Shape processing and analysis

Deformable and non-rigid objects, both natural and artificial, play an important role in many applications ranging from medical image analysis to robotics and gaming. Such applications require the ability to acquire, reconstruct, analyze, and synthesize non-rigid three-dimensional shapes. These procedures pose challenging problems both theoretically and practically due to the vast number of degrees of freedom involved in non-rigid deformations. While modelling and analysis of non-rigid shapes has greatly advanced in the past decade, existing solutions are largely based on parametric models restricting the objects of interest to a narrow class of similar shapes. Broadly speaking, reconstruction, analysis, and synthesis of arbitrary deformable shapes remain unsolved problems, a practical solution of which would be a major milestone in computer vision and related fields. This proposal aims at answering these fundamental questions by adopting tools from modern metric geometry, a field of theoretical mathematics which in the past few decades has undergone a series of revolutions that remained largely unnoticed and unused in applied sciences. We believe that metric geometry tools could systematically answer these questions, and, coupled with modern numerical optimization techniques and novel hardware architectures, pave the computational way to the next generation in deformable shape analysis. We plan to develop such numerical tools while demonstrating their efficiency on several challenging real-life applications such as surgery prediction and planning, biometry, and computer-aided diagnosis.