

# Real-Time Fish Detection, Size, Species and Migration Behaviour in River Environments

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## Summary

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*The main objective of this project is to develop, test and implement real-time computer vision solutions useful for fish biodiversity and migration monitoring in European rivers. Specifically, the project addresses two research questions, and one question to guide and inform future works: 1) What is the expected speed and accuracy of real-time computer vision solutions for fish detection, species classification and size estimation when compared to human raters? 2) What is the accuracy of modelled fish counts considering different migration behaviours, including videos with single fish, small groups and swarms when compared to the counts made by human raters? 3) What are the hardware (high performance desktop vs. embedded), software, environmental, human resource and financial requirements to develop real-time fish biodiversity monitoring systems based on the best available technologies?*

Research field:	Information and communication technology
Supervisor:	Jeffrey Andrew Tuhtan
Availability:	This position is available.
Offered by:	School of Information Technologies Department of Computer Systems
Application deadline:	Applications are accepted between October 01, 2024 00:00 and October 25, 2024 23:59 (Europe/Zurich)

## Description

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### *Background on the need for this research*

Underwater cameras are used to manually monitor fish biodiversity and migration in Europe because they provide non-invasive, continuous, and when water conditions are suitable, highly detailed observations of both individuals and groups. Recent advances in machine learning applied to computer vision systems over the last decade now allow for new and improved possibilities to replace the use of human raters to detect fish, identify their species, size and classify their swimming behaviour, which is especially important for monitoring up- and downstream migration. Despite the access to these advances, there remain major gaps in the testing, training and evaluation of machine learning methods to replace humans.

#### Gap 1: annotated datasets

Currently, the largest gap in the European context is that there are no openly available, human annotated datasets of European freshwater fish species which can be used to transparently compare methods. This is a substantial bottleneck for researchers, who need to evaluate computational performance and model accuracy, for commercial developers, who often claim performance and accuracy without a benchmark dataset against which to test their claims and for government agencies who need to be able to assess if data from machine learning models is worse, similar to or better than the human raters they currently depend on.

#### Gap 2: validation guidelines

The second major gap is that computer vision and freshwater fishing communities have little to no practical experience, references or guidelines to compare human-annotated data on fish species, size and migration behaviour data to results obtained from machine learning models. Specifically, there is poor community knowledge on the environmental effects such as biofouling and turbidity on model accuracy as well as effects due to human rater bias and misclassification errors in large human-annotated data. Without understanding how to properly compare “humans to machines” the results from machine learning methods will not be adequately and safely assessed, and cannot be counted on by European users. To address these gaps and substantially advance the state-of-the-art, the goal of this PhD project is to develop, test and validate computer vision software for the automated fish detection, species, size and migration behaviour of wild fish in river environments. Specifically, the project will provide the first systematic investigation of camera-based fish monitoring systems with a specific focus on European needs.

#### *Responsibilities and main tasks of this PhD position*

- Perform a literature review of computer vision methods for fish detection, species classification and size estimation.
- Curate and publish an open access journal paper on training, testing and validation data for riverine freshwater fish detection, species, size and swimming behaviours based on the more than 400,000 videos which have been manually evaluated by human raters during the 3-year collaboration with the German Federal Institute of Hydrology (BfG).
- Test and evaluate state-of-the-art computer vision models using the open access fish data set for fish detection, species, size and counting individual fish with different swimming behaviour.
- Prepare and publish an open access journal paper focused on comparing human rater counts of individual fish considering their behaviour in videos that contain single fish and small groups or swarms of fish, based on the open access data provided together with BfG.
- Collaborating with junior and senior researchers to learn how to prepare news articles, press releases and open house events disseminating the research outcomes from this PhD.
- Aid in the preparation of research proposals related to camera-based biodiversity monitoring.
- Participate in workshops, conferences and public events as a representative of the Tallinn University of Technology to share, improve and grow your knowledge on the topics of computer vision methods for biodiversity monitoring.

*Applicants should fulfil the following requirements:*

- a master's degree in computer science, with an emphasis on computer vision
- a clear and related interest in the topic of the position based on their previous experience
- excellent command of English
- strong and demonstrable software development, writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to provide assistance in organizational tasks relevant to the project
- be able to travel to Germany for up to two weeks per year for collaboration and training events

*The following experience is beneficial:*

- Programming in Python
- Experience in training, testing and validation of machine learning models
- Solid foundation in frequentist statistics
- Working knowledge of video and image annotation processes for classification
- Demonstrated skill in convolutional neural networks applied to image classification tasks
- Code documentation and the use of shared repositories
- Basic understanding of freshwater fish species and their visual appearance

**To be considered for evaluation, a candidate must submit a one-page research plan for the topic, including the overall research strategy. Here it is strongly encouraged to elaborate on their choices of suitable computer vision methods, based on those available in the literature. The format of the research plan is up to the candidate, but should include references to relevant books, journal and conference publications to highlight the candidate's ability to independently source references.**

*We offer:*

- 4-year PhD position in the leading environmental sensing research center in Estonia with a large portfolio of ongoing pan-European, regional, national and local projects.
- The chance to do high-level research in a leading international group on underwater sensing
- Opportunities for conference, research stays and networking with globally leading universities and research centers in the fields of computer vision, underwater sensing and fisheries.

*About the research group*

The Centre for Environmental Sensing and Intelligence is an internationally-recognized and highly interdisciplinary research group at the Tallinn University of Technology focusing on environmentally relevant and future-oriented research and teaching topics:

- Data-driven modelling of large-scale environmental sensing networks
- Computer vision applications for fish monitoring in freshwater environments
- Development of rugged and robust underwater sensors for extreme physical environments



- Human kinematic measurement systems for underwater and microgravity environments
- Environmental technology innovation with small to medium enterprises
- Teaching large-scale environmental sensor development (MSc) and academic writing (PhD)

*Additional information*

For further information, please contact:

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