NTNU
Norges teknisk-naturvitenskapelige universitet

Fakultet for informasjonsteknologi, matematikk og elektroteknikk
Institutt for teknisk kybernetikk

Master thesis

Candidate: Oscar Nissen

Discipline: Engineering Cybernetics

Project title (Norwegian): Matematisk modellering og styring av fleksible robotverktøy for smoltproduksjon

Project title (English): Mathematical modeling and control of flexible robotic tools for smolt production

Project description:
There is presently a trend in the aquaculture industry with operations and production methods becoming less reliant on manual labour and experience-based reasoning, and more based upon objective indicators, automation principles and decision support systems. This harmonises with the philosophy of Precision Fish Farming (PFF) where new technology and automation principles are employed to improve human control over the biological processes in different phases in the aquaculture production cycle. Although most of the weight gain in salmon production is achieved during the sea-based ongrowing phase, the success of the production also depends strongly on the quality of the fish when transferred to sea-cages. This is determined by how well the fish are managed during the smolt production phase that precedes the ongrowing phase. Smolt production is conducted in land-based tank facilities and covers the period from hatching until the fish undergo smoltification (i.e. a metamorphosis adapting them from living in fresh water to handling seawater).

SINTEF and NTNU, together with an industry consortium of technology providers and aquaculture production companies, are currently doing research in this area in an RCN-funded project called AUTOSMOLT 2025. The ultimate vision of the AUTOSMOLT 2025 project is to adapt and develop a holistic solution for the next generation smolt production by applying the principles of PFF at different stages of the smolt production cycle, thus bringing smolt production closer to realization within the framework of Industry 4.0. This entails increasing the level of autonomy and objectivity in smolt production operations to reduce dependencies on manual labour and subjective assessments, and to improve accuracy, precision, and repeatability.

This master project is associated with AUTOSMOLT 2025, represents a continuation of a specialization project conducted in the autumn 2020, and draws inspiration from a previously conducted master project related to the AUTOSMOLT 2025 project. The master project will focus on improving the advanced mathematical model of an underwater robotic manipulator arm developed in the specialization project, and use this model as a virtual laboratory to develop and test advanced control system components that will be useful for conducting automated operations in tanks for smolt production. Specifically, the model will be further developed in matlab, and will be adapted for underwater simulations.

The project willl include the following concrete sub-tasks:

- Literature study exploring:
  - Methods for implementing hydrodynamic and fluid dynamic effects on submerged robotic arms
- Improvement of dynamic mathematical model
  - Implement feedback control of joint positioning to achieve stability
  - Expand model to accommodate underwater use, e.g. hydrodynamics, added mass
- Implement methods for trajectory planning and tracking for controlling the robotic arm
  - Select suitable methods from those explored in literature study
  - Implementation and testing in Matlab
- Simulation experiments
  - Qualitative verifications of robotic arm model, and trajectory planning and tracking methods
  - Virtual experiments conducting one or more tank operations suitable for automation with a robotic arm.

Project starting point: January 04 2021

Delivery date: June 21 2021

Conducted at the Department of Engineering Cybernetics, NTNU

Main supervisor: Martin Føre

Co-supervisor(s): Herman Biørn Amundsen and Eleni Kelasidi, SINTEF Ocean

Trondheim, February 25, 2021

Supervisor signature