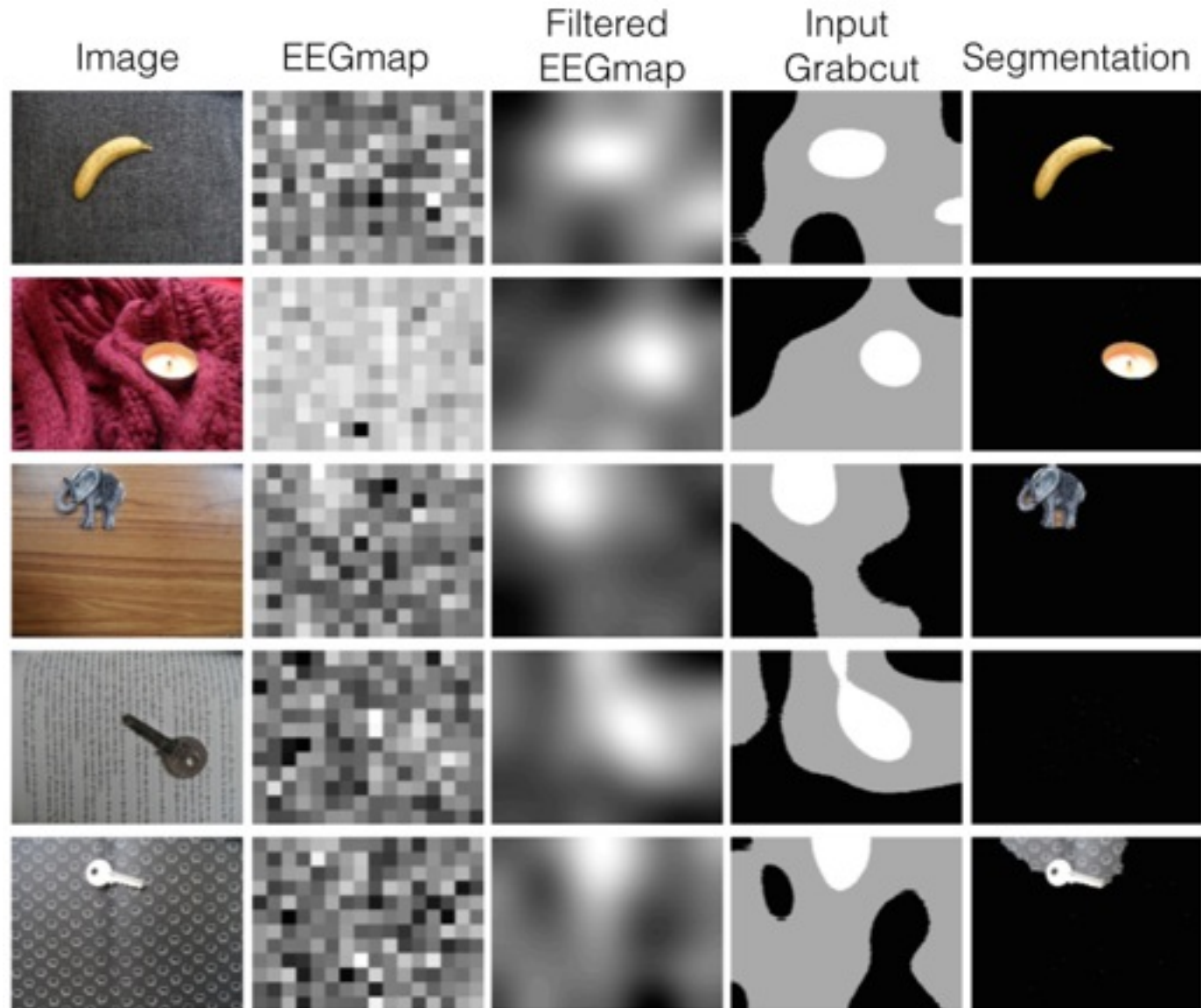
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# Results

- Single User

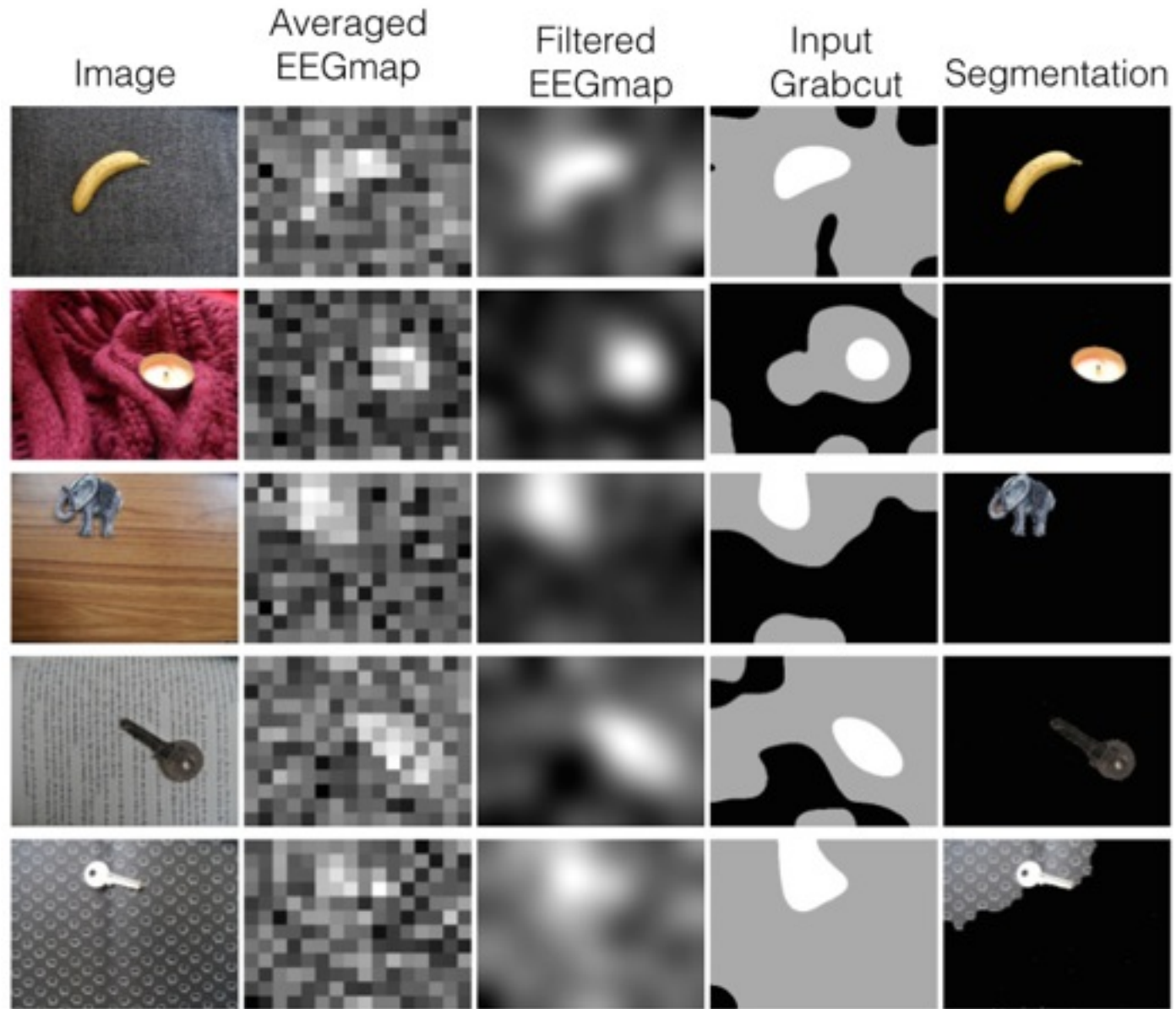
Jaccard Index = 0.47



# Results

- **Averaged Users**

Jaccard Index = 0.72



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# Conclusions



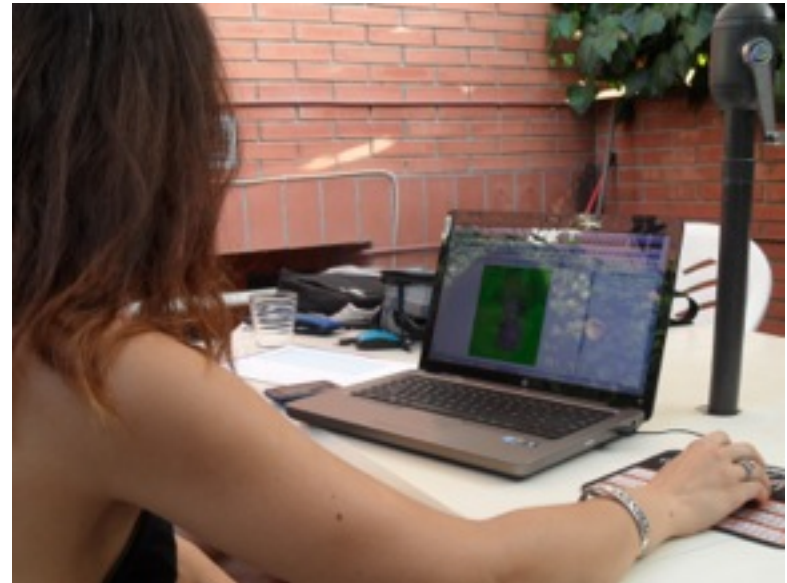
**The approach is feasible:** it is possible to use BCI as an interactive segmentation method based on simple EEG processing.

# Conclusions

## BCI Interaction for segmentation



## Mouse Interaction for segmentation



BCI is time consuming  
Mouse interaction provides better results

# Future work

- Improvements in EEG processing
- Change resolution of windows
- Use object candidates instead of a grid
- Active search
- Combine local EEG with eye tracker

# Thank you!

Questions?

This publication resulted from research conducted with the financial support of Science Foundation Ireland (SFI) under grant number SFI/12/RC/2289 and partially funded by the Project TEC2013-43935-R BigGraph of the Spanish Government.