ICT25-005 - Efficient Self-Supervised Machine Learning for Adaptive Wireless Communication Systems

Abstract

This project investigates self-supervised learning (SSL) for wireless communication systems to improve the adaptability, efficiency, robustness, and scalability of next-generation networks. While deep neural networks (DNNs) tailored for specific applications have shown strong performance, advances in fields such as natural language processing and computer vision reveal the even greater potential of general-purpose foundation models. These models, pre-trained by SSL on diverse datasets and fine-tuned for specific tasks, offer superior generalization and transferability with minimal human intervention. By leveraging channel state information (CSI), this project aims to realize SSL techniques for wireless systems, with a particular focus on optimization tasks at the physical (PHY) and medium access control (MAC) layers, laying the groundwork for compact, locally deployable, and adaptive foundation models capable of sustainably addressing the growing complexity of modern wireless networks.

But what are the keys to unlocking the potential of compact foundation models in mobile wireless systems?

While the structure and architecture of the DNNs employed clearly affect the performance, the primary underlying research task is to develop SSL techniques that are applicable to wireless signals. Therefore, this project will investigate and develop SSL techniques that use unlabeled CSI to extract transferable features that are applicable to different PHY/MAC tasks. These features will be generalizable across frequency bands and environments, and can be fine-tuned locally with minimal labeled CSI for real-time on-device adaptation. The project addresses key challenges such as designing SSL targets tailored to the dynamics of wireless systems, dealing with noisy or delayed CSI, and balancing model complexity and efficiency. The results will be compact, efficient, hierarchical foundation models capable of online learning, alongside a benchmarking framework for SSL in wireless systems.

Scientific disciplines:
Telecommunications (66%) | Machine learning (34%)

Keywords:
6G Wireless CommunicationsPHY Signal ProcessingSelf-Supervised LearningMachine Learning for Wireless SystemsChannel State InformationMulti-Task LearningTransfer Learning in Wireless Domains

Principal Investigator:	Stefan Schwarz
Institution:	TU Wien

Status: Ongoing (01.01.2026 - 31.12.2029)
GrantID: 10.47379/ICT25005

Further links to the persons involved and to the project can be found under
https://www.gmbh.wwtf.at/funding/programmes/ict/ICT25-005/