CERA-CRANUM: A Test Bed for Machine Consciousness Research

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Contents

- Introduction and objectives.
- Related work.
- Objectives.
- CERA-CRANIUM.
- Experimentation settings.
- Example of application.
- Conclusions.
Introduction (1)

- Theories of consciousness
  - Philosophical or psychological background.
  - Metaphorical descriptions.

- Need to bridge the gap between theories and implementation.
Introduction (II)

- Cognitive theories of consciousness
  - Global Workspace Theory (Baars, 1997).
  - Multiple Draft Model (Dennett, 1991).

- Inspiration for the design of a partial computational model of consciousness.
Introduction (III)

- Common ground
  - Non-unitary mechanisms producing the unity of self.
  - In other words, conscious contents emerge as a result of competition/collaboration (Minsky, Dennett, Hofstadter, Baars, Shanon).
Introduction (IV)

- Objectives
  - To understand how cognitive skills associated with consciousness can be integrated effectively.
  - To test different machine consciousness models.
Introduction (V)

- Functionalism:

  - Is this a reductionist approach?
  - Does this mean that phenomenal aspects are ignored?
Related work (I)


- IDA and LIDA (Ramamurthy et al., 2006).

- Computational Agent Framework for Consciousness (Moura & Bonzon, 2004).

- CERA-CRANIUM (Arrabales et al., 2007, 2008).
Related work (II)

- Common denominator:
  - Shared workspace and specialized processors.

- Different approaches in terms of:
  - Architecture.
  - Problem domain.
  - Perceptual flow.
  - Decision taking.
  - Modulation.
Objectives

- Experimentation platform.
- Test bed for high level cognitive approaches.
- Generic but configurable cognitive architecture.
CERA-CRANIUM (I)

CERA-CRANIUM Provides:

- Mechanisms for specialized processors
  - Creation,
  - Association,
  - Combination,
  - Competition.

- Mechanisms to regulate the former processes.
CERA-CRANIUM (II)

- **CERA**: layered control architecture.

- **CRANIUM**: runtime tool for the creation and management of high amounts of parallel processes in shared workspaces.

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CERA-CRANIUM (III)

- CERA: layered design
  - Sensorimotor services layer.
  - Physical layer.
  - Mission-specific layer.
  - Core layer.
Different levels of description
CERA-CRANI UM (V)

- CRANI UM
  - Blackboard
  - Pandemonium
CERA-CRANIUM (VI)

- Perceptual flow:
  - Sensory data.
  - Single percepts.
  - Complex percepts.
  - Mission percepts.
CERA-CRANI UM (VI bis)

Knowledge representation
CERA-CRANIUM (VI I)

- Behavior generation:
  - Mission behaviors.
  - Simple behaviors.
  - Single actions.
  - Motor controller commands.
CERA-CRANIUM (VI I bis)

Action generation

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CERA-CRANIUM (VIII)

- Bottom-up flow

Diagram:

- Sensors
- CERA S-M
- CERA Physical Layer
- CRANIUM Workspace
- Single Percepts
- Sensor Preprocessors
- Complex Percepts
- Percept Aggregators
- Mission Percepts
- Specialized Processors
- CERA M-S Layer
- CERA Core Layer

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CERA-CRANIUM (IX)

- Top-down flow
CERA-CRANIUM (X)

- CRANIUM processor types
  - Sensor preprocessors
    - Raw sensory data $\rightarrow$ single percepts
CERA-CRANIUM (XI)

- CRANIUM processor types

  - Action preprocessors
    - Atomic actions → Single actions.
CERA-CRANIUM (XII)

- CRANIUM processor types
  - Percept aggregators
    - Single percepts $\rightarrow$ complex percepts.
    - Complex percepts $\rightarrow$ complex percepts.
CERA-CRANIUM (XIII)

CRANIUM processor types

- Reactive processors
  - Single percept → simple behavior.
  - Complex percept → simple behavior.
CERA-CRANIUM UM (XIV)

- CRANIUM UM processor types
  - Action planners
    - Simple behavior → atomic actions.
CERA-CRANIUM UM (XV)

CRANIUM UM processor types

- Sensory predictors
  - Single percepts $\rightarrow$ mismatch complex percept.
  - Complex percepts $\rightarrow$ mismatch complex percept.

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**CERA-CRANIUM (XVI)**

- Multi-level concurrent feedback loops
CERA-CRANIUM (XVII)

- Physical level feedback loops
CERA-CRANIUM (XVIII)

- Software architecture

```
CERA Physical
CERA Sensory-Motor Services
DSS
CCR
.Net Framework

DSSP
CRANIUM

CERA Mission-specific
DSS
CCR
.Net Framework

DSSP
CERA Core
DSS
CCR
.Net Framework

Agent sensory-motor machinery

MCCM Configuration

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CERA-CRANIUM (XVIII bis)

- Software architecture

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<th>Workspace</th>
<th>Core Layer</th>
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CERA-CRANIUM (XI X)

- The proposed cognitive architecture is focused on:
  - Selecting next content of conscious perception.
  - Selecting next action to be executed.
Experimentation settings

- Variables:
  - Cognitive model of consciousness.
  - Agent (physical or simulated).
  - Problem domain and mission.
  - Environment (physical or simulated).
Applications

- Current applications:
Application example (1)

- Autonomous exploration and mapping
Application example (II)

- Autonomous exploration and mapping.
Application example (III)

- Percepts (bumpers).
Application example (IV)

- Single percept (bumper).

![Diagram showing bumper perceptions with left-j referent, j referent, and right-j referent with an impact event and N(δS_j)]
Application example (V)

- Complex percept (bumper).

- Left-j referent
- Right-j referent

Impact

\[ M(S_{Cl}) \]
Application example (VI)

- CERA Core Layer Design.

Cognitive Model

Meta-goals

Rule-based system

Meta-goals

Current Model State

Workspace Commands

$M(S_{Cj})$

Mission Percepts, Complex percepts, Mismatch Percepts, Novelty Percepts, ...

Core Layer

M-S Layer

Physical Layer

CRANIUM Workspace

CRANIUM Workspace

Contextual $J$-Index Calculation

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Conclusions (I)

- From sensory to qualia?
Conclusions (II)

- Different implementations of CERA layers.

- Explore workspace modulation techniques.
Thank you