Contrasting corneal implants for surgery and quality diagnostics using quasi-spectral analysis (in cooperation with the National Tissue and Cell Center)

The laboratory of experimental complex systems developed a method of quasi-spectral analysis, which allows us to obtain a transparent spectrum in the visible light region from the RGB camera image and contrast any optically active sample. In the current field of implant medicine, transparent materials are prepared using chemical dyeing (eg bromothymol blue). This staining introduces an unnecessary step into the process, another risk of contamination but, above all, is a chemical intervention with unclear consequences.

Within the project "Development of the process of evaluation of cadaveric corneal lamellae by innovation of microscopic systems for cellular analysis", registration number CZ.01.1.02 / 0.0 / 0.0 / 21_374 / 0027352, the Institute of Complex Systems FFPW USB uses large fields of view and quasi-spectral analysis.

Project aims:

1) To apply quasi-spectral analysis to samples of corneal implants, find the fastest contrast method using advanced statistics (multivariate analysis) and artificial intelligence, implement this method to work with corneal lamellae and evaluate the method quality.
2) To generalize the reasons for the suitability of individual methods and their applicability.
3) To participate in the implementation of the method on the Jetson microcomputer.

Candidate profile:
Master degree in biology, chemistry, physics, medicine or computer science.

Light microscopy monitoring of binding the mesenchymal stem cells to scaffolds (in collaboration with the Danube University Krems)

Mesenchymal stem cells (MSCs) are very readily available from the human placenta. The Danube University in Krems takes care of the MSC collection. The MSCs then specialize themselves to different tissues as needed, which is used in the implants manufacture. If the MSCs are not limited by spatial constraints during their growth, nor affected by chemical factors, they transform themselves into the most common form of wild-type human cells - fibroblasts. The fibroblasts no longer transform back to the MSC form and are unusable for regenerative medicine.

The Institute of Complex Systems of the FFPW JU has developed a microscope with a large field of view, which is able to monitor the development of entire MSCs and their aggregates with sufficient spatial resolution and without any staining. So far, due to the size of the cells, observation of the MSCs has always been a compromise between observing the whole cell and seeing the individual details. In addition, fluorescent staining was generally used.

Project aims:

1) To obtain a high contrast MSC image over time using large-field-of-view microscopy and quasi-spectral analysis.
2) To compare the degradation of MSCs to fibroblasts in free growth and in nanoprinted structures of different sizes and shapes in order to preserve the characteristics of stem cells for as long as possible.
3) To develop a method for monitoring MSCs in the growth of scaffolds of biological origin (bones, neuronal structures deprived of cellular material, etc.)

Candidate profile:
Master degree in biology, chemistry, physics or medicine.

Analysis of fish school behavior

School behavior is the most sensitive indicator of changes in water quality. Recent experiments have shown that systematic changes in behavior are already caused by trace amounts of psychoactive substances. In 2021, Kirill Lonhus (Institute of Complex Systems, FLFW JU) developed a method of automatic identification of individual roles in a school based on movement tracking. The water cleaning company ENVI-PUR has produced a professional aquarium that can be placed directly in a recirculation station, water treatment plant or wastewater treatment plant. The practical application of the method is also part of the project.

Project aims:

1) To test changes in school behavior in response to a set of common pollutants and psychoactive substances (so-called new pollutants) that occur in water.
2) To test analytical software and, in cooperation with SW engineers, ensure its stability for long-term use in practice.
3) To participate in the implementation of an industrial aquarium in practice, or ensure this implementation itself.

Candidate profile:
Master degree in chemistry, physics, fisheries, water protection, water engineering or software engineering.