

Fakulta rybnářství  
a ochrany vod  
Faculty of Fisheries  
and Protection  
of Waters

Jihočeská univerzita  
v Českých Budějovicích  
University of South Bohemia  
in České Budějovice  
Czech Republic

# How to study at the Institute of Complex Systems (ICS)





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**The Institute of Complex Systems** is one of three research institutes of the Faculty of Fisheries and Protection of Waters, University of South Bohemia in České Budejovice. The Institute is engaged in basic and applied research in the field of biological systems using cybernetics, mathematics, physics and chemistry. The Institute actually cooperates with foreign institutions in Norway, Spain and Austria, working on joint projects of signal processing and data analysis in fisheries or microscopy.

**ICS offers** to the students of the doctoral study interesting research topics that are motivated by a real need in research or commercial sphere. The topics are often closely linked to international cooperation, and therefore the study includes a stay abroad with the aim of research.

**More information about the institute:** <http://www.frov.jcu.cz/cs/ustav-komplexnich-systemu-uks>

### **Study program:**

ICS has only one study program. The agreement with other faculties allow us to offer two more study programs to match the Ph.D. topic:

Biophysics – under the Faculty of Science, University of South Bohemia

Cybernetics – under the Faculty of Applied Sciences, University of West Bohemia

Fishery – under the Faculty of Fisheries and Protection of Waters

### **Conditions:**

- Students study in the Czech study program
- Students are getting scholarship
- Students have little employment related to research project (10% - 50%)
- Students are usually getting premium scholarship related to internal university projects
- Students work at Institute of Complex Systems in Nové Hradky
- Students have to realize the research stay in foreign country
- Students have to publish research paper in peer-review journal

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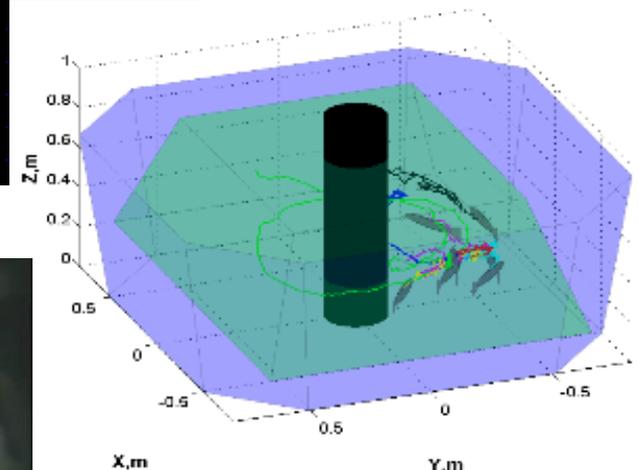
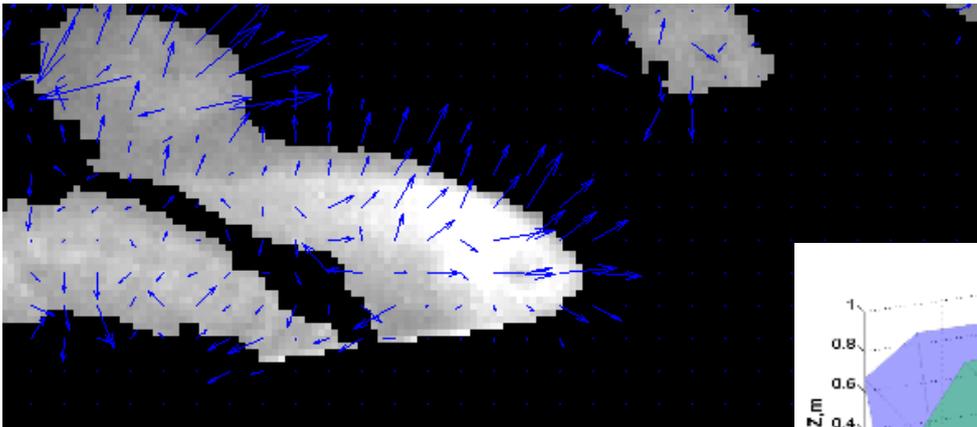
## Systems for monitoring fish behavior

The topic is focused on creating a system for automatic monitoring and analyzing behavior of fish in sea fish cages. A motivating factor is the requirement for research and commercial entities to optimize methods of feeding in marine fish cages where considerable savings in fish farming can be achieved by optimization of the methods. Research projects have already shown a link between behavior of fish and their feeding (fish trajectory is correlated with feeding and other stimuli in marine cages), but an automated system for monitoring and evaluating the behavior of fish has not been created so far. This is due to the high complexity of data from sea fish cages (video recording of fish behavior), particularly high density of fish, changing lighting conditions or camera and the whole cage movements due to the ocean currents. The aim is to design a system of capturing and to create a new method of the automatic analysis of fish behavior in the cage allowing classification of each state of fish shoals. The nature of the data will probably be a method without detection of individual objects in the scene. The topic is based upon an initial collaboration with the Norwegian partner (cage operator) and the possibility of using international infrastructure project Aquaexcel.

**Supervisor: Dipl.-Ing. Petr Císař, Ph.D.**

### **Minimal requirements:**

- Knowledge of methods of image and signal processing
- Knowledge of hardware options in image capturing





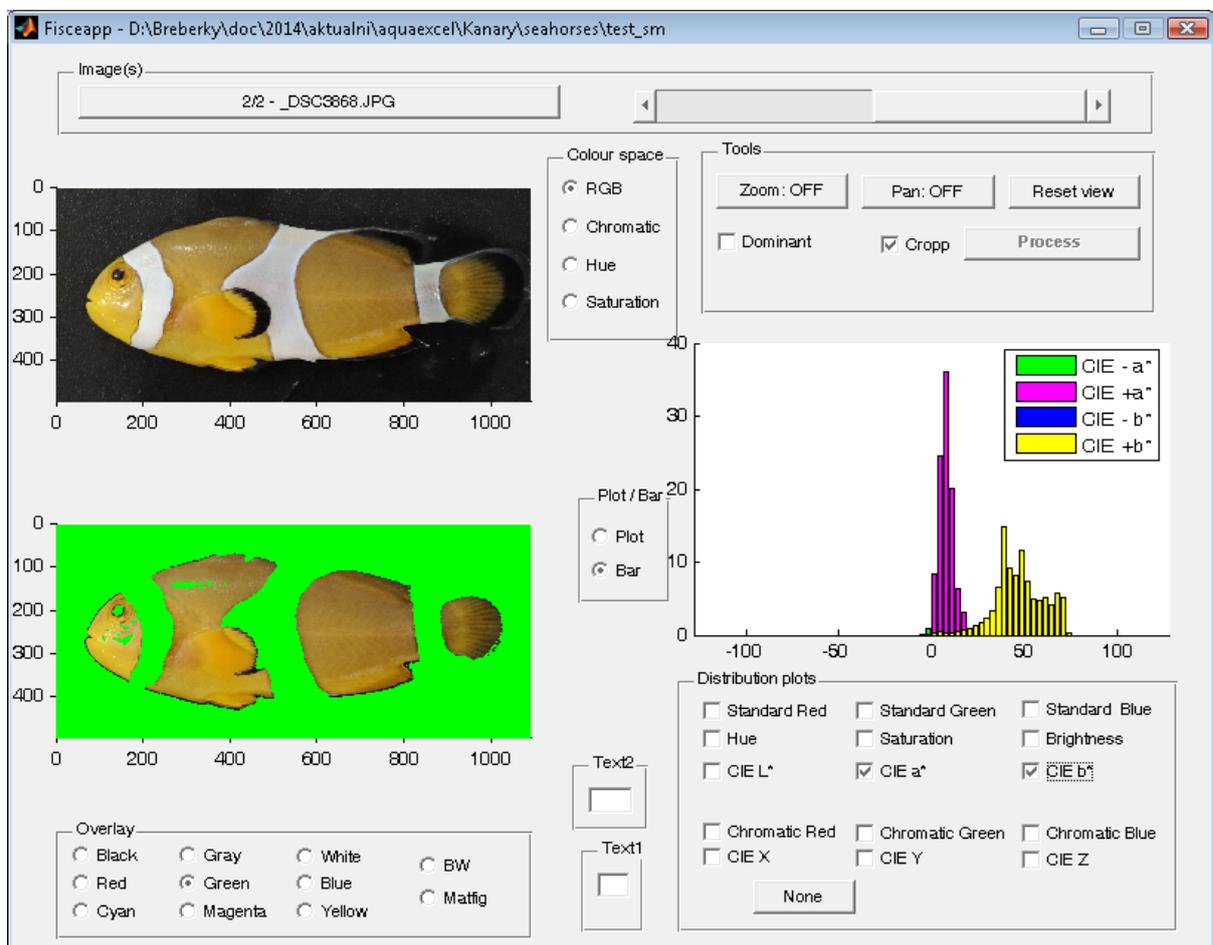
## Morphometric analysis of fish body images

The topic is focused on creating and testing methods, algorithms and software applications for measuring and quantifying morphological parameters of fish bodies photos or videos (ornamental fish, seahorses, etc.). Partial goals of solutions are automatic image segmentation (object/background), calibration standards, morphological operations, statistical self-parameterization, color space transformation, spectral and colorimetric verification. Data acquisition by non-invasive objective approach for assessing the impact of environmental factors, feed and other experimental conditions, is the motivational factor. In the context of this topic, pilot experiments, single purpose software and certified methodology have already been conducted. Experimental data come from the collaboration with institutions in the Czech Republic and abroad. The aim of this thesis is to create an application for automatic and supervised determination of the morphological parameters. The development of own methods of data acquisition will be an integral part of the thesis.

**Supervisor: Dipl.-Ing. Jan Urban, Ph.D.**

### Minimal requirements:

- Knowledge of methods of image processing and analysis.
- Skills in programming (Matlab or Python, or C/C++).
- Practice in linear algebra and statistic analysis.





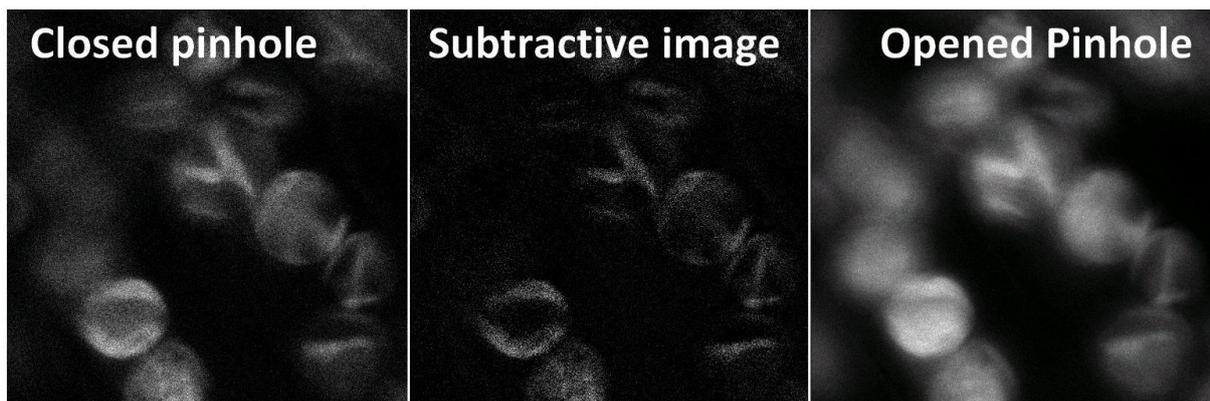
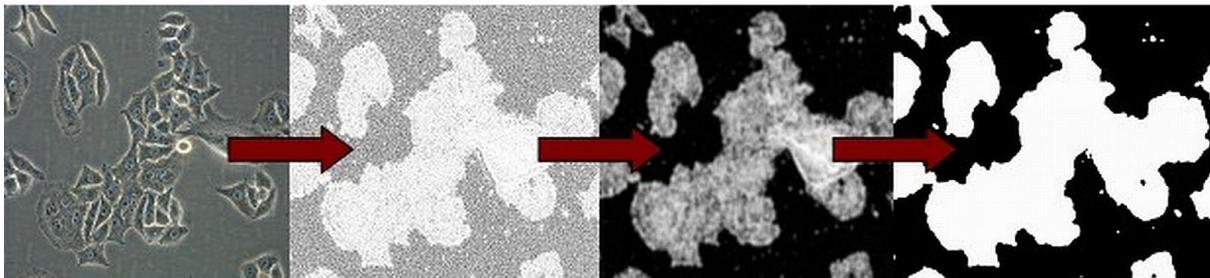
## Super resolution in optical microscopy

This thesis is focused on the suppression of the point blur (point spread function - PSF) in the frequency domain. PSF is given by the wave properties of light, which are clearly seen in optical microscopy and negatively affect the resolution of physical objects. In macroscopic photography, the superposition of these effects can be compensated by Gaussian filters due to the central limit theorem. Influence of PSF can be estimated from various levels of focusing. Pilot experiments in confocal fluorescence microscopy suggest that there will be procedures for estimation of the PSF in other types of microscopy, including other factors affecting resolution (optical path, wavelength, and detector). It will be possible to gain experimental data by different types of microscopes in South Bohemia and abroad (Vienna). Therefore the aim of this thesis is a methodology of the measurement procedures for estimating PSF, as well as a user application software for normalization of microscopy images.

**Supervisor: Dipl.-Ing. Jan Urban, Ph.D.**

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- Knowledge of methods of image processing and analysis.
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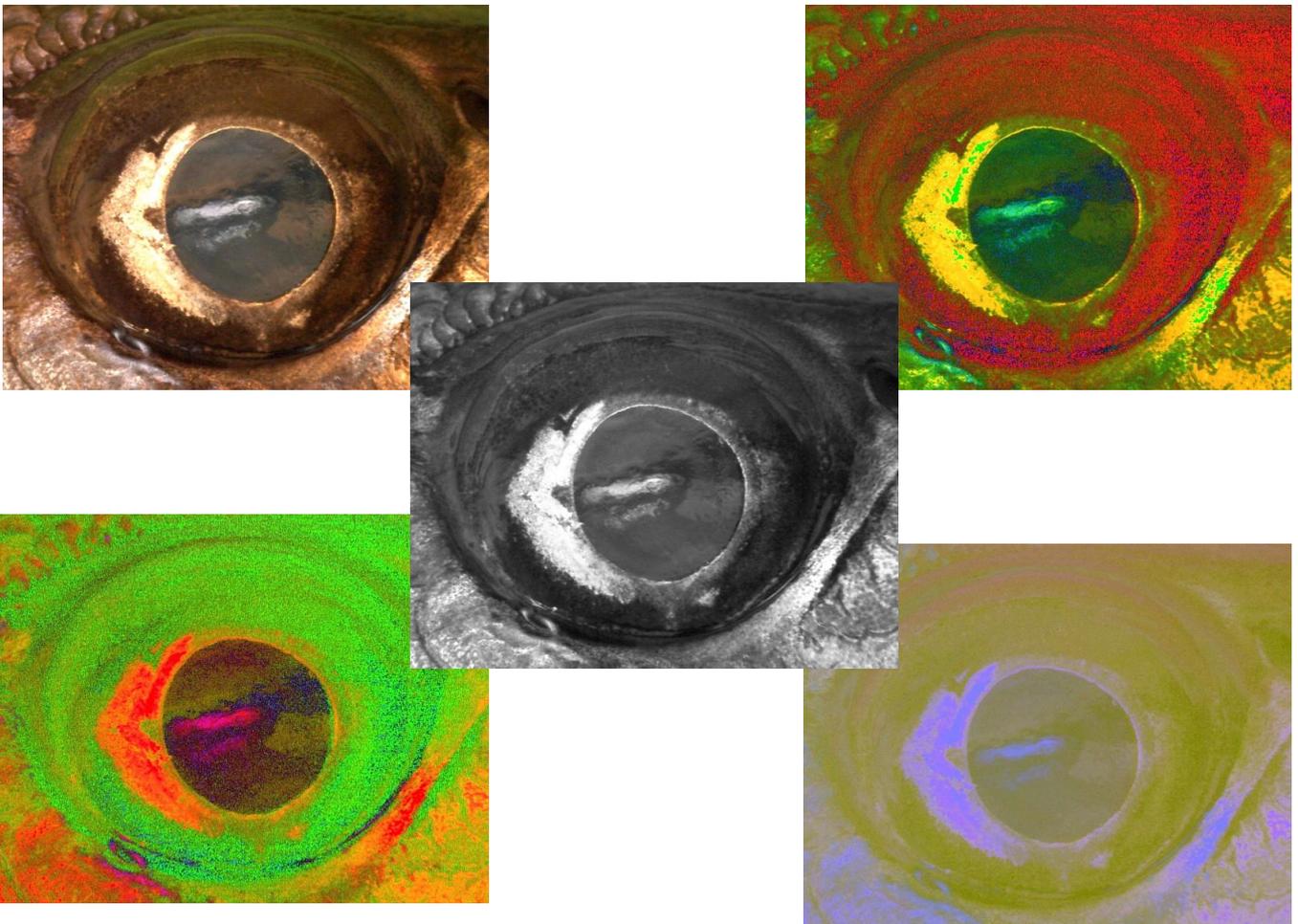
## Identification of fish according to pictorial bio-parameters

This thesis is focused on the ability to identify individual fish in aquariums or tanks by the means of images. Determination of suitable parameterization of the body image, recognition of the fish iris and verification classifier, are partial objectives of the thesis. Parameterization methods are widely used for images of people, which can serve as inspiration in approaches, yet they require extensive modifications and inventiveness. E.g. in fish iris, unlike in human, there is no sclera. Experimental data will be obtained in the workplace Nové Hradky in cooperation with foreign institutions (Norway, Spain), both for freshwater and marine species. The aim of the work is method and user application software for identifying individual fish based on appropriately selected parameters and their justification.

**Supervisor: Dipl.-Ing. Jan Urban, Ph.D.**

### **Minimal requirements:**

- Knowledge of methods of image processing and analysis.
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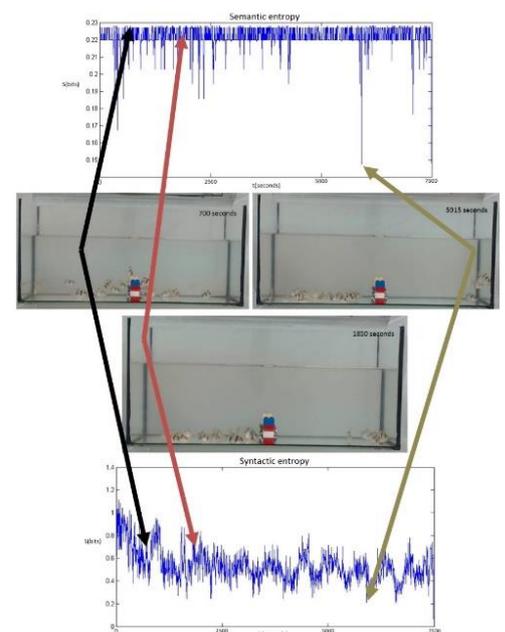
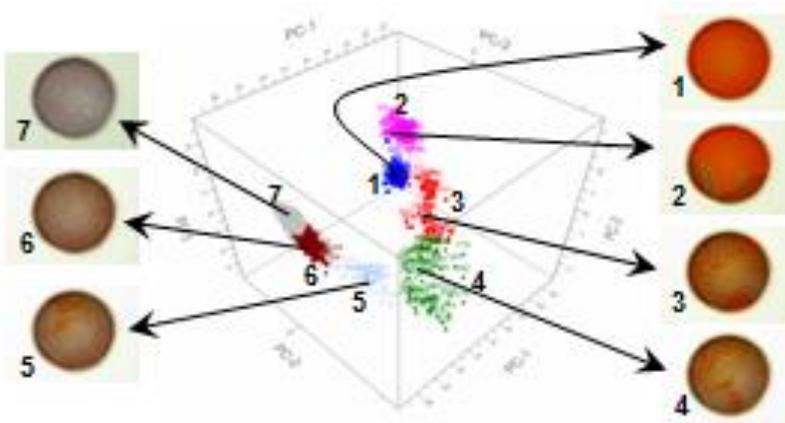
## Image analysis of self-organizing systems

Self-organizing systems are a manifestation of non-linear dynamics in nature. They are present at many levels, from which ICS studies Belousov–Zhabotinsky reaction, living cells and shoaling fish behavior. The aims of the project are:

- a) To objectify signal from the camera and to maximize its informational content; individual steps are calibrations of the signal from the individual points of the digital camera (16, 12, and 8 bits)
- b) Analysis of structures (patterns) using entropy image
- c) Classification of images using image entropy and identification of typical structures

The thesis contains a range of theoretical and practical outputs. The main *theoretical output* will contribute to the classification of structured systems that evolve over time (aging structured systems). These systems represent a substantial part of the phenomena observed in nature – there is a minimum amount of equilibrium systems and systems with stable oscillations/limit cycles. The study of such systems and their models is only in the beginning and proposed systems are among the most easily accessible experimentally. *Practical outputs* are the development of software for processing the primary signal from the camera, camera calibration and maximizing the information obtained at a given bit resolution, as well as testing the software for sensitive differentiation of typical images using image entropy. Both outputs have a specific use in all areas in which camera systems are used.

**Supervisor: Prof. RNDr. Dalibor Štys, CSc.**





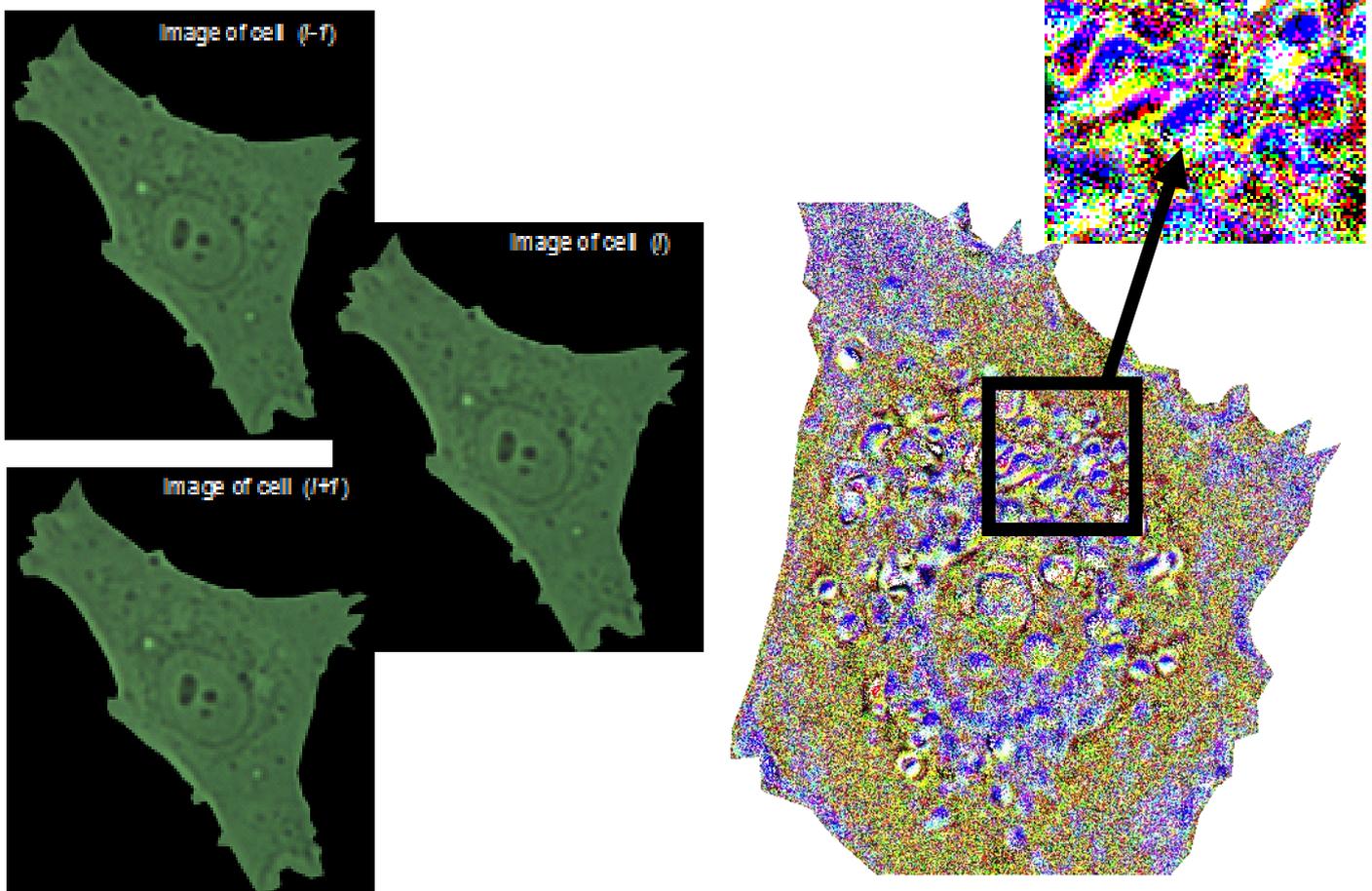
## Analysis and segmentation inner structures of unlabeled living cells from photon transmission micrographs

Institute of Complex Systems (ICS) USB in Nové Hradky and company Optax (Prague) develop a light-transmission microscope for high-resolution 3D segmentation and tracking organelles inside unlabeled living cells. The best approach is a classical bright-field method which enables to obtain the maximally intelligible image of such cells. Research is performed at the cutting edge of possibilities of optical microscopy and includes also basic research in microscopy image build-up, information theory and measurement in quantum-mechanical systems. First practical implementation is expected in 2016 at the Trondheim University Hospital (Norway) and at the Faculty of Health and Medicine of the Danube University Krems (Austria).

The task of the dissertation work will be software development for controlling microscope and image acquisition, collaboration in microscope construction and its testing, as well as image analysis and segmentation of cells and their interiors. A suitable Ph.D. candidate is supposed to be interested in physics (mainly optics and mechanics), mathematical and physical modelling (mainly methods of image analysis and processing and multidimensional analysis) and will communicate with companies Optax, ImageCode and employees of ICS.

Part of the project are also short term stays abroad (Vienna, Krems, Trondheim, Uppsala).

Supervisor: Prof. RNDr. Dalibor Štys, CSc.





## Measurement and analysis of shoaling behavior of fishes in cages, aquaria, and tanks using time lapse capturing in IR and visible light

Institute of Complex Systems (ICS) USB in Nové Hradý, in collaboration with international partners (Norway, Canary Islands), is developing biomonitoring system for observation of fish shoals in aquaculture, both saltwater and freshwater species. The aim is to develop systems for monitoring, image analysis, and events early warning system. Main tasks are device calibration, image segmentation, objects tracking, and behavior parameterization. Potential applications consists of feeding duration estimation, detection of extraordinary events, mortality, and so on. Research and development is performed directly with biggest world producers of fish and part of it is installation and measurement directly at breeding facilities. Research includes also large part of the basic research in self-organization and flocking behavior.

The work of the student will be focused on collaboration at testing, construction and optimization of the prototypes, determination of the minimal requirements for calibration measurements, fulfilling of the testing and reference experiments, development and implementation of the methods of image processing and analysis, implementation of software application for control, acquisition, and analysis of measured datasets. It is expected, that student is interested in physics, construction, image processing and analysis, and multivariate statistic.

Part of the project are also short term stays abroad (Las Palmas, Trondheim etc.).

**Supervisor: Prof. RNDr. Dalibor Štys, CSc.**

