Computational Imaging and Inverse Problems: Making the Invisible Visible

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Computational imaging is a rapidly evolving interdisciplinary field awarded of many Nobel prizes. In computational optical imaging, digital processing is employed in conjunction with an optical system to form images. That is, images are computationally formed from some indirect measurements by solving an inverse problem. Driven by advances in signal processing techniques and faster computing platforms, this approach continuously yields the development of next-generation imaging systems in consumer electronics, defense industry, space physics, bioimaging and medicine. These imaging systems enable new forms of visual information, new imaging functionalities, reduced hardware complexity, and cost, as well as higher resolution, that would be difficult, if not impossible, to achieve using traditional imaging.

In this talk, first the fundamentals of computational optical imaging will be described and a unified treatment of the mathematical principles, inverse problems, and computational methods underlying the development of modern optical imaging technologies will be provided. Afterwards, an overview of ongoing projects at METU Computational Imaging Lab will be presented with a focus on spectral imaging. In particular, a class of novel spectral imaging techniques will be described in detail. All of these involve distributing the imaging task between a novel optical system and a reconstruction algorithm. The optical systems take multiplexed measurements using diffractive lenses and coded apertures, and then these measurements are used with a reconstruction algorithm to digitally form the spectral images. Compressive sensing theory, convex optimization, sparsity- and deep learning-based image reconstruction approaches are exploited for this purpose. The developed spectral imaging techniques not only enable high spatial, spectral, and temporal resolutions that are beyond the reach of conventional techniques, but also allow reduced hardware complexity and cost.

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