A Bayesian Hierarchy as a Model of Human Active Visuoauditory Perception

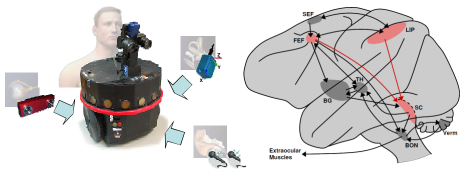
João Filipe Ferreira, Alexandre Malhão*, Miguel Castelo-Branco** and Jorge Dias**

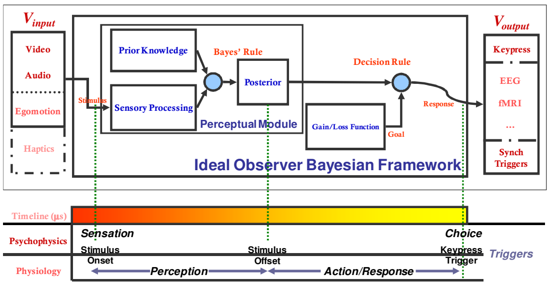
*ISR — Institute of Systems and Robotics, Coimbra, Portugal **IBILI — Biomedical Institute of Research on Light and Image

CogSys2010

Abstract

- We will present an experimental paradigm and protocol to develop a Bayesian hierarchical framework that models human visuoauditory-driven saccade generation.





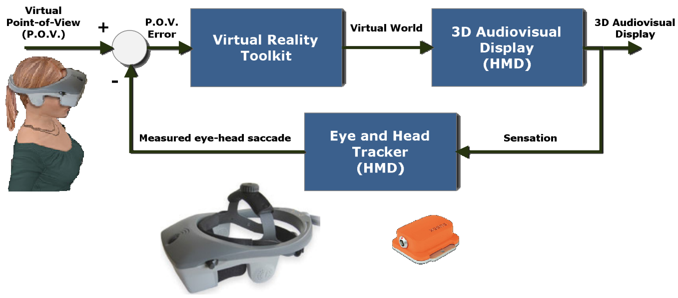
Goals

- Bayesian models for perception
  - fusion/multimodality
  - ambiguity
  - conflicts
- Biologically inspired
- Applicable to artificial systems
- Unified research framework

Background

- Humans and other animals do not look at a scene in a steady way.
- Sensors are directed to
  - unknown parts of the scene
  - interesting parts of the scene
- This way redundant evidence can be accumulated about a scene (i.e. active perception):
  - lowering uncertainty of individual sensor measurements
  - using limited-scope sensorial resources more efficiently

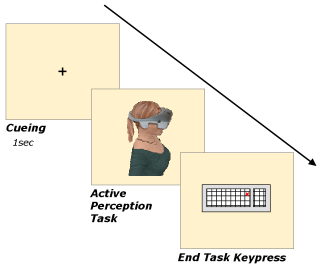
Experimental Setup



- NVIS HMDs with Arrington eye-trackers and xsens MTi Attitude and Heading Reference System head-tracker

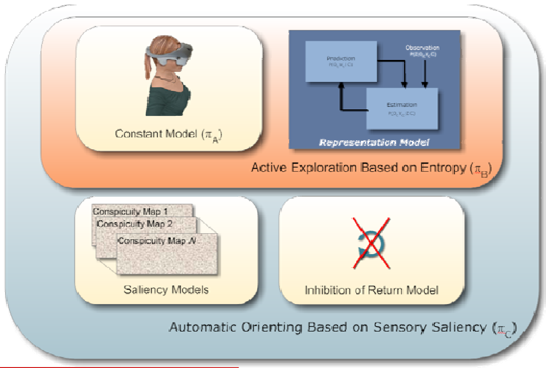
Experimental Protocol

- Generic Exploration Task:
  - "Look at the following scene; you must be able to describe it in detail when you're finished"



Bayesian Hierarchical Framework

- Constant Model (π_A):
  - model directly reflecting fixation points data from training set, without using representation model
- Active Exploration Based on Entropy (π_B)
  - model that includes π_A and representation model (the Bayesian Volumetric Map or BVM – see [1]), adding an active exploration behaviour based on the uncertainty of the representation model states
- Automatic Orienting Based on Sensory Saliency (π_C)
  - model that includes $\pi_A + \pi_B$, adding an automatic orienting behaviour based on sensory saliency taken from BVM sensor model operator extensions



Discussion

- Performances of models π_B and π_C are compared to the constant model π_A using the ratio of the geometric mean over all trials of the likelihoods of each model [2]:

$$\mu_{\text{geom}}(\pi) = \sqrt[N]{\prod_{n=1}^{N}\prod_{t=1}^{t_{\max}} P([G_t = g_n^{t+1}] \,|\, v^{1\to t}\, o^{1\to t}\, \pi)}$$

- Robotic simulations have already shown the potential of the hierarchical framework developed in this work.
- Psychophysical experiments are currently being conducted with just under 20 subjects with "normal-to-corrected perception" in order to validate hypothesis and train the models – preliminary results are very promising in this respect.
- Future experiments with autistic patients are already being planned.

This work has been supported by EC-contract number P6-IST- 027140, Action line: Cognitive Systems.

BACS — Bayesian Approach to Cognitive Systems

Project: BACS - Bayesian Approach to Cognitive Systems
http://www.bacs.ethz.ch/

Author e-mails: {jfilipe, malhao, jorge}@isr.uc.pt
mcbranco@ibili.uc.pt

Selected Biliography

[1] J. F. Ferreira, et *al.*, "Bayesian Models for Multimodal Perception of 3D Structure and Motion," in International Conference on Cognitive Systems (CogSys 2008), University of Karlsruhe, Karlsruhe, Germany, April 2008, pp. 103–108.

[2] F. Colas, F. Flacher, T. Tanner, P. Bessière, and B. Girard, "Bayesian models of eye movement selection with retinotopic maps," Biological Cybernetics, vol. 100, pp. 203–214, 2009.

Mobile Robotics Laboratory
Institute of Systems and Robotics
ISR – Coimbra