NTNU

Institutt for elektroniske systemer
Institutt for elkraftteknikk
Institutt for teknisk kybernetikk

# Oppgaveforslag bacheloroppgave elektroingeniør (BIELEKTRO) i Trondheim, vårsemester 2023

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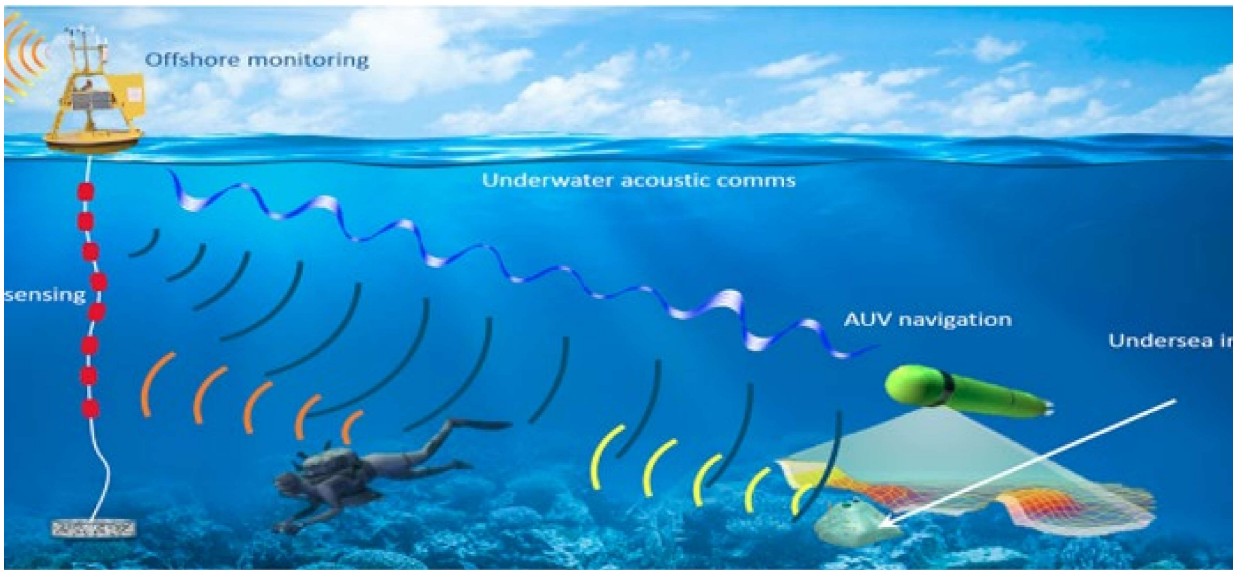
| **Tittel på oppgave:**<br>***Distributed Optimization Based Adaptive Underwater Communication Schemes*** | | |
| **Hvilke studieretninger passer oppgaven for?** (kryss av for alle aktuelle retninger; flervalg er mulig): | **Automatisering og robotikk** | ☒ |
| | **Elektronikk og sensorsystemer** | ☒ |
| | **Elkraft og bærekraftig energi** | ☐ |
| **Er oppgaven reservert for noen bestemte studenter?** (skriv navnene på studentene inn til høyre) | | |
| **Har dere arbeidsplass for studentene** | ☒ ja ☐ nei ☐ usikker? | |
| **Er dette en lukket oppgave?** Dvs. at sluttrapporten ikke kan publiseres fordi den inneholder sensitiv informasjon. | ☐ ja ☒ nei ☐ ikke enda bestemt | |

**Kort beskrivelse av oppgaven med problemstilling.**




*1 httpssipl.eelabs.technion. ac.il*

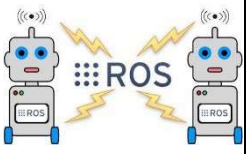
**Background**

The underwater world is attracting more attention and probably becoming the next hot topic in industries and academia. Among all the challenges that autonomous subsea devices face, using the best they can the communication channel they have is likely the most complicated one. More precisely, underwater communication systems (e.g., optical and acoustic) use channels that change in time (e.g., the turbidity or temperature of the water). Depending on the current environment conditions, one should adapt the way of exchanging information. This making the communication strategies dynamically adapt to the ever changing underwater environment is one of the most interesting but crucial tasks to be tackled. This project aims at testing a prototyped adaptive communication mechanism for dealing with this challenge in real life settings. In other words, the group will start with reading some code and algorithms that 'on paper' are correctly functioning, then move to field implementation of such algorithms using Subnero acoustic modems, python, ROS2 (Robot Operating System version 2), and three BlueROVs, and continue with field tests in the fjord.

**Project Details:** This project is a combination of very diverse and fascinating challenges. Therefore, it provides an exceptional opportunity for participants to enhance their knowledge and also expand the scope of their experiences, preparing them for their next career stage in industry or academia. Since this project is closely connected with other projects, the development would be in a very collaborative environment. The mentioned project is a combination of the following tasks:

**1- Understanding the initially proposed real-time adaptive communication mechanisms:** During this project, the students will be exposed to two different communication parameters adaptation mechanisms that ladder on off the shelf distributed optimization algorithms (ADMM, Newton Raphson Consensus). This initial part of the project (we expect 3 weeks on this) is thus quite theoretical, but is necessary to be able to cope with the next implementation phases.

**2- Development of the algorithms in ROS2:** the entire project is about being actually able to make underwater devices communicate. To ladder our existing hardware, that runs on ROS2, there will be the need for porting the algorithms there. This development will likely be one of the major tasks in this project, and will involve not only coding, but also testing "on air" (indeed the modems that will be used may also communicate outside the sea).




*2geeksforgeeks.org*

**3- Field testing:** finally, we want to verify how things work in the underwater environment. This means a series of shorter trips around Trondheim's fjord, scuba diving immersions for who has a diving license, and likely a final longer trip with our beloved Gunnerus. If things work well we will also visit Sintef Ocean's aquaculture infrastructures.

**Learning opportunities:** During this project, students will gain experiences in many different areas, including the following:
1- Working with hardware (especially acoustic modems, but also sensors readings).
2- Working with ROS2, widely used in industries and academia.
3- Gaining experience in acoustic communication and how it works.
4- Getting familiar with distributed optimization algorithms (and thus also numerical optimization in general, one of the most useful tools engineers should know when in the real world).
5- Organizing a collaborative project work and produced the final product.