

Doctoral dissertation supervisor's opinion

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Kirill Lonhus MSc.

Intrinsic behavioural parameters of autonomous objects based on motion

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The work of Kirill Lonhus is the culmination of a longer effort by our workplace to thoroughly map flock behaviour down to the level of the individual based on an objective analysis of the experiment. The work has two branches: analysis of shoal behaviour of fish, which we can experimentally influence, and monitoring of collective behaviour of people with practical application in marketing and security. Kirill Lonhus' s work summarises the publishable part, i.e., shoal behaviour of fish. This part also has its practical application; the company ENVI-PUR from Soběslav built an industrial aquarium, which will be placed in a trout hatchery equipped with a recirculation unit the next year. This application aims to use changes in flock behaviour as a sensitive biosensor that will respond to small changes in the composition of purified water and thus prevent contamination, which is generally fatal in breeding units with waters recirculation. Such continuous monitoring is, in fact, not achievable by another method. The only option for continuous monitoring is electrochemical probes, which are always focused on one chemical process. Electrochemical probes age over time, and their maintenance is much more demanding than breeding a school of fish.

However, the motivation of the work was mainly in the field of basic research. There is much literature on flock behaviour and the roles of individuals in flocks, but most of them are descriptive treatises. Our goal was to relate individual concepts such as leader, flock member, bullied individual to the measured data. This is interesting in animals and even more interesting in humans. Twelve years ago, when we started the issue, such an analysis was impossible because of computational capacity, especially because we ran into the limits of our mathematical knowledge. Kirill Lonhus arrived at our summer schools in July 2016 and immediately proposed a technically viable solution to the problem of identifying fish individuals. In 2017, we acquired the i-Secure TAČR Gama project, where we undertook to develop a system for analysing flock behaviour from security cameras.

In parallel, we also worked on developing a new microscope concept for biology and other applications. In parallel technical development, we learned how to process the primary signal from digital cameras, calibrate the cameras, select only the relevant parts of the image in real time and save them. Only due to this technical progress, of which Kirill is one of the main four authors, was the work presented in this thesis possible at all. The work in microscopy proved to be groundbreaking and allowed us to design a completely new concept of a light microscope with a large field of view and simultaneous very high resolution. At the same time, Kirill developed a completely new concept for the interpretation of data from digital cameras, where each point is assigned a spectrum corresponding to the influence of the incident radiation by the object. This also opens up the possibility of complete standardisation of recordings from digital cameras and much less lossy compression of image data.

However, Kirill refused to submit a dissertation based on the microscopic results because he was primarily interested in the exact approach to sociology. The result is the presented work, which shows how it is possible to convert the movement of individuals in a flock in three dimensions into an oriented graph and how to use it to precisely define roles and their time changes. It shows that the roles in the flock are detectable, and individuals differ in holding these roles in the long run. Roles can change under the influence of substances that affect consciousness. Based on Kirill's results, we may say that these effects are specific for each type of compound. This is just the beginning, the technical basis for further work. Due to both practical applications, there is a lot of data, and the data will grow faster than it can be thoroughly analysed

Looking at the list of publications, Kirill could submit at least two full-fledged dissertations: in flock behaviour and microscopy. I am not writing about a side project, which is a high-resolution pocket spectrometer, which would also be dissertable.

Kirill's work was, of course, affected by Covid19, and in the spring of 2020 he went home to Ukraine for a weekend and returned after three months. In the end, however, this delayed only the publication of microscopic works.

Kirill has also collaborated on three defended bachelor theses, two more are currently in, and two more have been proposed.

In conclusion, Kirill Lonhus is by far the best student we have ever met.

Nové Hradý, November 30th, 2021

