Image Based Analysis Coherency Directly From Movies

Erik Bollt (Clarkson University) Abd Al Rahman Al Momani (Clarkson University)

There has been significant emphasis in recent dynamical systems literature to define, and find “coherent structures.” It could be said that these methods generally fall into categories: those that follow interiors of sets by transfer operators, or those that define a property of boundaries of such sets and follow boundary curves. Perhaps most would agree that coherency should be defined in some manner to describe ensembles of particles that “hold together for some time,” or measurements thereof. In essentially all of the studies that have appeared in recent literature, one starts with a dynamical system. What we mean is that an underlying flow is assumed in the sense that generally a differential equation is required to proceed, explicitly as a vector field or flow map, or implicitly through observations of an experiment. However, it can be said that people “recognize” coherent sets when they see them; consider that the Great Red Spot of Jupiter is clear to any and all that have seen it as perhaps the most famous coherent set in the solar system. With this motivation we will develop an observer based perspective of coherence. If we do not have a model, as the dynamical system is known only by remote experimental observation. Here we will develop vision based analysis to infer coherency directly from observed measurements. We write an affinity matrix of observations that rewards like vector-valued measurements that are nearby in space, and nearby in time. From there, analogous to directed random walks through this affinity representation, we find coherency as ``bottleneckyness” as the weighted directed graph generalization of spectral graph theory to generalize the Cheeger constant, and from this we can infer sets that directed diffusion nonetheless partitions into coherency. Thus directly from image sequences we infer a concept of coherent sets, without developing a model or inferring a vector field as an intermediate step. There is an interesting interpretation of the affinity matrix we develop as a naïve Bayesian update estimator of a transfer operator, that we will discuss briefly.