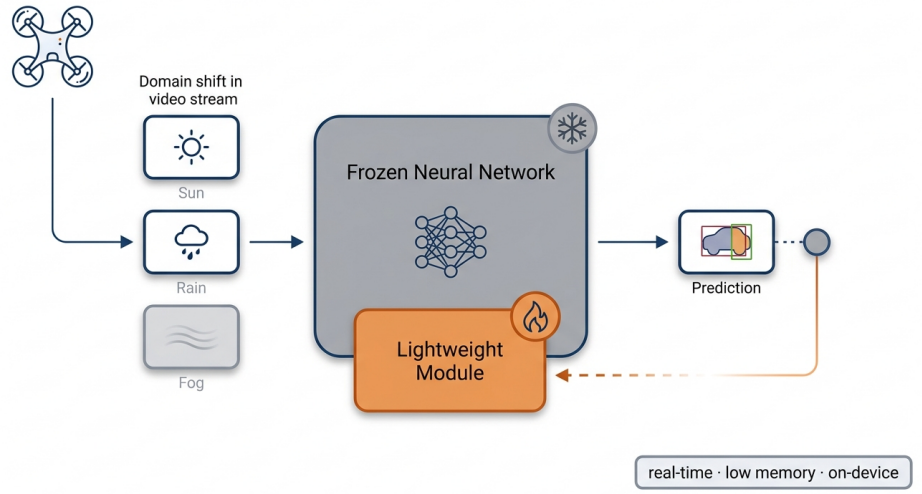
AARHUS UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINERING

Date: June 7, 2026

A3 Lab

MASTER'S PROJECT AVAILABLE

Efficient Test-Time Adaptation for Edge Intelligence



Motivation

Edge-AI systems such as drones must perform perception under continuously changing conditions—weather, lighting, altitude, and unfamiliar scenery—on resource-constrained hardware. Models trained offline often degrade under such continual domain shifts, while field re-labelling is infeasible. Test-time adaptation (TTA) addresses this by adapting from unlabeled sensor streams [1, 2]. However, existing backpropagation-based TTA methods incur substantial memory, latency, and energy costs, making them difficult to deploy on edge hardware [4]. Moreover, highly correlated, non-i.i.d. streams with effective batch size one can destabilize naive adaptation [3, 5]. Therefore, edge TTA must be accurate under shift while remaining low-latency, memory-efficient, and stable.

Objective & Methodology

This thesis develops a **Low-Latency, Efficient Test-Time Adaptation** framework for edge perception, aiming to improve robustness under continual deployment shift within fixed latency and memory budgets and, where possible, on Jetson-class hardware.

Key Tasks:

- **Streaming-shift benchmark:** Construct a continual, online evaluation from public aerial datasets (e.g. UAVid, VisDrone) and standard corruption suites (fog, motion blur, brightness, snow) to emulate weather/lighting/altitude shift. Establish source-model baselines and quantify degradation.
- **Efficient & low-latency adaptation:** Implement and compare recent efficient-TTA methods restricted to parameter-efficient subsets (LoRA / adapters / LayerNorm), with update scheduling to cut per-frame latency and examine stability under temporal correlation.
- **Edge benchmarking:** Map the accuracy–efficiency Pareto front — accuracy-under-shift vs. latency (ms/frame), peak memory, and updated parameters — against a frozen and a full-network continual-TTA baseline, on a single GPU.

Requirements

- Strong programming skills in Python and PyTorch.
- Solid understanding of Deep Learning, particularly CNNs and Vision Transformers for perception.
- Familiarity with test-time adaptation and/or model-efficiency techniques (quantisation, pruning) is a strong plus.
- Interest in edge / embedded AI; experience profiling on devices such as NVIDIA Jetson is welcome.

References

[1] Wang, D. *et al.*, "Tent: Fully Test-Time Adaptation by Entropy Minimization," *ICLR*, 2021.
[2] Niu, S. *et al.*, "Efficient Test-Time Model Adaptation without Forgetting," *ICML*, 2022.
[3] Niu, S. *et al.*, "Towards Stable Test-Time Adaptation in Dynamic Wild World," *ICLR*, 2023.
[4] Ma, K. *et al.*, "SURGEON: Memory-Adaptive Fully Test-Time Adaptation via Dynamic Activation Sparsity," *CVPR*, 2025.
[5] Tomar, D., Vray, G., Thiran, J.-P., Bozorgtabar, B., "Un-mixing Test-Time Normalization Statistics: Combatting Label Temporal Correlation," *ICLR*, 2024.

Application

If you are interested in this project, please email your CV and a brief transcript to:

Dr. Behzad Bozorgtabar at **behzad@ece.au.dk**.