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Guest editorial

Casting light on the objects of perception

Three central tasks of object perception are to determine individual object properties, an object's relationship to the viewer, and objects' relative relationships to each other in a scene. Individual objects are characterised by their geometrical and material properties, such as reflectance, whereas the information about object relationships is geometrical. The computational challenge is to understand how to estimate these properties given the enormous variability in image intensities for various occurrences of an object, or spatial arrangement of objects. Together with viewpoint, illumination is a pervasive source of image variation. Illumination is a description of the pattern of light energy falling on a scene. Illumination varies in intensity and direction, it can come from self-luminous sources as well as from the reflections off other surfaces, and the combination results in rich patterns of incident light. When illumination is combined with surface reflective properties, images of objects show the effects of illumination, including patterns of shading, specular highlights, and shadows.

This journal is devoting two issues to studies of the effects of illumination. This first issue focuses on cast shadows, and a second issue covers additional topics including light direction, shading, and specular reflectance.

Part of the fascination with illumination is that its effects can both obscure and illuminate those object properties the visual system cares about, such as surface reflectance, shape, and depth.

Illumination produces important features as well as noise to be discounted depending on the task. Thus, while specular highlights can provide information about material and curvature, they also confound the matching of stereoscopic surface points. Cast shadows at times provide remarkably strong information about depth, yet at other times need to be treated as noise. As entities themselves, shadows typically play only a secondary role on the stage of perceptual awareness (see the "Shadowy surprise" by Leonards and Trościanko). Jacobsen and Werner suggest that the sparse and judicious use of cast shadows in pictorial art may be the result of observers' insensitivity to much of the information shadows provide as well as the confusability of cast shadows with albedo changes in static images. They show that motion can reduce this ambiguity.

Detecting cast shadows in natural images continues to be a challenge in computer vision because local cues for shadows are ambiguous. Cast shadows typically have soft penumbra, but slowly changing spatial gradients also arise from changing surface orientation. Shadows can also be sharp, but so can transparent surface boundaries. Soranzo and Agostini discuss how the physical plausibility of intensity relations involving sharp illumination boundaries affects surface lightness, a perceptual correlate of reflectance.

Bonfiglioli, Pavani, and Castiello address the issue of task dependence and show that while inconsistent shadows tend to have little or no effect on object recognition, they can affect the kinematics of a reaching movement to grasp the casting object. An inappropriate shadow increases the proportion of time in the deceleration phase, consistent with the shadow acting as a distractor. They suggest that this difference may be a consequence of differing task demands for object recognition vs actions in the context of a scene layout.

To be useful for object depth perception, cast shadows must be identified, at some level, and linked with the casting object. Mamassian argues that establishing this linkage, which he calls the shadow correspondence problem, uses information at a coarse rather than fine spatial scale. A pair of objects can also be perceptually linked, raising the question of which factors lead to an object – shadow vs object – object grouping. In principle, the kind of grouping should have a significant effect on how the information is used. Using image compositing, Ni and Braunstein measured the apparent depth of a cylindrical object as a function of the darkness, thickness, and speed of a second coaxial cylinder, indicating ways in which a second object differs from a shadow. Using visual search, Rensink and Cavanagh describe results consistent with the idea that shadows are identified at an early level, but then discounted, making the shadow shape information difficult to access. Elder and colleagues use visual search and an elegant stimulus manipulation to show that rapid visual search is supported by cast and attached shadows, shadow direction, and shadow displacement. They point out that it is still an open question whether rapid discrimination is based on representations of the 3-D object shape or on shadow features.

The paper by Casati provides an overview and broad analysis of cast shadow information. Casati raises a number of outstanding questions that will likely be around to nag and intrigue us and future generations for years to come.

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