

Models of Visual Attention

International Lecture Serie

Nicolas P. Rougier
(ニコラ ルジエ)

INRIA
National Institute for Research
in Computer Science and Control

国立情報学研究所
National Institute of Informatics
Tokyo, December 3, 2010

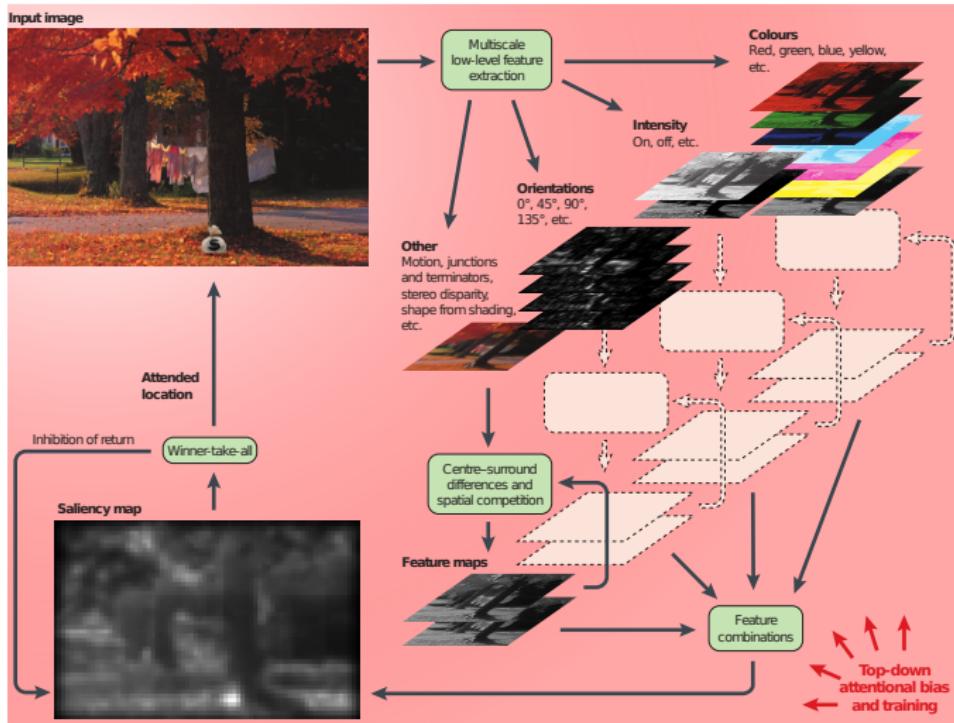
Outlook

- ① A model of saliency-based visual attention
- ② A model of visual tracking
- ③ A model of covert attention
- ④ A model of overt attention
- ⑤ A model of covert and overt attention
- ⑥ A step further
- ⑦ Conclusion

A model of saliency-based visual attention (Itti & Koch, 2001)

A model of saliency-based visual attention

(Itti & Koch, 2001)



A model of saliency-based visual attention

(Itti & Koch, 2001)



Evolution of saliency map

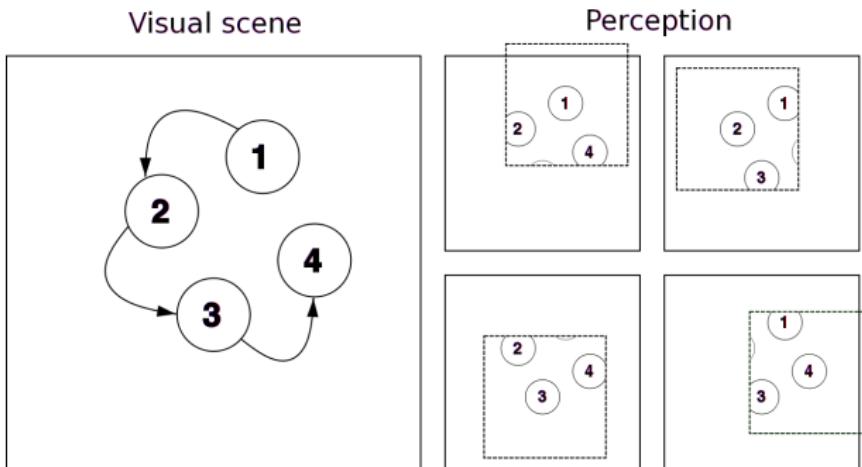


Traffic signs detection

A model of saliency-based visual attention

(Itti & Koch, 2001)

Making saccades



Occular saccades lead to drastic changes in visual perception.

A model of visual tracking

(Rougier & Vitay, 2005)

A model of visual tracking

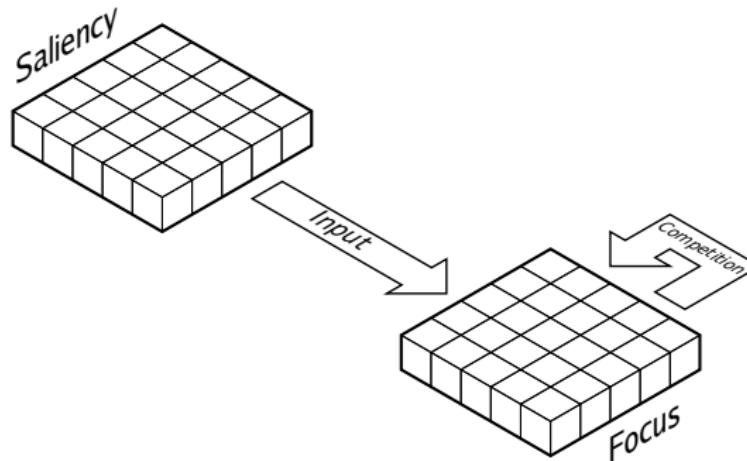
(Rougier and Vitay, 2005)

Evolution of neuronal activity

$$\tau \times \frac{\partial u(x, t)}{\partial t} = -u(x, t) + \int w(x - y) f[u(y)] dy + h + s(x, t)$$

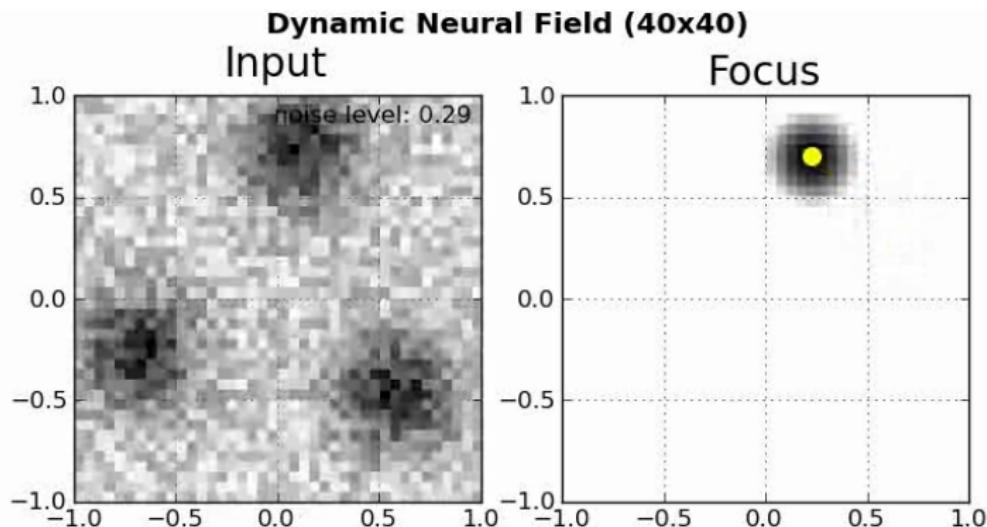
Lateral connectivity

Difference of Gaussian with short range excitations and long range inhibitions



A model of visual tracking

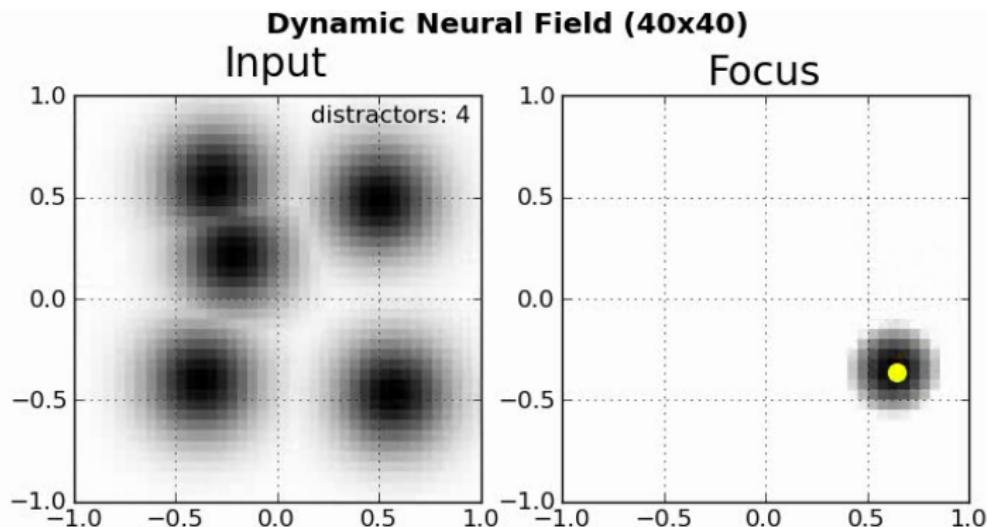
Robustness to random noise



(<http://www.loria.fr/~rougier/research/movies/noise-high.avi>,
<http://www.loria.fr/~rougier/research/src/attention-noise.py>)

A model of visual tracking

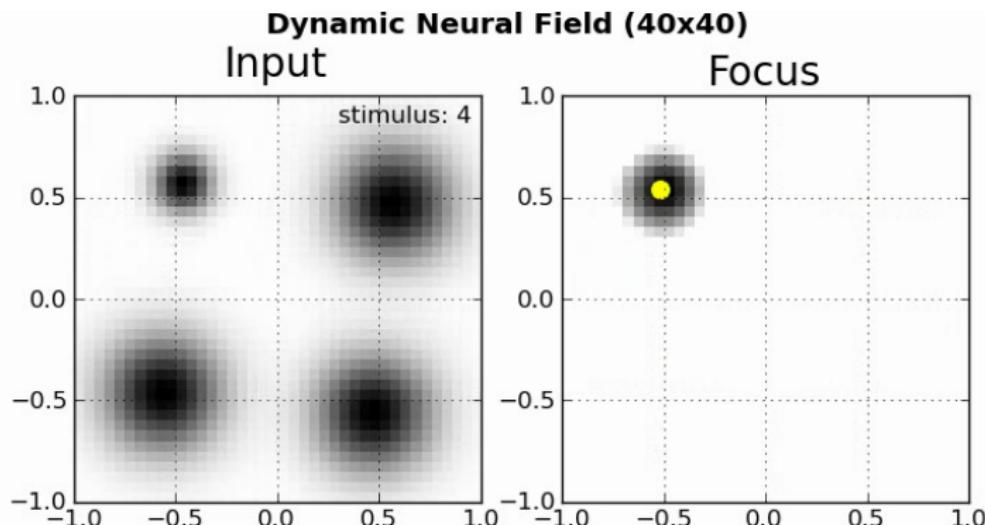
Robustness to distractors



(<http://www.loria.fr/~rougier/research/movies/distractors-high.avi>,
<http://www.loria.fr/~rougier/research/src/attention-distractors.py>)

A model of visual tracking

Robustness to saliency



(<http://www.loria.fr/~rougier/research/movies/saliency-high.avi>,
<http://www.loria.fr/~rougier/research/src/attention-saliency.py>)

A model of visual tracking

Roger and the orange



(<http://www.loria.fr/~rougier/research/movies/INRIA.mpeg>)

A model of visual tracking

Properties

- A simple model of visual tracking
- Emergent properties of units interactions
- Dynamic behavior based on distributed and numerical computations
- Robustness to noise, distractors and saliency

However...

- Reactive behavior
- Cannot disengage attention

A model of covert attention

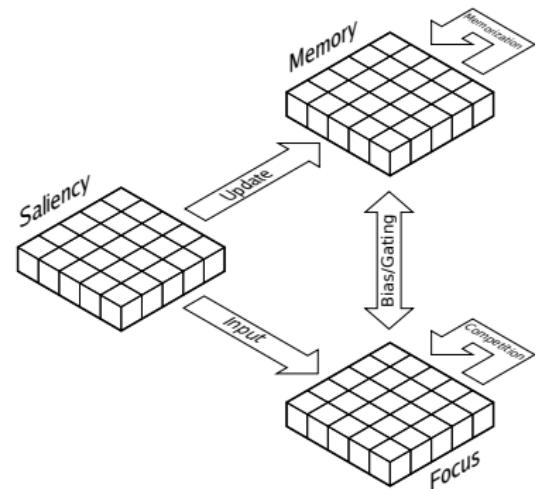
(Vitay & Rougier, 2005)

A model of covert attention

(Vitay & Rougier, 2005)

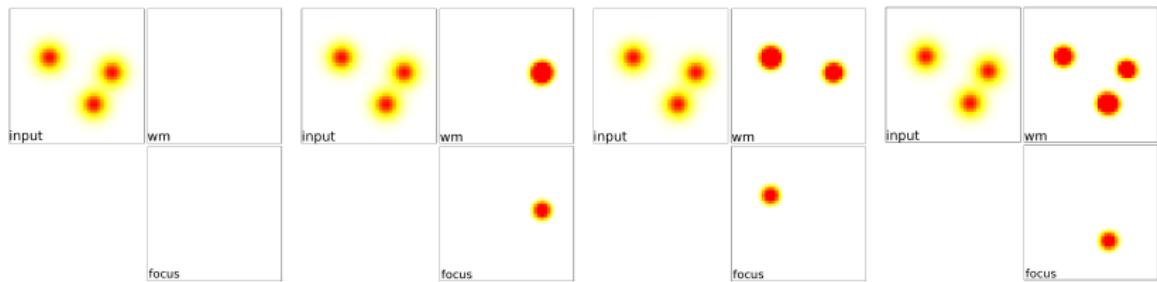
Working memory

- Gating is done using focus map as the gate
- Memory is continuously updated by perception
- Memory biases competition within focus



Working memory

The focus map serves a gate between input and working memory. When a stimulus is focused, it enters working memory and a dynamic bind now exists between working memory and input.

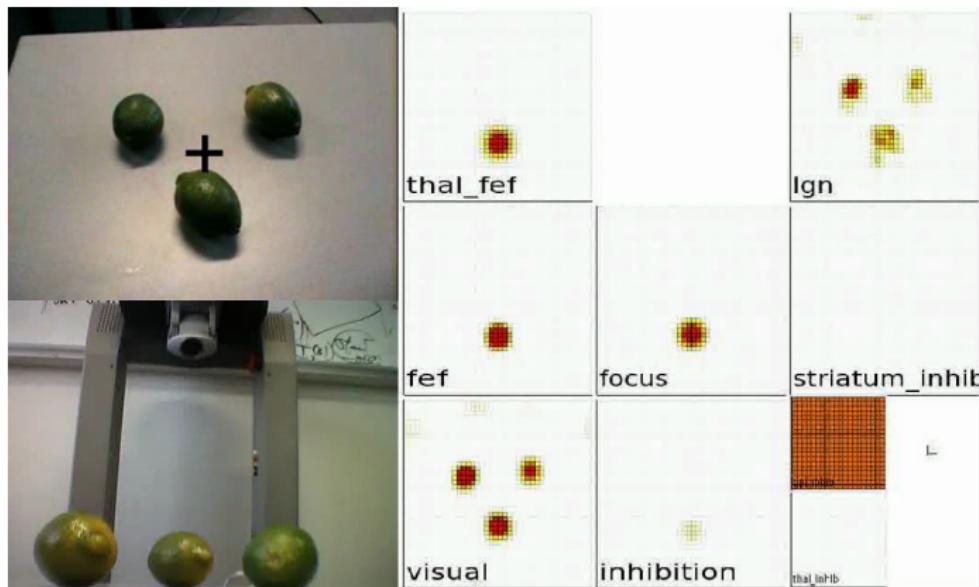


Any memorized stimulus will be now dynamically updated regarding the corresponding stimulus within the input.

A model of covert attention

(Vitay & Rougier, 2005)

Roger and the lemons



(<http://www.loria.fr/~rougier/research/movies/lemons.mpeg>)

A model of covert attention

(Vitay & Rougier, 2005)

Properties

- Actual control of attention switch
- Deals with moving targets
- Efficient serial search

However...

- Still reactive behavior
- Cannot cope with actual saccades

A model of overt attention (Fix et al., 2007)

A model of overt attention

(Fix et al., 2007)

Spatial reference

- Independent of eye movements
- Eye-centered

Action in perception

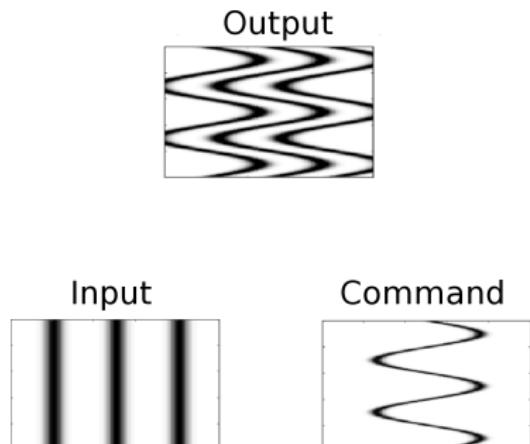
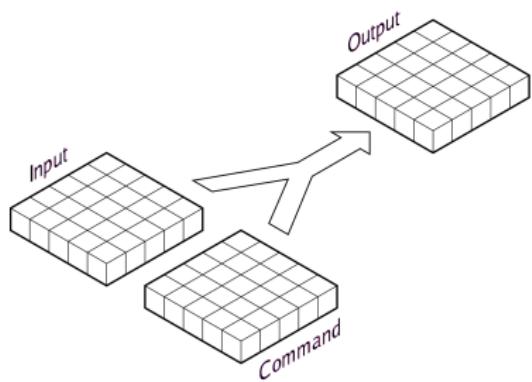
- To anticipate the consequences of own actions
- To update working memory accordingly

A model of overt attention

(Fix et al., 2007)

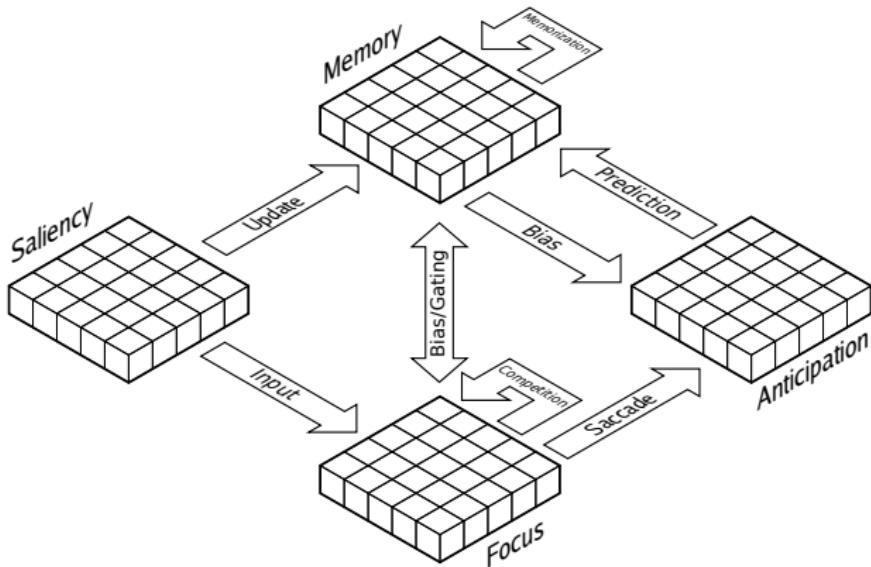
Anticipation

- Gain field mechanism
- Sigma-Pi connections



A model of overt attention

(Fix et al., 2007)

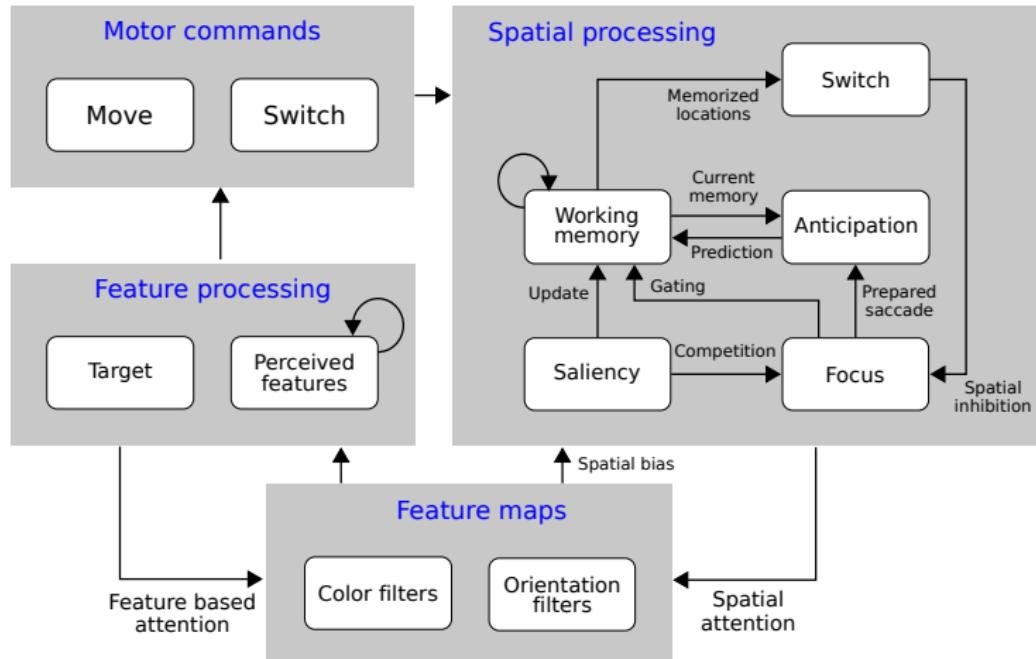


A model of covert and overt attention

(Fix et al., 2010)

A model of covert and overt attention

(Fix et al., 2010)

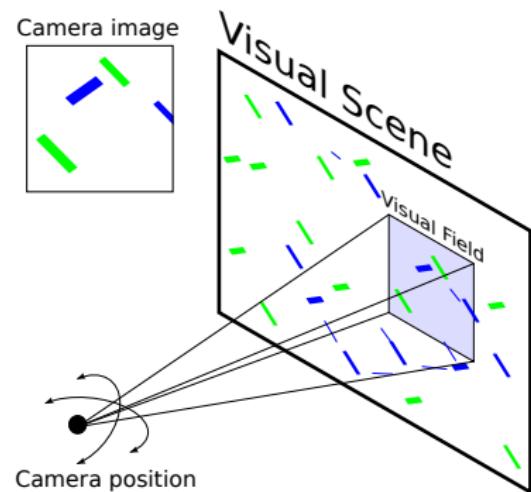


A model of covert and overt attention

(Fix et al., 2010)

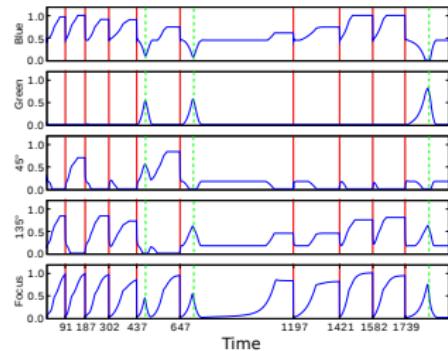
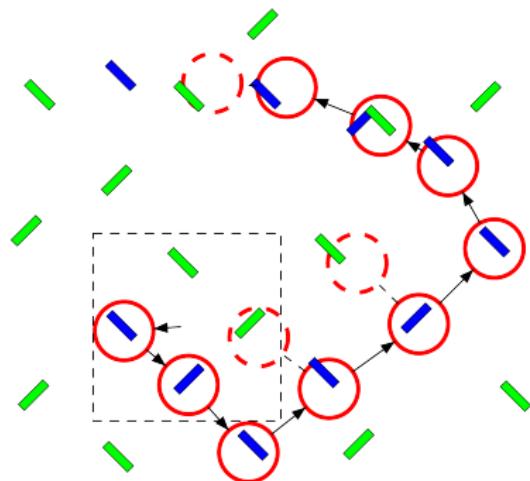
Search task

The camera is placed in front of a visual scene and is able to pan and tilt. The task can be either to look for a specific orientation or colour or to look for a conjunction of such features.



A model of covert and overt attention

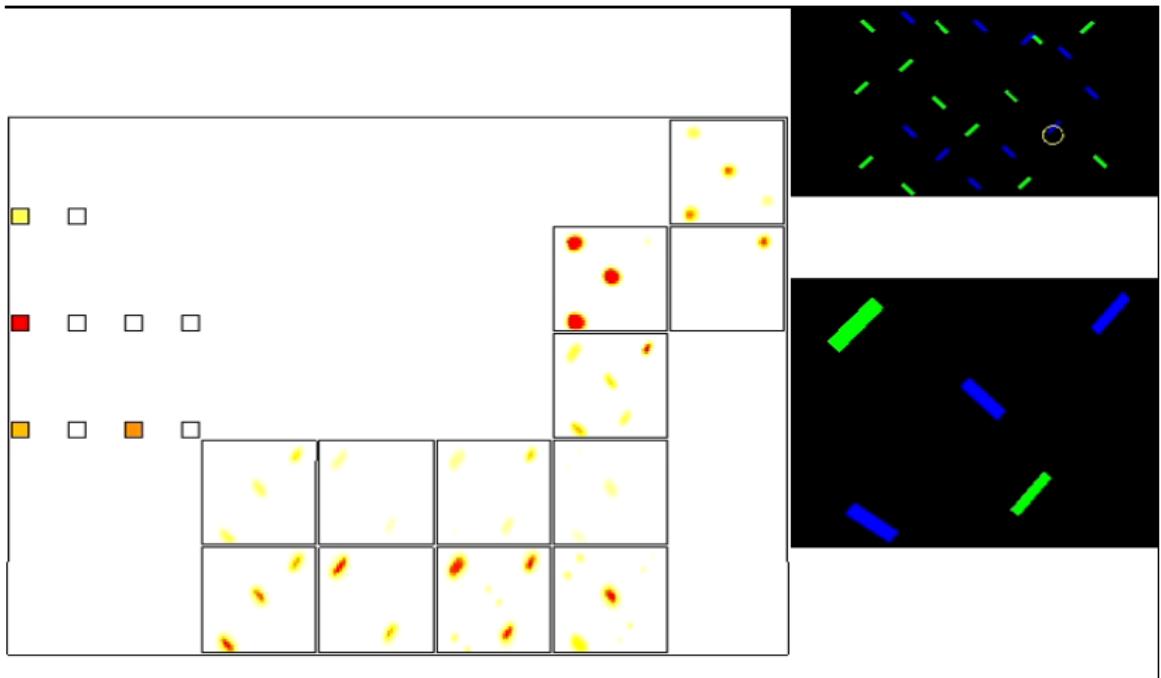
(Fix et al., 2010)



- Feature based attention facilitates processing of relevant features
- Spatial based attention facilitates processing of relevant region
- Working memory prevents to explore already seen location
- Model exhibits both overt and covert attention using same substrate

A model of covert and overt attention

(Fix et al., 2010)



(<http://jeremy.fix.free.fr/Publications/JPhysiol/Videos/overt.mpg>)

A step further

(ongoing work)

Toward the organization of visual behavior

(ongoing work)

From an automated behavior...

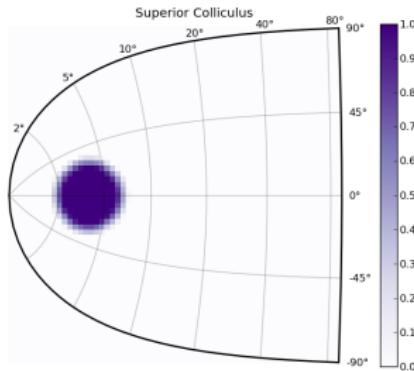
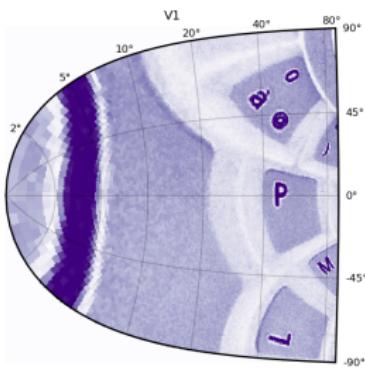
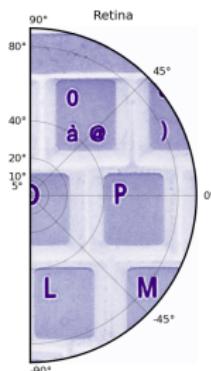
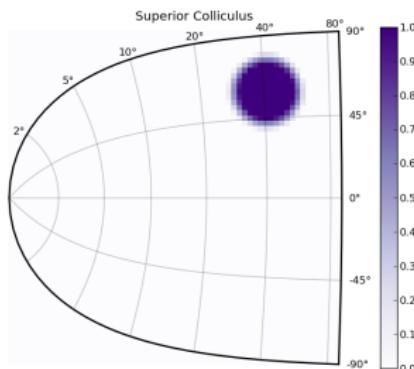
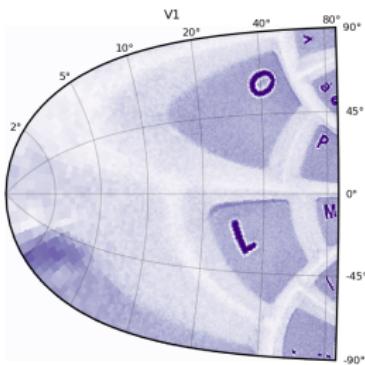
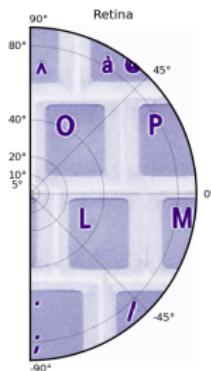
- Visual attention can be spatially or featurally biased
- Most salient stimulus are likely to be attended
- How to circumvent this *automated* behavior

...to a motivated one

- To consider saccadic behavior as a motivated exploration
- To make hypothesis about the world make saccades to try to confirm them

The deep superior colliculus

(Taouali et al., 2010)



From sensory to motor coding

(ongoing work)

Perception in action (Gibson, 1979)

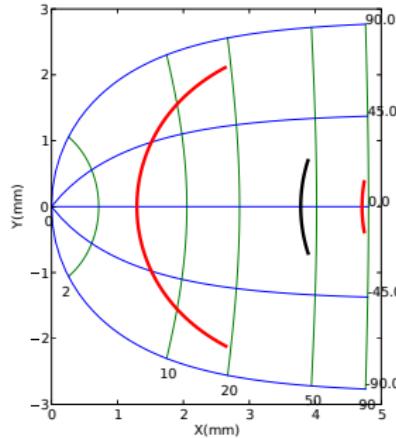
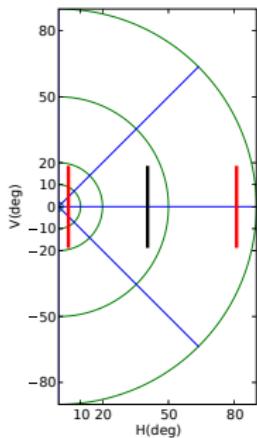
- Without perception action would be unguided
- Without action perception would serve no purpose

Sensori-motor account on vision (O'Regan & Noë, 2001)

- To refute the hypothesis of an internal representation of the world
- The outside world serves as its own, external representation
- To master the laws of sensorimotor contingency

From sensory to motor coding

(ongoing work)



- From a sensory perspective, a line is not perceived as a line in V1
- A line is invariant by translation along the main axis
→ property of the physical world, independent of the visual apparatus
- From a motor perspective, a line can be described as a simple linear movement

Conclusion

Perception is not something that happens to us, or in us. It is something we do.

(Noë, 2005)

Thanks to my colleagues and students



Frédéric Alexandre
Researcher, INRIA



Julien Vitay
Former PhD student



Jérémie Fix
Former PhD student



Wahiba Taouali
PhD student

Bibliography

- Rougier, N.P. and Vitay, J. (2006) *Emergence of Attention within a Neural Population*, Neural Networks, volume 19, number 5, pp 573-581.
- Itti, L., Koch, C. (2001). *Computational modeling of visual attention*, Nature Review Neuroscience 2 194—203.
- Fix, J., Rougier, N., Alexandre, F. (2007). *From physiological principles to computational models of the cortex*, Journal of Physiology 101 32—39.
- Fix, J. Rougier, N.P. and Alexandre,F .(2010) *A dynamic neural field approach to the covert and overt deployment of spatial attention*, Cognitive Computation, 2010. In press.