Propulsion systems of commercial and naval ships are typically large and expensive. They must be kept well-aligned and free of corrosion to efficiently and reliably transfer torque to a ship's propeller. Early identification of misalignment or surface corrosion is therefore crucial, making an easily deployable, reliable, lightweight system that visually indicates potential alignment and structural integrity issues desirable. This thesis demonstrates the design of a system for visual deformation and orientation indication based on naturally occurring micro-scale surface geometries that show a strong variation in their optical appearance as a function of illumination and observation directions. Specifically, the fabrication of a micro-structured surface covered with appropriately modified mimics of the spherical cavities on *Papilio blumei* butterfly wings is the first step in developing a low-cost, easy-to-install detection and indication system. For a specific illumination and observation geometry, the cavities' material and structural characteristics define the surface's reflection characteristics and the resulting visual signature for a far-field observer. Here we present an evolution and screening of the cavity design space, including cavity wall height and the combination of conformal and flat Bragg reflectors in order to identify suitable cavity designs. A MATLAB-based simulation environment was created to estimate the surfaces' intensity profile in monochromatic light and color chromaticity under any illumination source and incidence angle as a function of observation angle. The theoretical results are validated through characterization of a succession of physical prototypes – a macro-scale cavity before and after addition of a planar Bragg reflector cover as well as a conformally-clad microcavity array. The resulting data provides a basis for identifying the most suitable cavity designs for determination of misalignments, bends, and localized surface pitting in marine propulsion system components. The future development of specific *in situ* prototypes for the demonstration of the described visual sensing paradigm is facilitated through the results reported in this thesis.