

ICEA – Integrating Cognition Emotion and Autonomy

Evaluating the brainstem and midbrain substrates for self-defence in a commercial robotics application

A contribution in kind to the SEAS DTC

Introduction: Who is ICEA

- ICEA is a multi-national Framework 6 collaborative
 - CNRS – Centre National De La Recherche Scientifique,
 - University of Skovde,
 - KFKI - Részecske- és Magfizikai Kutatóintézet,
 - University of Sheffield,
 - aslab – Universidad Politenica Madrid,
 - Universite Pierre & Marie Curie Paris,
 - University of the West of England (UWE),
 - LARAL-ISTC-CNR – Laboratory of Autonomous Robotics and Artificial Life,
 - Cyberbotics



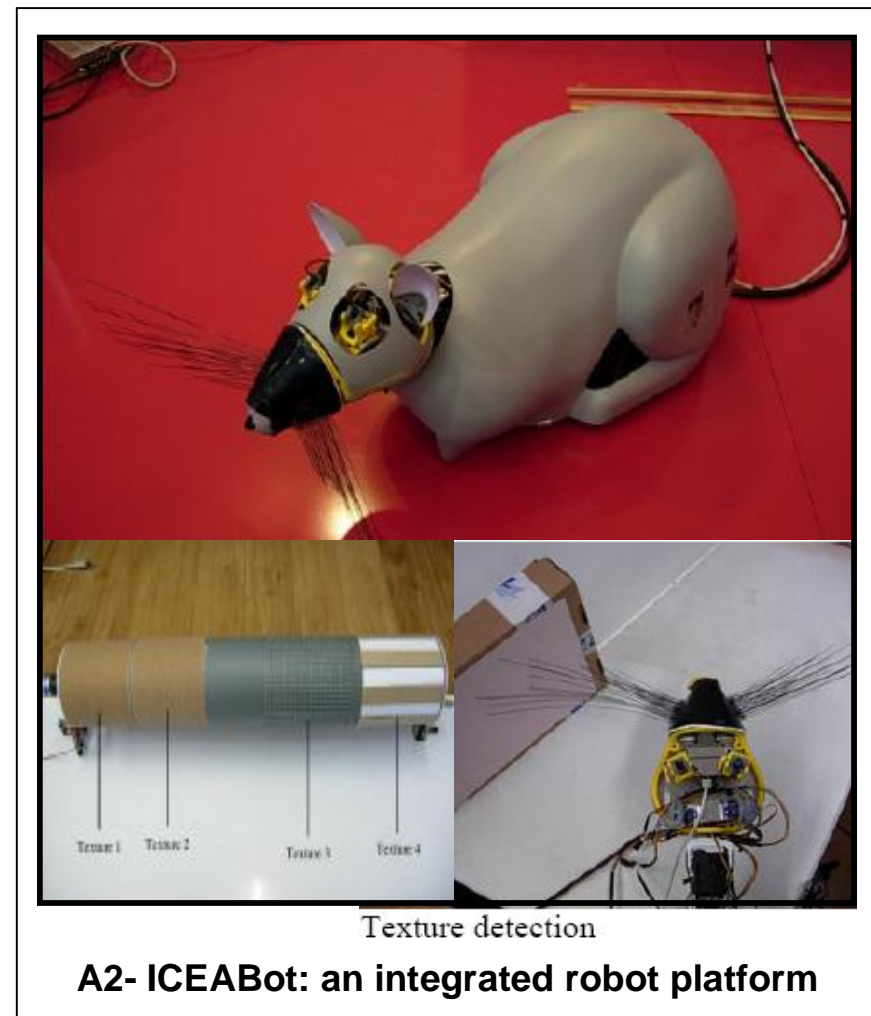
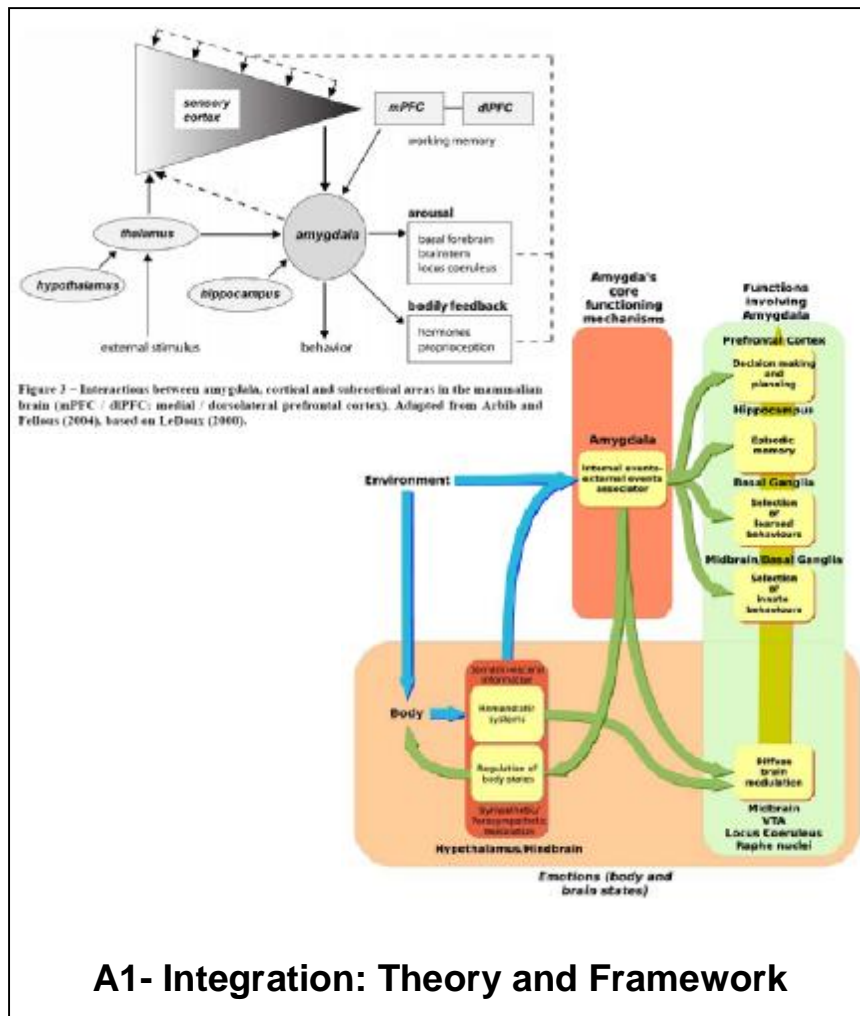
ICEA's aims

- Specifically, ICEA aims to develop, a *complete cognitive systems architecture* that integrates cognition, emotion and autonomy in the planning and control of external behaviour and interaction with the world (navigation, decision-making, action selection, etc.) and in the monitoring and control of internal homeostasis
- BAE's role within the consortium:
Evaluating the brainstem and midbrain substrates for self-defence in a commercial robotics application

Some Collaborative work

- The project is divided into seven work packages:
 - A1 – Integration: Theory and Framework
 - A2 – ICEAbot: an integrated robot platform
 - A3 – ICEAsim: an integrated simulation platform
 - A4 – Energy autonomy and bio-regulation
 - A5 – The layered cognitive architecture for self-defence
 - A6 – Spatial cognition, motivation and goal-directed navigation
 - A7 – Representation, abstraction and planning

Collaborative Activities



Collaborative Activities

A2- SCRATCHbot: an integrated robot platform

A3- ICEAsim: An integrated simulation platform

Collaborative Activities

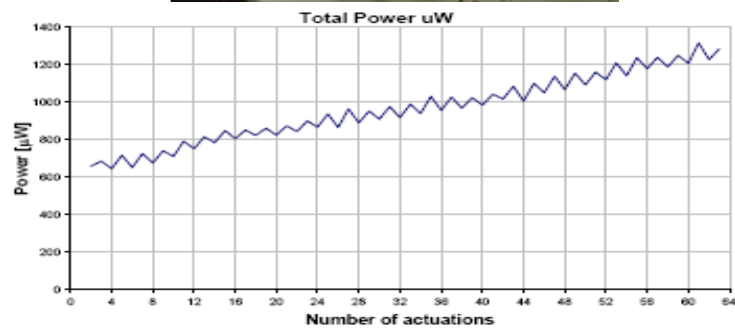
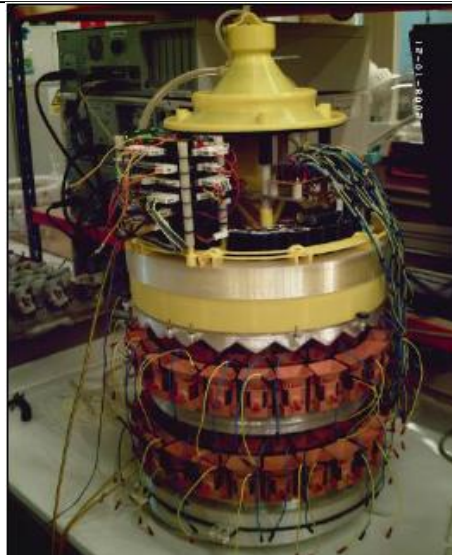
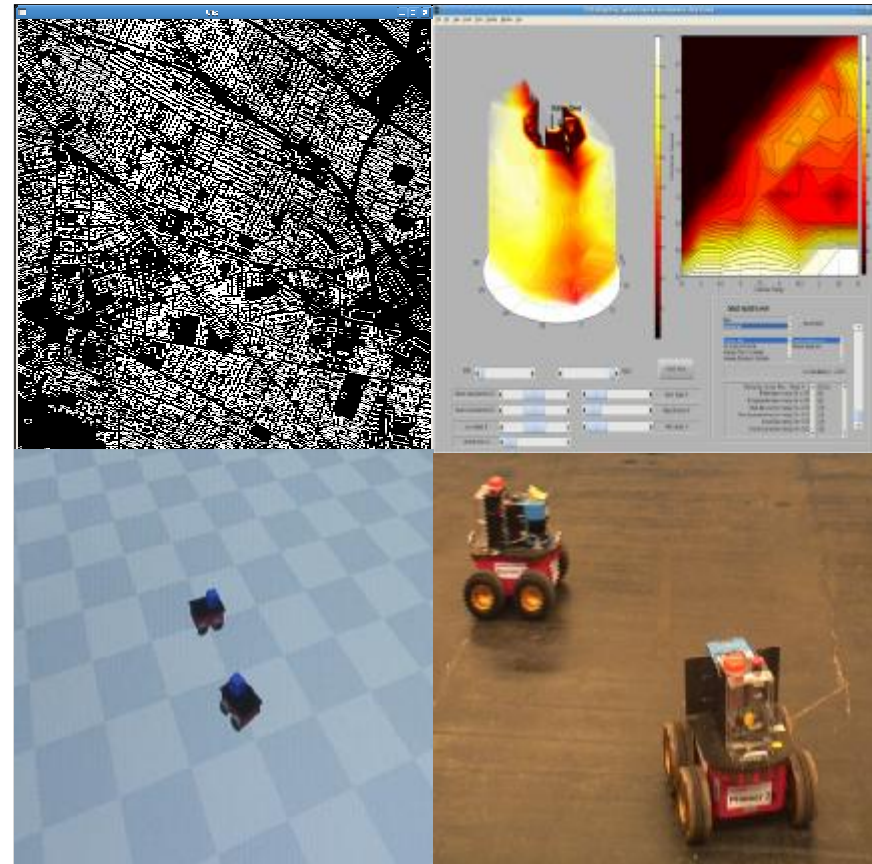


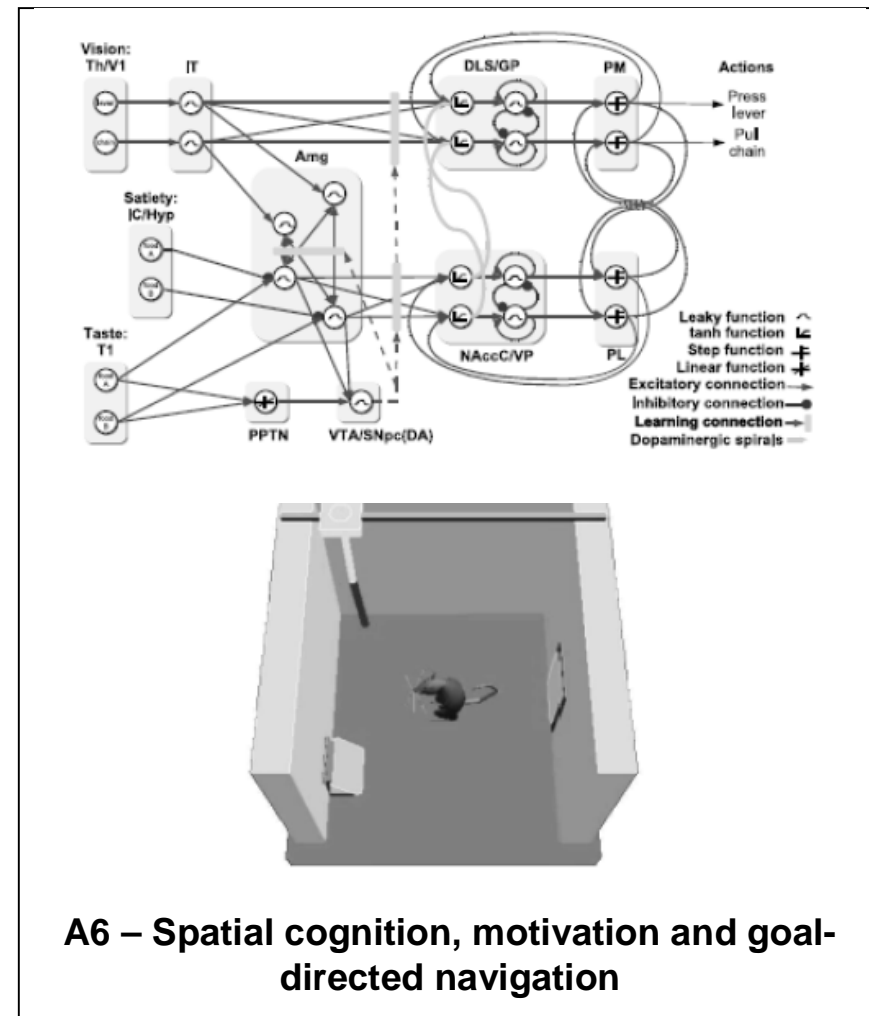
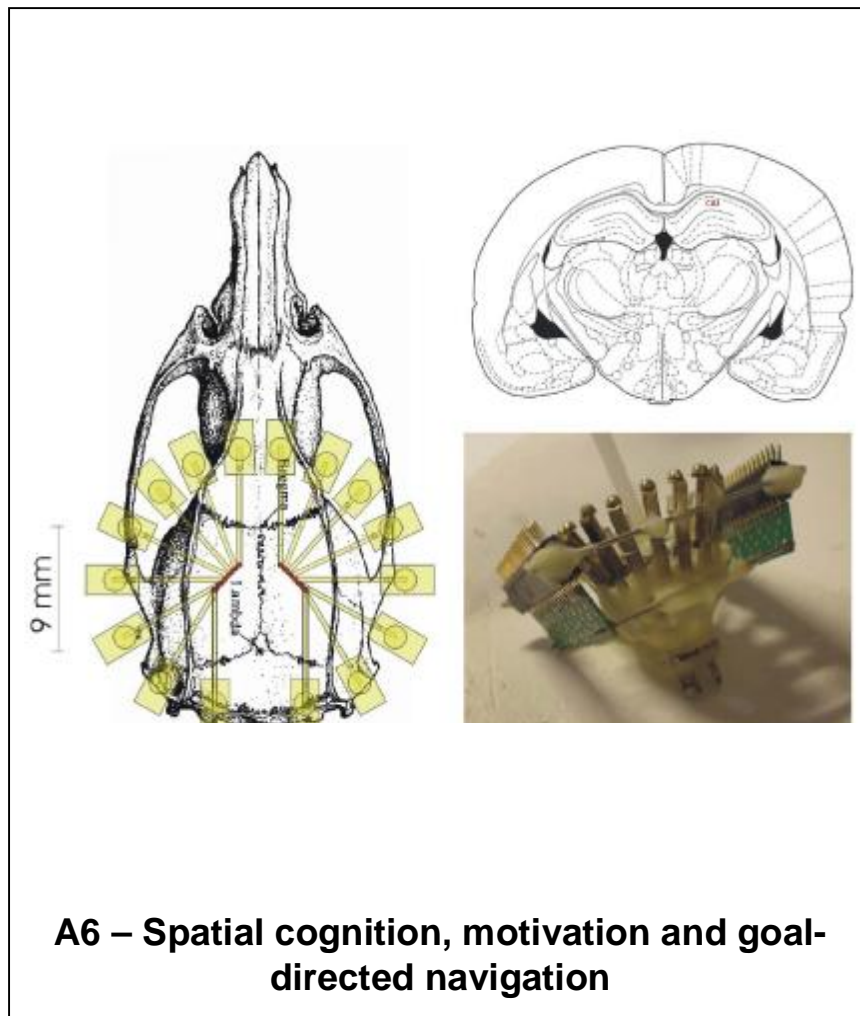
Figure 4. Total power produced from 48 MFCs per actuation.

A4- Energy autonomy and bio-regulation

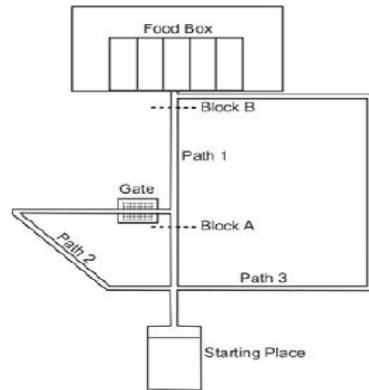
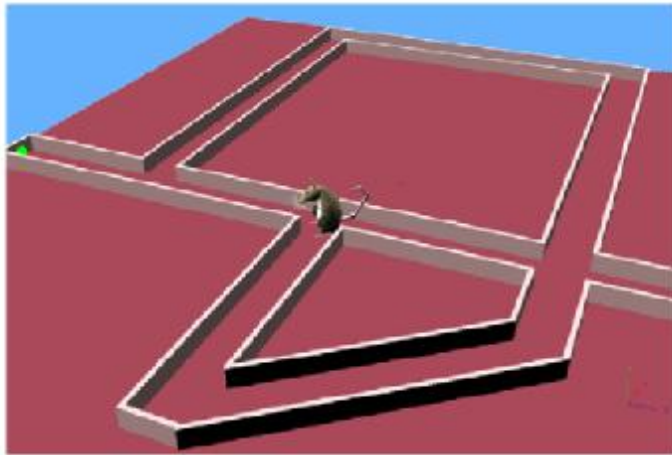


A5- The layered cognitive architecture for self-defence

Collaborative Activities



Collaborative Activities



A7 – Representation, abstraction and planning

Evaluating Cognitive Architectures for Collision Avoidance on Commercial Robots

Fundamental Principles

We work under the hypothesis that -

- “behaviour is the result of the interactions of an organism’s nervous system with both the external environment and the internal environment, i.e. with what lies within the organism’s body”

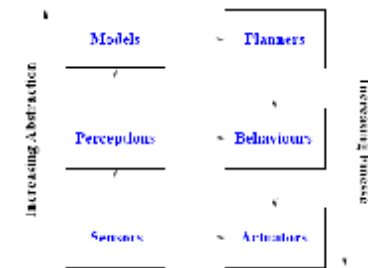
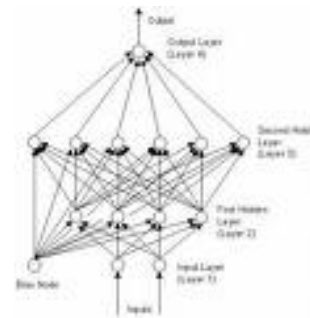
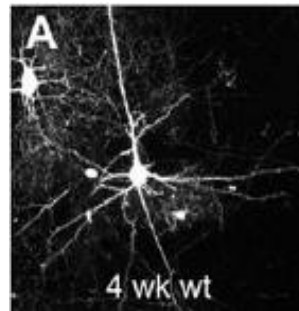
But crucially –

- It is the effect of those interactions and not the interactions themselves which result in the desired behaviour.

The Biological Approach

Using biologically inspired models to improve the capabilities of existing autonomous systems.

- examine the role of emotional learning in cognition and
- demonstrate the use of a layered self-defence architecture



Biology

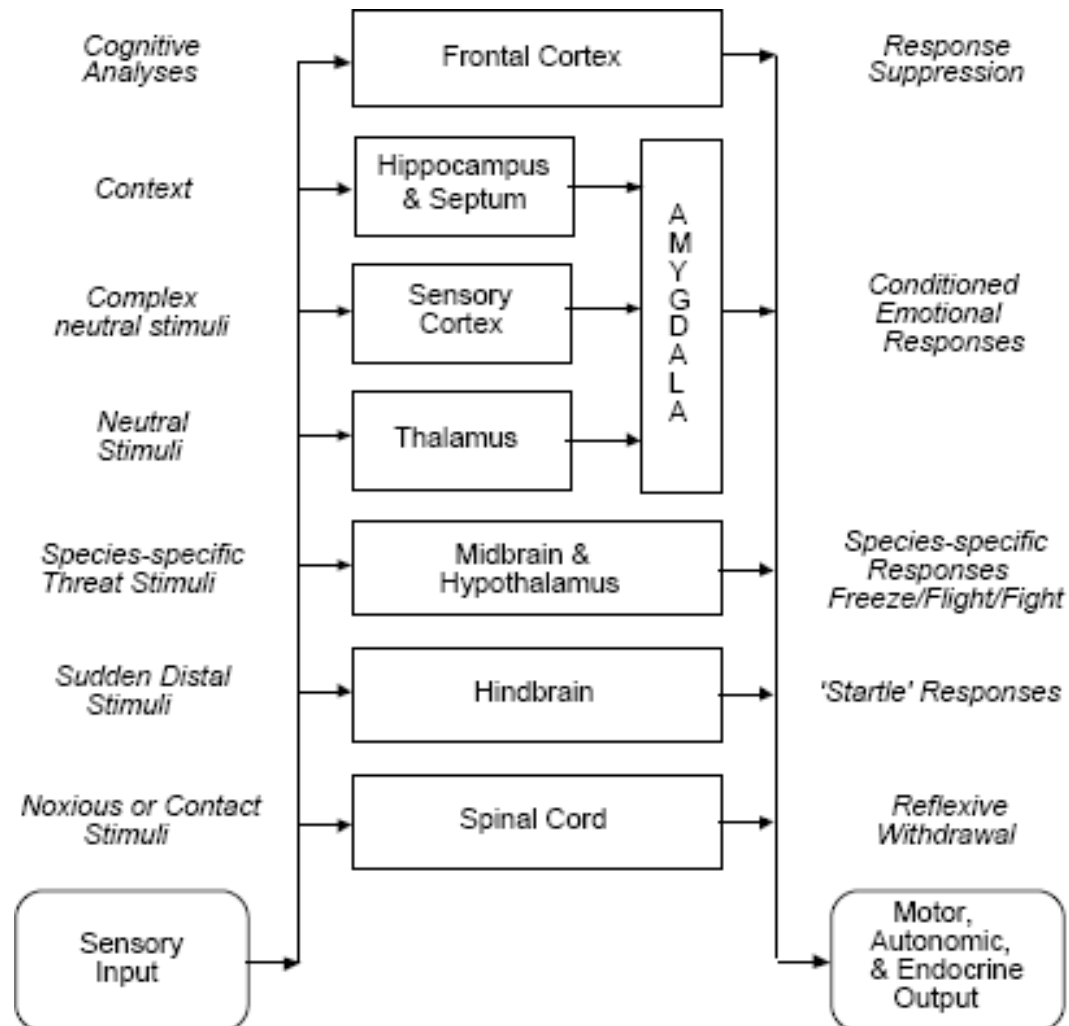
**Compartmentalised
Neural Models**

**Artificial Neural
Networks**

Conceptual Models

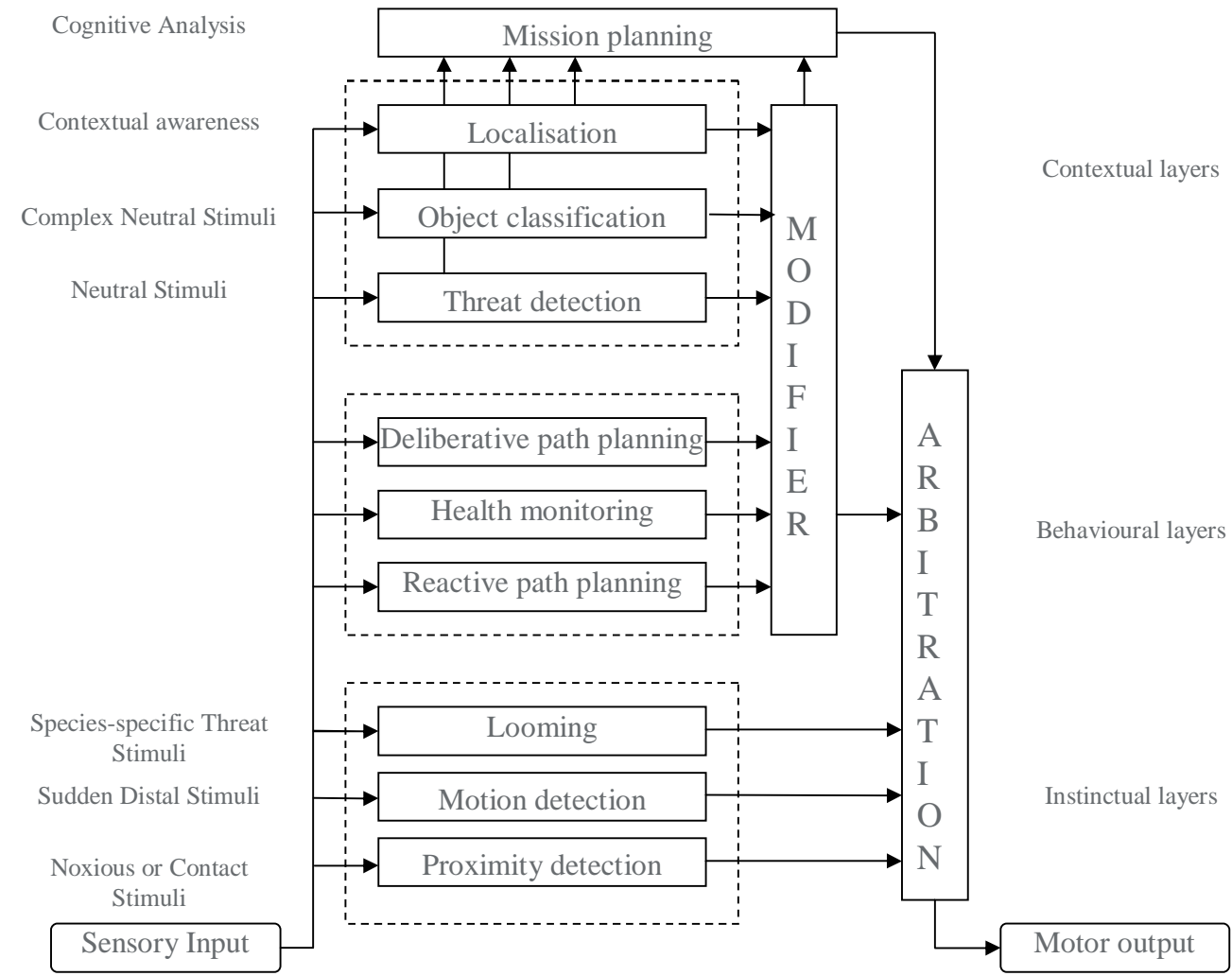


The Vertebrate Defence System

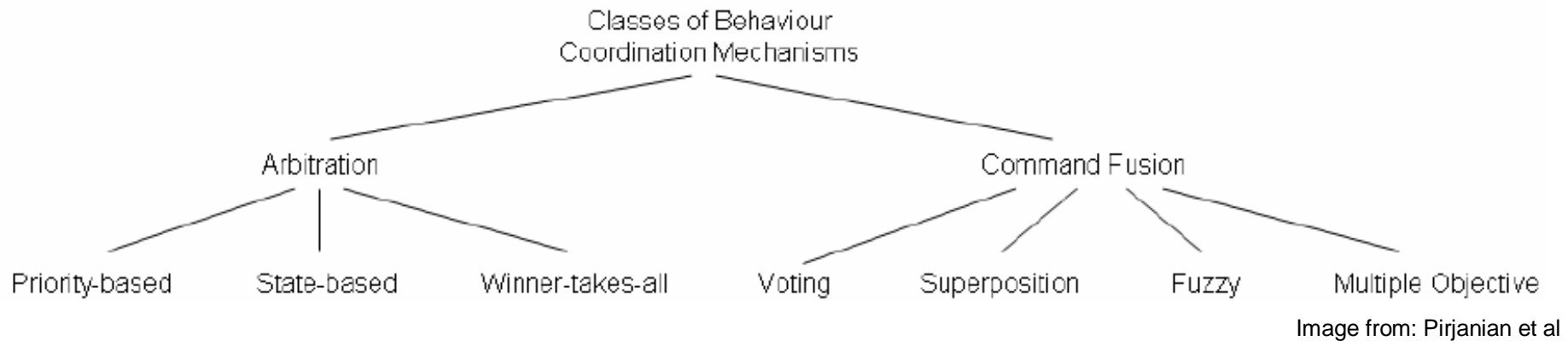


Prescott Gurney & Redgrave 1999

The Robotic Defence System



Contextual Arbitration



Priority based

- Requires knowledge of the priorities – which might change in different situations

Multi-objective optimization

- Slow and difficult to define the relevant cost functions

Selection of an arbitration technique is dependent on the current context
i.e. the current internal and external state

Currently no Well Principled method of evaluating the current context

Biological Arbitration

- Low level behaviours like the reflexive withdrawal and the startle response have been observed to operate instinctually
- Other behaviours have been observed to be modulated by fear and other emotions in general.
- However, many of these behaviours can be suppressed through conscious effort.

- The mechanism to allow this biological arbitration over behaviours does not strictly fit any of the current arbitration paradigms but the concepts involved show promise for use in robotics

Current Augmentations

- Currently we have developed a layered system for maintaining platform safety in dynamic environments with augmentations similar in concept to the mechanisms observed in biological arbitration.
- Low level reflexive behaviours attempt to keep the platform safe regardless of their consequence to overall goal achievement
- Fear or an aversion to uncertain behaviour, modulates the selection of safe routes, whilst attempting to satisfy high level objectives
- Goal directions are provided by planners that only consider high-level costs and not potential safety

Effects of Internal State

- By studying the interactions of various parts of the brain, it can be seen that it is the combination of both internal and external state that governs the final behaviour.
- For example, food that is located in a known risky location will only be collected once hunger exceeds the risk.
- Thus the arbitration paradigm adopted is a modified version of priority based selection where priorities can be dynamically altered based on the currently observed internal and external state.

The Algorithms

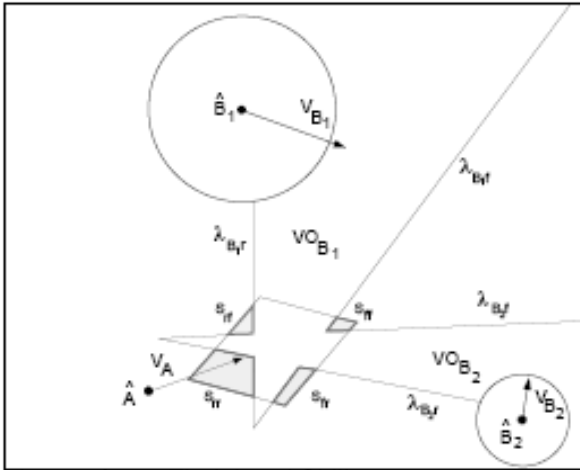


Image from: Fiorini and Shiller

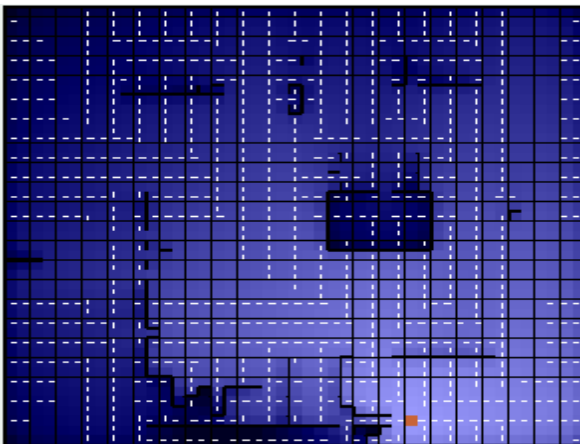


Image from: Kelkar and Mehta's Java MDP solver

Combination of two well understood algorithms to provide an experimental platform

- Reactive: Velocity Obstacles – Fiorini & Shiller
- Deliberative: Occupancy grid based Markov decision process solver
- Can provides conflicting goals. In order to make progress towards the goal some risk must be taken

The Robotic Platform

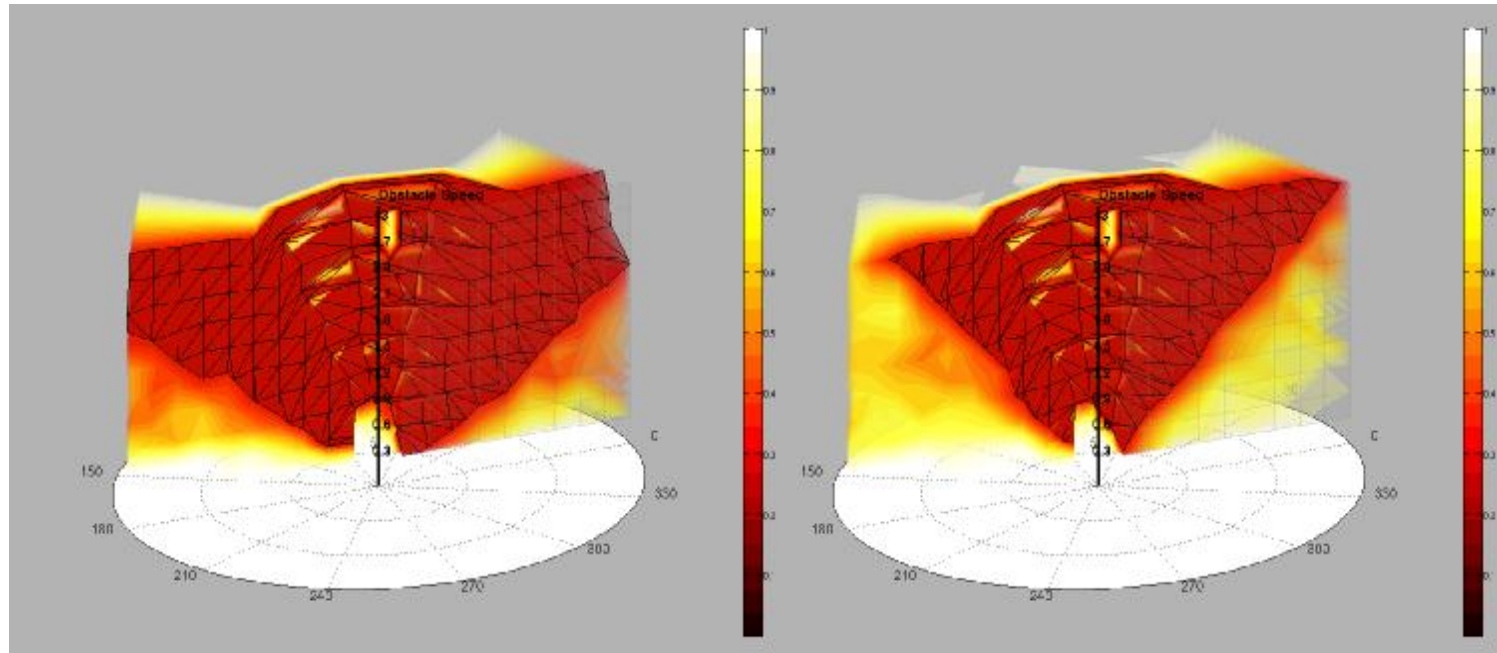


In addition to a simulated environment the applicability of the developed algorithms was tested on hardware to ensure compatibility.

This process was eased through the use of libASA based communications:

- Generalised broadcast based communications architecture
- Modular design
- Allows for distributed processing
- Scalable test platforms

Comparing Results

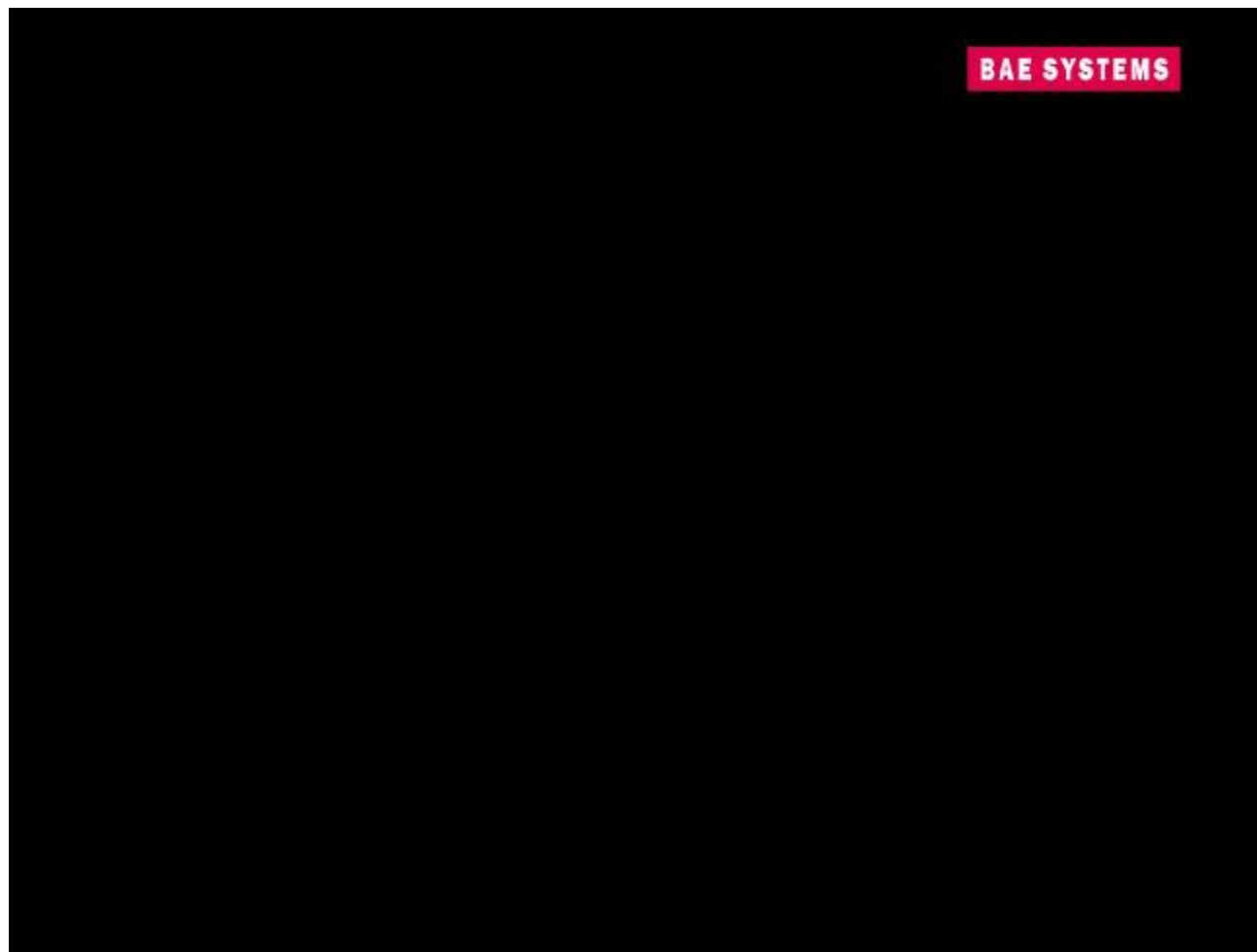


BaseLine System

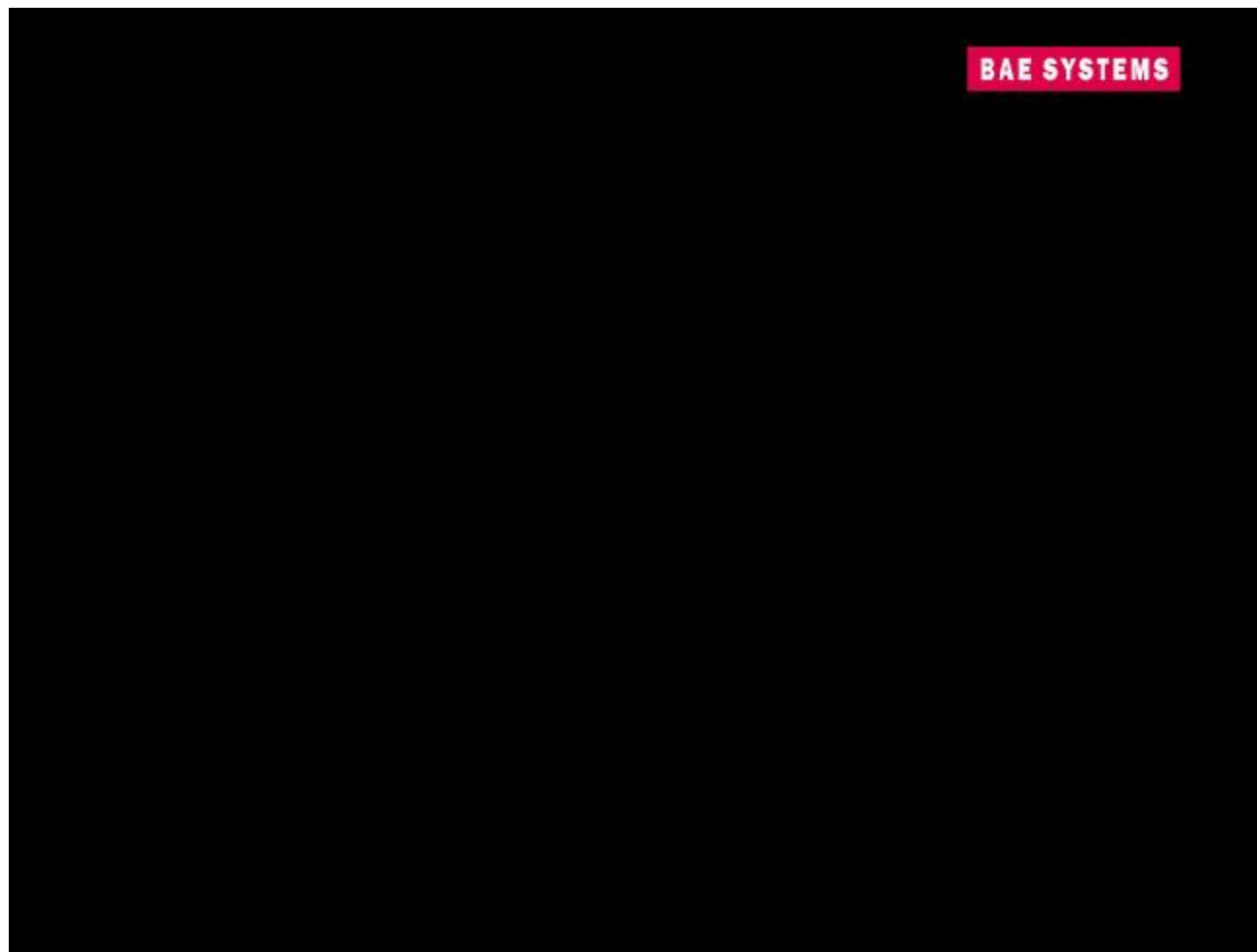
Augmented System

- Simulated results of survivability in uncertain dynamic environments whilst navigating towards a goal.
- Augmented system showing a modest improvement across the entire operating envelope

Comparing Results



Hardware Testing



Future Work

- Evaluating the effects of contextual arbitration of sensor measurement uncertainty
- Can changing behaviour result in improved sensor data and hence improved overall survivability.
- Can these behaviours be implemented on existing robotic hardware without adversely affecting their primary function.

Questions...

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