Digital Image Processing and Analysis with focus on data types from MAX IV

Four of the MAX IV beamlines will be able to produce image data; NanoMAX, SoftiMAX, DanMAX, and ForMax. As with any scientific experiment based on image data, moving from qualitative to quantitative analysis increases the scientific value of the data. Image processing and analysis also increase the possibilities to interpret and visualize the data content.

The Centre for Image Analysis (www.cb.uu.se) at the Dept. of Information Technology at Uppsala University has conducted research and education in digital image processing and analysis since 1988. It has since 2015 also been the host institution for the National SciLifeLab BioImage Informatics facility (https://www.scilifelab.se/facilities/bioimage-informatics/).

We propose a course on digital image processing and analysis, including general principles and methodologies, and also techniques especially suitable for MAX IV data. The suggested course length will be 7 focused days, aimed at seniors and PhD students.

We see that all of the above-listed beamlines may not be available in 2022. However, by inviting researchers interested in using MAX IV and image analysis, and allowing them to work on data of similar type, but produced elsewhere, the course has the added value of attracting more researchers to MAX IV and also increasing the awareness of future possibilities giving a head-start in defining and planning MAX IV projects. The basics of image analysis are general, but by designing examples and hands-on computer exercises based on published data from other world-leading X-ray facilities, we can prepare participants for the future. After the course, they will not only have a better understanding of the underlying theory and possibilities of image analysis but also be better at designing their experiments in the MAX IV environment.

This course will be offered online allowing participants from far away.

The course has a similar disposition as our bi-annual TekNat faculty-wide PhD-level course, *Digital Image Analysis for Scientific Applications,* but with a more specific focus on MAX IV data.

Contents and study format

The focus of the course is on reaching a broad understanding of computerized image analysis and a basic understanding of the theory and algorithms behind the computerized image analysis methods (Digitization, Filtering, Segmentation, Feature extraction, Shape description, Classification, Compression, Deep Learning, and Machine learning methods for image analysis). The course starts with basics, including computerized image analysis research methodology and computerized image analysis research ethics. This also includes three hands-on computer exercises, both to get familiar with the interfaces of common software and to solve realistic image processing problems. In the second (optional) part of the course, participants focus on a specific data type, related to data similar to what can be provided by MAX IV. The course participants will be divided into smaller groups that focus on a computer exercise with one specific data type; preferably connected to their research interests. The course will finish off with the course participants briefly presenting what they did with the

data in their projects, brainstorming on potential next steps and future possibilities. For this last session, we will invite one of the senior scientists from MAX IV, to give a presentation on the current status and plans of collecting data at MAX IV. He/she will also participate in the project discussions to give better insight into possibilities, limitations, and experimental design.

As part of the course, we are planning a hands-on workshop and lectures given by external guest researchers (from DTU and the Nano-Imaging beamline of the European Synchrotron).

Target group/s and recommended background:

The target group is graduate students and senior researchers from all subjects where computerized image analysis is (or could be) used as a research tool, in combination with MAX IV data. The limit of participants is 20.

Learning outcomes

The participants should be able to

§ Explain fundamental notions on computerized image analysis, such as digitizing, image enhancement, segmentation, and classification of features.

§ Describe fundamental notions on research ethics and methodology in image analysis.

§ Use software for solving image analysis problems.

§ Analyze and outline the steps necessary to solve a realistic image analysis problem in the participant's research area.

§ Recognize when image analysis can be a solution to a specific problem and when it will probably fail.

§ Discuss possibilities and limitations with MAX IV data and have a fundamental idea of experimental design in the MAX IV environment.

We realize that most participants will not come to a full solution to their (future) image analysis research questions in this short course. Here, we see that the research support provided via the National SciLifeLab BioImage Informatics (https://www.scilifelab.se/facilities/bioimage-informatics/) facility will be an excellent way to follow up and provide additional support to course participants in the future.