Minimum action principles and shape dynamics

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The functions of all life forms depend on organization in space and time. Spatial organization involves the interactions of shapes with their surroundings, while organization in time concerns changes in shape. Geometric methods therefore play an essential role in the analyses and simulations of biological systems. Geometry and topology are now used regularly for representing, searching, simulating, analyzing, and comparing biological systems. In this talk, I will focus on the latter. I will present a new method for computing a distance between two shapes embedded in three dimensional space. Instead of comparing directly the geometric properties of the two shapes, we measure the cost of deforming one of the two shapes into the other. The deformation is computed as the geodesic between the two shapes in the space of shapes. The geodesic is found as a minimizer of the Onsager Machlup action, based on an elastic energy for shapes. I will illustrate applications of this method to geometric morphometrics using data sets representing bones and teeth of primates. Experiments on these data sets show that the method performs remarkably well both in shape recognition and in identifying evolutionary patterns, with success rates similar to, and in some cases better than, those obtained by expert observers.