Project proposals 2020

Most of the proposed projects are possible to expand into M.Sc. thesis projects. Please let us know if you might be interested in this option as well. You can learn more about each of the projects by asking the named project supervisors.

1. Interpolating voices

This project investigates the difference between male and female voices, striving to construct an interpolated voice of an intermediate voice. The aim is to develop tools to aid persons undergoing a gender correction, transitioning from one gender to another. Such persons need to learn to speak with their new voice; the developed tool aims to help in this transition, giving a possibility to listen to a generated intermediate voice which originates with the persons original voice. This is part of an ongoing research project

Supervisors: Andreas Jakobsson, Susanna Whitling

2. Can denoising improve the reassigned spectrogram?

The reassigned spectrogram is a powerful tool for analysing non-stationary signals, its performance is however sensitive to noise. There are methods for denoising signals, where the most known probably are the different discrete wavelet transforms. In wavelet transform, one specific wavefunction is used to describe a signal by varying the scale of the wave. While Wavelet denoising methods are well researched and used, their effect on the reassigned spectrogram is not, and it is not a given that denoising will give better reassignment results. This project will work with simulated signals, so that the true spectral density is known, and investigate how denoising a signal before calculating the reassigned spectrogram will affect the result. Though the focus will be on simulated signals, the project results could also be visualised on measured data, from a medical cold pressure test.

Supervisors: Isabella Reinhold, Rachele Anderson

3. The bispectrum of EEG-signal spectrogram?

Most biological signals are non-Gaussian, and techniques for studying non-Gaussian signals relies on the spectral representations of higher moments, known as polyspectra, where the most commonly used technique is the bispectrum. The bispectrum can be related to phase amplitude coupling (PAC), a technique to measure cross-frequency dependences, especially in the context of EEG signals. The aim of this project is to study the bispectrum for simple models of EEG-data and some real-data measurements of steady-state visual evoked potentials.

Supervisors: Maria Sandsten, Rachele Anderson

4. Robust spectral estimation

This project aims at examining ways of creating robust versions of some of the discussed spectral estimation algorithms, to make these less sensitive to outliers and non-Gaussian data. As a first step, the robustness should be investigated to determine the level of the sensitivity of the algorithms, which should then be addressed using robust estimation techniques. This is a research project that may be extended to an independent study or thesis.

Supervisors: Andreas Jakobsson, Filip Elvander

5. Beat AI with the best time-frequency features.

Signal classification and clustering are currently performed with a variety of machine learning methods, including regression, K-means, and artificial neural networks (deep learning). Deep learning methods can be very powerful when a large amount of data is available, which often is not the case. Even more important of the classification algorithm used are the features given as input to the algorithm. Signal classification is usually performed based on the raw data or their spectrograms; however, these are not the only choices. In this project, you will classify different classes of non-stationary simulated signals using one or several machine learning algorithms, feeding your classifier with features extracted from different time-frequency representations. With the best features, the simplest classifier can perform as good (or better) than the most complicated deep learning architecture, and you will investigate which time-frequency representation offers the best features for classifying the considered classes.

Supervisors: Rachele Anderson, Isabella Reinhold

6. Sparse spectral estimation.

In the course, you have seen how the LASSO can be used for achieving state-of-the-art estimation performance when applied to line spectral estimation, with a remarkable property being the ability to estimating also the number of spectral lines. However, the LASSO formulation inherently places a downward bias on the estimated signal amplitude. This can cause problems when the measured signal contains both strong and weak signal components, especially in high noise settings. Specifically, in order to arrive at a denoised spectrum, the weaker signal components may be suppressed to point of being undetectable. In this project, you will study a newly proposed approach to remedy this problem by replacing the LASSO penalty by a non-convex regularization function. If you like optimization, this is the project for you!

Supervisors: Filip Elvander, Andreas Jansson

7. Investigation of the Hilbert transform on low frequency signals

The Hilbert transform is used in spectral analysis to get an analytic representation of a real-valued signal. The analytic signal has some advantages in spectral analysis, one is it has no negative frequencies, which vastly improves the readability of the quadratic time-frequency representations. There is however a problem with the Hilbert transform, it is not well suited for real-valued signal with very low frequencies. This project aims to investigate what happens with the Hilbert transform of signals where the frequency goes towards zero for well defined simulated signals.

Supervisors: Maria Sandsten, Isabella Reinhold

8. Denoising of speech signals

This project aims at reducing background noise in speech recordings. Typically, many forms of audio measurements are made in noise environments, such as in a car or with strong winds affecting the voice quality. This project aims at investigating some ways of measuring the level of such background noise and to reduce this without affecting the voice quality more than marginally. This project may be extended to an independent study or thesis.

Supervisors: Andreas Jakobsson, Filip Elvander

9. Modeling inharmonicities in voiced speech

It is well known that several forms of string-based instruments, such as a piano or a guitar, exhibit inharmonicities in the harmonic line spectral structure. This means that the overtones appear slightly higher than a multiple of the fundamental frequency, a fact that needs to be considered when constructing pitch estimation algorithms. In this project, we will examine similar frequency shifting in voiced speech, and try to determine how this could be modelled as a function of frequency.

Supervisor: Andreas Jakobsson

10. How does convolutional neural networks perform spectral analysis?

Convolutional neural networks (CNNs) is a deep learning method that is having great success with image recognition and classification. With a general deep learning approach, pre-processing of raw data is usually discouraged, as the network is meant to learn what filters are best to apply. This raises the question whether it is best to train a CNN on unprocessed signals or on time-frequency (TF) representations of the signals, as TF representations essentially are TF images of signals, and CNNs perform best with images. The results would probably depend on the type of signal and application. Therefore, this project could be performed by multiple groups, investigating different signals and situations.

Supervisors: Isabella Reinhold, Rachele Anderson

11. Short-range radar measurements

This project aims at investigating high resolution algorithms for Acconeer AB's high frequency radar system. The project will involve making actual measurements and investigate different scenarios (*sorry about the description being rather vague – the guy at Acconeer has been sick and have not been able to give us feedback yet; this will hopefully be sorted during the week*).

Supervisor: Andreas Jansson, Andreas Jakobsson

12. Spectral analysis using multitapers

The Wigner-Ville distribution has the best obtainable spectral resolution, but also a major drawback in cross-terms. The appearance of cross-terms can be supressed by filtering with a function, called a kernel, but this will result in some loss of auto-term concentration and resolution. One computationally efficient way to calculate the filtered Wigner-Ville distribution, is the multitaper spectrogram. The tapers, i.e. windows, can have different shapes and be made to fulfil certain properties, making them useful in many applications. In this project, the aim will be to design multitapers for spectral analysis of a specific data set. We have a few data sets that are suitable, but students are also welcomed to provide their own data set.

Supervisors: Maria Sandsten, Isabella Reinhold

13. Removing clutter using a group-sparse SPICE algorithm

This project aims at deriving a novel clutter rejection algorithm combining a recent group-sparse SPICE clutter rejection algorithm with the q-SPICE formulation. Many forms of signals are corrupted by known interference sources, which if not properly treated will corrupt the parameter estimates. This is a research project that may be extended to an independent study or thesis.

Supervisor: Andreas Jakobsson

14. Classification of peaks on a 2D surface

The matched reassignment spectrogram finds the time-frequency centres of signal components and ideally results in a time-frequency distribution with narrow peaks at those centre points. Identifying these peaks by eye is easy, but when dealing with large datasets, it is desirable to detect those peaks automatically. This automatic process is made harder when the signals are disturbed by noise, as the peaks in the spectrogram will then spread out and become jagged. This project aims to develop a method for classifying peaks and find their centre point in the time-frequency distribution, which essentially is a 2D surface. Students are free to try their own ideas or to improve on existing methods. The developed method can then be tested on a set of dolphin echolocation signals, where it is of importance to classify individual clicks.

Supervisor: Isabella Reinhold

15. Classification of medical data

Heart rate variability (HRV), is the variation of inter-heartbeat intervals, i.e. changes in the time between two consecutive heartbeats is measured. When monitoring HRV, serious conditions and compromised health can be detected much earlier than changes in the actual heartbeat can be found. The data in this project comes from a study where the participants were asked to hold one of their hands in ice-cold water for a few minutes, a so-called cold pressure test, where the HRV was measured. The participants also got their HRV measured when holding their hand in room temperature water. This project aims to investigate if the HRV-data from the cold pressure test can be distinguished from the HRV measured while resting. This will require time-frequency analysis but also classification methods to be used, students are welcome to combine spectral analysis with methods from other courses, such as machine learning.

Supervisor: Isabella Reinhold

16. Classification of bird species

The aim of this project is to classify a few of our most common bird species from their song, using features extracted from time-frequency images but could also include novel techniques based on the ambiguity domain cross-terms. A few different recordings from all species will be available in mp3-format. Comparison of different algorithms and features should be made for all species but a pairwise evaluation can also be made especially for species with similar songs. A challenge is to minimize the required song length.

Supervisor: Maria Sandsten

*The projects can be performed individually or in groups of up to four persons. By **Thursday February 6th**, please let us know your or your group's project preferences, ranking 1st, 2nd, and 3rd choice to allow us to distribute the projects fairly. Please E-mail the two addresses below. If you have your own project suggestion, please let us know as well, giving a brief description of the project, preferably as soon as possible. Please also feel free to approach the suggested supervisors to discuss the different projects; typically, the projects are quite open to modifications. Do not hesitate to get in touch if you have questions!*

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