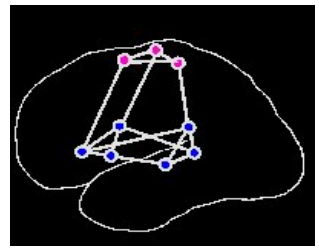
MirrorBot
Biomimetic multimodal learning in a mirror neuron-based robot
IST-2001-35282



Stefan Wermter, Frederic Alexandre, Günther Palm,
Friedemann Pulvermüller, Giacomo Rizzolatti/Vittorio Gallese

University of Sunderland
INRIA at Nancy
University of Ulm
Medical Research Council at Cambridge
University of Parma

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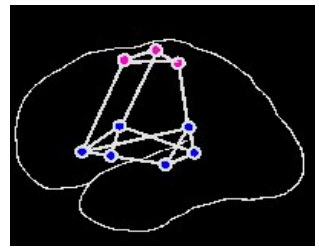
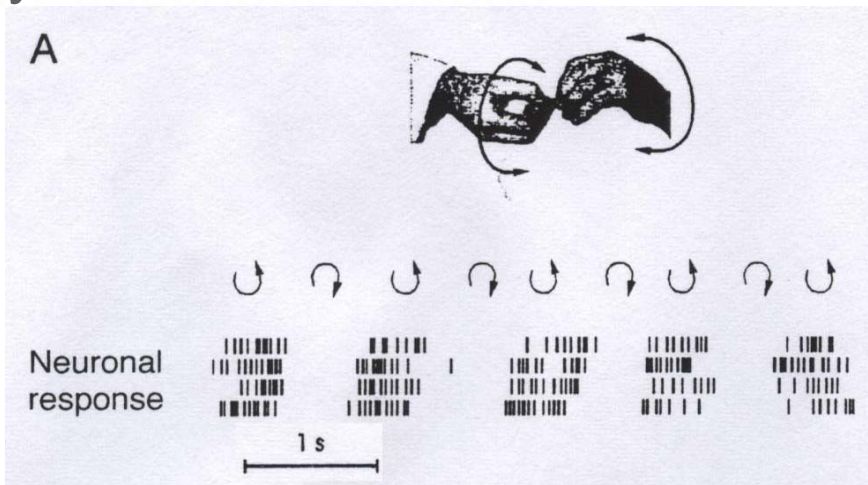
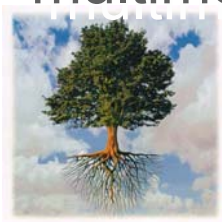
Objectives of MirrorBot



- Mirror neurons fire for specific actions, visually observed actions and acoustically described actions



- How can mirror neuron-based associative networks be used for multimodal actions in robots?



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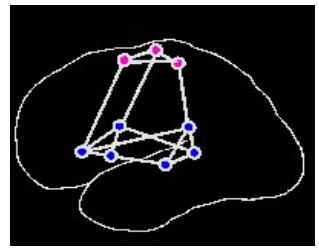
Individual goals



- collect imaging and neural recording data: EEG, MEG, fMRI, TMS
- identify neural architectures for perceptual visual and language data
- develop associative networks for mirror neuron concept
- train and evaluate the MirrorBot robot to perform actions

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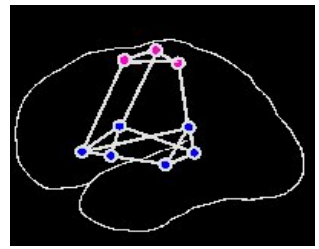
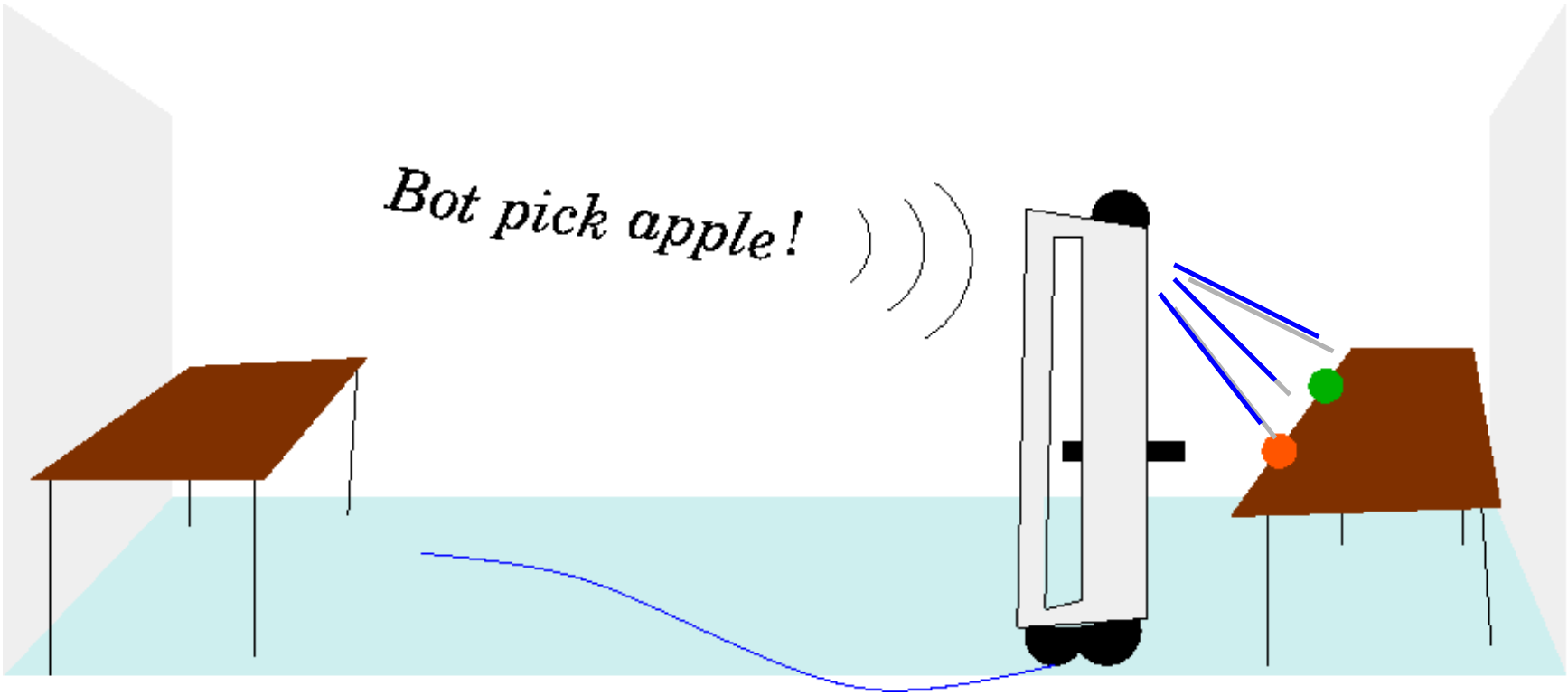
MirrorBot scenario





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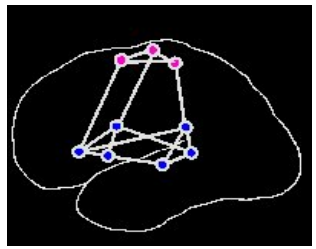
MirrorBot scenario



agent::= SAM action
BOT action

action::=	body_action	
	head_action	
	hand_action	
	stop	
body_action::=	go	object
	move_body	x_direction
	turn_body	y_direction
head_action ::=	turn_head	y_direction | z_direction
	show	object
hand_action ::=	pick	object
	put	object
	lift	object
	drop	object
	touch	object

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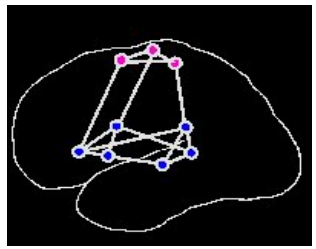
MirrorBot grammar



x_direction::= forward | backward

y_direction::= left | right

z_direction::= up | down

object::= [colour] natural_object

[colour] artefact_object

colour ::= brown | blue | black | white

natural_object::= nut | plum | dog | cat

artefact_object::= desk | wall | ball | cup

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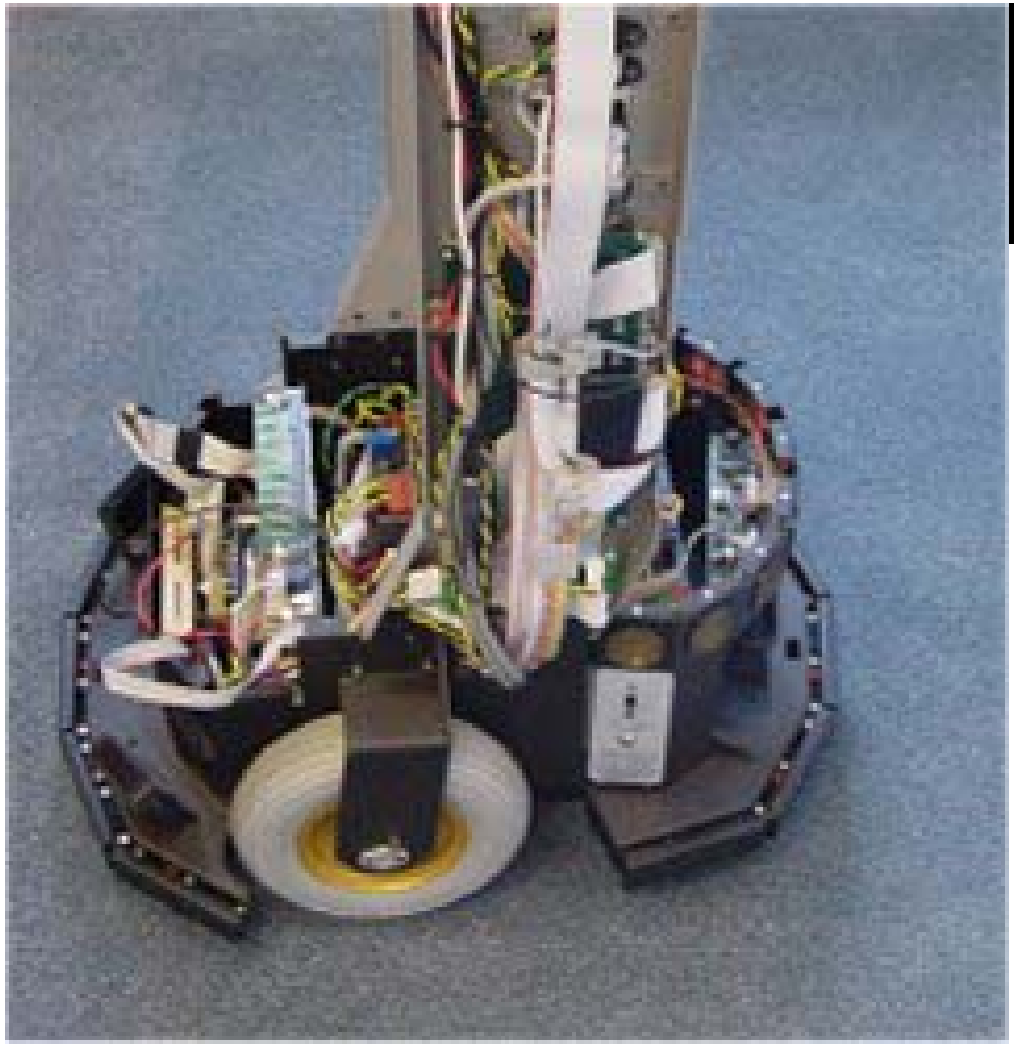
MirrorBot platform



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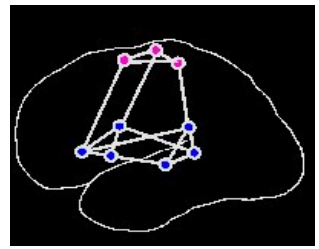

Examples of ongoing Work

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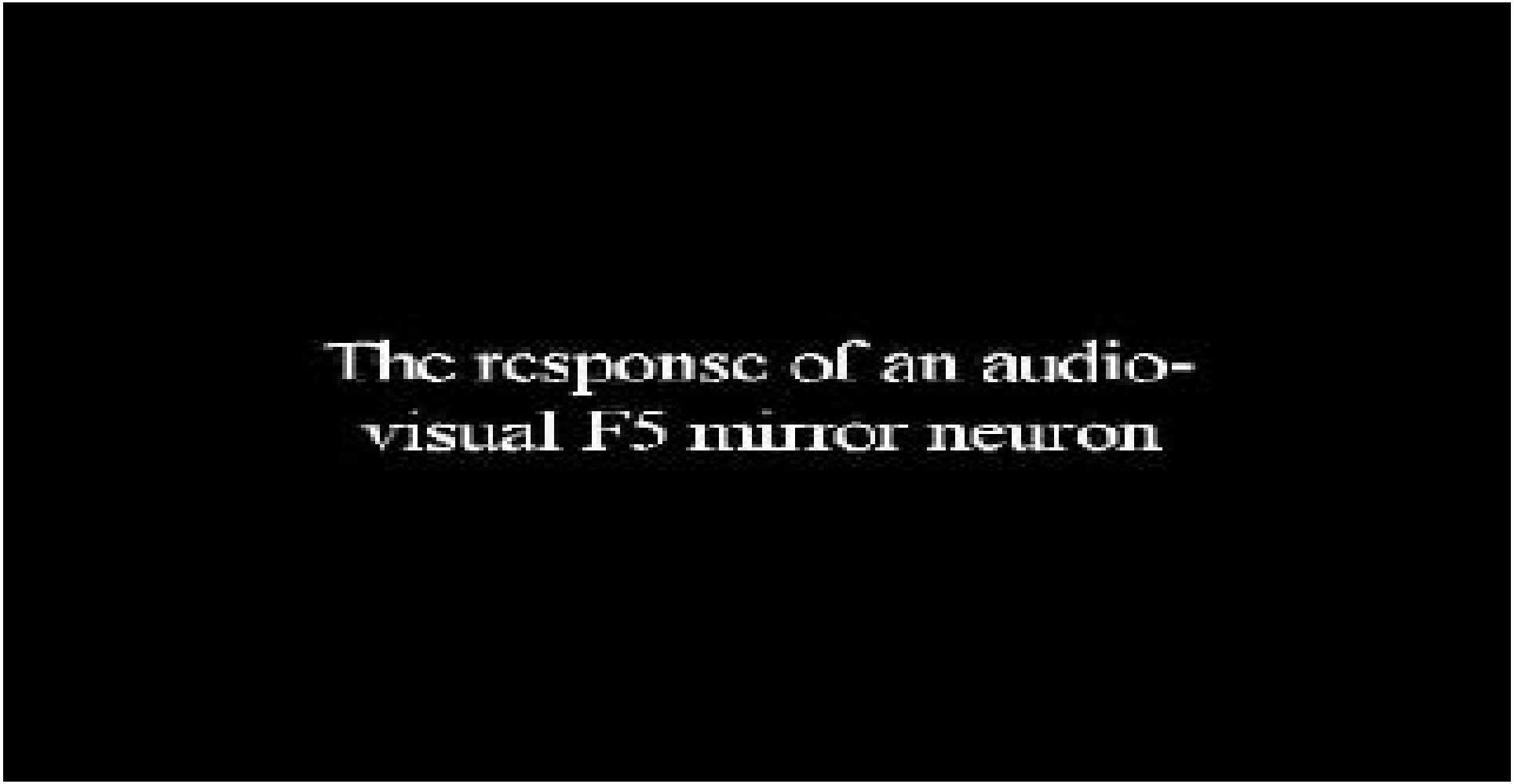
F5 Neuron Responses



Audio-visual response

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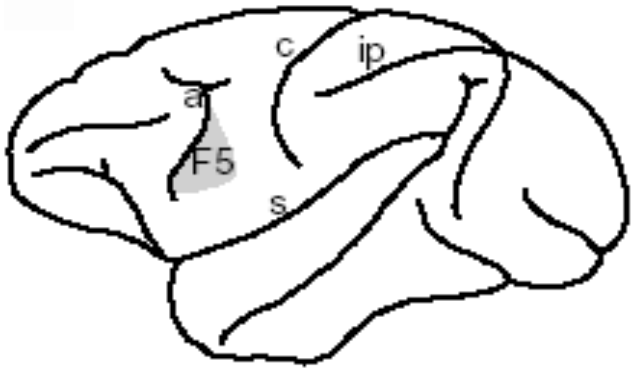
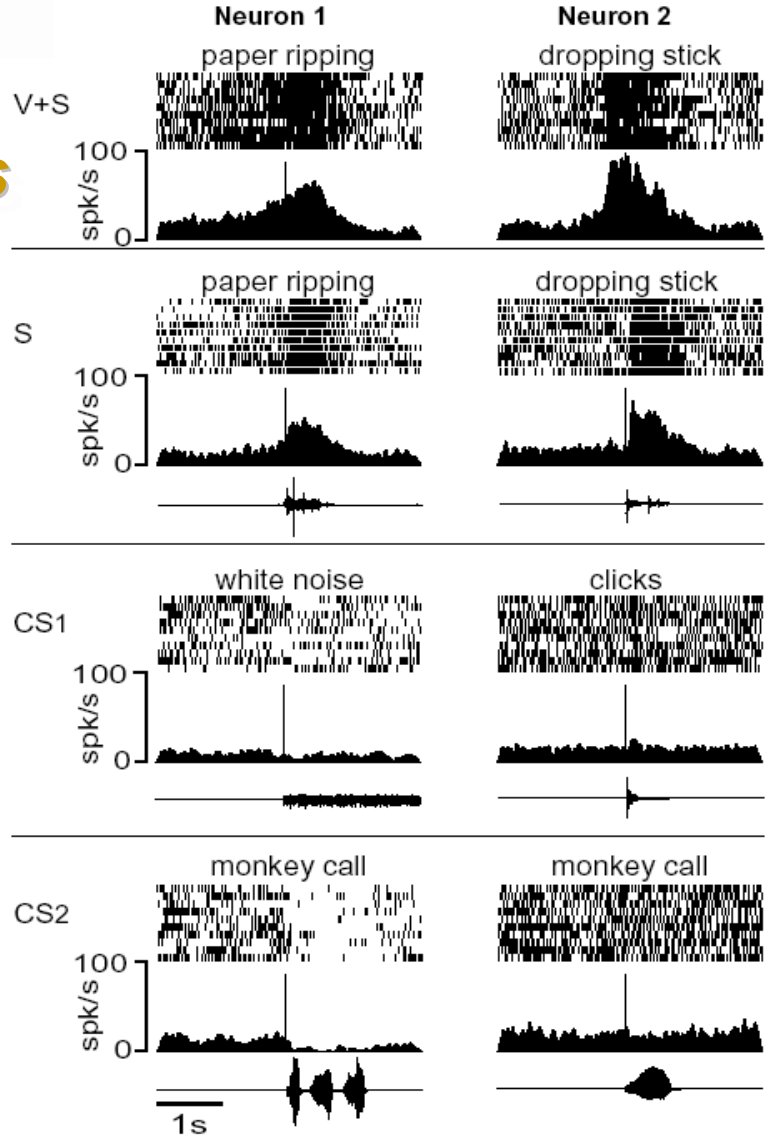
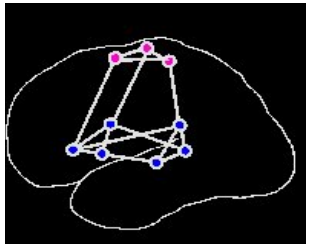
F5 responses







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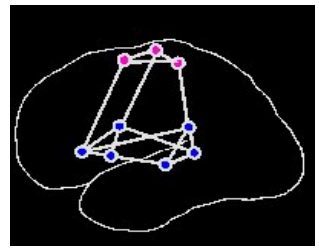
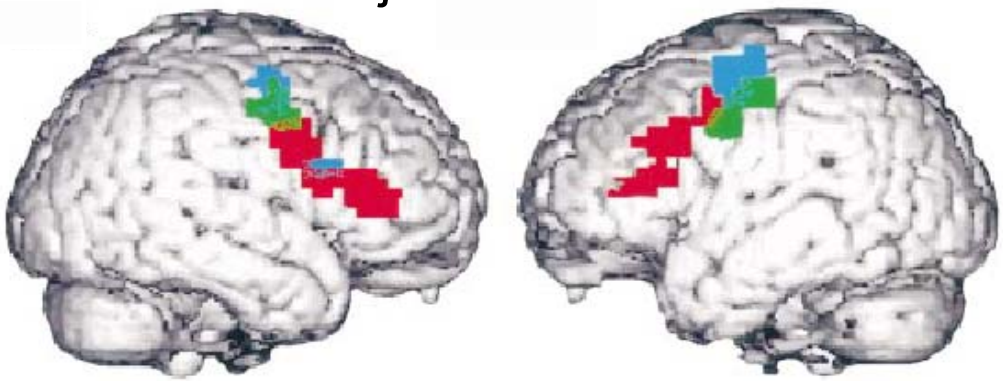
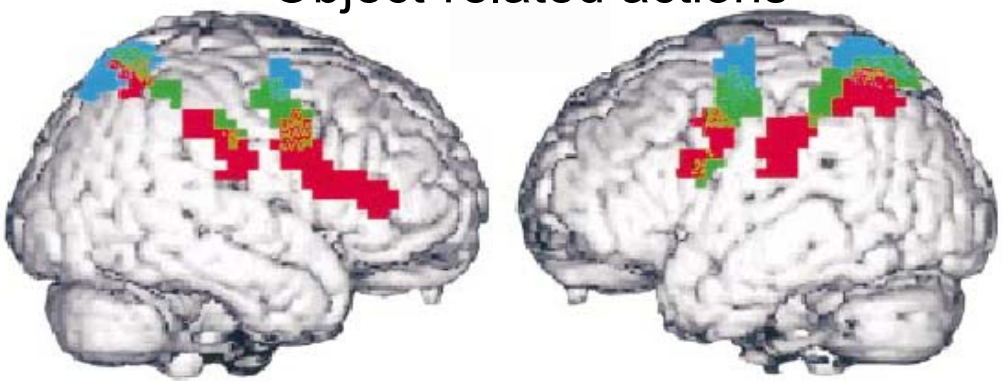
Somatotopy of visual action observation (fMRI)



Non-object-related actions



Object-related actions



Foot Action

Hand Action

Mouth Action

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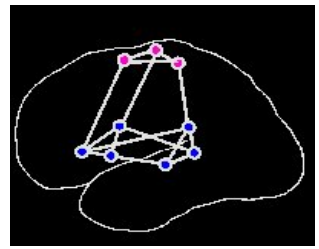
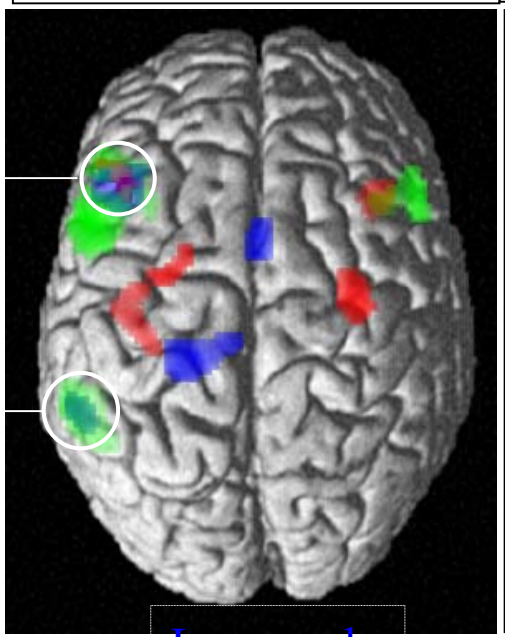
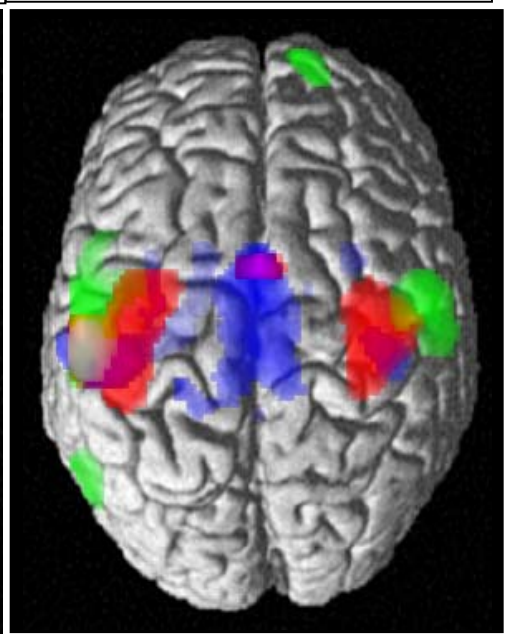
Somatotopy of actions words and actions (fMRI)



	Action Words	Actions
Broca area		
Word form area		
	Leg words Arm words Face words	Foot movements Finger movements Tongue movements

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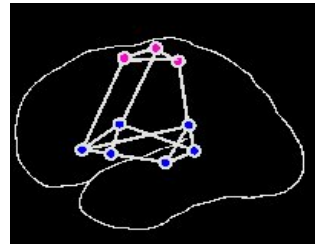
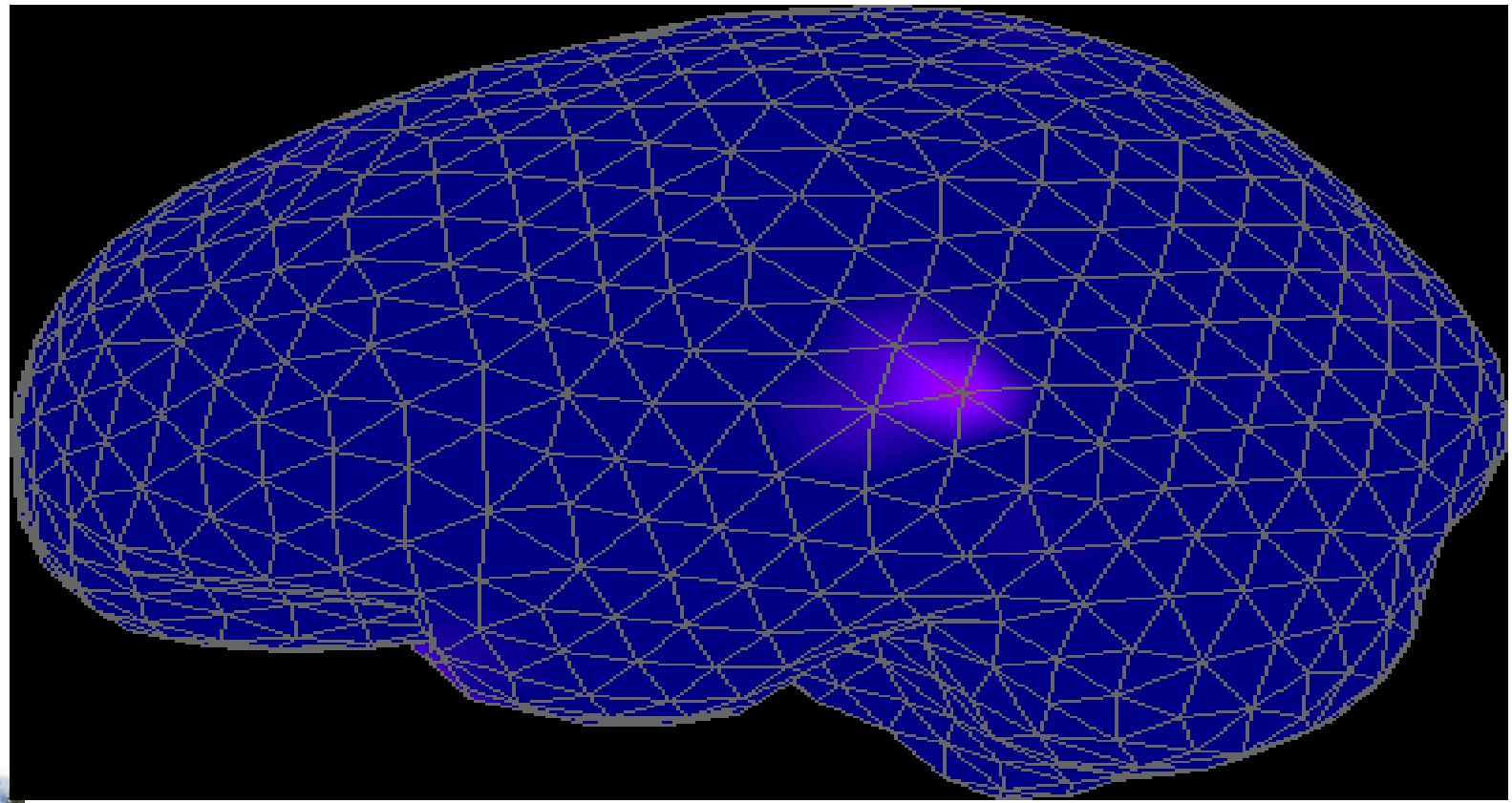
Word-related neuronal ensembles distributed over perisylvian cortex





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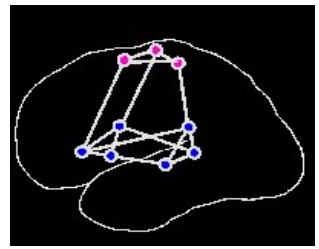
Findings



- Performed actions, visually observed actions and actions described in language are associated with related cortical circuits
- The cortical circuits are topologically organised as areas for mouth, hand and leg areas
- How do we model these findings for language, vision, motor control?

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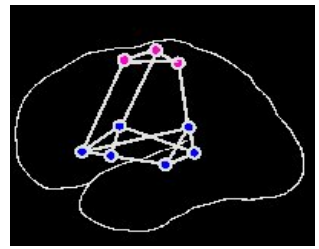
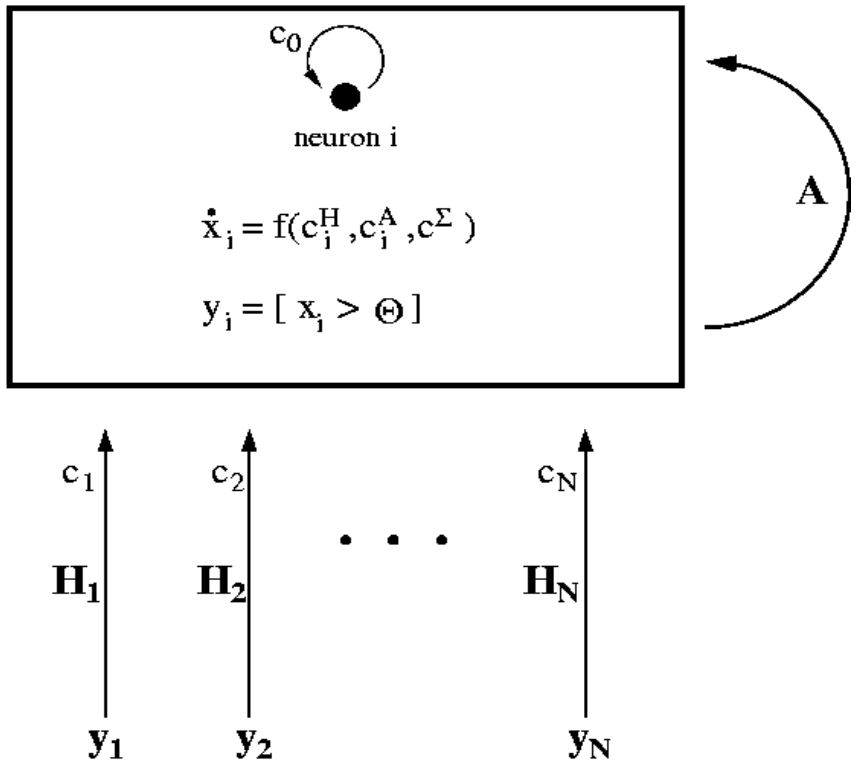
Associative spike counter model for a cortical language area





- spiking variant of binary Willshaw associative memory
- requires sparse binary patterns
- binary memory matrices:
  A auto-associative
  H_i hetero-associative
- sequence processing by delayed feedback (in H)

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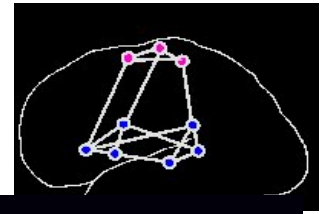
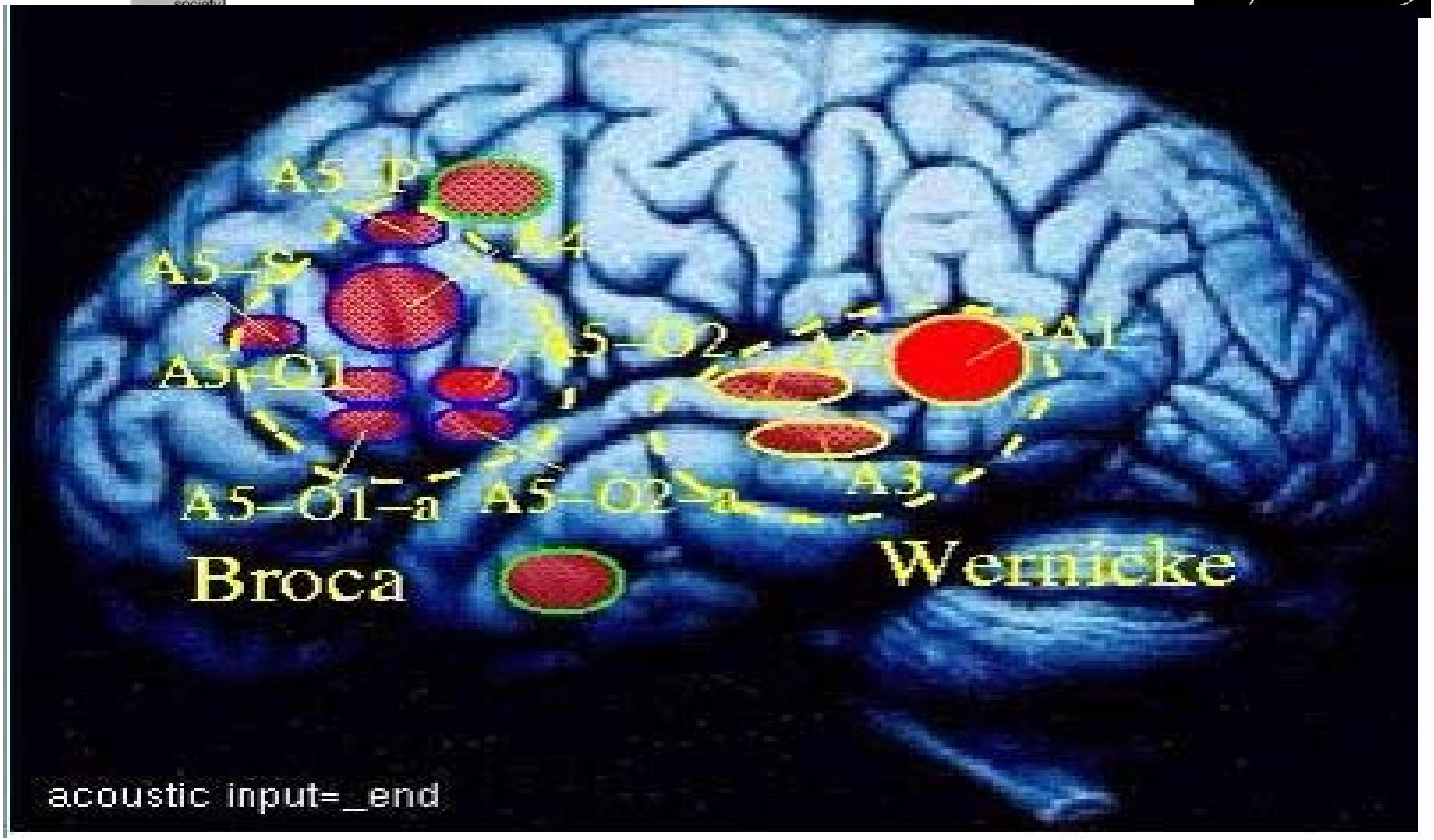
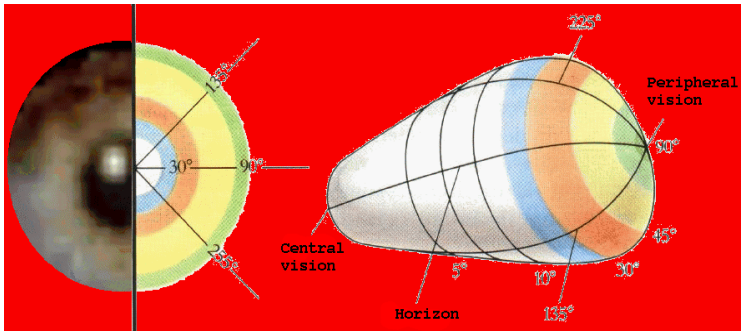
Language areas of MirrorBot: Bot show red apple





Visual encoding



- Non-uniform distribution on the retina
- Visual neural filters
- Overlapping receptive fields

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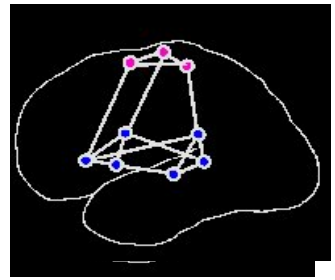
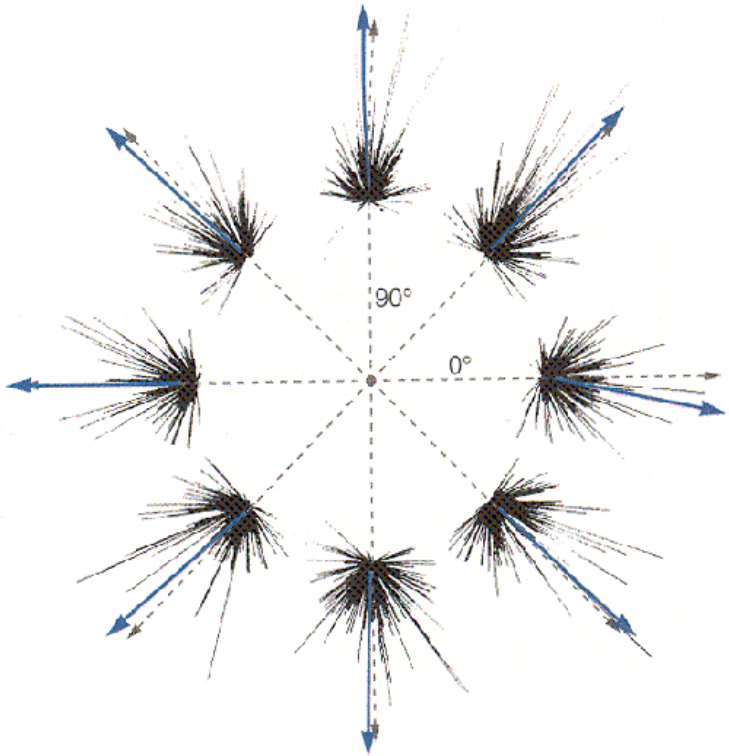
Motor encoding





- Maximal activities when movement in preferred direction of neuron
- In M1, topographic organization: neighboring neurons have similar preferred directions
- Neural maps realise population encoding for motor commands

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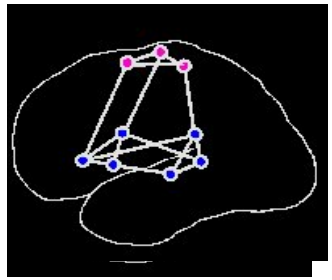
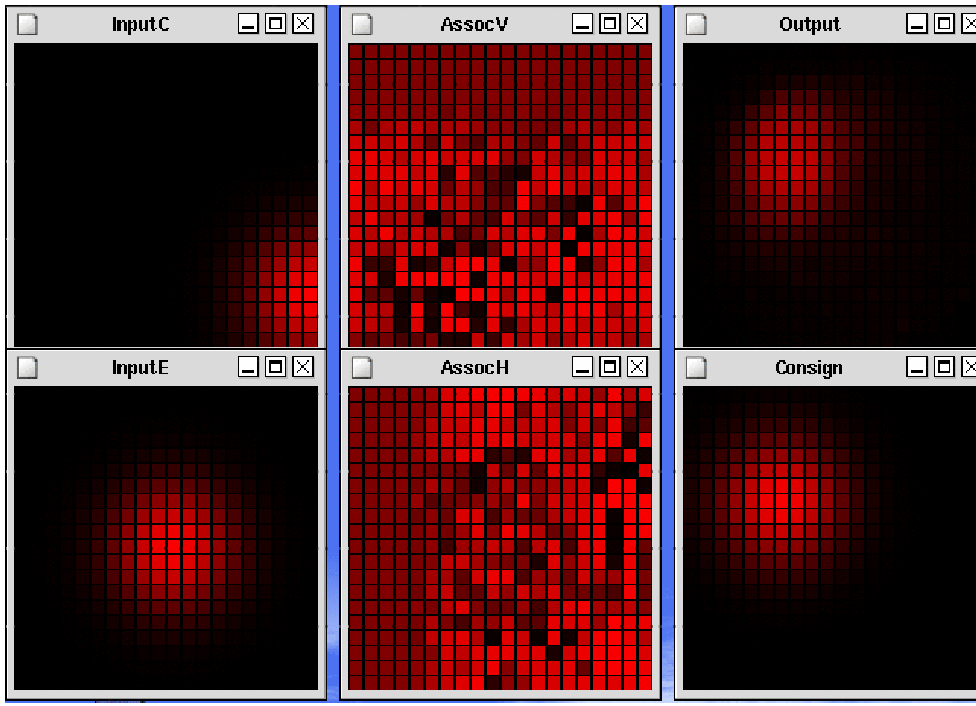
Associative model for sensor motor representation



- control of saccadic eye movements towards a target



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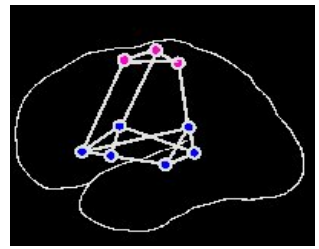
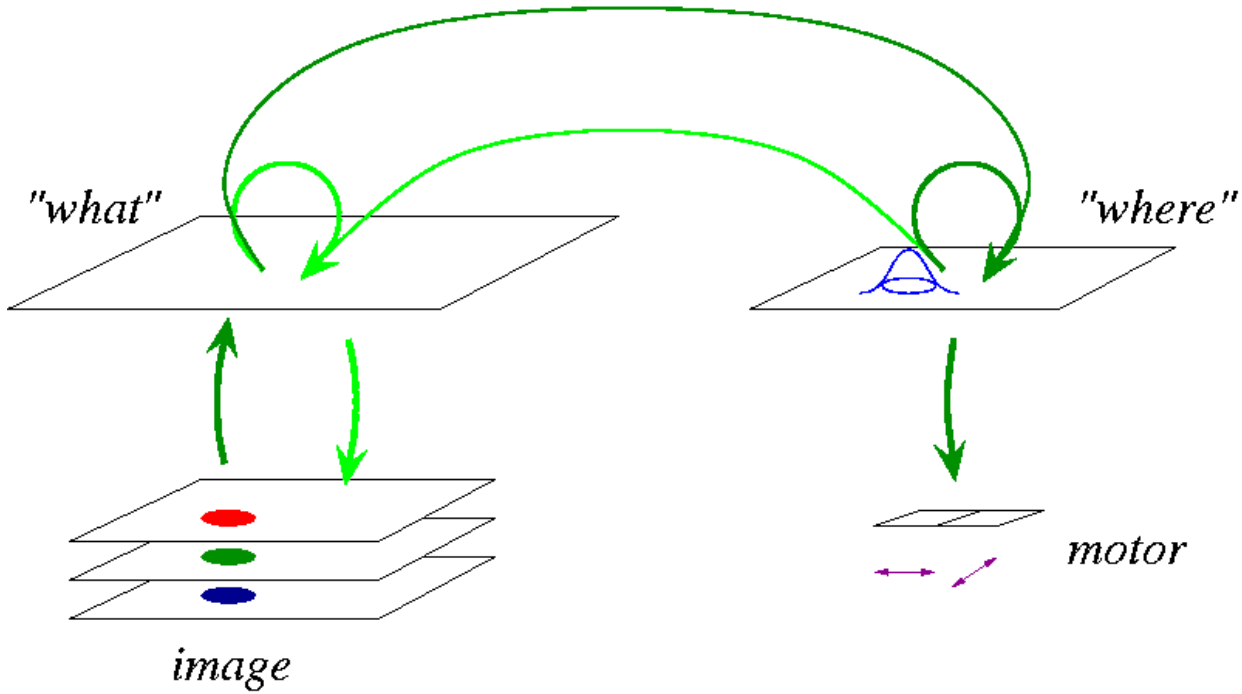
Associative network for “Bot show orange”





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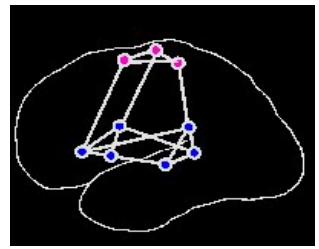

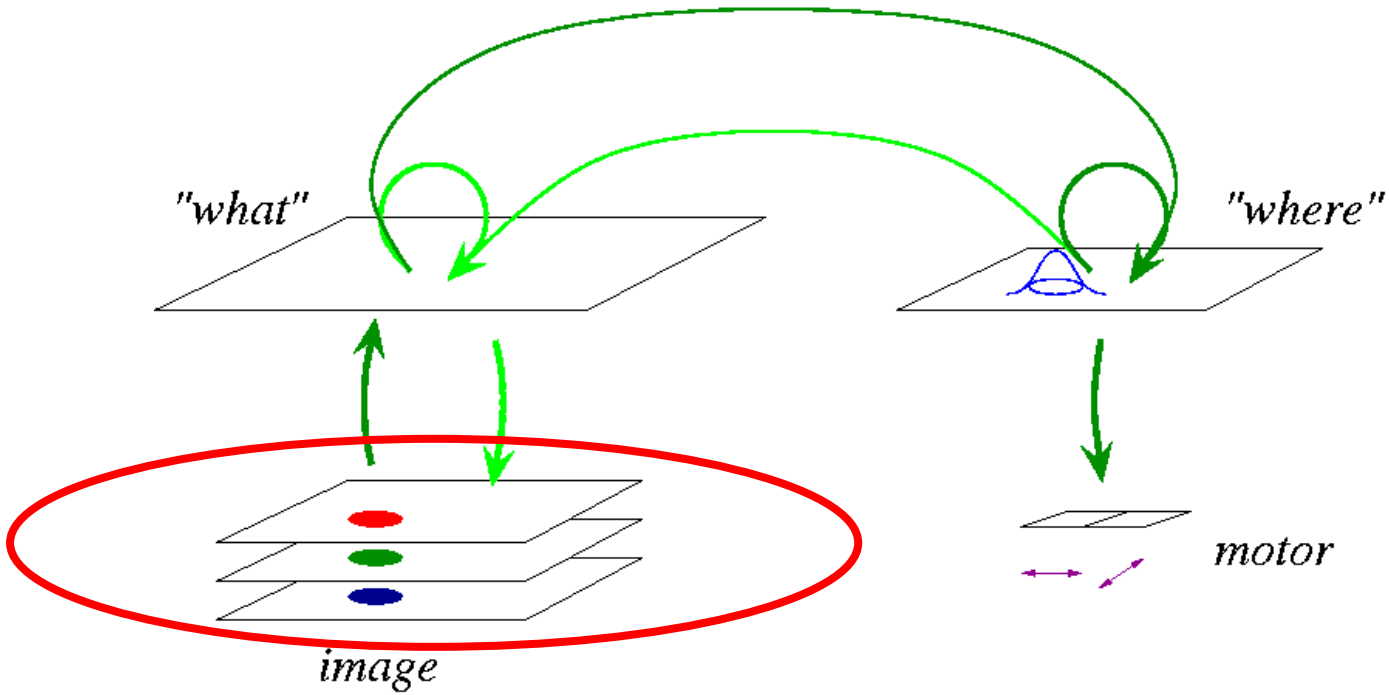

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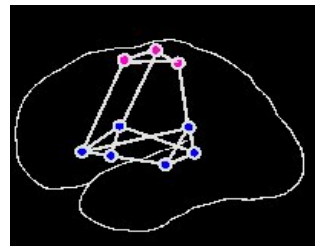

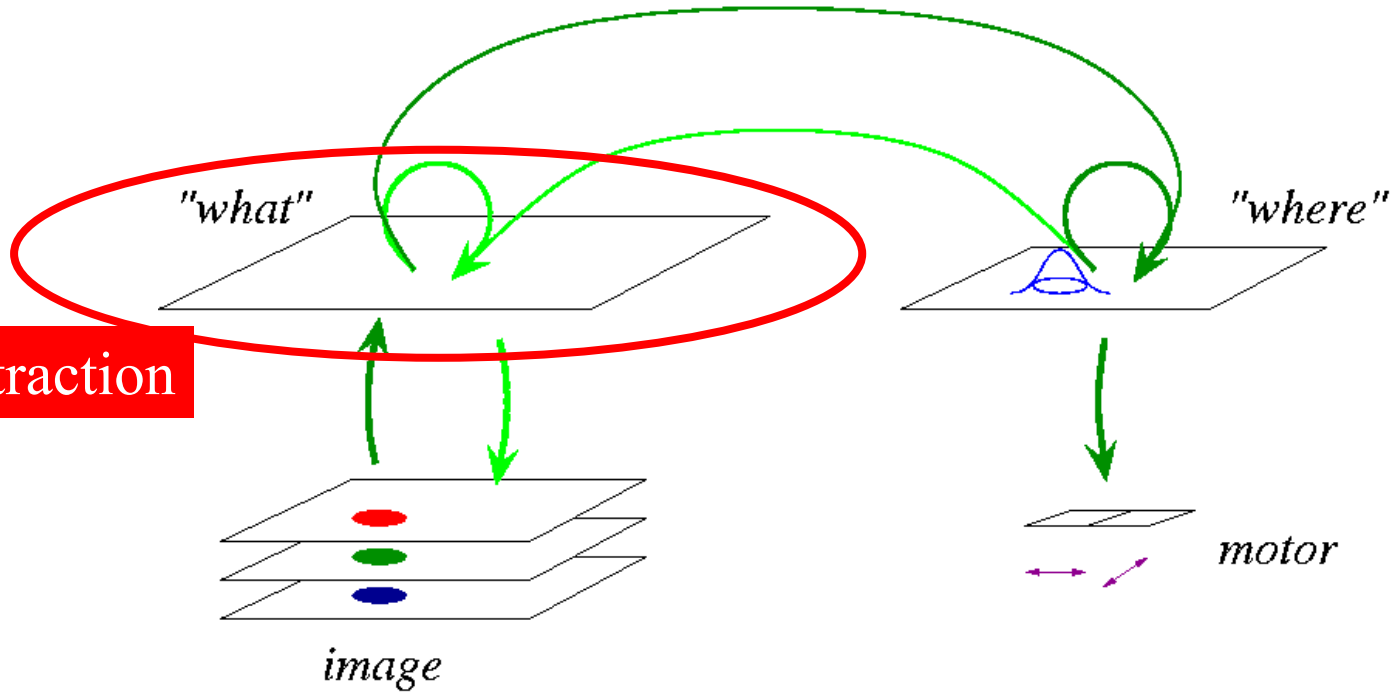

feature extraction

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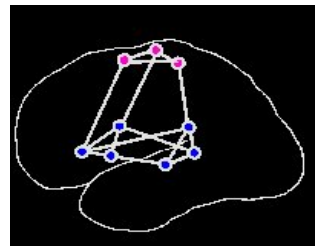
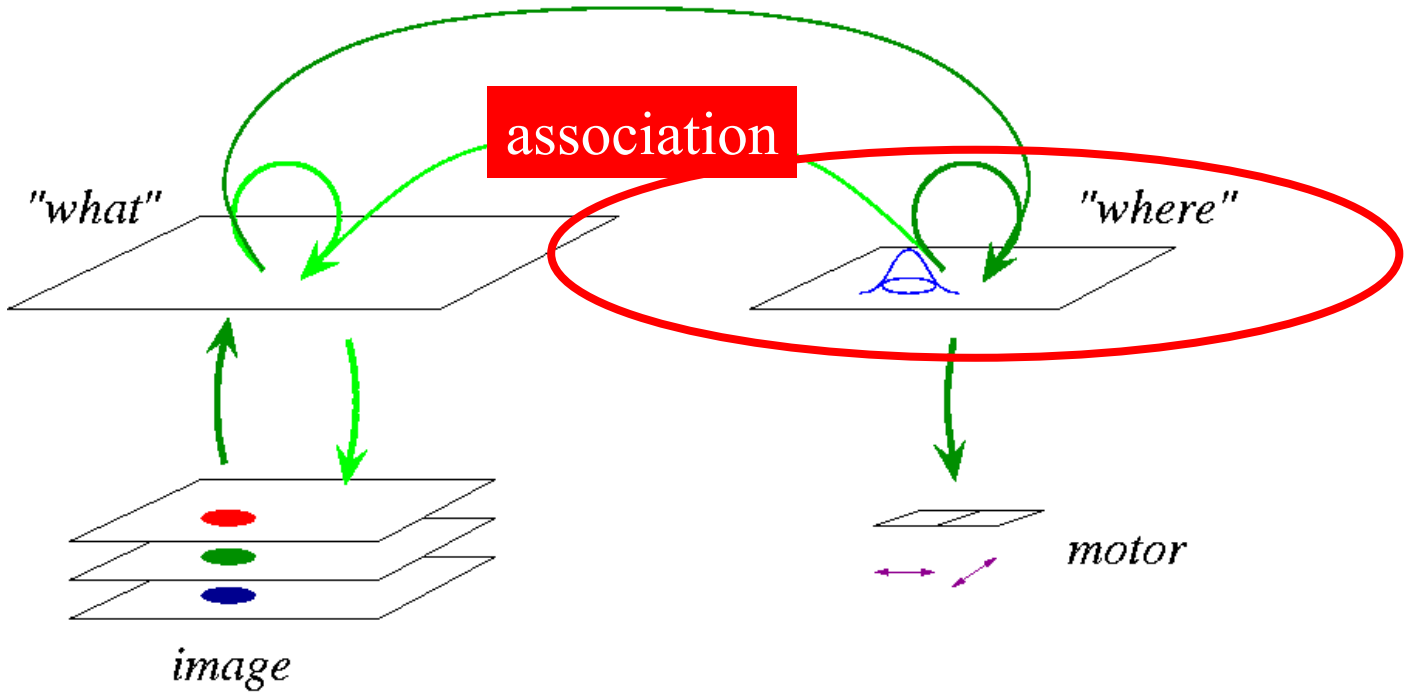
Associative network for “Bot show orange”





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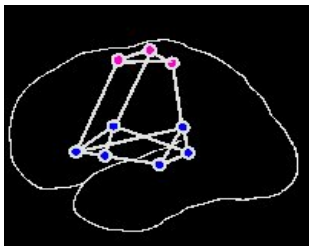
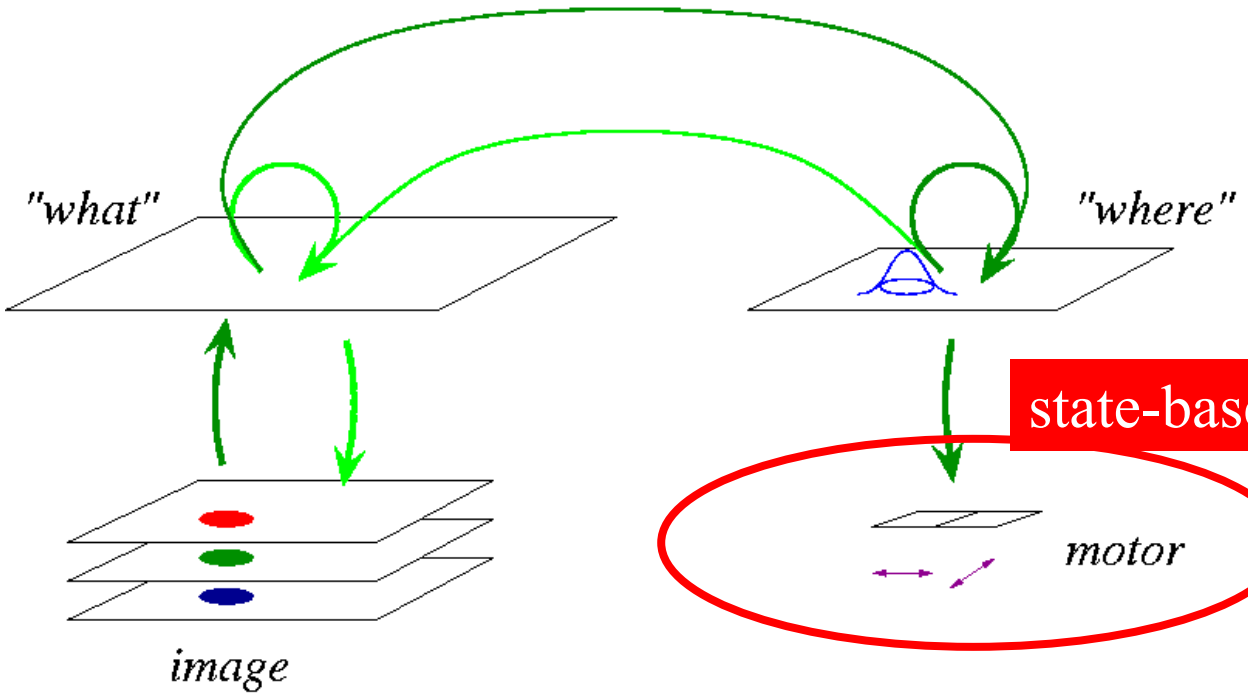
Associative network for “Bot show orange”





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Network activations

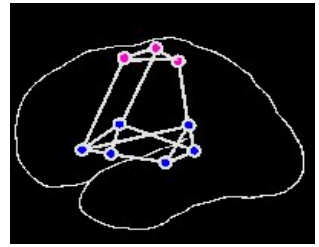
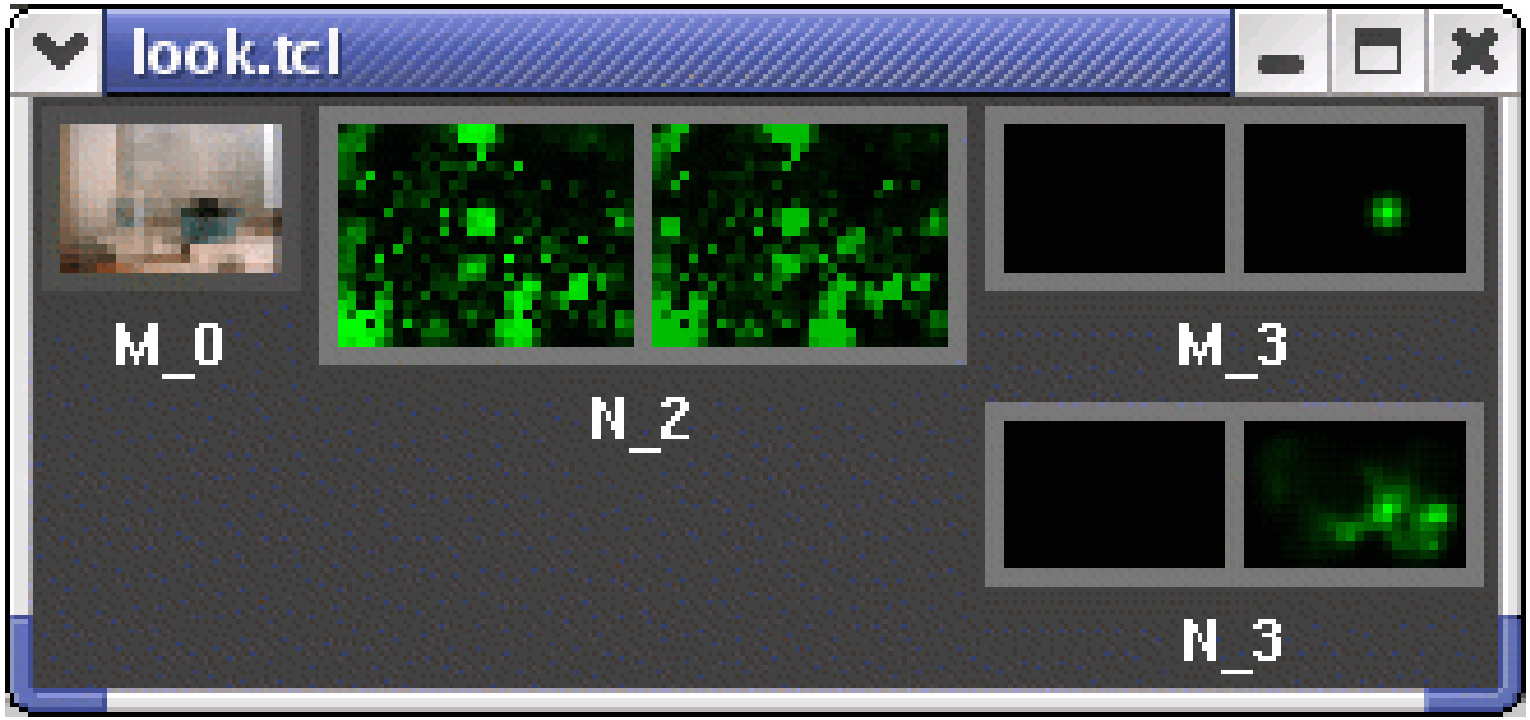


Image "what" "where"



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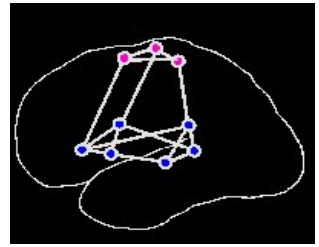
Docking



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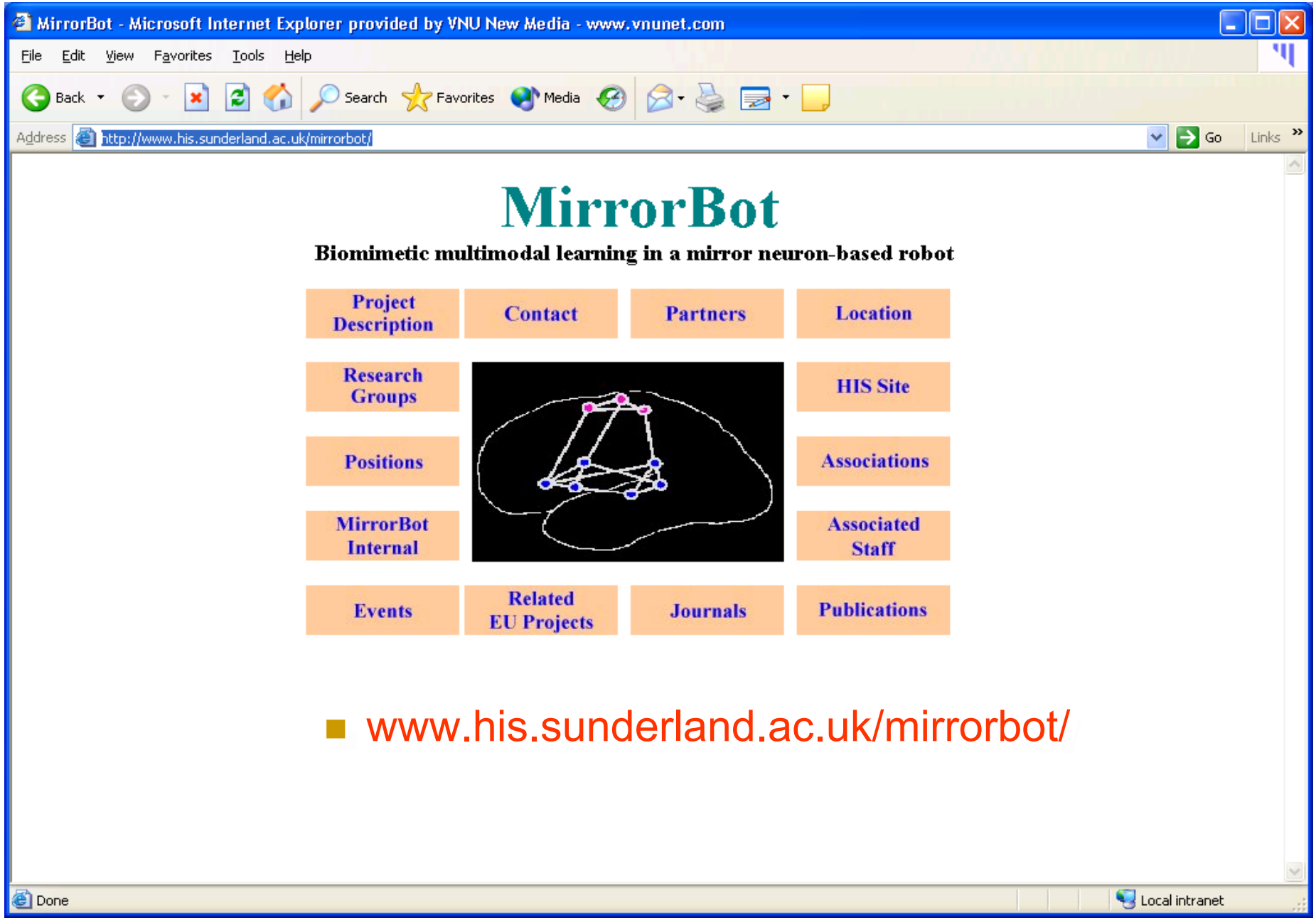
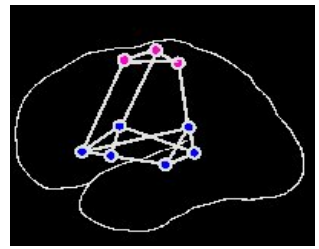
MirrorBot website



- www.his.sunderland.ac.uk/mirrorbot/

Conclusions



- Experiments on action-oriented cortical organisation
- Computational models for language, vision, action on robot
- Aim towards mirror neuron-based association of multiple modalities in neural models

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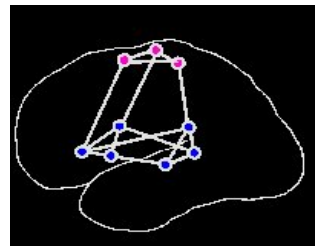
European MirrorBot Workshop



- A multidisciplinary approach for the study of frontal cortex
- 20 October 2003, Convention Centre, Nancy, France
- www.his.sunderland.ac.uk/mirrorbot/

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