Analysis and Differential Geometry Seminar

Space Object Shapes from Unresolved Imaging in Space Situational Awareness

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Abstract: Space Situational Awareness is concerned with the knowledge of objects in the near-earth realm. The vast majority of those objects are human-made; only about three percent of the currently tracked objects are active satellites, the others are objects without a function (anymore), dead satellites, mission-related objects, upper stages, and fragments. For objects in high altitude orbits, only non-resolved measurements are available, e.g. in the electro-optical realm, which means that shape and attitude information is not readily available. Shape information allows to characterize and identify the objects and their potential origin; furthermore, the shape influences the orbit of the objects via orbital perturbations. As a result shape information is also of interest for accurate prediction for collisions and reentry. In contrast to natural objects, human-made objects expose a variety of surface materials and sharp edges. In general, human-made shapes are not optimal in the sense of reducing surface area relative to the mass/volume of the object, hence leading to larger area-to-mass ratios than natural objects.

Light curve measurements, i.e. brightness measurements over time are sufficiently easy measurements to obtain, however, especially for less reflective resp. small objects, significant noise is inherent to those measurements. In this talk, the general problem of Space Situational Awareness is discussed. Specific attention is given to engineering solutions to the problem of shape retrieval from light curve measurements. An inversion scheme is shown determining first the Extended Gaussian Image and then finding iterative approximations for the solution of Minkowski problem. Following a multi-hypothesis approach, likely shapes hypotheses are ranked fusing multiple measurement instances. The effect of the measurement noise and measurement geometry are discussed and results are shown for simplified shapes.

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