



A Top-Down Attentional System scanning multiple targets with saccades

CCNCV 2007

Jeremy Fix, Nicolas P. Rougier, Frederic Alexandre.
contact : Jeremy.Fix@Loria.fr

INRIA Lorraine
Campus Scientifique - BP 239
54506 Vandoeuvre-lès-Nancy Cedex, FRANCE

Outline

- 1** The psychological and physiological bases
 - Visual search
 - Visual search and visual attention
 - Eye movements
 - Current approaches
 - Summary
- 2** The computational bases
 - An example of task to solve
 - Model's architecture
 - Simulation and results
- 3** Conclusion

An example of task to solve

▸ Screenshots

Outline

- 1 The psychological and physiological bases
 - Visual search
 - Visual search and visual attention
 - Eye movements
 - Current approaches
 - Summary
- 2 The computational bases
 - An example of task to solve
 - Model's architecture
 - Simulation and results
- 3 Conclusion

Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- Eye movements
- Current approaches
- Summary

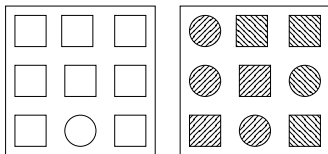
2 The computational bases

- An example of task to solve
- Model's architecture
- Simulation and results

3 Conclusion

How the brain may processes the visual information

- The brain extracts basic features from the visual information. Two modes of visual search are distinguished :
 - feature search : the time to find the target **doesn't depend** on the number of stimuli
 - conjunction search : the time to find the target **depends** on the number of stimuli



A. Treisman and G. Gelade (1980), *Cognitive Psychology*
J. Duncan, G.W. Humphreys (1989), *Psychological Review*
J.M. Wolfe (1998), *Attention*, UK College Press

How the brain may processes the visual information

- This information follows two pathways :
 - What pathway : extracts and processes the features information
 - Where pathway (or How pathway) : extracts and processes the spatial information

L. Ungerleider and M. Mishkin (1982), *Analysis of Visual Behavior*.

M.A. Goodale and A.D. Milner (1992), *Trends in Neuroscience*.

Outline

1 The psychological and physiological bases

- Visual search
- **Visual search and visual attention**
- Eye movements
- Current approaches
- Summary

2 The computational bases

- An example of task to solve
- Model's architecture
- Simulation and results

3 Conclusion

Visual search and visual attention

Visual search is closely linked to visual attention.

Visual attention can be defined as the property to select the relevant informations from what is perceived.

Two modes of visual attention are considered :

- Feature attention
- Spatial attention
 - covert mode : no eye movement is initiated
 - overt mode : involves an eye movement to center an object on the fovea

Reynolds 1999, Treue 1996, Desimone 1995, Motter 1994, Chelazzi 1993

Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- **Eye movements**
- Current approaches
- Summary

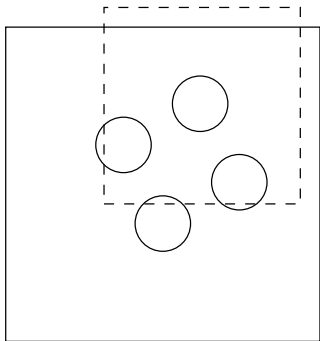
2 The computational bases

- An example of task to solve
- Model's architecture
- Simulation and results

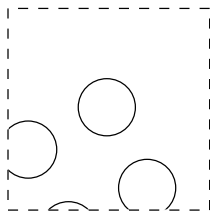
3 Conclusion

A Simple visual search experiment

Real World

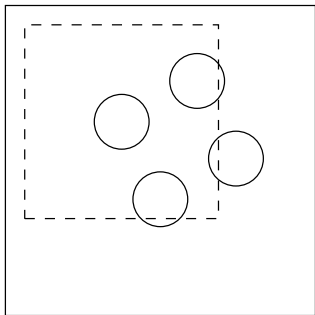


What is perceived

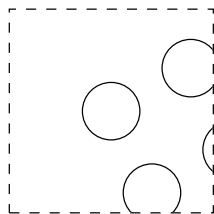


A Simple visual search experiment

Real World

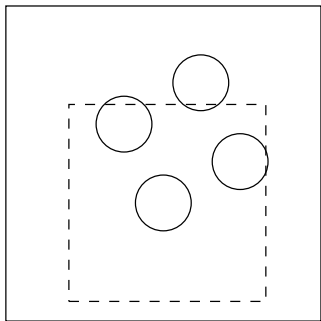


What is perceived

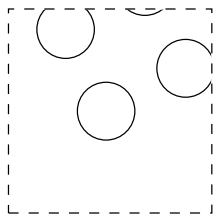


A Simple visual search experiment

Real World

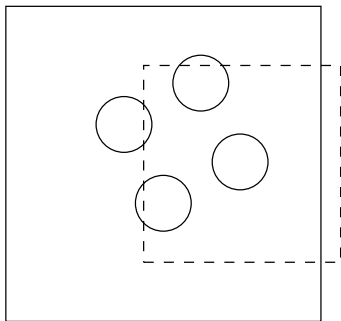


What is perceived

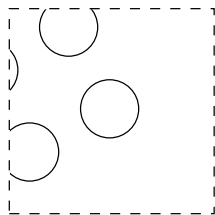


A Simple visual search experiment

Real World



What is perceived



Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- Eye movements
- **Current approaches**
- Summary

2 The computational bases

- An example of task to solve
- Model's architecture
- Simulation and results

3 Conclusion

The current approaches

Over the past few years, several models of visual attention relies on two central notions

- Saliency map (Koch et Ullman) : represents the behavioral relevance of the locations in the visual field
- inhibition of return (Posner) : memorizes the scanned locations and inhibits them in saliency map

In general, the current models do not take into account **the eye movements**.

- static visual input
- covert mode of attention

Koch et al., Tsotsos et al., Wolfe , Itti et al., Hamker

Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- Eye movements
- Current approaches
- Summary

2 The computational bases

- An example of task to solve
- Model's architecture
- Simulation and results

3 Conclusion

- Feature Integration Theory
 - filters for basic features
- Two processing pathways
 - feature information
 - spatial information
- Two kinds of attention
 - feature attention
 - spatial attention
- Saliency map, inhibition of return
 - Spatial competition among relevant locations
 - scanned locations memorized to bias that competition
- Anticipatory update of spatial representations
 - efferent copy of the eye movement to update the memory

Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- Eye movements
- Current approaches
- Summary

2 The computational bases

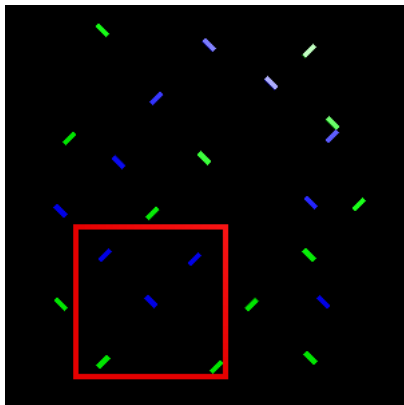
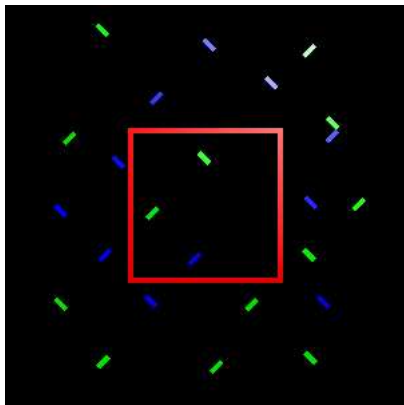
- An example of task to solve
- Model's architecture
- Simulation and results

3 Conclusion

Outline

- 1 The psychological and physiological bases
 - Visual search
 - Visual search and visual attention
 - Eye movements
 - Current approaches
 - Summary
- 2 The computational bases
 - An example of task to solve
 - Model's architecture
 - Simulation and results
- 3 Conclusion

An example of task to solve



Outline

1 The psychological and physiological bases

- Visual search
- Visual search and visual attention
- Eye movements
- Current approaches
- Summary

2 The computational bases

- An example of task to solve
- **Model's architecture**
- Simulation and results

3 Conclusion

The model combines three computational models :

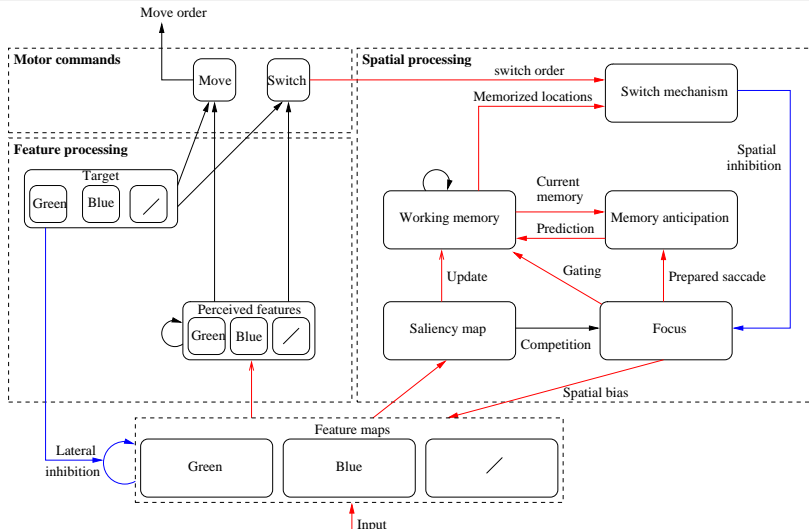
- A computational model of visual attention proposed by [Hamker, 2005]
- A computational model of working memory and dynamic switch [Vitay et Al., 2005]
- An extension of the previous model that anticipates the visual consequences of an eye movement [Fix et al., 2006]

Hamker (2005), *Computer Vision and Image Understanding*.

Vitay et Al. (2005), *Biomimetic Neural Learning for Intelligent Robotics*

Fix et Al. (2006), *Post-workshop proceedings - ABIALS 2006 (to appear)*

The architecture of the model



The mathematical basis of the model (1/2)

The maps in the model consist of basic units, called neurons, whose activity satisfies (1).

$$\tau \cdot \frac{\partial u(x, t)}{\partial t} = -\alpha \cdot u(x, t) + \sum_M w_M(x - x') u(x', t) + \sum_{M'} s(x, y) \cdot u(y, t) \quad (1)$$

$$w_M(x - x') = A \cdot e^{-\frac{\|x - x'\|^2}{a^2}} - B \cdot e^{-\frac{\|x - x'\|^2}{b^2}} \text{ with } A, B, a, b \in \mathbb{R}^{+*} \quad (2)$$

Dynamical study of formation of cortical map, S.I. Amari, *Biological Cybernetics*, 1977.

Neural bubble dynamics in two dimensions, J.G. Taylor, *Biological Cybernetics*, 1999.

The mathematical basis of the model (2/2)

We also use Sigma Pi units in the anticipation map, whose activity satisfies (3).

$$\tau \cdot \frac{\partial u(x, t)}{\partial t} = -u(x, t) + \sum_M w_M(x - x') u(x', t) + \sum_{i \in I} w_i \cdot \prod_{y \in M_i'} u(y, t) \quad (3)$$

A general framework for parallel distributed computing, D. Rumelhart and al., *Journal of Neuroscience*, 1987.

Outline

1 The psychological and physiological bases

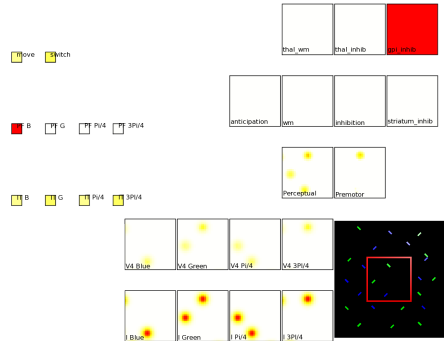
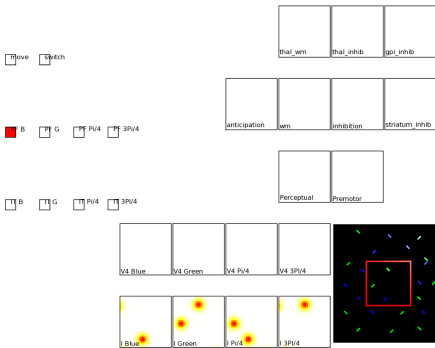
- Visual search
- Visual search and visual attention
- Eye movements
- Current approaches
- Summary

2 The computational bases

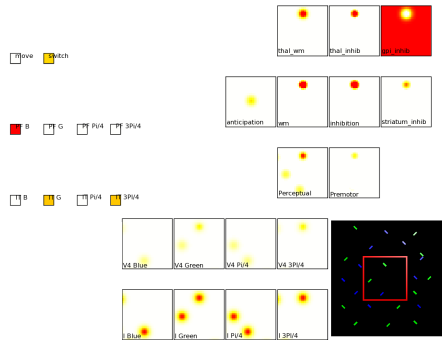
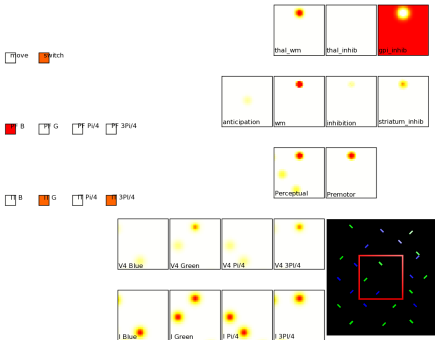
- An example of task to solve
- Model's architecture
- **Simulation and results**

3 Conclusion

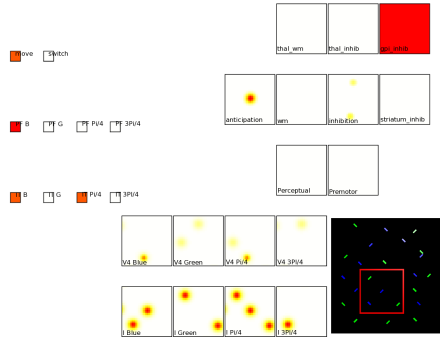
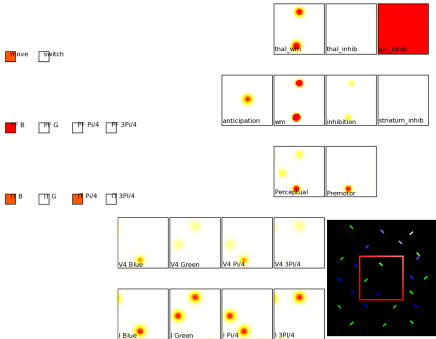
Screenshots of the model



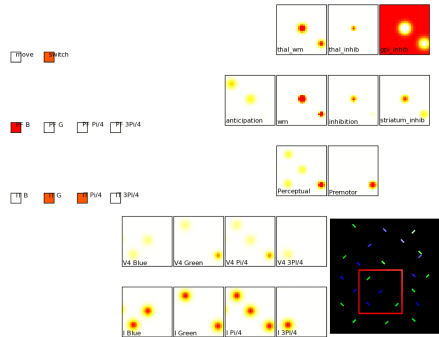
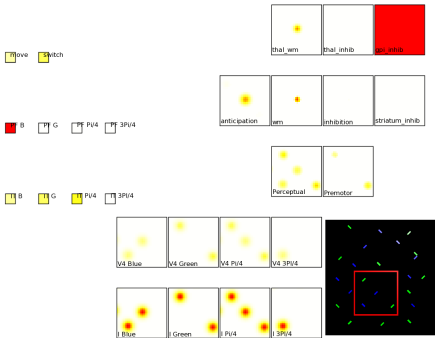
Screenshots of the model



Screenshots of the model



Screenshots of the model



▶ Video

Outline

- 1 The psychological and physiological bases
 - Visual search
 - Visual search and visual attention
 - Eye movements
 - Current approaches
 - Summary
- 2 The computational bases
 - An example of task to solve
 - Model's architecture
 - Simulation and results
- 3 Conclusion

Conclusion - Perspectives

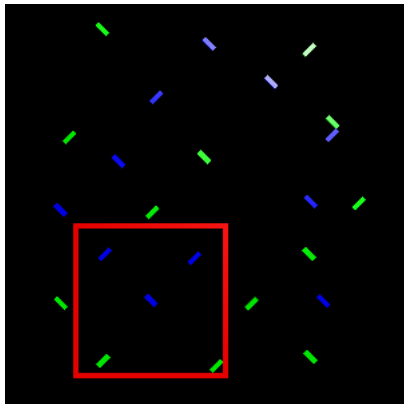
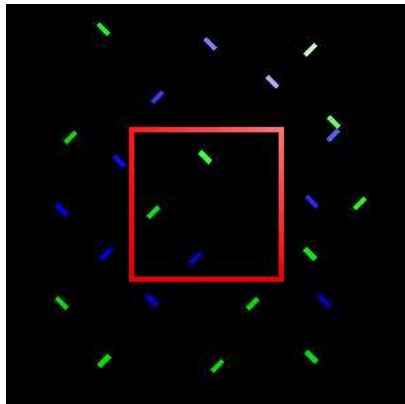
- Scan the stimuli in covert or overt mode to find a target
- Scalability, Distributed asynchronous numerical computations
- Biological plausibility
 - ↪ Increasing the number of features, and combining them
 - ↪ Adding a real visual module to work with natural images
 - ↪ Extending the memory
 - ↪ Extending the model to object recognition tasks

Thank you for your attention.
Any questions?

Jeremy Fix, Nicolas P. Rougier, Frederic Alexandre.

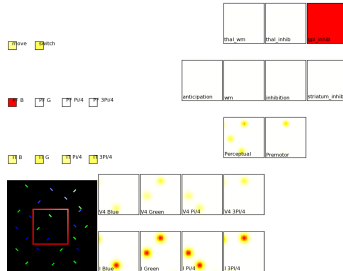
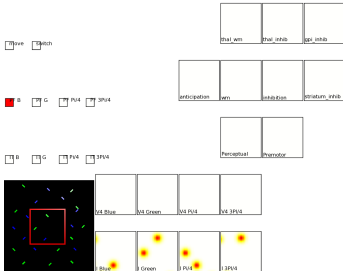
Contact : Jeremy.Fix@Loria.fr

An example of task to solve

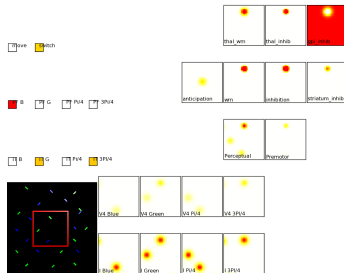
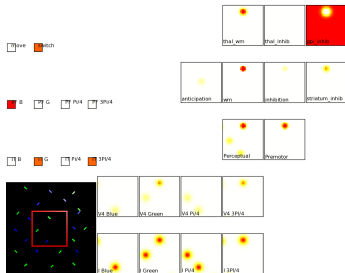


▶ Back

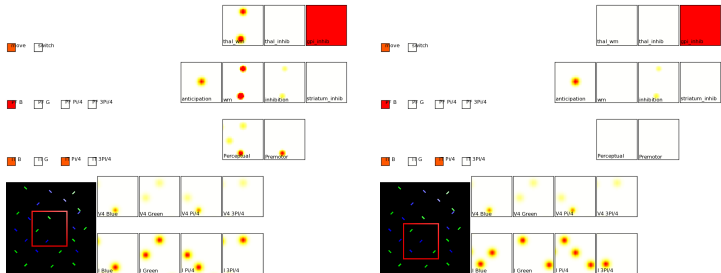
Screenshots of the model



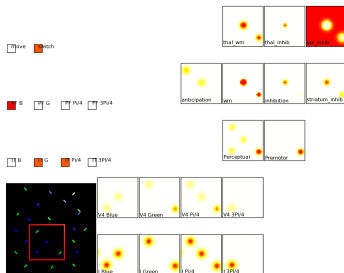
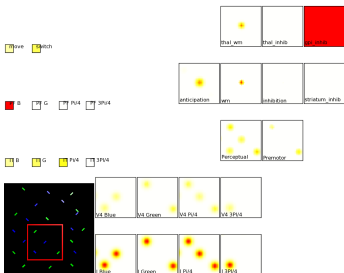
Screenshots of the model



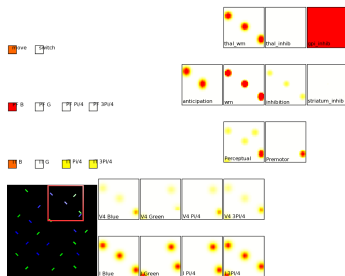
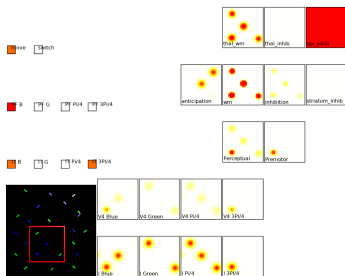
Screenshots of the model



Screenshots of the model



Screenshots of the model



▶ Back