ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

Collective Self-awareness in Progress and Plans

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Dynamic systems

Generalized state space

$$\vec{X} = \{X, \frac{\partial X}{\partial t}, \frac{\partial^2 X}{\partial t^2}, \ldots, \frac{\partial^L X}{\partial t^L}\}$$

state
position

Motion (action)
such as Velocity, acceleration

Generalized space state

Semantic SA - State space segmentation

To either capture traits such as left turning of a moving object along time courses or constant motion zones

- Self-organizing maps (SOM)
- Growing Neural Gas (GNG)
- Gaussian process division (GP)

Generative/predictive models

Filtering (State estimation from observation):

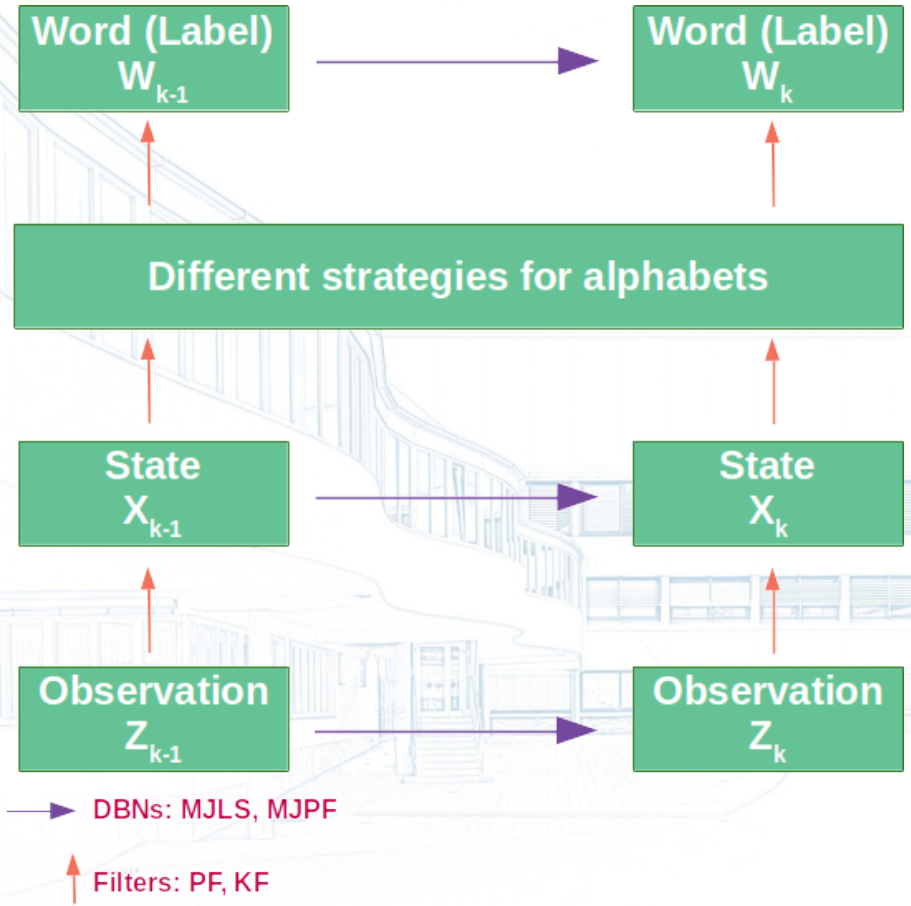
- **Kallman Filter (KF):** Continuous state prediction for linear, dynamic systems from incremental observation.
- **Particle Filter (PF) - Sequential Monte Carlo (SMC):** Discrete state prediction for non-linear, none Gaussian (error-wise) dynamic systems

Switching models (Next state estimation according to current observation):

- **Markov Jump Linear Systems (MJLS):** For linear dynamic systems with continuous state space
- **Markov Jump Particle Filter (MJPF):** For dynamic, none linear system with any noise distribution which contains:
  - Bank of KFs to map continuous observation to states
  - Banks of PFs to map discrete observations to states

Generative/predictive models

A very rough sketch of existing models:

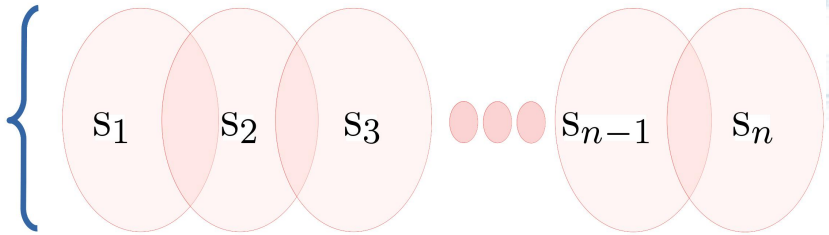


Semantic SA - Words as synchronously happened static motion z

Could be used in anomaly detection of a force field driven environment

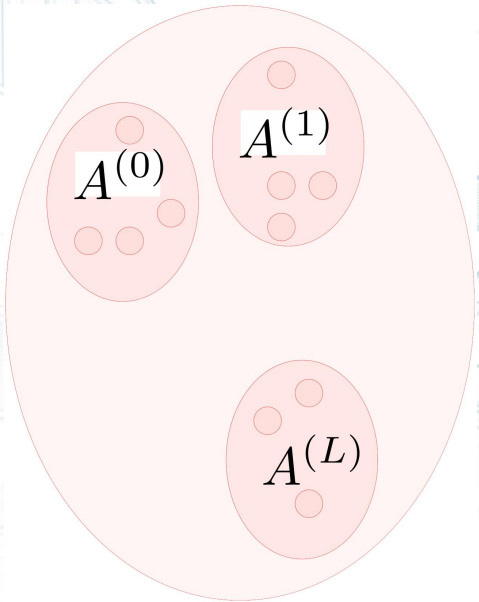
- **Semantic segmentation**: SOM
- **Alphabet level**: Zones/prototypes where the motion remains constant
- **Word level**: Simultaneous occurrence of alphabets in a reference(training) task
- **Sentence/Grammar level**: The sequence of words from the beginning of an interaction to the end

Words are synchronously activated Zones in the absence of repulsive forces



Semantic SA - Words as classes of generalized state traits

- **Semantic segmentation**: Self-organizing maps (SOM) / Growing Neural Gas (GNG)
- **Alphabet level**: Centroids of time's i-th derivative of states derived from resulting clusters in state space segmentation phase



Semantic SA - Words as classes of generalized state traits - 2

- **Word level**: A set of alphabets containing all time derivative orders

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

  where α^i is the centroid of i-th time derivative order of the states in a cluster.
- **Sentence/Grammar level**: The sequence of words formed in a reference task

Future plans for Words as classes of generalized state traits

Building words/semantics on sensor heterogeneity level

- Different sensors (e.g one agent Temperature)

Future plan: Investigating applications in the following areas:

- Internet of things (IoT)
- Cyber physical systems (CPS)
- Swarm intelligence

Future plan for synchronously activated motion zones

- Relating Reinforcement learning(RL) with Force-field(FF) analysis
  - Rewards will be modeled by attractive forces
  - Costs will be modeled by repulsive forces

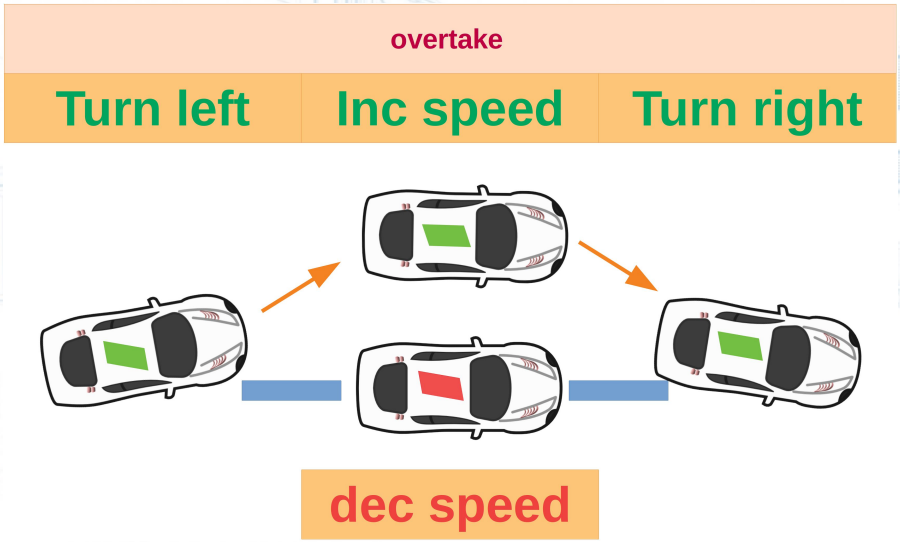
Question? Can semantic state description from robots help them to adapt gradually to new versions of the task they are trying to accomplish by better cooperation using RL and FF?

Future plan - words as traits - 1

- Similar word in different sequences must induce new actions (Semantic context awareness)

Such as in driving

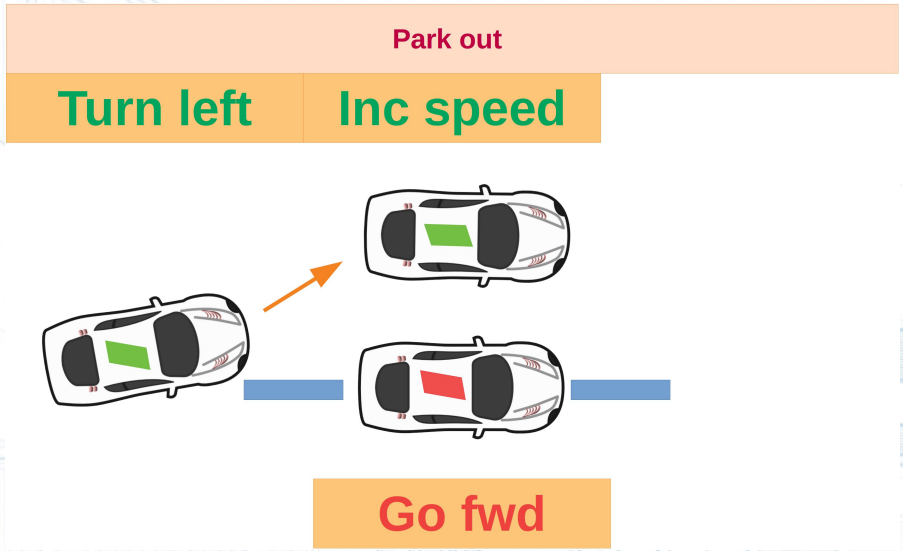
- Taking over
  - Attractor vehicle = Turning left + increase speed + Turning right
  - Follower vehicle = nothing + decrease speed a little + nothing



Model creation from anomaly

Future plans - words as traits - 2

- Getting out of park:
  - Attractor vehicle = Turn left + increase speed
  - Follower vehicle = move forward a little



Turning left in both examples are the same but they must partially contribute to inducing different actions.

Other future plans to investigate - 1

- Unifying "Words as traits" and "synchronously activated motion zones" into one idea to build more efficient CA system.
- What other strategies can be taken to suggest words which improve semantic awareness?

Other future plans to investigate - 2

- How to relate hierarchical composition of semantics from one agent to actions in another agent?
- How to prove semantic awareness of IAs improves the balance in goals of a system?

Other future plans to investigate - 3

- How does semantic-awareness help with improvements in minimum AI SA requirements such as initialization, memorization, predictive model temporal-causal model creation, anomaly detection and decision making?