Prediction of Flow and Direction in Complex Systems by use of Inverse Relational Maps with Remarks on Applications to Image-Guided Processing Applications

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Abstract

Inverse methods are widely used in the study of physical processes where direct observation is not possible or practical, such as certain chemical and heat transfer reactions, and also in surface and subsurface sensing and imaging (acoustic, optical, electromagnetic). We suggest that they can be applied along with elements drawn from nonlinear dynamics (soliton theory), combinatorics (Ramsey theory) and topology (Morse theory) to form a potentially useful branch of mathematics applicable to a number of problems in science and engineering. The fundamental distinction from existing methods is in focusing attention not upon particle-oriented events such as scattering of photons but upon the identification of relational attributes between processes including physically distinguishable objects that govern the behavior of waves, particles and phenomena that can be modeled as wave-like or scatter-like behavior. The new approach, introduced as a Inverse Relational Map, applies network dynamics and graph representation to localize critical and dominant processes that are the influential determinants within the otherwise unknown functions that modulate basic forward models, and suggests a function analogous to a solitary wave or soliton as a measure of stability within the form of the network's relational topology. Problems that may benefit from this approach include real-time image processing for localization and tracking of hard-to-detect, amorphous, shape-changing objects as well as other distinctively non-imaging applications in both physical and cognitive domains (e.g., improvement of particle beam intensity and focus, prediction of nanoscalar defects and aberrations, behavioral tracking and forecasting. cognitive interest and attention). The potential wide diversity of such applications may be served by applying a relational framework that treats complex interdependent processes as a network characterizeable over time into several distinctive variants using inverse problem-solving methods, resulting in mapping functions that can be applied to improve both inverse and forward solver algorithms used in sensing, imaging and recognition tasks.