Point information gain entropy density, and an ideal image from light microscopy

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The derivation of PIED was inspired by the need to extract the maximum amount of information from a microscopic image. Instead of the traditional approach to entropy, which seeks to characterize a macroscopic system as a whole, we derived a quantity that quantifies each element's contribution to the information in a discrete data set. Here, it is necessary to distinguish between (1) the system itself, such as a structured mesoscopic system like a living cell, a metal alloy, or a self-organized chemical system in the Belousov-Zhabotinsky reaction, and (2) our information about this system, such as an image from a light microscope or a camera. From an experiment, we always obtain a partial reflection of the system's structure, but never complete information about the system itself.

In this presentation, we focus on the implications of extracting information about a metal alloy from a light microscope. In light microscopy, an image refers to an interference object we observe in a plane called the focal plane. The relationship between the observed structure and the image is defined, on the one hand, by the formation of the image itself–i.e., by interference phenomena that often make observation impossible–and, on the other hand, by the non-idealities of the optics, which typically project the image at different wavelengths into different planes and in different ways, and both of these occur differently in different parts of the image. It follows that the very definition of a single focal plane for all wavelengths is practically impossible. Digitizing a color image is a problem in itself, introducing additional distortion.

In our lecture, we will demonstrate how to define the focal plane using PIED and how this definition differs from that based on standard Shannon entropy. We will also show how PIED varies within a single focal plane at different wavelengths. Finally, we will propose a method for obtaining an idealized light image from any imaging device. This method is general and always provides improved information about the observed system at the physical-chemical level. It has been implemented in the Spectral Spaces wide-field microscope allowing simplest possible sample manipulation and thus providing space for any scientific and industrial use.

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