ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

From individual perception to collective behavior in drones. A self-aware approach

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Intelligent Agents, Sensors and Actuators

Each intelligent agent, biological or artificial, incorporates:

- Sensors
  - Proprioceptive (Cochlea, IMU)
  - Exteroceptive (Eyes, Camera)
- Actuators (Feet, Engine)

Self-awareness (SA)

Self-awareness incorporates agent's ability to become the object of it own attention which translates to the following abilities (See next slide) [1]

[1] Regazzoni, C. S., Marcenaro, L., Campo, D., & Rinner, B. (2020). Multisensorial generative and descriptive self-awareness models for autonomous systems.

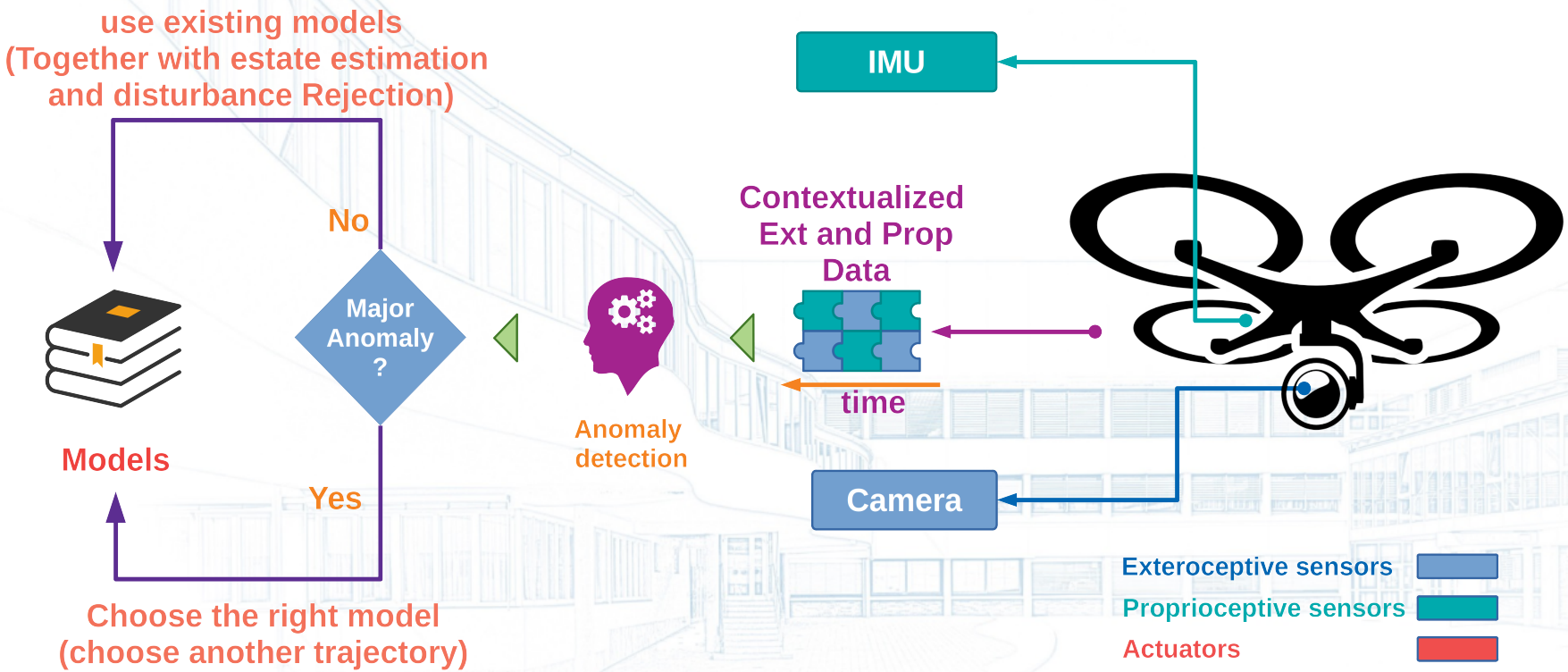
Self-awareness (SA) - Abilities list

- **Initialization** Ability to follow a reference task over the course of time (Time-awareness)
- **Major anomaly detection and Generative Model building**: Ability to detect new experiences from exteroceptive and proprioceptive sensory data
- **Memorization and discrimination**: Ability to memorize and provoke the appropriate learned experience

Self-awareness (SA) - Abilities list - 2

- **Decision making**: Converting anomaly signals to appropriate actions
  - **Disturbance rejection**: convert minor anomaly signals to actions such the distance between estimated states and current practicing model minimizes
  - **Changing practicing model**: changing from one model to another model in case of major anomaly detection

Simple illustration of an SA drone



SA, sensors and actuators

SA in Single drone navigation and aerial manipulation

The aforementioned abilities in a single drone translates to:

- Path/motion planning
- State estimation
- Trajectory tracking
  - **Minor anomaly detection** Disturbance rejection
- **Major anomaly detection** Anomaly detection: Collision avoidance
  - Corridor turning points
  - Vertical collision avoidance
  - Horizontal collision avoidance

Collective Awareness CA abilities

In addition to individual SA abilities in the collection, CA must incorporate anomaly detection ability for

- the course of relationship/formation which should be kept along time

Our examples will be based on collective load transportation which entails keeping drones close to each other in particular formation which are either

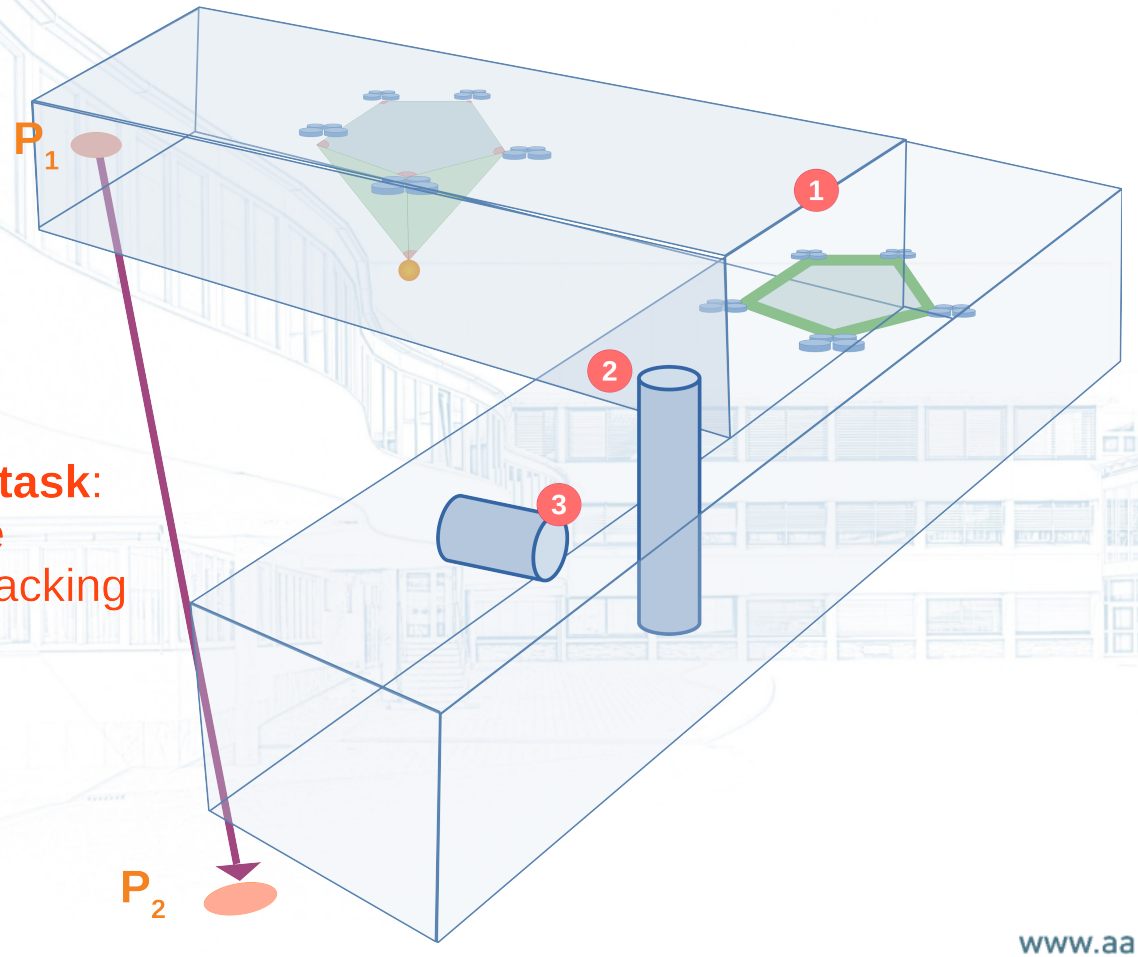
- attached to rigid loads
- suspended from a cable

CA in multi drones navigation and aerial manipulation

- Collective path/motion planning
- Formation state estimation
- Formation Anomaly detection while individuals perform collision avoidance maneuvers and taking the right decision toward a new appropriate formation to avoid load and system collision

CA scenarios

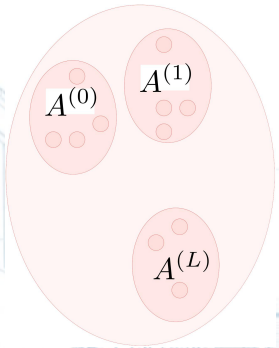
CA formation models from which appropriate actions should be practiced



Reference task:
Straight line
trajectory tracking

Individual semantic emergence

Discretized[2] generalized state for different derivatives of time forms the alphabet of words by which each individual agent can describe the experiences it is practicing to other agents[3]



$$w = \{\alpha^{(0)}, ..., \alpha^{(L)}\} \tag{1}$$

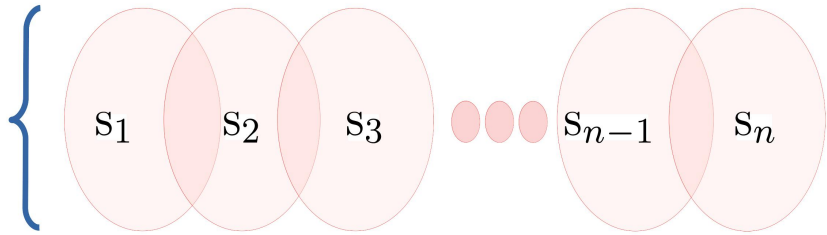
[2] Fiser, D., Faigl, J., & Kulich, M. (2013). Growing neural gas efficiently.

[3] Kanapram, D., Marin-Plaza, P., Marcenaro, L., Martin, D., & Arturo de la Escalera, C. R. (2019). Cognitive dynamic systems: Perception-action cycle, radar and radio.

Collective semantic emergence

Mutually activated discretized generalized state space for the collective language[4]

Words are synchronously activated Zones in the absence of repulsive forces



[4] Baydoun, M., Campo, D., Kanapram, D., Marcenaro, L., & Regazzoni, C. S. (2019). Prediction of multi-target dynamics using discrete descriptors: An interactive approach.

Question

How should emergence and frequency of locally communicated phrases of individual agent experiences persuade an agent toward either

- **Reacting to major collective anomaly** Taking actions to perform a part of a collective behavior to keep homeostasis situation
- **Reacting to minor collective anomaly** To ignore them and devolve it to individual disturbance rejection module in each individual agent.