GROUNDING ARTIFICIAL GENERAL INTELLIGENCE WITH ROBOTICS: THE PETITCAT PROJECT

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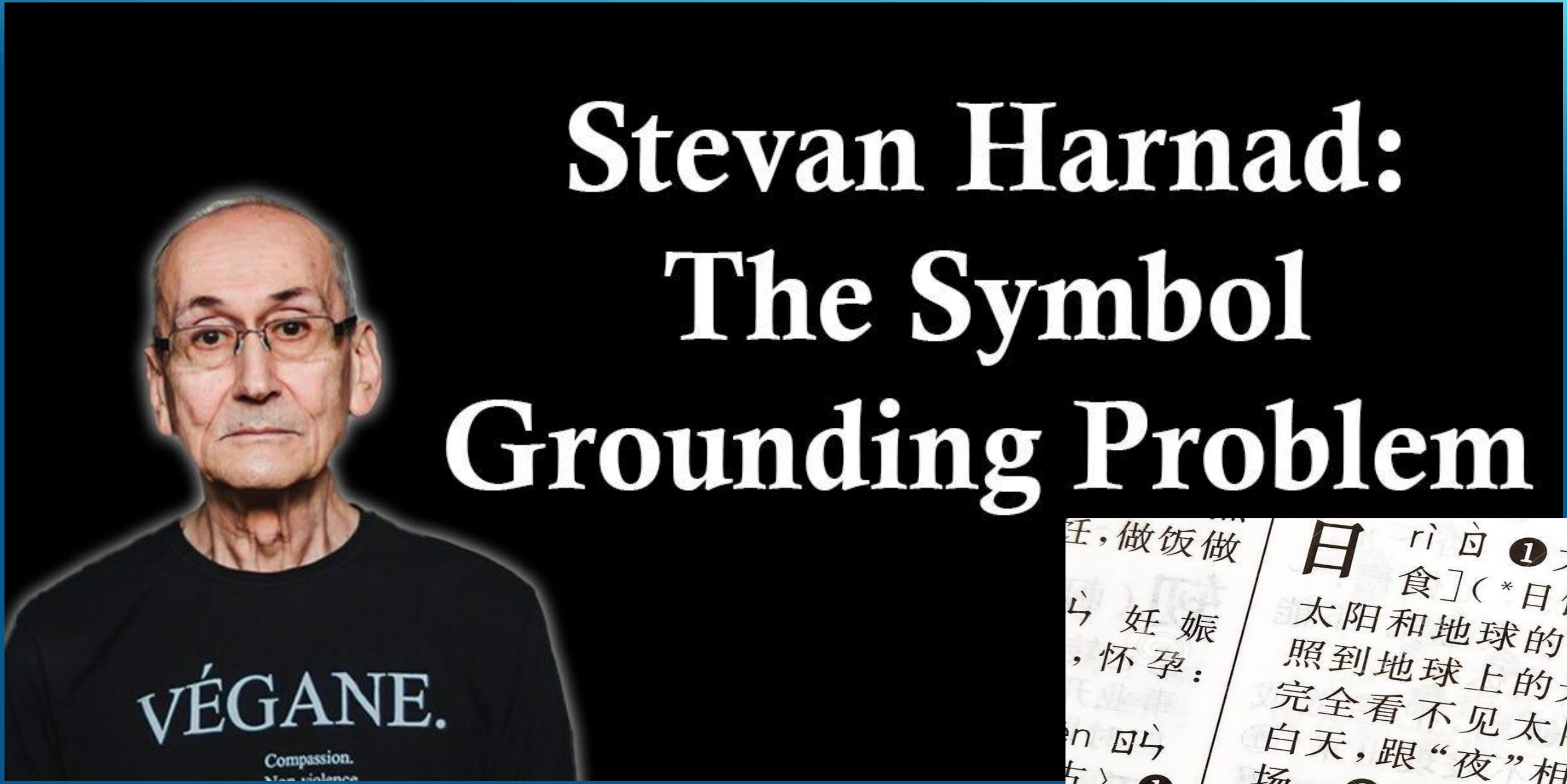
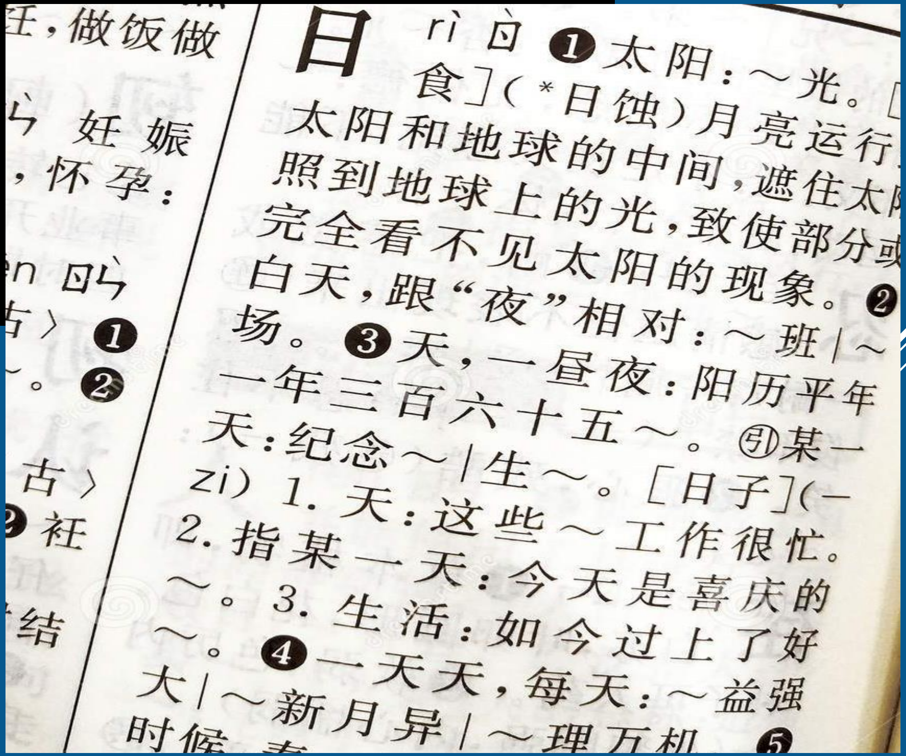

Stevan Harnad:
The Symbol
Grounding Problem
VÉGANE.
Compassion.


日 rì ❶太阳：～光。
食]（*日蚀）月亮运行
太阳和地球的中间，遮住太
照到地球上的光，致使部分
完全看不见太阳的现象。❷
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场。❸天，一昼夜：阳历平年
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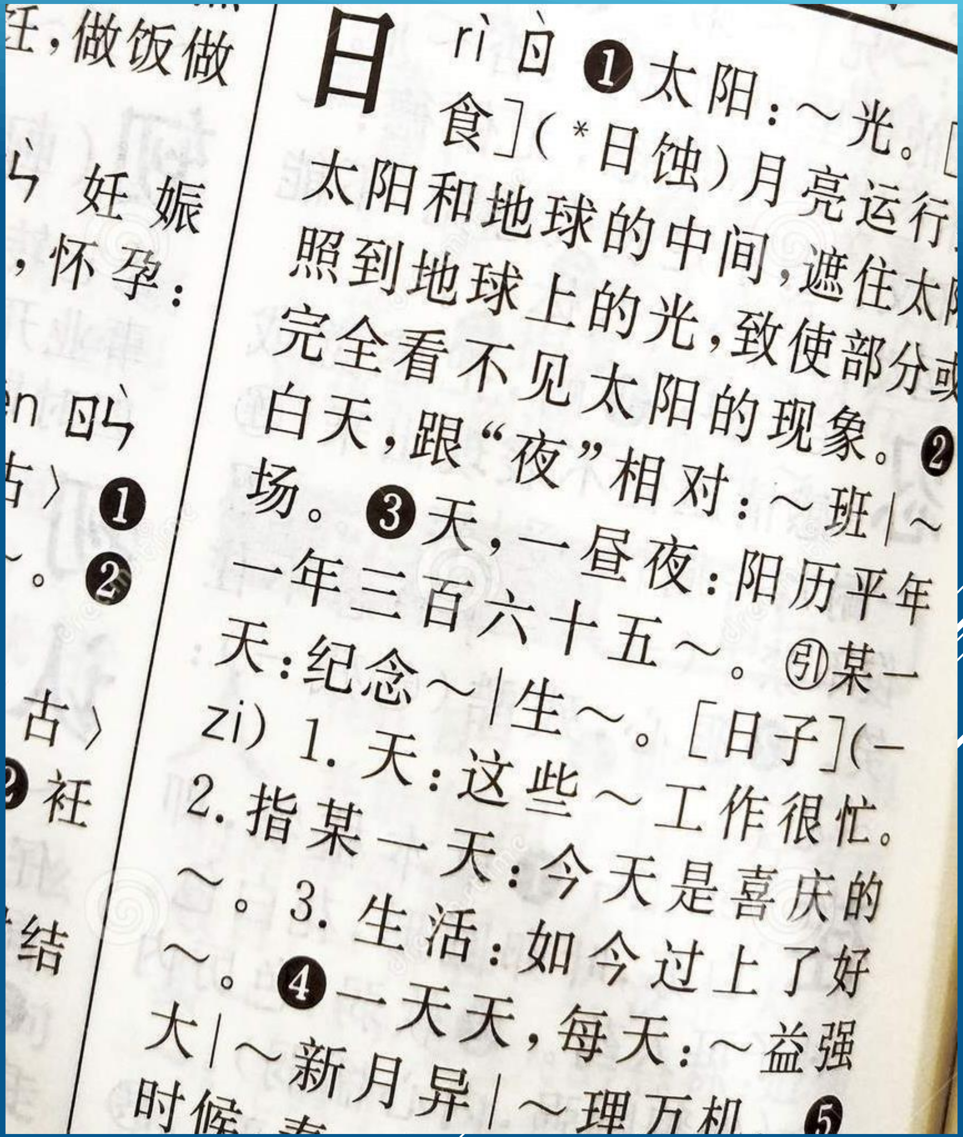
天：纪念～|生～。[日子](～
zi) 1. 天：这些～工作很忙。
2. 指某一天：今天是喜庆的
～。3. 生活：如今过上了好
～。❹一天天，每天：～益强
大|～新月异|～理万机 ❺

- try to learn Chinese language from Chinese-Chinese dictionary

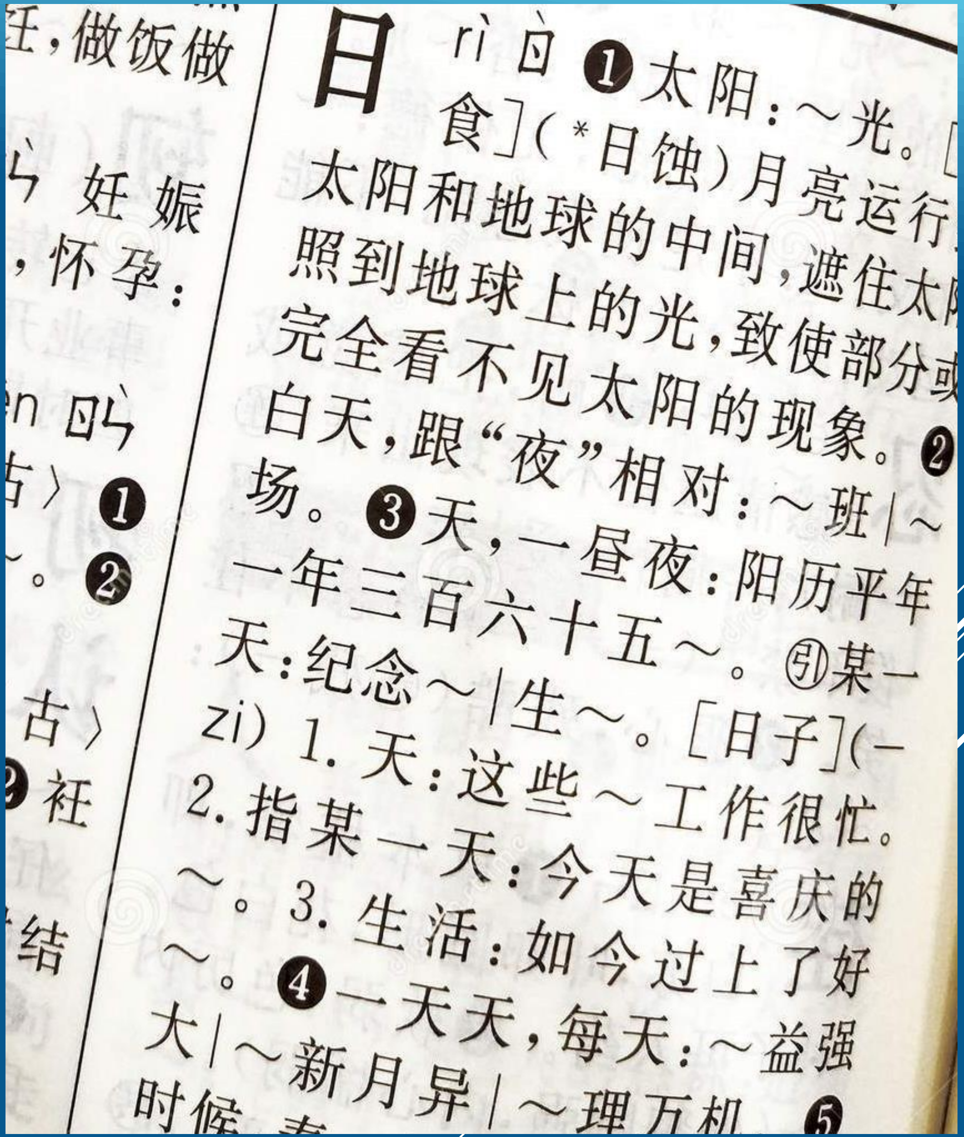
符号接地问题



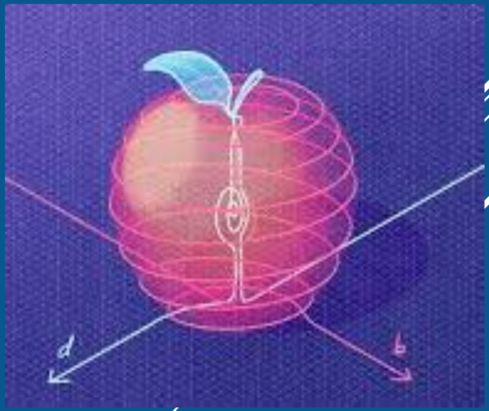
Google translate:
strip: "symbol grounding problem"
Dictionary page: Sun: ~light. Eclipse (solar eclipse) The moon moves between the sun and Earth, blocking the light that hits the Earth….

Go from one string of symbols without any meaning attached to the symbols to another string of symbols

符号接地问题



- How can the abstract symbols of a computing system actually understand the external world?



Symbol Grounding Problem

Computer: deals with the **symbols as "shapes"** rather than their "**meaning**"

→How to make these **arbitrary symbols meaningful** without an external interpreter?

e.g., human providing context

Harnad:

- ground symbols with their **real-world** sensations and interactions, objects and actions they are linked to
- **provides meaning to symbols**

Putting philosophy aside, what are the **practical advantages** to grounding an AI or AGI project?

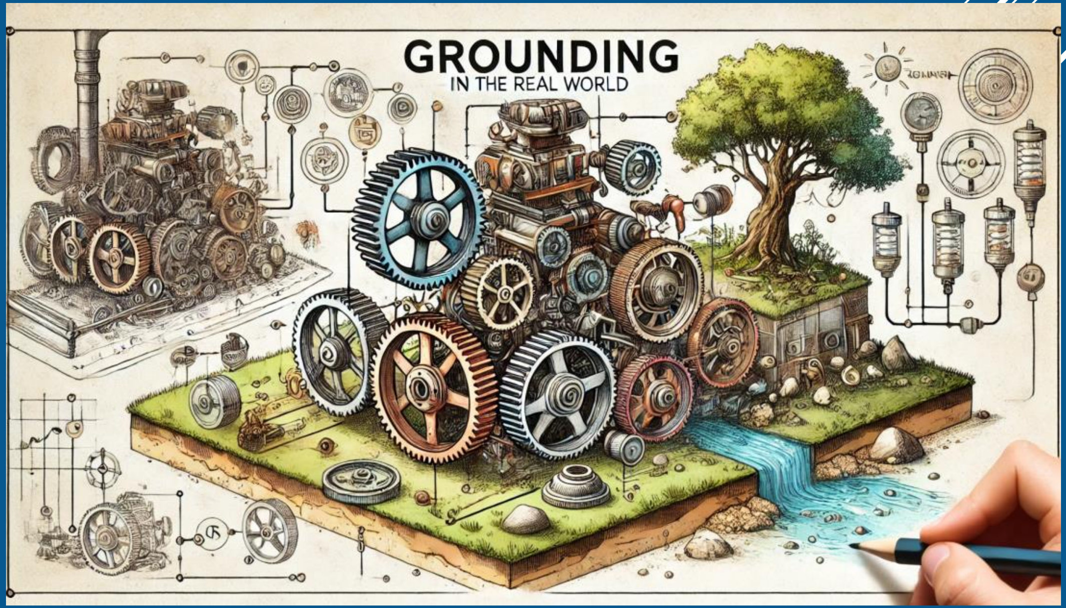


Image by DALL-E, 2024

- GROUNDING ADVANTAGES: AI/AGI can **understand** information with better context → **more accurate decisions**

Partial grounding only. Not full, complex, nuanced understanding for ChatGPT.
[vs GLAM via RL, Pavlick symbols and grounding LLM, etc.]

GROUNDING ADVANTAGE:

AI/AGI can **learn and adapt** from real-world experiences

- GROUNDING ADVANTAGES : AI/AGI can understand **real-world implications** of different actions → **more accurate decision/action**

GROUNDING ADVANTAGES:

AI/AGI can understand information with better context → **safer action, better alignment with human values possible**

GROUNDING ADVANTAGES : AI/AGI can anchor concepts in real-world experiences → can uses these reference points when encounter a new situation →**better generalizations**

GROUNDING → BETTER GENERALIZATIONS VIA:

- Reference points when encounter new situation
- Multimodal integration
- Reduce overfitting since exposure to diverse real-world data
- Better abstract the essential features from a situation

→ GROUNDING IS ADVANTAGEOUS

→THERE IS A **NEED FOR A ROBOTIC PLATFORM** FOR AN AI/ AGI/ BICA PROJECT

PETITCAT PROJECT

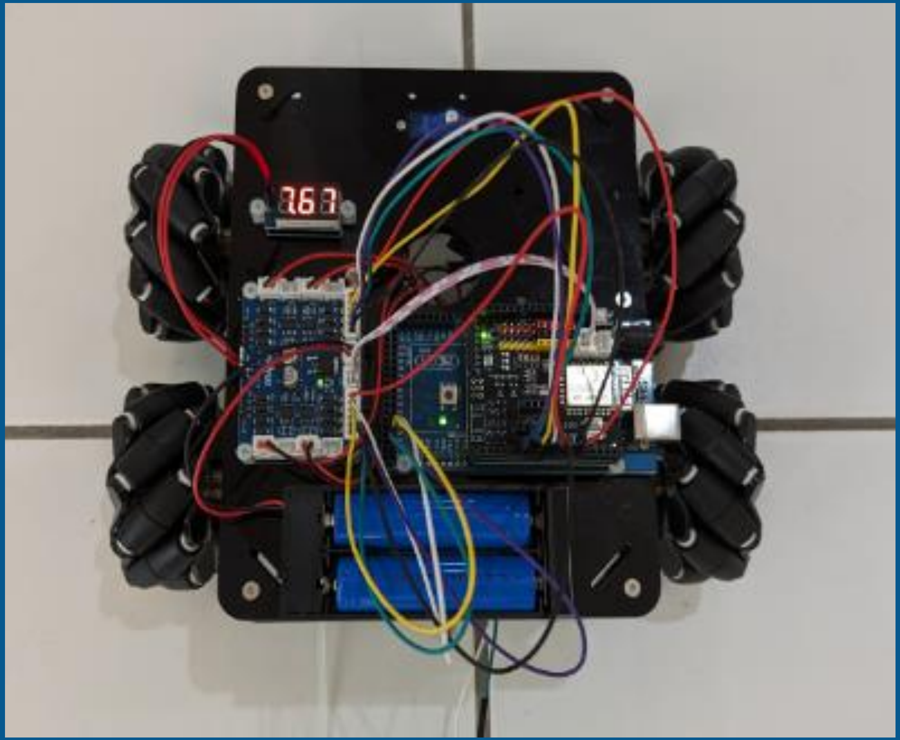
- Free, open-source software, GitHub
- Olivier Georgeon started, contributions by Schneider and others
- Interfaces an AI/ AGI/ BICA Python software project to a real-world embodiment
- **Allows you to ground your Python AI project**

ROBOTS ARE EXPENSIVE (2024)

e.g., Boston Dynamics Spot
US$75,000 (2024)

PETITCAT PROJECT USES OPEN-SOURCE HARDWARE → LOW-COST ROBOTS POSSIBLE

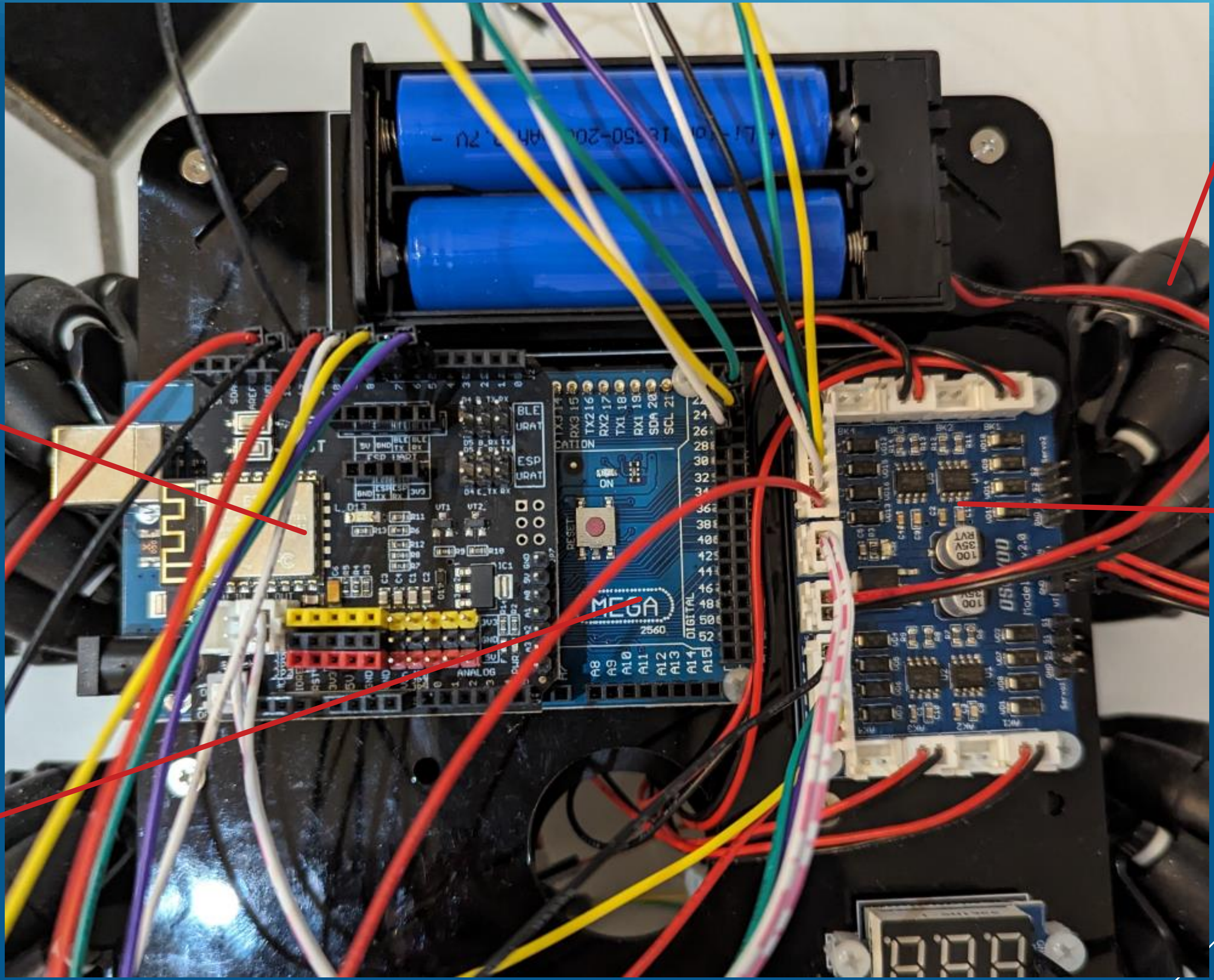
PETITCAT PROJECT USES OPEN-SOURCE HARDWARE -- ARDUINO/OSOYOO PLATFORM



Total costs
~ US$ 150

Wi-Fi Board

Arduino Microcontroller Board

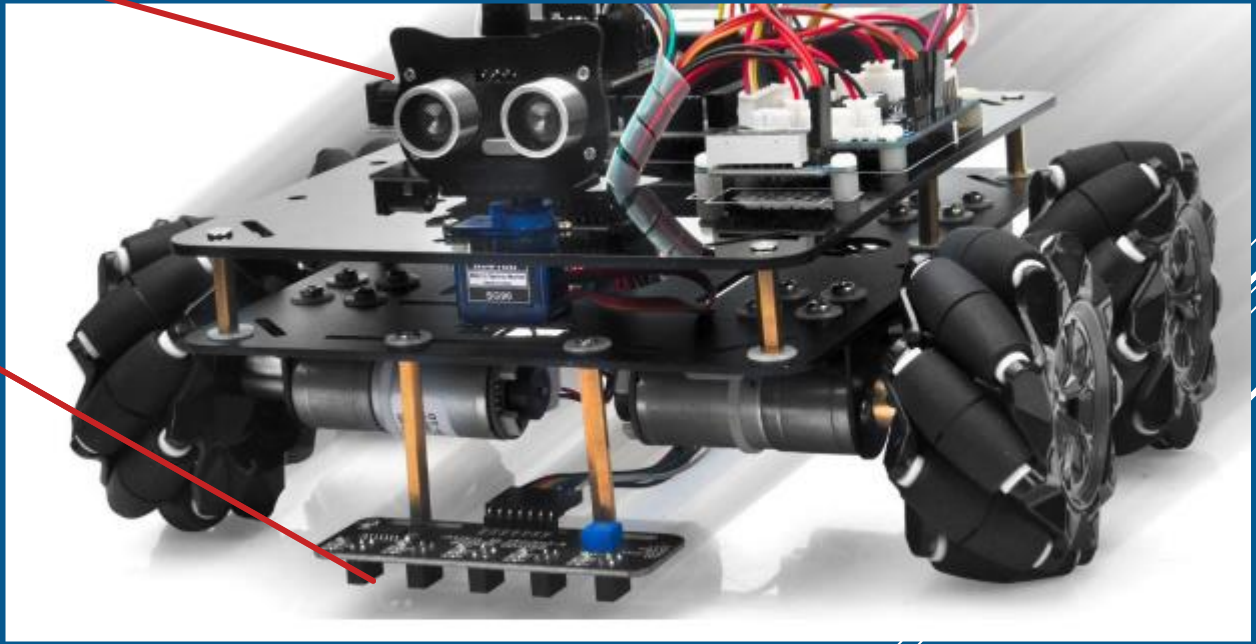


Mecanum Wheels, individual motors

Motor Driver Board

Ultrasonic sensors (moved by servomechanism)

Infrared sensors



EASY TO CUSTOMIZE WITH OTHER SENSORS & ACTUATORS

e.g., 9-axis inertial measurement unit, color sensor, emotion LED

ROBOT SOFTWARE IS COMPLEX TO LEARN AND TO IMPLEMENT

e.g., ROS2 Robot Operating System (framework)

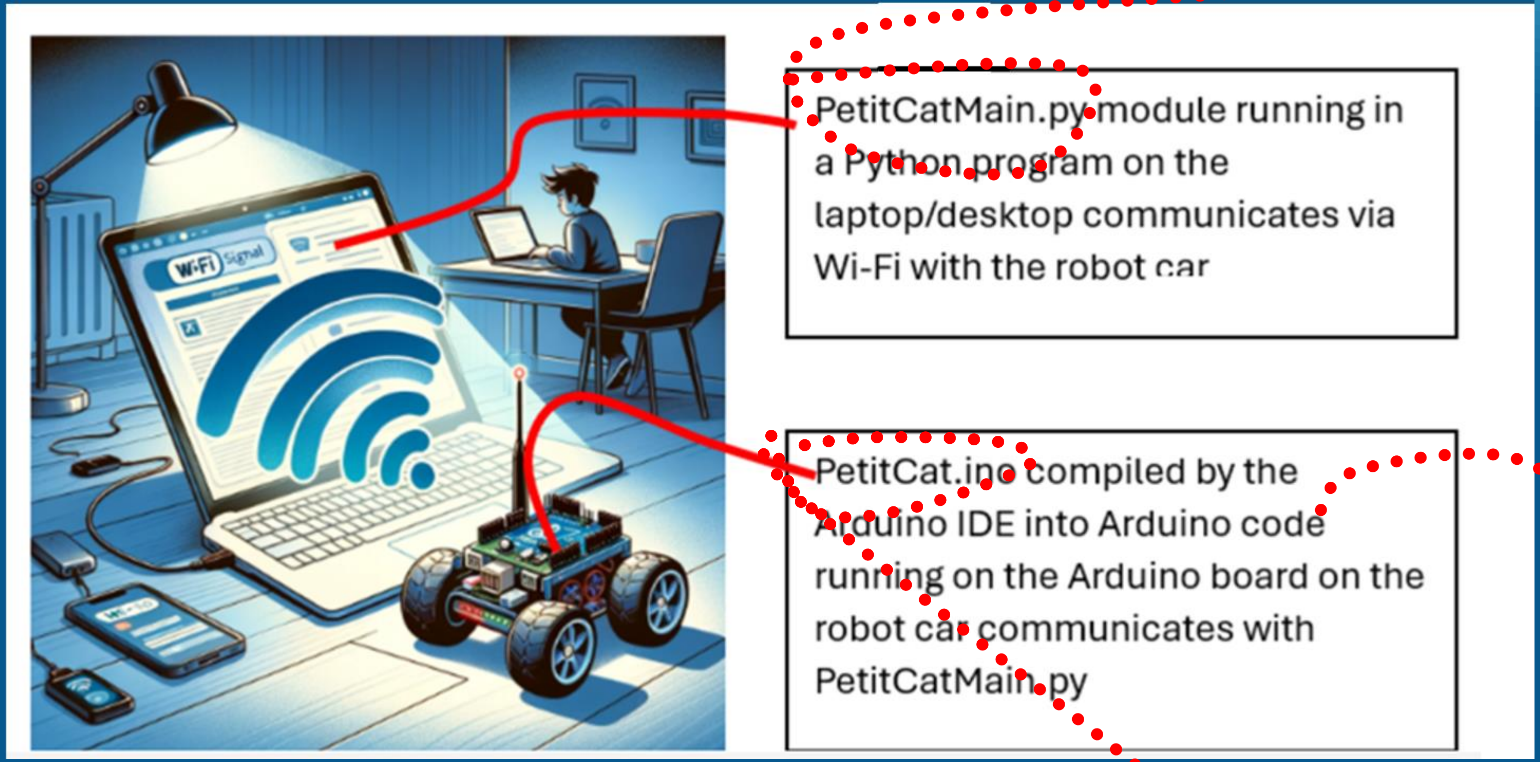
nb.:
-ROS1 required Linux but ROS2 also allows Windows and macOS
-many sophisticated modules now, e.g., control multiple robots
-very secure communications now built into ROS2
-supports C/C++ and Python
-learning curve much higher, i.e., ROS2 time >> Arduino time

PETIT CAT SOFTWARE HAS A SHORT LEARNING CURVE

PetitCatMain.py module running in a Python program on the laptop/desktop communicates via Wi-Fi with the robot car

PetitCat.ino compiled by the Arduino IDE into Arduino code running on the Arduino board on the robot car communicates with PetitCatMain.py

Image by DALL-E, 2024

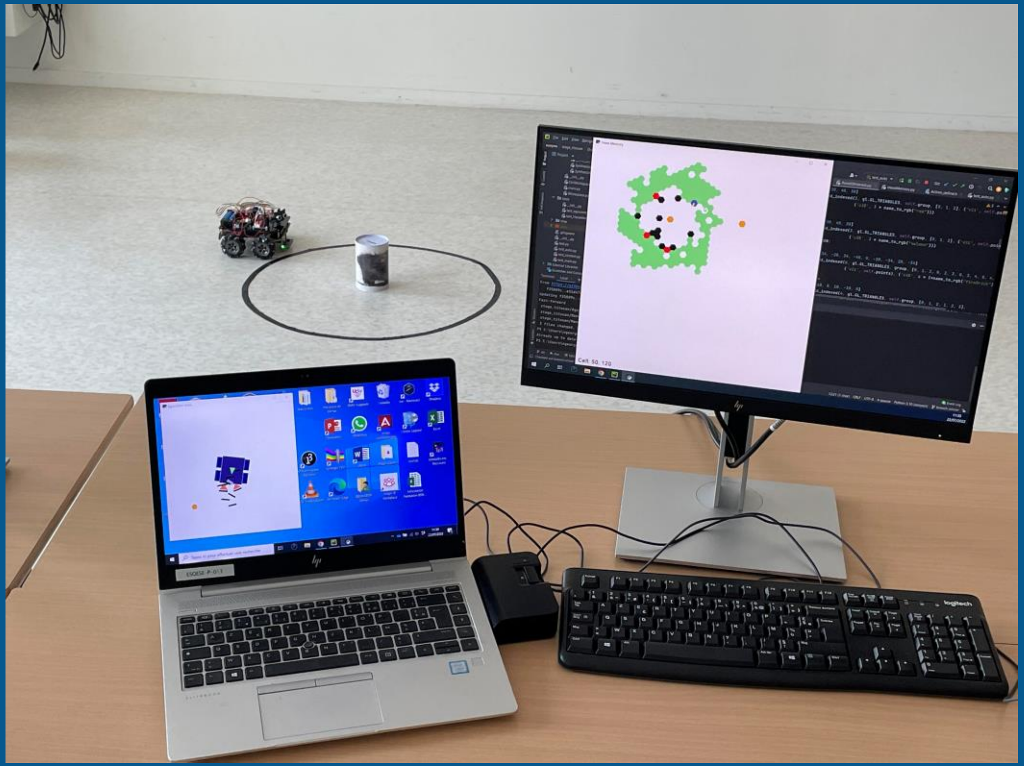


Python code of your AI/ AGI/ BICA project uses PetitCatMain.py to interface with the robotic embodiment

C/C++ code is compiled by Arduino IDE into **machine code** for over a hundred different Arduino and non-Arduino microcontrollers

You can use the existing PetitCat **C/C++ code** to run the embodiment or you can easily modify it

PETITCAT USE EXAMPLE



Implementation of enactive inference (Georgeon et al.)

Perceive world by mismatch of prediction of world and sensory input (action-perception loop)

Reduced computational load; real-time adaptation; more robust with noise; enhanced learning

PetitCat Internal Simulator (screenshots)

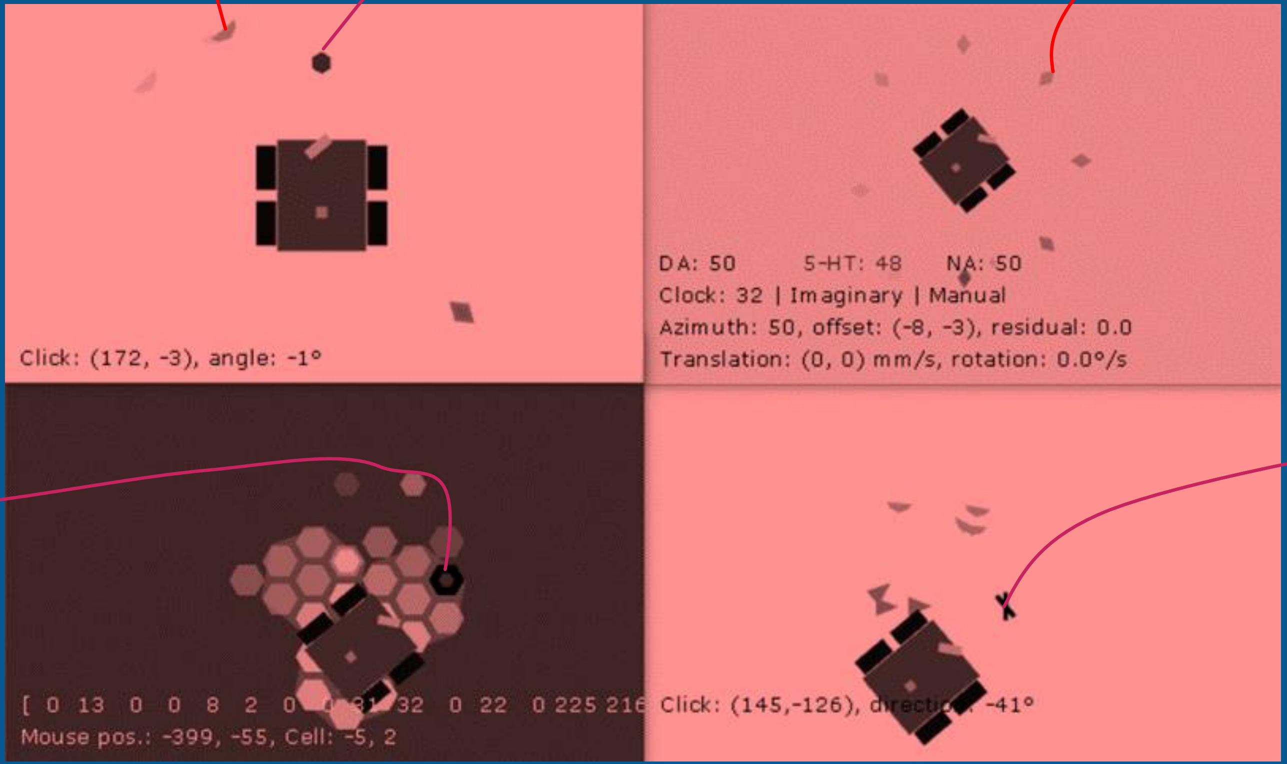
Egocentric Spatial Memory (relative to agent's position)

e.g., hexagon in front of agent

Half-circle - echo

Hexagon – focus of attention

Agent Memory (compass points over time as robot turns around)



Black mark on the floor

Interactions with the black mark on the floor

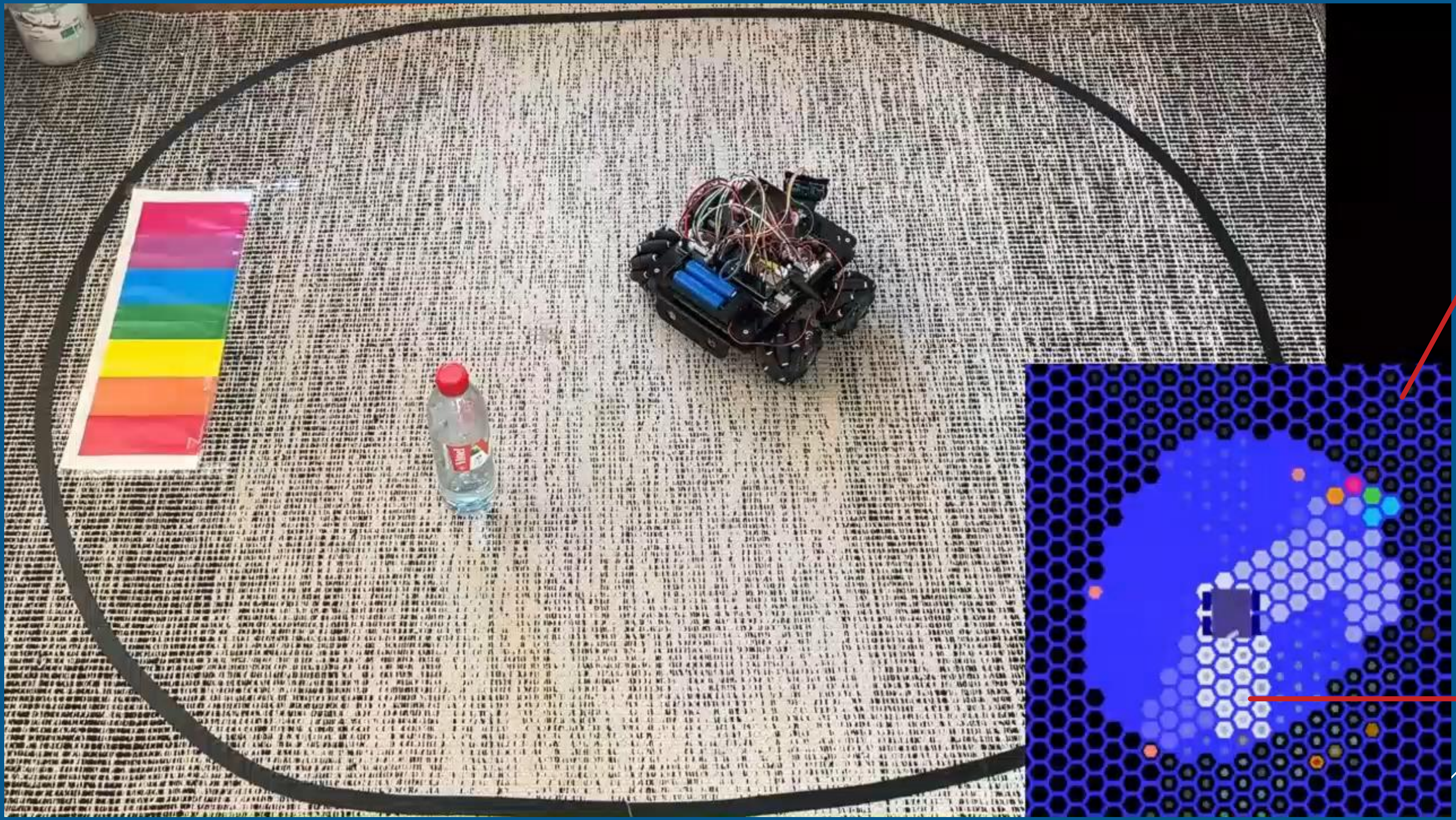
Allocentric Spatial Memory (bird's-eye view)

i.e., navigate from any perspective

Object-Centric Spatial Memory (relations between objects, not agent)

e.g., black mark vs. other echos

VIDEO: ENACTIVE INFERENCE

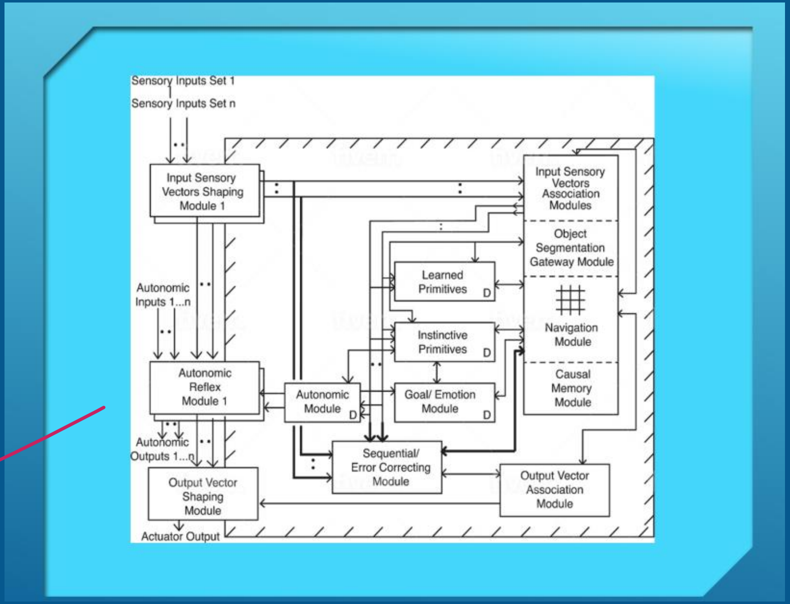


Hexagons represent grid cells (darker ones not used yet)

White hexagons – place recently covered by agent

OTHER PROJECTS USING PETIT CAT FOR EMBODIMENT

- Gay – bio-inspired spatial navigation
- Schneider – interface to a BICA (Causal Cognitive Architecture)



Free, open-source project, accessible via GitHub

https://github.com/OlivierGeorgeon/osoyoo
https://github.com/UCLy/INIT2