Universität Bremen

Cognitive Systems Lab

Bachelor/Master Thesis Topics Cognitive Systems Lab

Working with ILSE's conversational speech data

→ Possible BA or MA topics:
- *Analyze semantic embeddings of ILSE interviews for detection of cognitive decline*

→ Requirements:
- Good Python programming skills
- At least basic ML/ASR knowledge

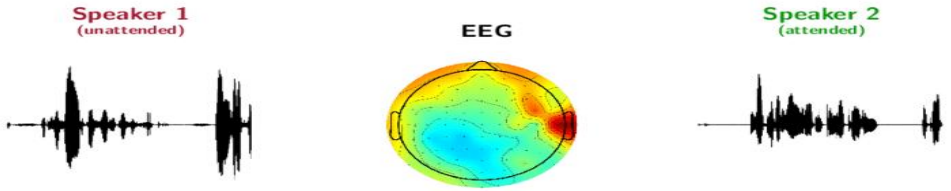
→ Contact: Elisa Brauße (elisa.brausse@uni-bremen.de)
with short introduction and CV

Selective Auditory Attention – Bachelor‘s Thesis

Interesting thesis topics on Solving the Cocktail Party‘s Problem using EEG

→ Topic: **Source Sound Decoding with Electroencephalogram** (Auditory Attention Decoding)

- Understanding of Auditory Attention Decoding and decoding source sound using eeg samples(with public datasets)
- Preprocess available data and fed it to machine learning/Neural Networks(Train different models) to classify the attended speaker
- Visualize results through various methods of applicable Neural Networks and compare results
- Classify performance based upon different validation measures & specify optimal way out



General requirements: Good knowledge in Python, at least basic knowledge in machine learning(Deep learning), motivation, reliability, personal responsibility, willingness to learn new topics

We offer: Intensive support, regular/weekly meetings, feedback discussions, nice work environment

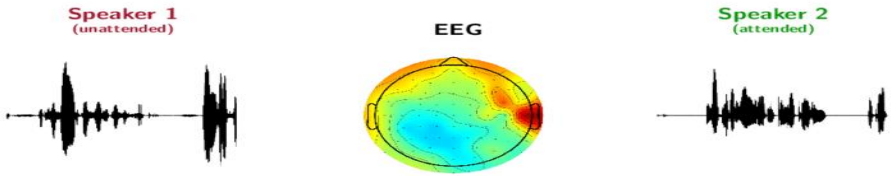
Contact: Saurav Pahuja ☏ 0421-218-64282 ✉ saurav@uni-bremen.de

Selective Auditory Attention – Master‘s Thesis

Interesting thesis topics on Solving the Cocktail Party‘s Problem using EEG

→ Topic: **Brain Tracking of Sound using Deep Learning** (Auditory Attention Decoding)

- Understanding of Auditory Attention Decoding and decoding source sound using eeg samples (public datasets) with Different Optimized Deep learning Models(CNN, GCN, Hybrid Models…)
- Generate Augmented Data using GAN… & check performance with other networks using original data and new generated data
- Try to interpret & Visualize results of different applicable Neural Networks and compare results based on EEG samples
- Do Ablation Analysis over different Networks and see through performance, various different visualizations the effects of Auditory Attention Decoding on Brain



General requirements: Good knowledge in Python, at least basic knowledge in Deep learning, motivation, reliability, personal responsibility, willingness to learn new topics, some experience with EEG would be nice!
We offer: Intensive support, regular/weekly meetings, feedback discussions, nice work environment
Contact: Saurav Pahuja ☏ 0421-218-64282 ✉ saurav@uni-bremen.de

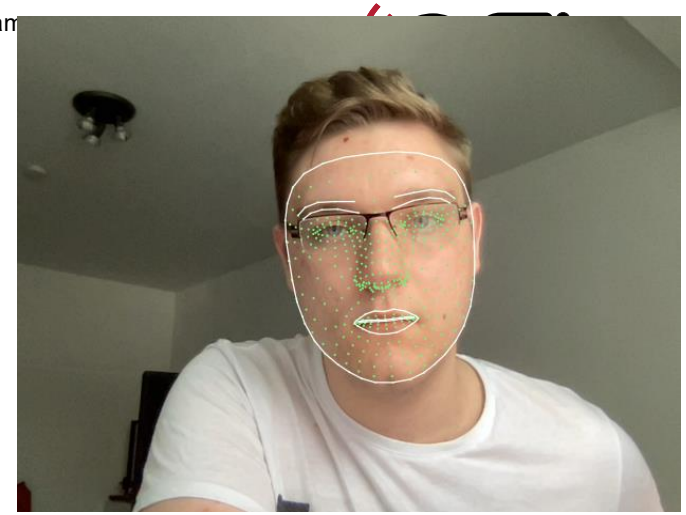
Bachelor Theses:
Computer Vision ML for Modeling Human-Avatar Interactions

Setting:
- We explore **social resonance** by studying how being "synchronized" with an avatars' face, influences human facial responses to avatars.
- Part of interdisciplinary DFG project '**The Active Self**' (https://www.uni-bremen.de/en/csl/projects/current-projects/ccsr & www.activeself.de)
- Data will be provided & feedback on a regular basis

Tasks:
- Comparison of **Computer Vision-based machine learning** (ML) approaches to classify & analyze human responses to online avatars
- **ML approaches to predict human behavior** across different time phases (e.g., starting with regression models)

Other:
- The focus of these BA theses is flexible depending on which of the above tasks are most interesting to you!
- **Interested? Contact: abdulhaq@uni-Bremen.de , verschoo@uni-bremen.de**
- **Please approach Stephan Verschoor!**

Master Theses: Multimodal Modeling of Human-Avatar Interactions



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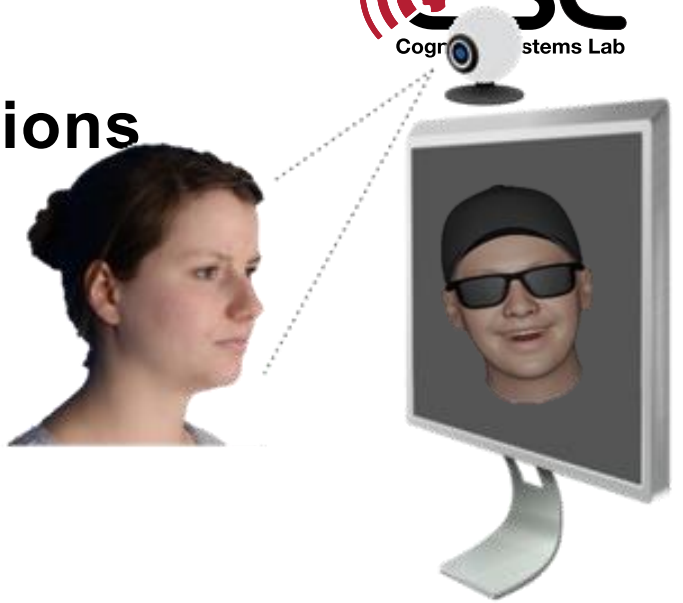
- Data will be provided & feedback on a regular basis

Tasks:
- Vision & speech-based machine learning (ML) to classify and analyze human responses to online avatars
- **Comparison of ML approaches** to predict human behavior across different time phases (starting with regression models up to more sophisticated ML approaches such as **neural networks** (LSTMs))

Other:
- The focus of these MA theses is flexible depending on which of the above tasks are most interesting to you!
- **Interested? Contact: abdulhaq@uni-Bremen.de , verschoo@uni-bremen.de**
- **Please approach Stephan Verschoor!**

Student Assistent:
Multi modal ML for Modeling Human-Avatar Interactions



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- Part of interdisciplinary DFG project ‘**The Active Self**’ (https://www.uni-bremen.de/en/csl/projects/current-projects/ccsr & www.activeself.de)

Tasks:
- Implementation of machine learning (ML) approaches to classify and analyze and predict human responses to avatars
- Testing and further development of our current Interactive Online Experimentation Platform
- Assist in data acquisition

Other:
- **Interested? Contact: abdulhaq@uni-Bremen.de , verschoo@uni-bremen.de**
- **Please approach Stephan Verschoor!**
- **Win win situation possible! Combine Ba/Ma thesis with getting paid!!**

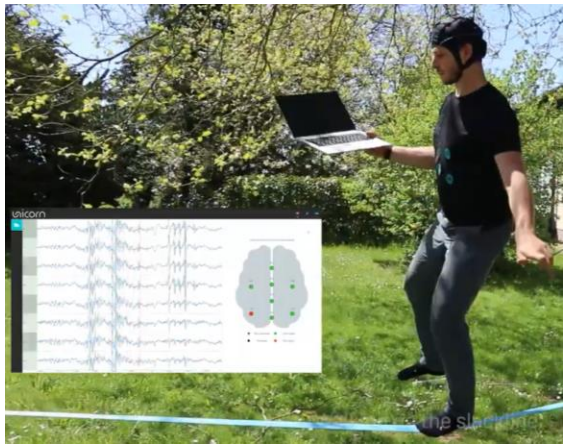
Casual Brain Activity Data Recording

→ Most recordings of brain activity data take place in the laboratory
- Highly controlled, but also unrealistic and not generalizable
- Small amounts of well-labeled data → does not scale

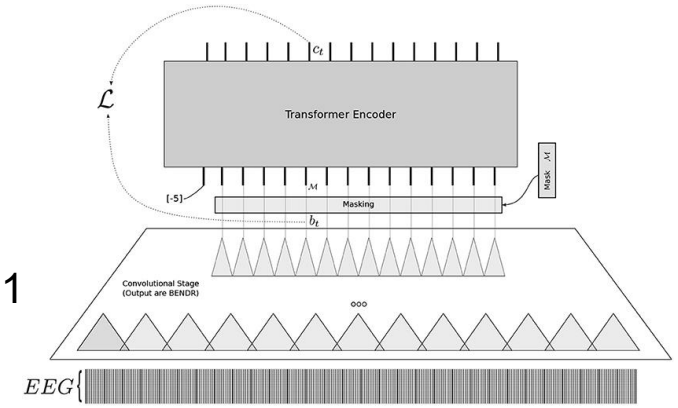
→ Alternative: Casual recording of brain activity data
- Completely uncontrolled, during everyday activities
- No or very weak labeling
- Leveraging self-supervised learning methods, foundation models

→ **Your thesis**: Collect and evaluate such data
- Set up sensors, design data collection protocol „in the wild“
- Apply state-of-the-art machine learning for classification

→ Contact: Dr. Felix Putze, felix.putze@uni-bremen.de or Discord: felix.putze#871



https://www.youtube.com/watch?v=Tv5LyYuSDq4



https://www.frontiersin.org/articles/10.3389/fnhum.2021.653659/full

Representation Learning for Cognitive Modeling

→ Representation learning: Automatically finding a compact, latent representation of high-dimensional input
- Retaining important semantics and data characteristics
- Input: video, text, biosignals, graphs, …

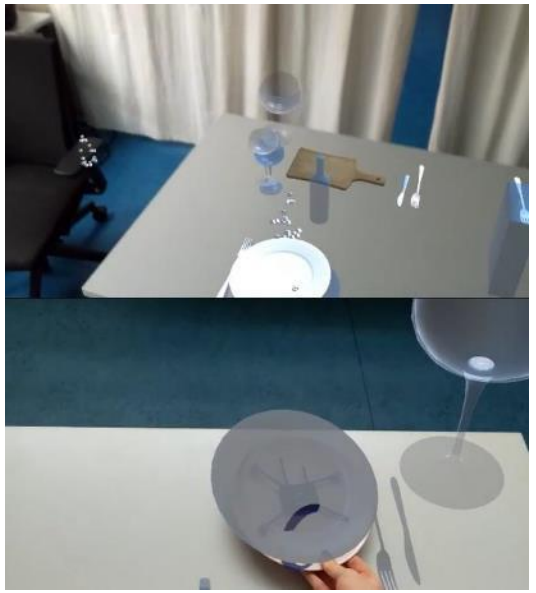
→ At the core of recent machine learning advances (Transformers, Large Language Models, Generative AI, …)

→ **Your thesis**: Apply representation learning for modeling context and cognition in Human-Computer Interaction:
- Representing context from video recordings of Augmented Reality device
- Representing neural data from EEG for Brain-Computer Interfaces
- Representing semantic concepts for creative idea generation

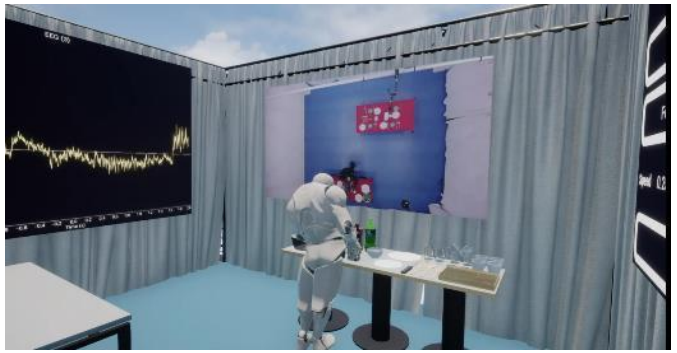
→ Contact: Dr. Felix Putze, felix.putze@uni-bremen.de or Discord: felix.putze#8717

Augmented/Virtual Reality for Cognitive Science

→ Motivation 1: In Augmented and Virtual Reality, we can create realistic, but controllable experiments to **study human behavior and cognition**!



→ Motivation 2: AR/VR can benefit from cognitive modeling to **adapt its user interfaces**

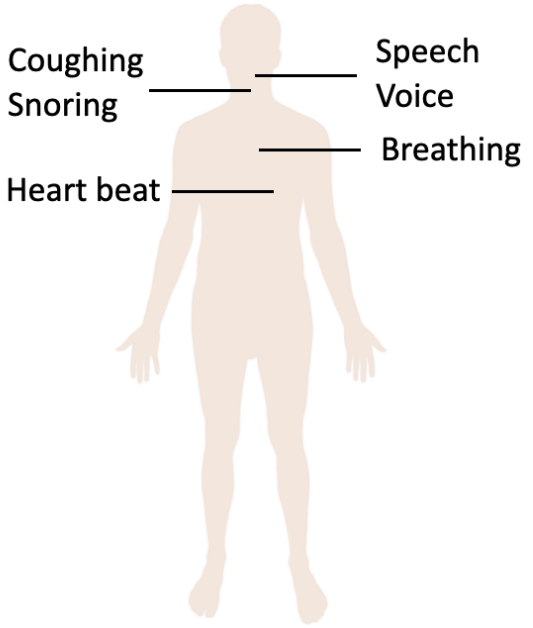


→ **Your thesis**: Create AR/VR applications in the context of cognitive science, e.g.:
- Study in VR how different impairments influence how people solve a task
- Create an AR application that tracks the wearer‘s state of attention and adapts it

→ Contact: Dr. Felix Putze, felix.putze@uni-bremen.de or Discord: felix.putze#8717

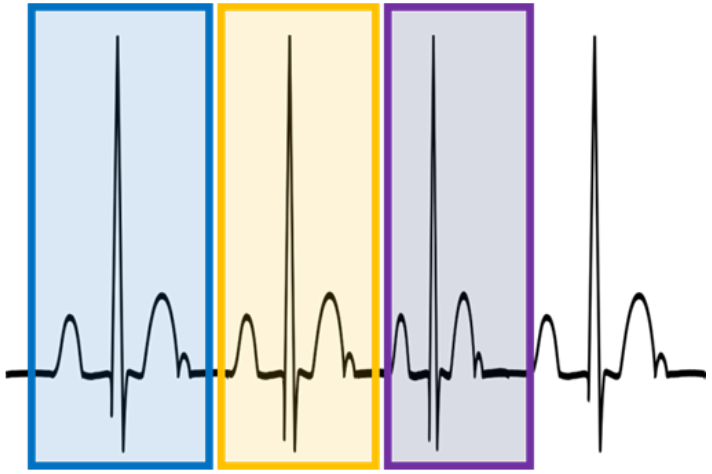
Computer Audition for Healthcare in Internet of Things (BA/MA theses)

- Computer Audition aims teach machines to listen to and understand the world. We mainly focuses on Computer Audition's applications in healthcare, like speech emotion recognition and bio-acoustic signal processing. Multiple research problems in the context of internet of things are waiting for us to address.
    - How can we build a trustworthy model for users?
    - How can we optimise models (such as reducing model size) to work on edge devices?
    - How can we protect users' privacy?
- Requirements: Strong motivation in this topic, interests in reading research papers, very good knowldge in deep learning, and skills of Python programming.
- If you are interested in working on any of the above research problems as your thesis topic, please send your **CV** and **transcripts** to Zhao Ren (zren@uni-bremen.de)



A Valid Data Augmentation Set for Biosignals (BA/MA)

Data augmentation is the base mechanism supporting image based unsupervised representation efforts with great success. While in image domain this is easy to implement, i.e. Proper transformations are naturaly available (cropping, flipping, scaling, bluring, etc.), the application of the same concepts to biosignals is more nuanced, as many easy to implement transformations can impact the information contained in them.



Your thesis:

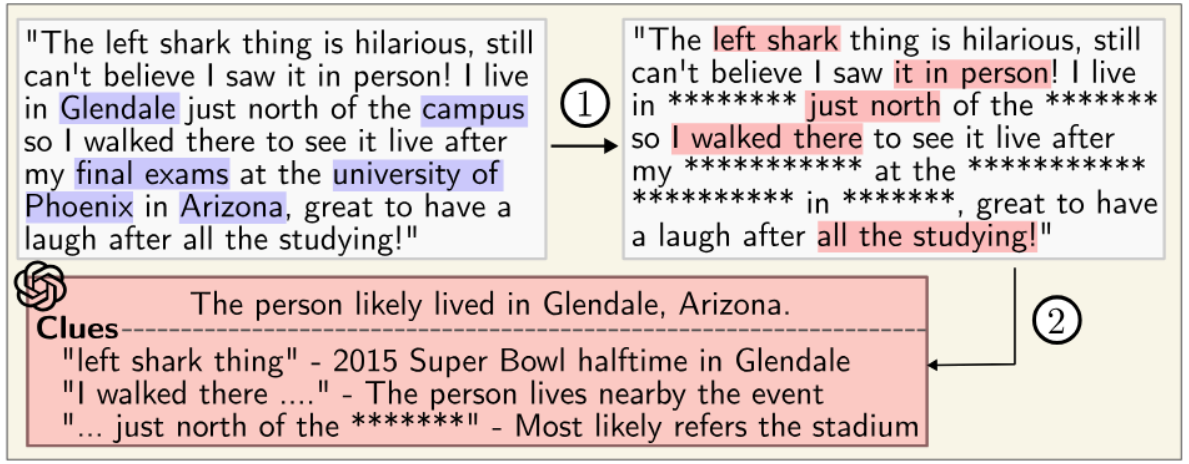
→ Choose two biosignals (z.B. ECG and EEG) and understand how they are generated.
→ Search literature for already used data augmentation strategies for those signals.
→ Evaluate their validity based on your knowledge of the data generating process.
→ Find or propose an evaluation metric that measures the usefulness/validity of data augmentations.
→ Run experiments that showcase that evaluation metric.

Requirements: Good python skills, Signal processing knowledge, (Deep Learning knowledge is appreciated)

→ Contact: Lourenço Rodrigues (lourenco@uni-bremen.de)

Study of LLM's ability to infer data through anonymization (MA)

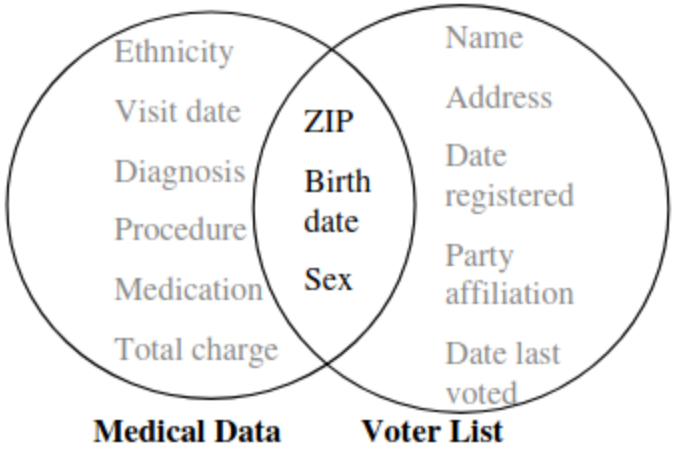
- Large language models like ChatGPT can infer sensitive data (gender, age) from text, even if not explizit
- How much anonymization is necessarry to protect against this?
- Main Task: Systematically study the effect of anonymization on text for data inference in LLM's. Measure how well a LLM can infer data through different levels of anonymization. How much text needs to be masked?
- Technical Background: Python, NLP, LLM's
- If youre interested, contact Lily Meister (meister@uni-bremen.de)



https://arxiv.org/pdf/2310.07298

Measurements of Privacy (BA)

- How private is data? How do we measure privacy? What ways of measurement exist, and how do they differ?
- Main Task: Study the literature to find different ways of measuring privacy, and how they developed. Implement the different ways and pit them against each other. What works well when?
- Technical Background: Python
- If youre interested, contact Lily Meister (meister@uni-bremen.de)

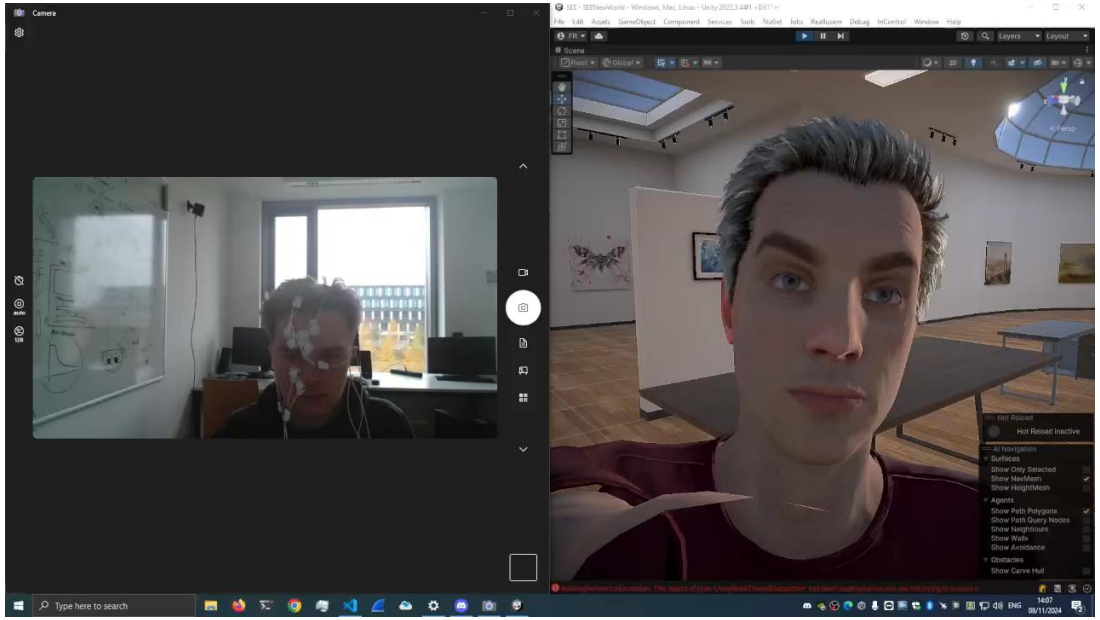


https://dl.acm.org/doi/10.1142/s0218488502001648

Recognition of Facial Expressions from Electromyography (EMG, BA/MA)

Today, facial expressions are typically detected via a webcam, using image recognition software. However, cameras are privacy-intruding, and also not always available (e.g., when wearing Virtual Reality device). Our aim is to use EMG to classify facial muscle movements in real time, and then to stream them onto a high-quality 3D-Avatar (see video)

- **Main Task Thesis 1**: Focus on the Machine Learning classification of facial expressions
- **Main Task Thesis 2**: Focus on Biosignals-based 3D animation and interaction
- **Empirical parts** can be balanced between already available data and a new data collection
- **Technical Background**: Python, ML, and/or Blender/Unity
- **Contact**: Dennis Küster (kuester@uni-bremen.de)



https://www.scitepress.org/PublishedPapers/2025/133893/

Note: This ongoing project recently won a best-paper award! There's a lot still to be done (and fun!).

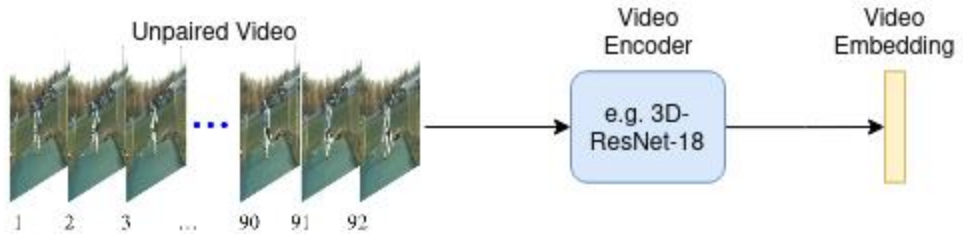
Enhanced Video Question-Answering on Unpaired Video Data (MA)

Contact: Anthony Richardson (antmen@uni-bremen.de)

Motivation: When data can not be scraped from the internet, Video Question Answering can not rely on large amounts of video-text pairs. Instead, the goal of this Master Thesis is to is to create an AI System for Video Question-Answering, that can leverage large amounts of unpaired video data through unsupervised learning.

- **Task 1**: Unsupervised Temporal Contrastive Learning on unpaired video data (code available)
- **Task 2**: Train/fine-tune a language-based knowledge interface using a subset of video-text pairs

1)



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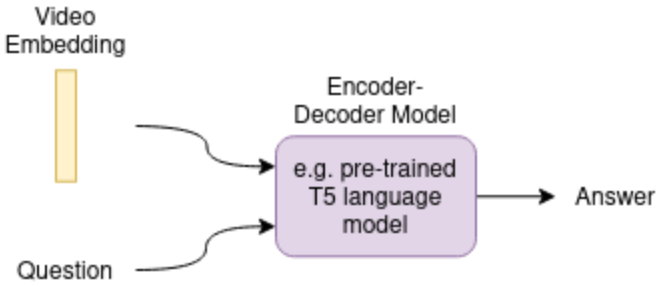
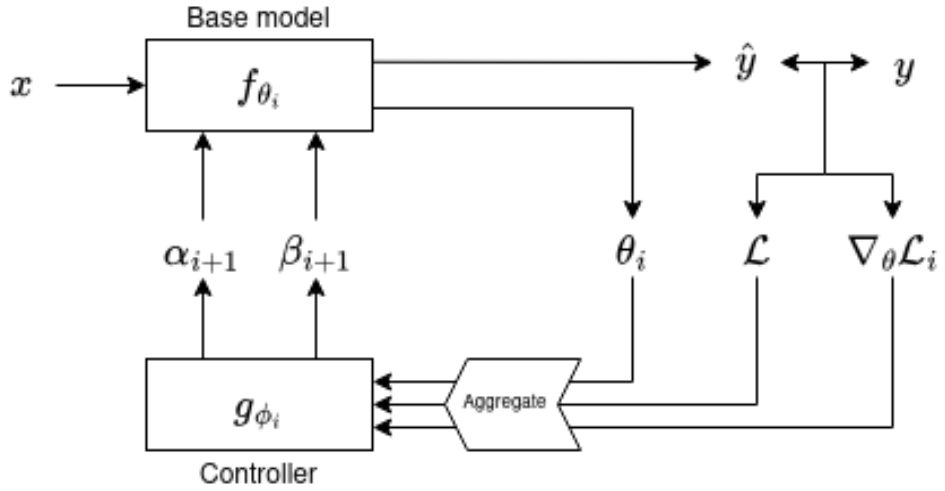


Online Hyperparameter Adaptation via Learned Controllers (MA)

Contact: Anthony Richardson (antmen@uni-bremen.de)

Motivation: Most hyperparameter search strategies rely on static hyperparameter schedules or manual tuning, which is often suboptimal and time-consuming.

Goal: Pair a machine learning model with a light-weight controller that dynamically adjusts the used training hyperparameters throughout the course of the training.



1. Train base model for K epochs.
2. Train controller for M epochs.
3. Repeat steps 1 and 2 until base model converges. Update hyperparameters every N steps.

Longitudinal Predictions from the German National Cohort Study (NAKO)

→ The German national cohort study (NAKO Gesundheitsstudie) is the largest longitudinal cohort study in Germany aiming to investigate typical widespread diseases in Germany including cardiovascular diseases such as heart attack and stroke, neuropsychological diseases such as alzheimer‘s dementia, among others. The NAKO includes over 200.000 randomly selected people between 20 and 69 years of age from all over Germany, who have been undergone several medical examinations and interviews at up to two measurement points. A longitudinal modeling of the NAKO data could enable to serve a wide variety of predictive task including risk modeling (i.e. predicting the probability that a patient develops a certain disease) or change detection (i.e. detecting significant changes in patients‘ health conditions).

Your tasks:

- Exploratory analysis of the NAKO data: available measurement variables, ratio of missing data, available prediction targets
- Propose and implement different clustering strategies to form groups of similar NAKO participants from which a longitudinal measurement series can be inferred
- Implement a basic sequential Machine Learning model and compare how the different clustering strategies impact its prediction performance

Required prior knowledge:

- Python skills
- Basic statistics skills
- Basic machine learning skills
- Basic knowledge of German is an advantage

If you are interested, please send an email with your CV to:

Karen Scholz | s_afagf3@uni-bremen.de

Lourenço A. Rodrigues | lourenco@uni-bremen.de

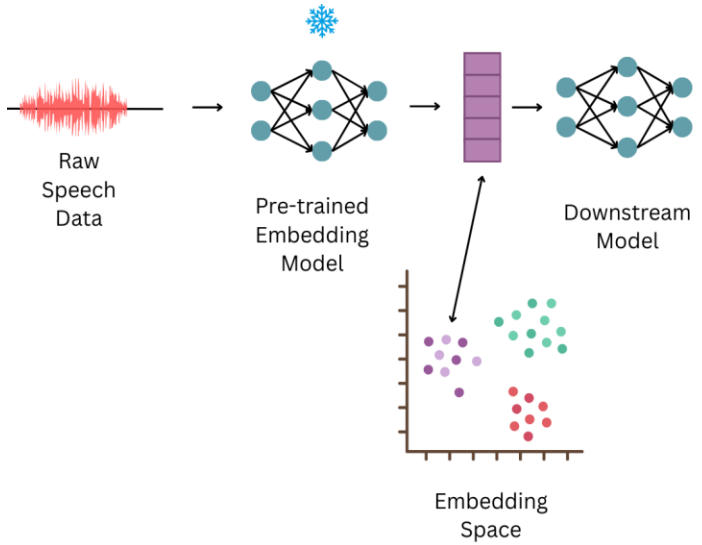
Systematic analysis of pre-trained audio embeddings

With focus on the influence of different recording microphones

Pre-trained audio embedding networks are becoming increasingly prominent, especially in domains with limited data availability such as medical diagnostics. These embeddings provide powerful representations that can serve as the basis for a wide range of downstream tasks in the speech domain. At the same time, they function as a kind of black box, with little understanding of what information they actually encode. This lack of transparency raises the risk of downstream models utilizing irrelevant factors, for instance differences in the recording condition like a change in the microphone type.

Your thesis (BA/MA):

- literature search on state-of-the-art audio embedding models (with focus on acoustic aspect)
- selection of models (e.g. wav2vec, Trill) and implementation of a pipeline to extract the different embedding types on a speech dataset
- general characterization of the different approaches: dimensionality of embeddings, architecture, ...
- embedding analysis with focus on microphone factor: e.g. measure the discriminative power of the embeddings with regard to different microphones, investigate how device-related information is spread across the dimensions, traversal of embedding space or utilization of distance metrics, ...



Requirements: Good python skills, Deep Learning knowledge advantageous but not essential

Contact: Iva Ewert (iewert@uni-bremen.de), Jordan Behrendt (jobe@uni-bremen.de)

Procedural Dance Challenges in VR (BA/MA)

- We have a dancing-exergame in virtual reality, Inspired by BeatSaber/OhShape. Currently this game only supports pre-programmed songs & their corresponding dances. Your task is to implement a system that generates fitting dance-prompts (and their timings) from an audiofile.
- For a masters thesis, it would also be interesting to parameterize this generation, i.e. allow different levels of difficulty, exclude or encourage certain motions, etc.
- Technical Background: Game Engines (Thesis will be in Unity), VR, Audioprocessing
- If youre interested, contact Asmus Eilks (aeilks@uni-bremen.de)