ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

# NES Kickoff meeting

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# General Research Studies

General papers were reviewed in the following research areas:

- Main area: Semantic interaction and collective semantic-awareness in self-aware MRS
  - **Self-awareness (SA)**: Temporal-causal inference from contextually couple internal and external sensory data of a robot
  - **Collective SA (CA)**: Temporal-causal inference while the internal sensory data of one robot is used as the external sensory data of another robot
  - **Semantic interaction in CA**: The aforementioned coupled data is clustered such that each class can be considered as a letter and the inference and model creation of future states must be done from composition of such letters.

# General SA Tasks

- Initialization
- Memorization
- Abnormality detection
- Model creation
- Decision making

# General SA Tasks - Initialization

Two possible types of initialization:

- Training DBNs/ Switching DBNs (in Collective SA) using human training data. Exemplary reviewed paper Kanapram, D. [Divya], Patrone, F., Marín-Plaza, P., Marchese, M., Bodanese, E. L., Marcenaro, L., ... Regazzoni, C. S. (2020). Collective awareness for abnormality detection in connected autonomous vehicles.

**Future plans**

- Checking for application of random walks for initialization and self-modeling.

# General SA Tasks - Anomaly detection - 1

Based on the distance between observation and predicted state

- Predicting models (Reviewed papers)
  - **Kalman Filtering (KF)** Simon, D. (2010). Kalman filtering with state constraints: A survey of linear and nonlinear algorithms. *IET Control Theory Applications*, *4*(8), 1303–1318
  - **Particle Filtering (PF)** Gustafsson, F. (2010). Particle filter theory and practice with positioning applications. *IEEE Aerospace and Electronic Systems Magazine*, *25*(7), 53–82
  - **Markov Jump Linear System (MJLS)** Doucet, A., Gordon, N., & Krishnamurthy, V. (2001). Particle filters for state estimation of jump markov linear systems.

# General SA Tasks - Anomaly detection - 2

- Predicting models (Read papers)
  - **Markov Jump Particle Filter (MJPF)** First time appeared in: Baydoun, M., Campo, D., Sanguineti, V., Marcenaro, L., Cavallaro, A., & Regazzoni, C. (2018). Learning switching models for abnormality detection for autonomous driving. and was used in
    - Further exemplary papers Regazzoni, C. S., Marcenaro, L., Campo, D., & Rinner, B. (2020). Multisensorial generative and descriptive self-awareness models for autonomous systems. (Vol. 108, 7, pp. 987–1010)

Future Plans:

- Finding and studying more discrete-time dynamic models

# General SA Tasks - Anomaly detection - 3

Metric system to measure the distance between predictions and observations. Determines whether a new class/letter should be created.

- **Hellinger** Lourenzutti, R. & Krohling, R. A. (2014). The hellinger distance in multicriteria decision making: An illustration to the topsis and todim methods.

Future plans, other metrics

- Bhattacharya distance
- JensenShannon divergence
- KullbackLeibler (KL) divergence

# Future plans: Memorization, Model creation and Inference

- **Memorization**: Searching for more studies about different approaches in saving and retrieving predicting models.
- **Model generation**: Searching more studies about existing biological and computational approaches of creating new models from large abnormalities (Model creation, one is introduced in Regazzoni et al., 2020).
- **Decision making**: Searching for more studies about different approaches of evolving an observation to a decision in a SA agent.

## Collective SA(CA) applications

Reviewed Papers:

- Agent collision avoidance Selvaggio, M., Grazioso, S., Notomista, G., & Chen, F. (2017). Towards a self-collision aware teleoperation framework for compound robots. In *2017 IEEE world haptics conference, WHC 2017, munich, germany, june 6-9, 2017* (pp. 460–465). IEEE
- Traffic jam avoidance Hu, Q. & Xu, L. (2017). Real-time road traffic awareness model based on optimal multi-channel self-organized time division multiple access algorithm.
- Collective incident locating Kosak, O., Wanninger, C., Hoffmann, A., Ponsar, H., & Reif, W. (2019). Multipotent systems: Combining planning, self-organization, and reconfiguration in modular robot ensembles. *Sensors*, *19*(1), 17

# Semantic CA - Discreeting the continuous state space

For semantic segmentation of states (Building the letters), an unsupervised clustering method is needed (Reviewed papers)

- Growing Neural Gas (GNG) online unsupervised clustering Fiser, D., Faigl, J., & Kulich, M. (2013). Growing neural gas efficiently. *Neurocomputing*, *104*, 72–82
- Self-organizing maps (SOM) Kohonen, T. (2001). Self-organizing maps. *Springer Berlin Heidelberg*

Future plans

- Searching for new improvements in GNGs for online clustering

# CA - Prediction and anomaly detection

Discrete state prediction and anomaly detection

- Baydoun, M., Campo, D., Kanapram, D., Marcenaro, L., & Regazzoni, C. S. (2019). Prediction of multi-target dynamics using discrete descriptors: An interactive approach.
- Kanapram, D. [Divya], Marin-Plaza, P., Marcenaro, L., Martin, D., & Arturo de la Escalera, C. R. (2019). Cognitive dynamic systems: Perception-action cycle, radar and radio.
- Kanapram, D. [Divya], Patrone, F., Marín-Plaza, P., Marchese, M., Bodanese, E. L., Marcenaro, L., ... Regazzoni, C. S. (2020). Collective awareness for abnormality detection in connected autonomous vehicles.

# CA - Future Plans

- More papers from different research groups are planned to be read in future. Example: Dutt, N. & TaheriNejad, N. (2016). Self-awareness in cyber-physical systems. (pp. 5–6)
  Lukas Esterle, N. A. B. (2020). I think therefore you are: Models for interaction in collectives of self-aware cyber-physical systems. Kanapram, D. [D.], Campo, D. A., Baydoun, M., Marcenaro, L., Bodanese, E. L., Regazzoni, C. S., & Marchese, M. (2019). Dynamic bayesian approach for decision-making in ego-things. *2019 IEEE 5th World Forum on Internet of Things (WF-IoT)*, 909–914

## Future plan

Reading about semantic implementation of semantic awareness in the following fields

- Reading previous studies which extend CA to heterogeneous robots
- Reading previous studies in modeling other agents' state transition matrix by dispatching semantic discreet composition of E/P states

# References I


- Baydoun, M., Campo, D., Kanapram, D., Marcenaro, L., & Regazzoni, C. S. (2019). Prediction of multi-target dynamics using discrete descriptors: An interactive approach.
- Baydoun, M., Campo, D., Sanguineti, V., Marcenaro, L., Cavallaro, A., & Regazzoni, C. (2018). Learning switching models for abnormality detection for autonomous driving.
- Damasio, A. (1999). *The feeling of what happens : Body and emotion in the making of consciousness*. New York: Harcourt Brace.
- Doucet, A., Gordon, N., & Krishnamurthy, V. (2001). Particle filters for state estimation of jump markov linear systems.
- Dutt, N. & TaheriNejad, N. (2016). Self-awareness in cyber-physical systems. (pp. 5–6).

# References II


- Fiser, D., Faigl, J., & Kulich, M. (2013). Growing neural gas efficiently. *Neurocomputing*, *104*, 72–82.
- Friston, K. J. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience*, *11*, 127–138.
- Gustafsson, F. (2010). Particle filter theory and practice with positioning applications. *IEEE Aerospace and Electronic Systems Magazine*, *25*(7), 53–82.
- Haykin, S. (2012). Cognitive dynamic systems: Perception-action cycle, radar and radio.
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- Kanapram, D. [D.], Campo, D. A., Baydoun, M., Marcenaro, L., Bodanese, E. L., Regazzoni, C. S., & Marchese, M. (2019). Dynamic bayesian approach for decision-making in ego-things. *2019 IEEE 5th World Forum on Internet of Things (WF-IoT)*, 909–914.
- Kanapram, D. [Divya], Marin-Plaza, P., Marcenaro, L., Martin, D., & Arturo de la Escalera, C. R. (2019). Cognitive dynamic systems: Perception-action cycle, radar and radio.
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- Kohonen, T. (2001). Self-organizing maps. *Springer Berlin Heidelberg*.

## References IV


- Kosak, O., Wanninger, C., Hoffmann, A., Ponsar, H., & Reif, W. (2019). Multipotent systems: Combining planning, self-organization, and reconfiguration in modular robot ensembles. *Sensors*, *19*(1), 17.
- Lewis, P., Bellman, K., Landauer, C., Esterle, L., Glette, K., Diaconescu, A., & Giese, H. (2017). Towards a framework for the levels and aspects of self-aware computing systems. (pp. 51–85).
- Lourenzutti, R. & Krohling, R. A. (2014). The hellinger distance in multicriteria decision making: An illustration to the topsis and todim methods.
- Lukas Esterle, N. A. B. (2020). I think therefore you are: Models for interaction in collectives of self-aware cyber-physical systems.

# References V


- Regazzoni, C. S., Marcenaro, L., Campo, D., & Rinner, B. (2020). Multisensorial generative and descriptive self-awareness models for autonomous systems. (Vol. 108, 7, pp. 987–1010).
- Selvaggio, M., Grazioso, S., Notomista, G., & Chen, F. (2017). Towards a self-collision aware teleoperation framework for compound robots. In *2017 IEEE world haptics conference, WHC 2017, munich, germany, june 6-9, 2017* (pp. 460–465). IEEE.
- Simon, D. (2010). Kalman filtering with state constraints: A survey of linear and nonlinear algorithms. *IET Control Theory Applications*, *4*(8), 1303–1318.