Collective awareness in MAVs

Mohammad Rahmani

Pervasive Computing Group (Klagenfurt university)

22 September 2020

Self-awareness (SA)

SA is an approach in Artificial Intelligence (AI) to enable Intelligent Agents (IAs) to make a distinction between their previous experiences and new experiences observed by their sensors. [1] and

- build new predictive models of these new experiences
- store them and retrieve them to predict and plan future
- make appropriate decisions according to the new situation

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

Experience definition

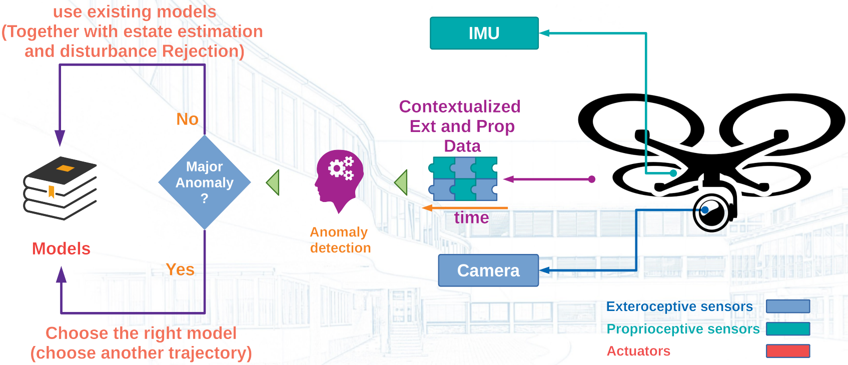
- Having experience means being equipped with a model that can predict future states (location, motion ...) of an IA by current observation through their sensors

Sensors

Each IA, either biological or artificial, incorporates:

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

Simple Illustration of an SA drone



SA, sensors and actuators

The Ultimate Goal of a Self-aware IA

- To maintain its homeostasis condition over the course of time by taking advantage of the modeled experiences to improve issues such as
  - Resource management
  - Security
  - Safety

Collective Self-awareness (SA)

- The ability to detect abnormality in the course of relation a couple of IAs were supposed to maintain and make appropriate decisions to improve collective homeostasis conditions
  - **Example**: Taking an appropriate **formation** when the collection faces a factor detrimental to its collective homeostasis condition

Tools and Theories to Implement SA/CA

- Dynamic Bayesian Networks such as
  - Markov Jump Linear Systems (KF+DBN) [2]
  - Markov Jump Particle (KF+PF+DBN) Systems[3]
- Force Field Analysis (Autonomous navigation)
- Variational Auto Encoders (To generate different versions of the same experience)
- Continual/Lifelong learning (To include all experiences in one model)

[2] doucet-2001-particle-filters-for-state-estimation-of-jump-markov-linear-system

[3] baydoun-2018-learning-switching-models-for-abnormality-detection-for-autono

SA in Single UAV Navigation for Aerial Manipulation

The aforementioned abilities in a single UAV navigation in tight spaces such as buildings translates to:

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

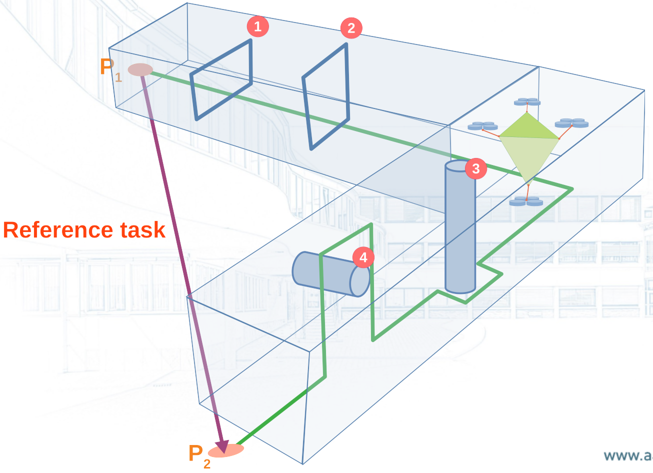
CA in Multi UAV Navigation for Aerial Manipulation

Not only each individual IA must be SA, but also the whole collection should include these abilities:

- **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

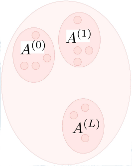
CA scenarios

CA formation models from which appropriate actions should be practiced



First Language: Individual Semantic Emergence

Discretized[4] 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 [5]



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

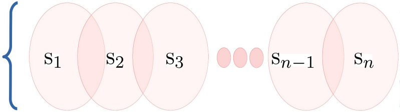
[4] Fiser, D., Faigl, J., & Kulich, M. (2013). Growing neural gas efficiently.

[5] 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.

Second language: Collective Semantic Emergence

Mutually activated discretized generalized state space form the collective language which can describe the relation(Formation) a collection of agents are supposed to maintain over the course of time [6]

Words are synchronously activated Zones in the absence of repulsive forces



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