

## MLAdapt - Self-Adapting Machine Learning

Sometime in the future, humanity launches an advanced robotic explorer, affectionately nicknamed "Łazik", on a groundbreaking mission to unravel the mysteries of Mars. Equipped with state-of-the-art visual systems, Łazik embarks on its journey, tasked with collecting crucial data on Martian geology, climate, and the potential for past or present life. However, as Łazik encounters the harsh and unpredictable conditions of the Martian landscape, unforeseen challenges arise, causing the mission to fail. Sandstorms, extreme temperature variations, and rocky terrains take a toll on Łazik's visual systems, hindering its ability to navigate and fulfill its mission objectives. The setback raises questions about the adaptability of our technology to the unpredictable nature of extraterrestrial exploration.

For the next mission, in response to the challenge, scientists and engineers on Earth decide to infuse Łazik with a groundbreaking upgrade—self-adapting machine learning algorithms. These algorithms, designed to learn and evolve continuously, are integrated into Łazik's visual systems. The robot becomes a dynamic learner, analyzing and adapting to the ever-changing Martian conditions. As it roams the Martian terrain, the self-adapting algorithms allow Łazik to swiftly respond to unexpected challenges. It learns to recognize and navigate around obstacles, adjust its visual parameters to accommodate varying light conditions, and even predict potential issues based on past experiences.

While this story represents a distant future, it showcases the transformative potential of self-adapting machine learning models. This is in contrast to current algorithms characterized by fixed data sets and periodic model retraining. By allowing the model to adapt after the initial training, it can use the information available during deployment to improve its capabilities, similar to learning in humans. Such technology could be utilized in many domains such as voice assistants, medical systems, etc.

**Significance of the project.** Current deep learning approaches assume that the training data is alike to the deployment data. However, performance drops significantly when faced with dissimilar data distributions or domains, limiting real-world applications.

Preparing models for an open-world application scenario is nearly impossible due to its diverse and uncontrolled environments. It would necessitate immense or infinite and varied datasets for training, resulting in high costs for data labeling and computational resources. Furthermore, addressing newly acquired labeled data frequently requires complete model retraining, escalating costs and computational requirements, underscoring the disparity between artificial and human intelligence.

Resolving these issues is crucial as deep learning methods play an increasingly integral role in everyday applications, propelling technological advancements across various fields beyond computer science.

**Goal of the project.** The goal of this project is to address the above-mentioned problems in an online manner after the initial training and the deployment of the neural network. Such an approach will minimize inconveniences related to the initial training and at the same time make it more intelligent, closing the gap between human and artificial intelligence. Leveraging unlimited unlabeled data streams to not only generate predictions, as it is done with traditional approaches, we aim to adapt and continuously acquire the knowledge, making the predictions more accurate. We will use this unlimited, not conventionally exploited, potential of the test data, by employing i) self-supervised training objectives, ii) modular neural network model architectures, and iii) online hyper-parameter selection.

The goal is to refine traditional deep learning methods, enabling them to continuously learn from unlabeled data, adapt to real-world deployment challenges, and most importantly, allow to finish the mission entrusted to our model.

**Expected results.** The research will yield highly flexible and dynamic neural networks that not only leverage knowledge gained during initial training but also evolve continuously based on unlimited data used for inference. It will empower deep learning methods to remain robust in unpredictable and uncontrolled environments, effectively handling unforeseen situations.

The developed approaches are expected to be applicable in many real-world applications ranging from medical image processing to the automotive industry and robotics. We will focus on computer vision tasks as it is an ideal testbed, considering the diversity of possible visual domains, and the requirement for models to comprehend and interpret rich visual information accurately. By concentrating on computer vision challenges, we aim to establish a strong foundation for the widespread implementation of these techniques in real-world settings, contributing to advancements in several critical industries.