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Effects of optical material properties on detection of deformation of non-rigid rotating objects

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The pattern of image motion (optical flow) produced by dynamic changes in position, orientation and/or geometry of a 3D object can vary greatly depending on the objects' optical material. This is because different image components, such as surface textures, occluding contours, shading, highlights (for glossy materials), and internal reflections (for transparent materials), have different dependencies on the surface orientation, viewing direction, illumination, etc. This material dependency of image motion makes correct perception of dynamic realistic 3D objects a challenging task for the human visual system. We therefore tested the human ability to perceive non-rigid deformations across ten materials. Materials varied exclusively on optical properties (e.g., textured matte, glossy, mirror-like, and transparent), without changing mechanical properties. The target object was an infinite knot stimulus rotating around a vertical axis at 3 degrees per frame for 120 frames under one of three light conditions. The object was deformed by an inward pulling force in six levels of intensity (including zero force, rigid, condition). The movie of each object was rendered in one of three illumination conditions using Maxwell Renderer. Observers performed a 2-IFC task to choose which of the two stimuli deformed more, and a yes-no judgment as to whether the presented stimulus deformed or not. The results show that there was no effect of illumination on deformation detection while the different optical materials had a moderate effect on deformation detection. We found the largest performance difference between the optically more complex transparent stimuli and the simpler textured matte stimuli. We did find individual differences, where the performance for some observers was clearly more stable across material conditions. These results suggest that the visual system can robustly interpret the deformation of a moving 3D object despite large variations in the optical flow caused by changing optical conditions.