Session 1. Introduction

What is image science?

Image processing is a technique to handle images, or visually captured information. Generally speaking, the term "image" here means the digital image, which is a set of numbers, and "handling images" means the digital image processing, which is performed as calculations by computers. Since high-performance computers that can handle images and image communications via the internet have been spread even to personal daily lives, the digital image processing has been getting more and more familiar to us recently. The image science, which is discussed in this course, is a science of investigating theoretical frameworks of image processing techniques. This course explains the image science with background mathematics required for its comprehension.

Topic 1. Sampling and digital processing of images – Fourier transformation and sampling theorem

Although an image is naturally a continuous distribution of brightness, it has to be converted to a discrete set of pixels for digital processing. This conversion is called *sampling;* If the sampling period is sparse, information of fine image structure will be lost. In image science, the degree of fineness is represented by the concept of *spatial frequency.* In this topic, the definition of spatial frequency and Fourier transformation, the sampling theorem for deriving the maximum period for lossless sampling, and the discrete Fourier transformation for digital images will be explained.

Topic 2. Image compression by orthogonal transformation – principal component analysis, KL transformation and cosine transformation

A digital image is a set of pixel values, or brightness values assigned to pixels. This is regarded as an expression of image by a vector whose elements are its pixels, and in other words, the image is expressed by a vector whose basis is each pixel. It is possible to make the elements assigned to a few specific bases have large values and the other elements have almost zero, by a proper selection of bases. This selection makes it possible to compress the amount of image data by omitting the elements whose values are almost zero. In this topic, the *principal component analysis* and *KL (Karhunen-Loéve) transformation,* which compose the theoretical framework of this technique, will be explained. The *cosine transformation,* which is a framework for the *JPEG image compression,* will be also explained.

Topic 3. Mathematical morphology

We will focus on the shape of objects in images in this topic. How can we handle quantitatively the shape and size of objects in image? *Mathematical morphology* is an approach to treat this problem. The mathematical morphology, *Minkowski set operations,* which compose a background of mathematical morphology, and the application of mathematical morphology such as *granulometry* and the *filter theorem,* will be explained in this topic.

Topic 4. Computed Tomography – Image reconstruction from projection

The CT scanner is known as a system to see inside of the human body as if it is sliced. The sliced image is reconstructed from projections captured from the side of the body in various directions. Each projection is regarded as an integral of the X-ray absorbance distribution inside the body along the paths of X-rays. The reconstruction of sliced image is equivalent to reconstruction of the absorbance distribution from the integrals of various directions. The method of reconstruction and *Radon transformation,* the theoretical framework of the reconstruction, will be explained in this topic.