

Bachelor Theses at the Institute of Pervasive Computing



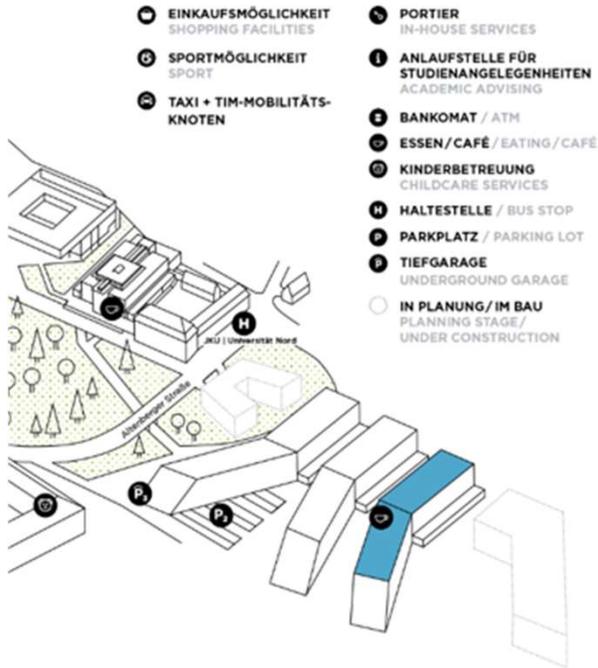
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Current Fields of Research at IPC

Empower ::



Streaming AI ::



TextileCycle ::



Empower



Empowered Workers through Motion Assessment

Empower :: Intention prediction based on movement recognition



Abstract

Exoskeletons for supporting industrial workers are an emerging technology that have the potential to reduce impact on workers, fatigue and injuries. However its acceptance requires proper and reliable response time. Therefore different technologies will be tested to assess interesting sensor / machine learning algorithms in terms of intent recognition speed and accuracy

Technologies and Approaches:

Sensor + ML prediction --> actuator

Hardware: Digital Oscilloscope + EMG + IMU + Actuator 1 or 2 dimensional

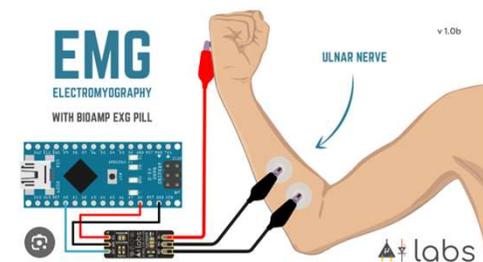
Goals:

Provide real time feedback loop

Expected Outcomes:

Get an operationl feedback loop for the intention prediction, actuate it and measure response times

Contact: *Miguel Vazquez Pufleau*



Empower :: Prediction correction based on Physiological cues



Abstract

Exoskeletons for supporting industrial workers are an emerging technology that have the potential to reduce impact on workers, fatigue and injuries. However, its usability should also consider physiological aspects such as the current state of skill of the worker, the degree of expertise and the level of fatigue in order to provide the most adequate response for supporting the movement and the safety of the user.

Technologies and Approaches:

Sensor + ML prediction – parameter for support

Hardware: - Digital Oscilloscope (Data acquisition device) + physiological sensor (PH, humidity meter), Gyroscope

Goals:

Provide real time information on tiredness level / expertise level of user derived from sensor data

Expected Outcomes:

Get a functional real time classifier from physiological sensors

Contact: *Miguel Vazquez Pufleau*



Empower :: Response time considerations for ML speed / response time



Abstract

The effectiveness of industrial exoskeletons is based on two aspects. First its proper prediction capabilities and secondly the time response. The larger the model, the better the prediction but also the slower the response time. Therefore, a sweet spot needs to be found where the model is good enough but at the same time simple and small enough as to provide the required response time for its intended application

Technologies and Approaches:

Sensor + different sizes and types of ML + Actuators

Hardware: - Digital Oscilloscope + Intention Sensor + Computer + Actuator

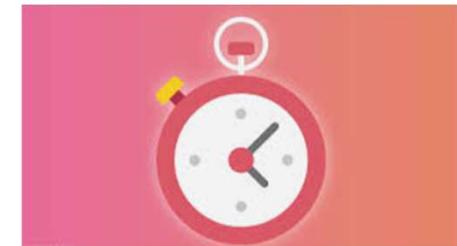
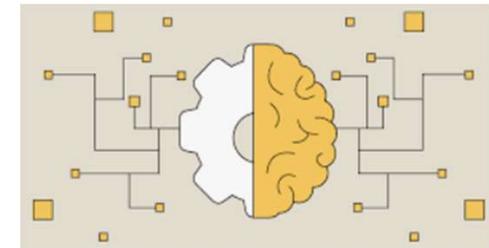
Goals:

Develop graphic of the model accuracy vs computational resources vs response time

Expected Outcomes:

Assess the effect of different parameters in the model selection on its effect in time critical systems such as an Exoskeleton.

Contact: *Miguel Vazquez Pufleau*



Streaming AI



Distributed AI for Industry

Streaming AI :: Smart Energy Scheduling for Homes Using Lifelong Learning



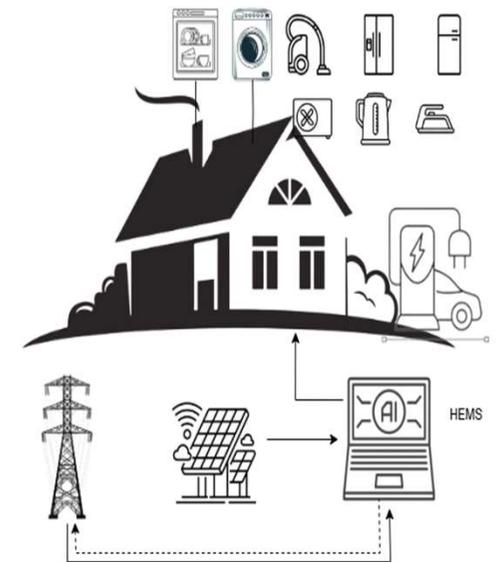
Abstract: This project develops models that learn from energy usage patterns and weather data. Using lifelong learning, the system adapts to seasonal changes to schedule home appliances during off-peak hours, reducing electricity costs. It also minimizes grid dependency by optimizing renewable energy use, benefiting smart grids and energy management.

Tasks:

- Create and test online learning strategies for home appliance scheduling.
- Lower energy costs and increase renewable energy usage.
- Validate methods with energy forecasting models and deploy prototypes.

Goals: Develop a working prototype that can be tested in real-world energy scheduling scenarios, demonstrating its potential to enhance energy efficiency and reduce reliance on non-renewable resources.

Contact: *Aftab Hussain*



Streaming AI :: Detecting Malicious Nodes in VANETs Using Reinforcement Learning.



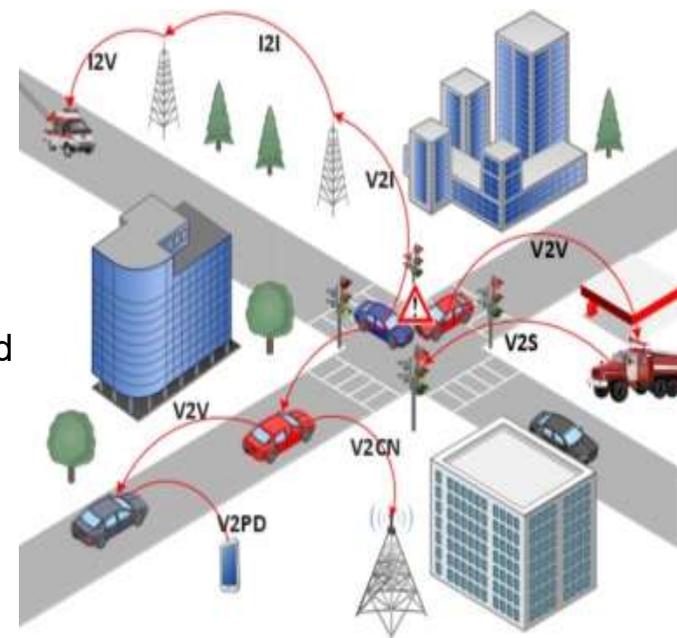
Abstract: This project develops a system to detect and mitigate malicious nodes in Vehicular Ad Hoc Networks (VANETs) using Reinforcement Learning (RL) for real-time decision-making and Continual Learning (CL) to adapt to evolving attack patterns. The approach ensures reliable detection of threats, prevents catastrophic forgetting, and enables collaborative mitigation, enhancing VANET security and resilience.

Tasks: Develop RL-based detection models, integrate CL for adaptability, enable collaborative mitigation via knowledge sharing, and validate the system in simulated and real-world scenarios.

Goals: Build a scalable system for online malicious node detection and mitigation, ensuring adaptability to evolving threats and robust VANET security.

Contact: *Aftab Hussain*

Reference: Gupta, N., Prakash, A., & Tripathi, R. (2015). Medium access control protocols for safety applications in Vehicular Ad-Hoc Network: A classification and comprehensive survey. *Vehicular Communications*, 2(4), 223-237.



Streaming AI :: Smart IoT Security: Real-Time Malicious Node Detection with Streaming AI



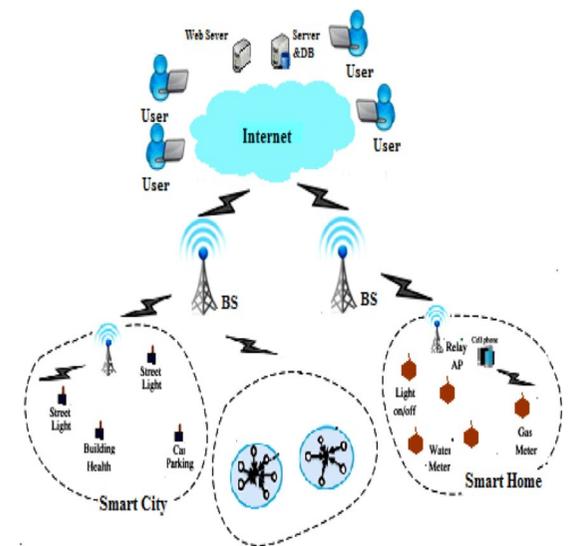
Abstract :This project focuses on developing methods to detect and classify malicious nodes in IoT networks using Streaming AI. Lightweight, resource-efficient models will monitor network activity and classify nodes in real-time. By leveraging distributed knowledge streams, IoT nodes can collaboratively detect threats and adapt to evolving attack patterns, ensuring robust network security for large-scale IoT systems.

Tasks: Develop and test anomaly detection and node classification strategies for IoT networks.

Enable real-time knowledge sharing across the network to identify and mitigate malicious nodes.

Validate the approach through real-world IoT security use cases.

Goals: Develop a Streaming AI-based model for real-time detection and classification of malicious nodes in IoT networks, leveraging incremental learning and distributed knowledge streams to enhance security and adaptability in dynamic environments.



Reference: https://www.researchgate.net/figure/oT-Network-architecture_fig1_325254311

Streaming AI :: Few-Shot Learning in Decentralized Federated Learning



Abstract: This thesis looks at using few-shot learning (training AI with very little data) in decentralized systems. It aims to improve how these systems work when data is scarce or imbalanced.

Tasks:

- Study few-shot learning methods and where they are used.
- Design models that can handle small datasets in decentralized systems.
- Test how these models perform and their communication costs.

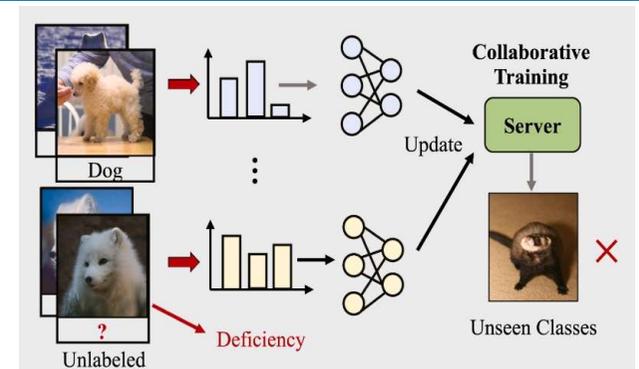
Goals:

- Make AI systems work better with less data.
- Solve the problem of data imbalance in decentralized setups.
- Find efficient ways to use few-shot learning in real-world applications.

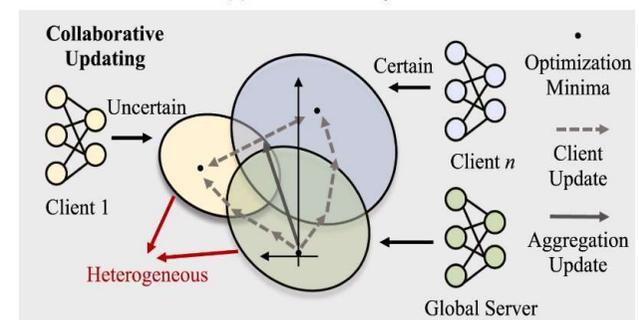
Key Skills: Few-shot learning basics, understanding decentralized systems, Python.

Reference: <https://doi.org/10.1016/j.knosys.2024.112848>

Contact: *Waleed Kahn*



(1) Label Deficiency



(2) Client Heterogeneity

Streaming AI :: Scalable Model Compression for Decentralized Federated Learning



Abstract: Focus of this thesis is about creating a simple tool to shrink AI models using techniques like pruning (removing less important parts), quantization (simplifying numbers), and sparsification (removing redundant data). This helps run AI on small devices like IoT sensors by reducing the size and communication needs of the models.

Tasks:

- Learn about existing methods to make AI models smaller.
- Create and test these methods on models used in decentralized systems.
- Measure how well the smaller models perform and how much they save on communication and energy.

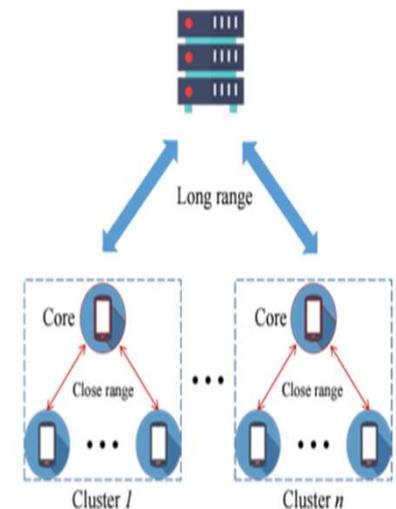
Goals:

- Make AI models smaller without losing much accuracy.
- Save communication resources to make systems scalable.
- Improve AI for real-world use on small devices.

Key Skills: Python, TensorFlow Lite/PyTorch, basic research, AI model optimization.

Reference: <https://doi.org/10.48550/arXiv.2405.17522>

Contact: *Waleed Kahn*



Streaming AI :: Adaptive Peer Selection for Decentralized Federated Learning



Abstract: The thesis focuses on creating a smart way to choose which devices in a network should share AI updates. It focuses on making communication efficient and ensuring the system scales well as the network grows.

Tasks:

- Review how peer selection works in distributed systems.
- Design a method to choose peers based on similarity, speed, or available resources.
- Test the method in a simulated federated learning setup.

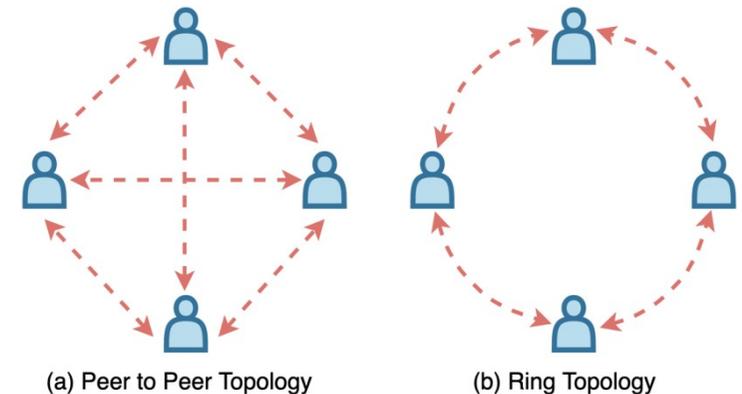
Goals:

- Make AI systems communicate more efficiently.
- Keep systems running smoothly even in changing environments.
- Create a scalable peer selection strategy.

Key Skills: Python, distributed systems basics, creating algorithms.

Reference: <https://ieeexplore.ieee.org/document/9779505>

Contact: *Waleed Kahn*



Other Topics



Other open theses

Knowledge Transfer via Eye-Tracking and Augmented Reality



Abstract: Experts are known to have significantly different gaze-patterns compared to novices. Those gaze-patterns can help to reveal important visual aspects, e.g. in visual search tasks, manufacturing processes, quality control, etc.

Eye-tracking allows to extract these gaze patterns and thus determine those areas of visual importance while augmented reality can be utilized to provide visual clues to novices.

Tasks: Design and implement an experimental framework to extract gaze patterns based on a head-worn eye-tracker and provide visual cues to novices via an augmented reality headset. Conduct a user study to empirically analyse the differences in novice's performance when visual cues are provided for certain tasks.

Hardware: Pupil Labs Neon head worn eye-tracker. Microsoft HoloLens AR headset.

Goals: Create a prototypical implementation that can be applied to real-world industrial scenarios. Empirically analyse the impact of visual cues on task performance.



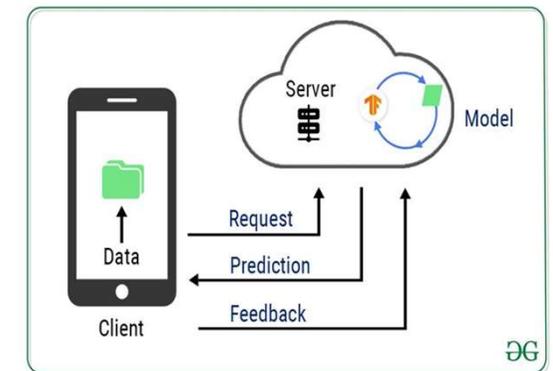
Contact: *Martin Schobesberger*

The Role of Weather Conditions in Energy Demand Predictions Using Federated AI ::



Objectives:

- To explore the influence of real-time weather data on energy demand predictions within a federated AI framework.
- Identifying challenges in creating efficient and lightweight AI systems for federated energy prediction.
- Analysing the impact of weather data on prediction accuracy and its limitations.



Contact: Achref Rihani achref.rihani@pervasive.jku.at

Enhancing Privacy and Typing Experience with Federated Learning ::



Objectives:

- Investigate how real-time typing patterns and user behaviours influence typing prediction accuracy in a federated AI system.
- Incorporating user-specific features, such as typing speed, frequently used words, and autocorrect habits.
- Identifying key problems in applying federated learning to keyboard applications.



Contact: Achref Rihani achref.rihani@pervasive.jku.at