Recent Advances in AI and Machine Learning @ OsloMet AI Lab

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URL: https://ailab.oslomet.no/
A Snapshot of OsloMet AI Lab

MISSIONS

• conduct cutting-edge AI research
• educate graduate (MS and PhD) students and train postdocs.
• bridge the gap between AI theoretical research and real-world applications.
• host academic conferences and other scientific events.
• foster close partnership with national and international research groups and companies in the AI field.
Memebers

Different research groups:

• [Applied Artificial Intelligence](#), IT, OsloMet
• [Machine Intelligence Department](#), SimulaMet (Simula Metropolitan Center for Digital Engineering)
• [Living Technology Lab](#)
• [Autonomous Systems and Networks](#)
• [Mathematical Modelling](#)
• [Automation, Robotics and Intelligent Systems](#), MEK, OsloMet
• [Motion Analysis Lab](#)
• [Digital Innovation and Strategic Competence in Organizations](#)

Figures:

• > 40 Professors and Associate Professors
• 5 Senior Researchers
• 20 PhDs and Postdocs
Focus R&D Areas

FUNDAMENTAL:

- Machine learning algorithms and optimization: Improvements of ML and other AI models and hard multi-objective optimization problems (Supervised, unsupervised, and reinforcement learning; Deep/wide learning; Neuro-evolution; Multi-objective evolutionary algorithms)

- Computational intelligence: Recurrent neural networks; Fuzzy systems; Evolutionary computation

- Complex systems and artificial life

APPLIED:

- Robotics and IoT: Adaptive and Autonomous Systems in robotics (HW - vehicles/drones; SW – intelligent control, knowledge-based systems) and IoT across various application domains.

- Healthcare: Using AI as intelligent decision support or to develop personalized/individualized systems based on learning from the users.

- Neuroengineering: Neurocomputing; Neuroergonomics; Brain-machine interaction; Human-machine symbiosis; Adaptive automation
PARTNERS

• IBM Norge

• Norwegian Artificial Intelligence Research Consortium (NORA)

• Confederation of Laboratories for Artificial Intelligence Research in Europe (CLAIERE)

• Norwegian Open AI Lab
ONGOING PROJECTS (SELECTED)

Third-party funding:

- **Socrates** – Self Organising Computational Substrates, **NFR**, Nichele
- **OASYS** – Ocean-Air synoptic operations using coordinated autonomous robotic SYStems and micro underwater gliders, **EU**, Alcocer
- **SCOTT** – Secure Connected Trustable Things, **EU**, Van Do & Feng
- **Pacer** – Patient Centric Engineering in Rehabilitation, **NFR**, Mirtaheri & Hammer & Yazidi
- **Artificial intelligence** – a novel tool in assisted reproduction technology, **NFR**, Hammer & Yazidi
- **DeepCA** – Hybrid Deep Learning Cellular Automata Reservoirs, **NFR**, Nichele

Internally funded:

- **Adaptive Automation** of Safety-Critical Human-Machine Systems, Zhang
- **FELT** – Futures of Living Technologies, Bergaust
- **CAOS** – Complex Adaptive and Self Organising Systems, Nichele
- **Personalised Cervical Cancer from Historical data**, Naumova
- **Multi-modal Data Fusion based on Coupled Factorizations**, Acar Ataman
**TOPIC 1: NFR Socrates - Biological Neural Networks**

- Better understanding of neural networks
- Medical: right neural stimulations for rehabilitation/treatment

EvoDynamic: EVOLUTION of discrete DYNAMIC systems based on self-organization through local interactions

Dynamic system
- Sparsely connected network

Evolution
- Network structure
- Communication rules
- Learning rules

Goals
- Improve reservoir quality
- Model dynamic behavior of physical reservoirs
- Self-learning through interaction with environment

- Sparsely connected network for reservoir computing
- Dynamics of reservoir simplify complex inputs

Physical reservoirs for SOCRATES project
- Biological neurons over microelectrode arrays
- Nanomagnetic ensembles

1 https://www.ntnu.edu/socrates
# SOMA – Self-Organizing Models of Artificial learning in neural substrates

## SOCRATES project:
Inspired by the self-organizing behavior of neurons, to develop arrays of nanomagnets for new computing hardware that is scalable, energy efficient, fault tolerant, and self-learning.

[https://www.ntnu.edu/socrates](https://www.ntnu.edu/socrates)

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**Data analysis**
- Analysis of electrophysiological data recorded from neuronal cultures
- Clustering of recordings from different cultures

**Self-organizing model**
- Sparsely connected network model
- Tune model parameters to epitomize neuronal behavior

**Proof-of-concept**
- Perform classification and computational tasks with both the model and the physical substrate

**Perturbed dynamics**
- Evaluate dynamics and computational capabilities of cultures with synaptic perturbation
- Propose strategies to restore unperturbed dynamics

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Kristine Heiney, PhD fellow  
Supervisor: Stefano Nichele
The real-time mental workload (MWL) monitoring is crucial for designing adaptive aiding/assistance systems.

Although data-driven approaches have potential for MWL recognition, it is usually difficult or expensive to acquire sufficient labeled data.

This work applied semi-supervised extreme learning machine to MWL classification based only on a small number of labeled physiological data.
Conclusion

- The proposed SS-ELM method can effectively improve the accuracy and efficiency of MWL classification.
- When only a small number of labeled data are available in practice, SSL algorithm is suitable for online real-time MWL pattern recognition task.

References

3. J. Li and J Zhang, Mental workload classification based on semi-supervised extreme learning machine, *26th Int. Conf. on Artificial Neural Networks (ICANN17)*, 11-15 Sep. 2017, Alghero, Sardinia, Italy.
Motivations
Mental Workload (MWL) is an important indicator of mental activity of human operator in Human-Machine System (HMS).

Aims & Objectives
- Recognition of Momentary MWL using electrophysiological data.
- Application of deep learning to MWL classification.
Conclusion

- The two deep learning architectures proposed can extract features automatically and are also computationally efficient.
- The selected optimal EEG channels can be used to design wearable devices for high-risk MWL detection.

References

TOPIC 4: EEG-based Emotion Recognition Using Machine Learning

- Used clustering to determine 4 target classes of human emotion.

- Performance comparisons:
  - 2 feature extraction methods: wavelet transform, nonlinear dynamics
  - 5 feature reduction algorithms: KSR, LPP, mRMR, ReliefF, PCA
  - 4 classifiers: k-nearest neighbor (kNN), naïve Bayesian (NB), support vector machine (SVM), random forest (RF)
Conclusion

- **4-class emotion classification accuracy** can be significantly improved by taking into account baseline EEG features.
- **Nonlinear dynamics** features lead to higher accuracy than wavelet-derived features.
- **EEG gamma-band** features are more salient than other frequency bands.
- **Best combination**: Kernel Spectral Regression (KSR) for dimensionality reduction + RF for classification.

References

3. P. Chen and **J Zhang**, Performance comparison of machine learning algorithms for EEG-signal-based emotion recognition, **26th Int. Conf. on Artificial Neural Networks (ICANN17)**, 11-15 Sep. 2017, Alghero, Sardinia, Italy.
TOPIC 5: *Intelligent Robotics*

**Pepper Humanoid Robots**
- 1) Speech to text, 2) Text input to chatbot, 3) Chatbot response to speech
- Using different IBM Watson modules

**Swarm Robots**

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Fig. 6. Illustration of components involved in task being solved.
TOPIC 6: Assisted Living Technology (ALT) for People with Mild Cognitive Impairment or Dementia

- Predict the next sensor to be activated/deactivated in a sequence.
- Useful for automation functions, such as:
  - turn on the coffee machine, when such event is predicted
  - turn on the lights in the kitchen, when the person wakes up at night
**TOPIC 7: Ocean-Air synoptic operations using coordinated autonomous SYStems (OASYS)**

- **Unmanned Aerial Vehicle (UAV):**
  - Deployment/recovery of MUGs
  - Communication link with MUGs and USV

- **Micro Underwater Glider (MUG):**
  - Pressure compensated, no pressure housings
  - Small size <40cm, <2kg, low cost (<5k€)
  - MEMS+GPS navigation
  - CTD and Optical fluorescence payload
  - Communicates with UAVs while on surface
  - No need for satellite communication capabilities

- **Unmanned Surface Vessel (USV):**
  - Wave and solar powered
  - Base station for MUGs and UAV
  - Satellite communication link
  - Charging station for MUGs and UAV

- **Long endurance missions:**
  - Use of USV as base platform for MUGs and UAV
  - Satellite communication
  - Low investment
  - Extends capability of long endurance operations

- **Funding:** 1M €
- **Duration:** 3 yrs

- **Key Points:**
  - Drones (UAVs): Deployment and recovery of gliders (MUG)
  - Gliders (MUG) measure environmental parameters
  - USV plays the role of mothership
  - Drones (UAVs) are charged on board of the mothership
TOPIC 8: Intrusion Detection using ML