Adaptive modulations for underwater acoustic communications

Context

The use of Adaptive Modulations (AM) for underwater acoustic communication is a recent research endeavour, whose principle is to dynamically adapt modulation parameters (e.g., the modulation order *M* of a *M*-PSK or *M*-FSK modulations) or even switch between fundamentally different modulations (e.g., switch from QPSK to 2-FSK). The switch from one modulation to another depends on environmental data (e.g., bathymetry data) and communication data (e.g., estimated signal-to-noise ratio and channel impulse response) and is triggered in such a way that the "best" modulation is chosen at any given time; if correctly designed, adaptive modulation should translate into throughputs that are higher than those obtained with a fixed modulation.

A few representative papers about adaptive modulations are [Pelekanis, 2018] (based on boosted regression trees), [Huang, 2020] (based on support vector machines), [Kojima, 2021] (based on convolutional neural networks) and [Su, 2019] as well as [Cui, 2023)] (based on reinforcement learning).

Given that underwater acoustic channels are complex and that real-world experiments are difficult to carry out, researchers increasingly rely on modern acoustic propagation simulators (e.g., the world oceanic simulation system (WOSS) [Casari, 2014]).

Objectives and steps

The main goal of the master's thesis is to implement (and possibly extend), simulate and compare two representative adaptive modulation approaches. The steps are *i)* to setup WOSS in a Debian/Ubuntu-based operating system (computing servers are available for that purpose) and get familiar with it, *ii)* to implement (at least) two modern adaptive modulation algorithms on WOSS (extending them to a wider breadth of modulations than originally designed for is recommended for motivated students) and *iii)* to investigate which adaptive modulation methods perform best and in which circumstances (shallow vs deep waters, short-range vs long-range communication, etc.)

Student profile

Although not mandatory, the student should ideally have followed the courses "Modulation and coding" and "Communication channels". Having followed or following a course on machine learning (e.g., "Machine Learning and Big Data Processing") is also a plus. The subject is particularly suited to students willing to apply modern machine learning to telecommunications problems.

References

[Casari, 2014] Casari, Paolo et al. "Open source suites for underwater networking: WOSS and DESERT underwater." IEEE Network 28, no. 5 (2014): 38-46.
[Cui, 2023] Cui, Xuerong et al. "Reinforcement learning-based adaptive modulation scheme over underwater acoustic OFDM communication channels." Physical Communication 61 (2023): 102207.
[Huang, 2020] Huang, Jianchun, and Roee Diamant. "Adaptive modulation for long-range underwater acoustic communication." IEEE Transactions on Wireless Communications 19, no. 10 (2020): 6844-6857.
[Kojima, 2021] Kojima, Shun et al. "CNN-based joint SNR and Doppler shift classification using spectrogram images for adaptive modulation and coding." IEEE Transactions on Communications 69, no. 8 (2021): 5152-5167.
[Pelekanis, 2018] Pelekanakis, Konstantinos, and Luca Cazzanti. "On adaptive modulation for low SNR underwater acoustic communications." In OCEANS 2018 MTS/IEEE Charleston, pp. 1-6. IEEE, 2018.
[Su, 2019] Su, Wei et al. "Reinforcement learning-based adaptive modulation and coding for efficient underwater communications." IEEE access 7 (2019): 67539-67550.

Contact

Jean-François Determe, jean-francois.determe@ulb.be

Solbosch campus, building U, level. 5, BEAMS-EE department