FCAI Finnish Center for Artificial Intelligence

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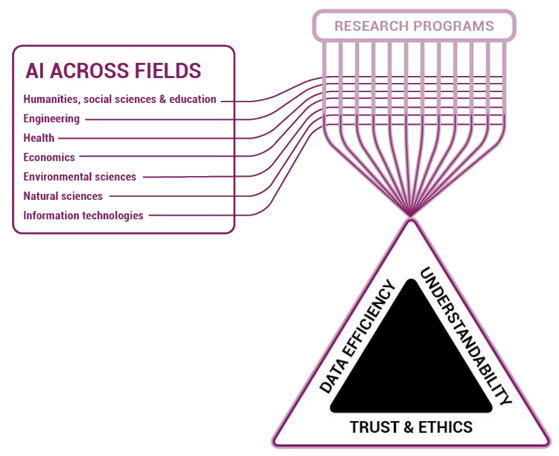
# Autonomous AI (Research Program R6)

Autonomous systems are increasingly reliant on AI methods. FCAI Research Program R6 addresses the fundamental challenges of long-term autonomous operation, in particular, how learning and planning can be performed to ensure safe operation over long time horizons.




## Program objectives

Long-term autonomous operation requires dynamic planning and learning over long time horizons, being outside the capabilities of current state-of-the-art. This program aims to make Autonomous AIs data-efficient by actively collecting data while acting in the world. A central challenge for learning while acting in the world is safety, especially when new information is needed from exploration of the environment.

**1. Long-term decision making**

The research aims to increase significantly the temporal horizon of goal-driven decision making.

This is achieved through: long-horizon temporal models for system dynamics, data-efficient temporal models for system dynamics, and efficient planning (inference) for hierarchical dynamics models.

**2. Safe learning during operation**

The research aims to guarantee safety of learned models and associated decisions during operation of a system.

This is achieved through: safety guaranteed exploration, and safety guaranteed simulation to real transfer.

**3. Reliable perception and navigation**

The research aims to develop methods for reliable navigation and awareness through efficient sensor data processing.

This is achieved through: data efficient learning of perception models, robust perception methods capable of uncertainty quantification, and mitigating the effects of interference.

## Methodologies

To reach our objectives, we apply a diverse set of methodologies:

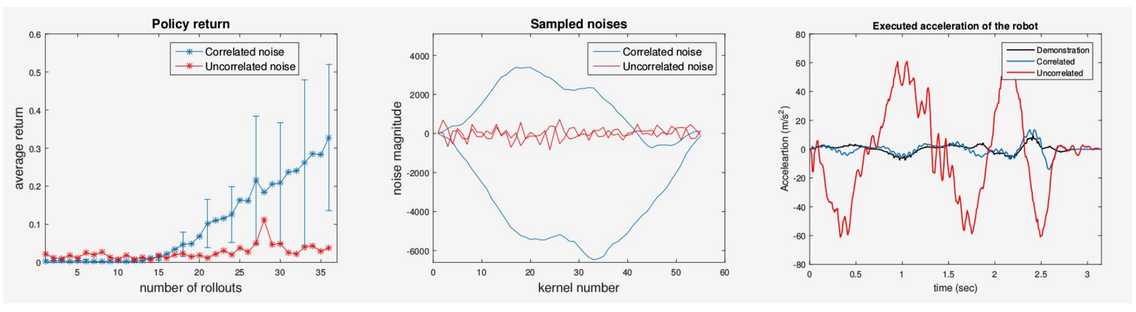
- Mathematical analysis and development of models that have desired properties such as data efficiency.
- Benchmarking developed approaches with computer simulations.
- Implementing the methods in open-source software.
- Evaluating the methods in physical world use-cases together with partners.

Considering machine learning methods, the program integrates reinforcement learning and model predictive control with other methodologies across FCAI research programs, including simulation-based inference, probabilistic models and inference, and deep learning.

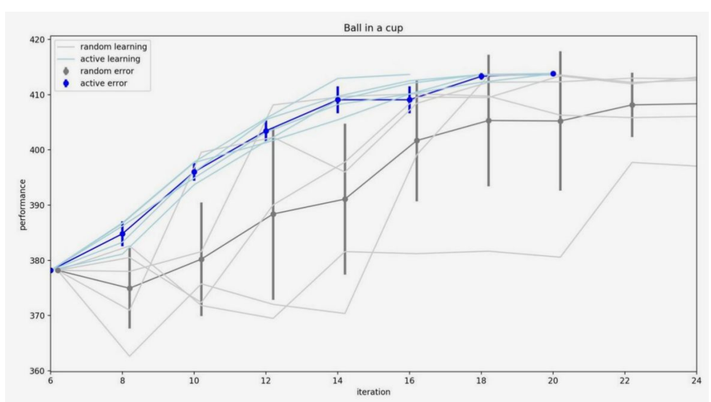
## Research results

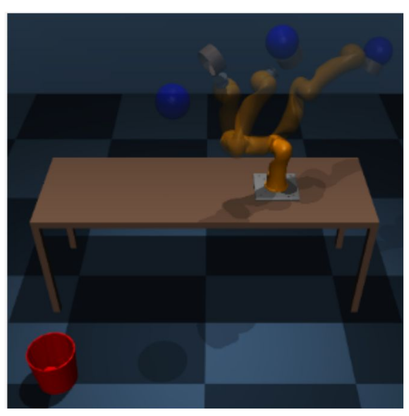
The program has started in 2020. The program builds on results from earlier research including:

**Enabling safe exploration in reinforcement learning by exploring in safe correlated subspaces. (Lundell et al. 2017)**

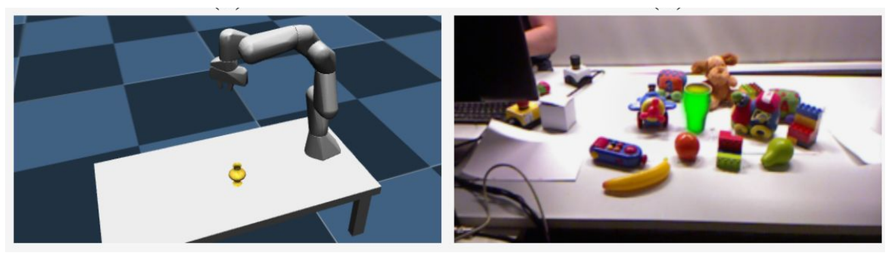



**Increasing data efficiency in exploration policies by active choice of context. (Hazara et al. 2019)**

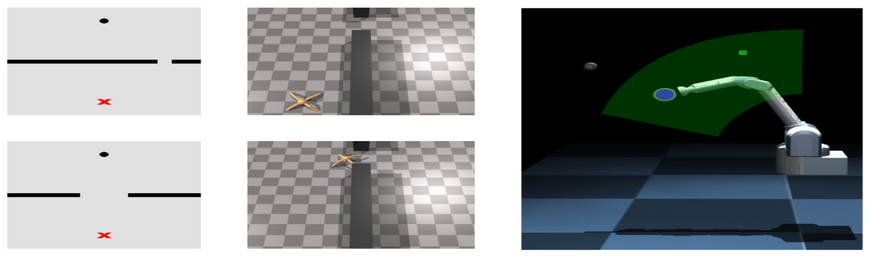


**Safe and efficient learning of decision policies using learned subspaces. (Hämäläinen et al. 2019)**



**Curriculum reinforcement learning for challenging long-term goal-based tasks (Klink et al., 2020)**

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Finnish Center for Artificial Intelligence FCAI is a community of experts in artificial intelligence in Finland, initiated by Aalto University, University of Helsinki, and VTT Technical Research Centre of Finland. FCAI is one of the six Academy of Finland Finnish flagships.

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