BIBA

(2000 -> 2005)

Bayesian Inspired Brain and Artefacts

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Objective

Explore an alternative paradigm of cognition

(perception, action, inference and learning):

Bayesian probabilistic reasoning

- New models for cognition in life science?
- New methods to develop better artefacts?

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Partners

- Life Sciences
  - Collège de France (LPPA - A. Berthoz; J. Droulez)
  - University College of London (UCL GATSBY - P. Dayan)
  - University of Cambridge (UCAM - H. Barlow)
- Information Sciences
  - Ecole Polytechnique Fédérale de Lausanne (ASL - R. Siegwart)
  - INRIA - CNRS (GRAVIR - P. Bessière; E. Mazer)
  - MIT (NSL - J.J. Slotine)

Axes

- Biological plausibility of Bayesian reasoning at a microscopic level?
- Biological plausibility of Bayesian reasoning at a macroscopic level?
- How to develop better artefacts using Bayesian reasoning?

Publications

	Published	Soon
PhD	9	4
Journal	12	7
Books	1	2
Conference	41	
Patents	2	

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Shape from Movement

[Colas06]

Courtesy of MPI-BC

Programme
- Description
  - Spécification
    - Variables Pertinentes
      X, Υ, V_x, V_z, R_y, Λ, $\vec{T}$, $\vec{\Omega}$, $\vec{\Phi}^0$, $\vec{\Phi}^1$ et $\vec{\Phi}^2$
    - Décomposition
      $P(\mathrm{X}\ \Upsilon\ V_x\ V_z\ R_y\ \Lambda\ \vec{T}\ \vec{\Omega}\ \vec{\Phi}^0\ \vec{\Phi}^1\ \vec{\Phi}^2)$
      $= P(\mathrm{X}\ \Upsilon)P(V_x\ V_z\ R_y)P(\Lambda)$
      $\times\ P(\vec{T}\ \vec{\Omega} \mid V_x\ V_z\ R_y)$
      $\times\ P(\vec{\Phi}^0 \mid T_x\ T_y)$
      $\times\ P(\vec{\Phi}^1 \mid \mathrm{X}\ \Upsilon\ \vec{T}\ \vec{\Omega})$
      $\times\ P(\vec{\Phi}^2 \mid \mathrm{X}\ \Upsilon\ \vec{T}\ \vec{\Omega}\ \Lambda)$
    - Formes Paramétriques
      $P(\mathrm{X}\ \Upsilon)$: uniforme en coordonnées sphériques ;
      $P(V_x\ V_z\ R_y)$, $P(\Lambda)$: non spécifié ;
      $P(\vec{\Omega}\ \vec{T} \mid V_x\ V_z\ R_y)$: gaussienne centrée autour de l'opposé du mouvement propre ;
      $P(\vec{\Phi}^0 \mid T_x\ T_y)$: gaussienne centrée sur le flux théorique ;
      $P(\vec{\Phi}^1 \mid \mathrm{X}\ \Upsilon\ \vec{\Omega}\ \vec{T})$: *idem* ;
      $P(\vec{\Phi}^2 \mid \mathrm{X}\ \Upsilon\ \vec{\Omega}\ \vec{T}\ \Lambda)$: gaussienne dont la covariance dépend de la taille du champ λ.
  - Identification :
    Aucune.
- Question :
  $P(\mathrm{X}\ \Upsilon \mid \vec{\phi}^0\ \vec{\phi}^1\ \vec{\phi}^2\ v_x\ v_z\ r_y\ \lambda)$

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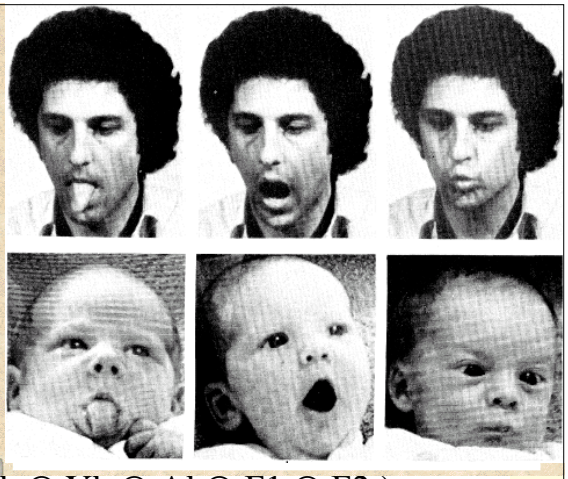
Early development of speech: Orofacial imitation

[Serkhane05a]
[Serkhane05b]

[Meltzoff]



$$P (Lh \otimes Tb \otimes Td \otimes Xh \otimes Yh \otimes Al \otimes F1 \otimes F2)$$
$$= P (Xh) * P (Yh) * P(Al)$$
$$* P (Lh / Al)* P(Tb / Xh \otimes Yh)*P(Td / Xh \otimes Yh \otimes Tb)$$
$$* P (F1 / Xh \otimes Yh \otimes Al) * P (F2 / Xh \otimes Yh \otimes Al)$$

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Training Video-Games Avatars

[LeHy05]

Program

Description

- Specification
  - Variables:
    - Perception: L(I FN(PL(
    - State: S_t, S_{t+1} {
  - Decomposition:
    - $P(S_t\ S_{t+1}\ L\ W\ FW\ N\ FN\ PW\ PL)$
      $= P(S_t)xP(S_{t+1}|\ S_t)xP(L|\ S_{t+1})x\ xP(W\ |\ S_{t+1})x\ xP(FW\ |\ S_{t+1})$
      $xP(N\ |\ S_{t+1})\ xP(FN|\ S_{t+1})\ xP(PW|\ S_{t+1})\ xP(PL|\ S_{t+1})$
  - Parametric Forms:
    - Tables
- Identification

Question

- Utilization
  - Playing : $P(S_{t+1}|S_t\ L\ W\ FW\ N\ FN\ PW\ PL)$

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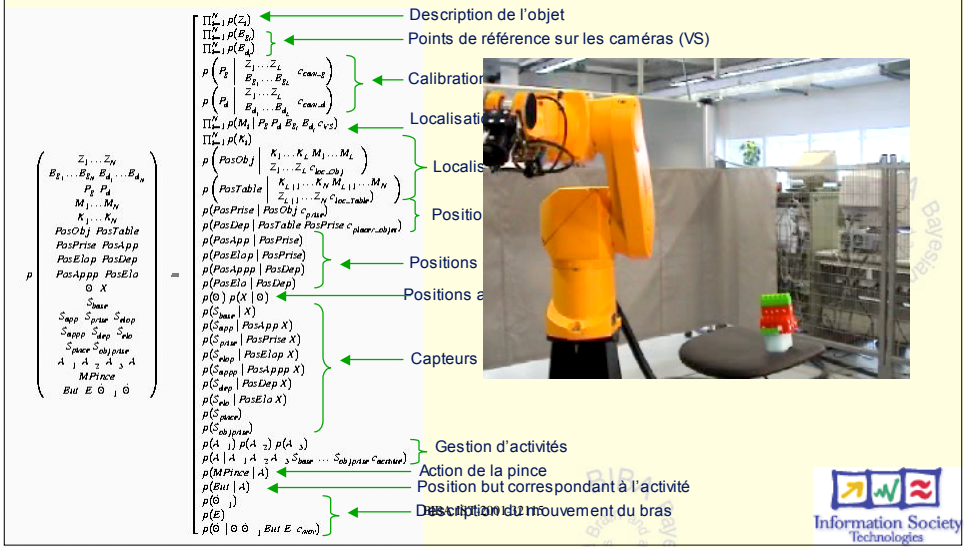
Bayesian Control of Robotics Arms

[Garcia03]



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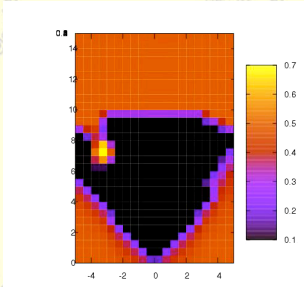
Bayesian Occupancy Filters for ADAS

[Coué03][Coué05]

Spécificatio



$P(V^k \mid V^{k-1}\ G^k)$

d'occupation

rentissage?)

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Mobile Robot Navigation

[Pradalier04]
[Pradalier05]

Programme
- Description
  - Spécification
    - Variables Pertinentes
      - (V, Φ) : Commandes recherchées
      - (V_d, Φ_d) : Commandes demandées
      - I_d : Variable de diagnostic associé
      - $D_1 \dots D_8$: Distances mesurées
      - $I_1 \dots I_8$: Variable de diagnostic associé
    - Décomposition
      - $P((V, \Phi)\,(V_d, \Phi_d)\,I_d\,D_1 \dots D_8\,I_1 \dots I_8) =$
      - $P(V, \Phi)P(V_d, \Phi_d)P(I_d \mid (V, \Phi)\,(V_d, \Phi_d))$
      - $\prod_{i=1}^{8} P(D_i)P(I_i \mid (V, \Phi)\,D_i)$
    - Formes Paramétriques
      - $P(V, \Phi), P(V_d, \Phi_d), P(D_i)$: Uniformes
      - $P(I_i \mid (V, \Phi)\,D_i)$: Questions a… d'obstacles
      - $P(I_d \mid (V, \Phi)\,(V_d, \Phi_d))$: Question a… consignes
  - Identification :
    - $P(I_i \mid (V, \Phi)\,D_i)$: Construction à partir d…
    - $P(I_d \mid (V, \Phi)\,(V_d, \Phi_d))$: *a priori*
- Question :
  - $P((V, \Phi) \mid (V_d, \Phi_d)\,D_1 \dots D_8\,[I_i = 1]_{i=1\dots8}\,[I_d = 1]) \propto$
  - $P([I_d = 1] \mid (V, \Phi)\,(V_d, \Phi_d)) \prod_{i=1\dots8} P([I_i = 1] \mid (V, \Phi$

x3

FIG. 6.12: Fusion de sous-modèle par …

Bayesian Approach to Action Selection and Attention Focusing

[Koike05]

$$P(M^{0:t} S^{0:t} Z^{0:t} B^{0:t} C^{0:t} \lambda^{0:t} \beta^{0:t} \alpha^{0:t} \mid \pi)$$

$$= \prod_{j=1}^{t} \begin{bmatrix} \prod_{i=1}^{N_i} P(S_i^j \mid S_i^{j-1} M^{j-1} \pi_i) \\ \prod_{i=1}^{N_i} P(Z^j \mid S_i^j C^j \pi_i) \\ \times P(B^j \mid \pi) \prod_{i=1}^{N_i} P(\beta^j \mid B^j S_i^j B^{j-1} \pi_i) \\ \times P(C^j \mid \tau) \prod_{i=1}^{N_i} P(\alpha^j \mid C^j S_i^j B^j \pi_i) \\ \times P(M^j \mid \pi) \prod_{i=1}^{N_i} P(\lambda^j \mid M^j B^j S_i^j M^{j-1} \pi_i) \end{bmatrix} \times P(M^0 S_i^0 C^0 B^0 Z_i^0 \lambda_i^0 \beta_i^0 \alpha_i^0 \mid \pi)$$

- Inclusion of intermediary state variables
- Bayesian time filtering
- Motor model addition
- Domains of interest
- Behaviour selection, synergies and strategies
- Reduction of perception data pre-processing

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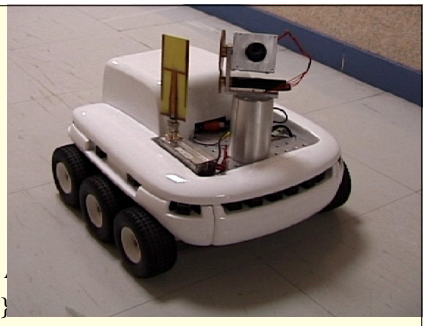
Bayesian Maps

[Diard03]



Description

Spécification

- Variables :
  - **P** = $P^{gîte} \wedge L_t^{gîte} \wedge L_{t'}^{gîte} \wedge$ …
  - $\mathbf{L_t} = \{c^{gîte}, c^{e\text{-}v}, c^{lac}, c^{nourr}\}$
  - $\mathbf{L_{t'}} = \{c^{gîte}, c^{e\text{-}v}, c^{lac}, c^{nourr}\}$
  - **A** = {Sortir-gîte, Dormir, Aller-Boire, Se-Balader, …}
- Décomposition :
  - $P(P^{gîte} \wedge L_t^{gîte} \wedge L_{t'}^{gîte} \wedge A^{gîte} \wedge P^{e\text{-}v} \wedge L_t^{e\text{-}v} \wedge \ldots \wedge A^{nourr}\ L_t\ L_{t'}\ A) =$
    $P(L_t)$
    $P(P^{gîte} \wedge L_t^{gîte} \wedge L_{t'}^{gîte} \wedge A^{gîte} \mid L_t)$
    $P(P^{e\text{-}v} \wedge L_t^{e\text{-}v} \wedge L_{t'}^{e\text{-}v} \wedge A^{e\text{-}v} \mid L_t)$
    $P(P^{lac} \wedge L_t^{lac} \wedge L_{t'}^{lac} \wedge A^{lac} \mid L_t)$
    $P(P^{nourr} \wedge L_t^{nourr} \wedge L_{t'}^{nourr} \wedge A^{nourr} \mid L_t)$
    $P(L_{t'})\ P(A \mid L_t\ L_{t'})$

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Answers ???

- Biological plausibility of Bayesian reasoning at a microscopic level?
- Biological plausibility of Bayesian reasoning at a macroscopic level?
- How to develop better artefacts using Bayesian reasoning?

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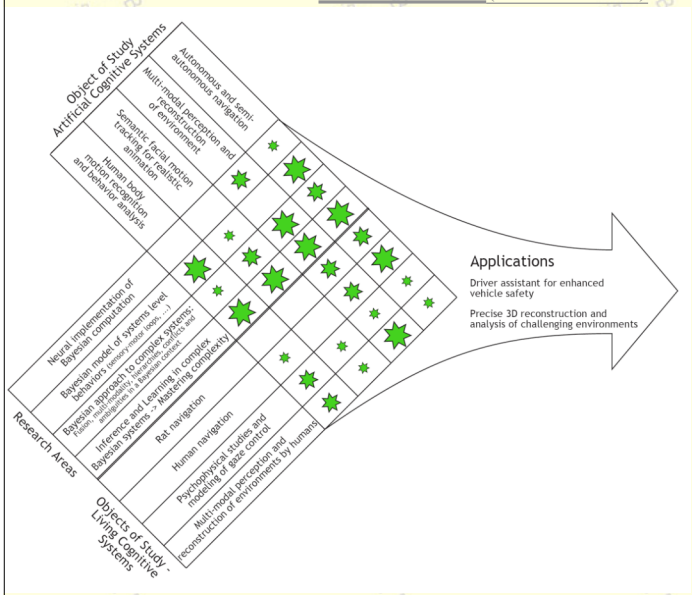
BACS (2006 -> 2010)



- ETZH
- Coimbra University
- HUG
- IDIAP
- MPI - Tubinghen

- BlueBotics
- EDF
- ProBAYES

Labo GRAVIR (CNRS-INRIA) recrute des :

Ingénieur d'étude

PostDocs

Pierre.Bessiere@imag.fr

Bayesian Cognition

International workshop on probabilistic models of perception, inference, reasoning, decision, action, learning and neural processing

Paris, January 16-18, 2006

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- Alain Berthoz, Collège de France
- Pierre Bessière, CNRS
- Heinrich Bülthoff, Max Planck Institute
- Peter Dayan, University College of London
- Sophie Denève, CNRS,
- Jacques Droulez, LPPA
- Ian Hacking, Collège de France
- Ben Kuipers, University of Texas
- David MacKay, University of Cambridge
- Pascal Mamassian, Paris V University
- Jose del R. Millan, IDIAP Research Institute
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