Workshop 2
Keynote Address 1

On Spectral Shape Analysis

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What is the optimal space for representing functions on surfaces?
What is the relation to the celebrated Fourier transform?
Why are these issues relevant for shape matching under various transformations?
In this talk we will review recent advances in the field of shape matching using spectral representation. We will try to answer further questions like, why do researchers favour the eigen functions of the Laplace Beltrami operator? Are there better alternatives, and how does it all relate to PCA/SVD/MDS/GMDS/SGMDS/ETC.
A popular approach for finding the correspondence between two nonrigid shapes is to embed their two-dimensional surfaces into some common Euclidean space, defining the comparison task as a problem of rigid matching in that space.

We propose to extend this line of thought and introduce a novel spectral embedding, using gradient fields, for point to point surface matching.

With this new embedding, a fully automatic system for finding the correspondence between shapes is introduced. The method is demonstrated to accurately recover the natural maps between nearly isometric surfaces and shown to achieve state-of-the-art results on known shape matching benchmarks.
Recent years have witnessed a growing number of different descriptors for various shape analysis tasks. These methods, inspired by their computer-vision counterparts, strive to capture the “interesting” geometric data about the shape allowing quantitative comparisons. The complementary part of this notion of “interesting” is that these descriptors should be insensitive, if not invariant, to noise and other distracting phenomena that may cause false matches. Most of the research effort was dedicated to model the undesired effects, and design a robust descriptor to overcome them. We show that sometimes invariance can be hard to model, while it is much easier to learn it from examples. This is especially true when there is a fine-grain difference to be detected. We show two specific cases for which we learn a descriptor to deal with a specific task: correspondence and retrieval. In both cases the learned descriptor outperforms its axiomatically modeled counterparts.
Matching deformable 3D shapes is a pervasive problem in Computer Vision and arises in several different fields ranging from robotics to medical imaging. In this talk I will present an effective attempt to bridge the gap between general shape matching methods and application-specific algorithms, by taking a learning-by-examples approach. In this scenario, we assume to be given a small set of training shapes which are equivalent up to some class of (generally non-isometric) deformations; the goal is then to learn from these examples how to match two shapes falling into the equivalence class represented by the training set. In this novel view, the shape matching problem is treated as a classification problem, where input samples are points lying on the shape manifold and the output class is an element of a canonical label set. We tackle this unconventional classification problem by means of an ad-hoc random forest classifier built upon a general parametrizable shape descriptor. This process yields an ordered set of matching candidates for each point on previously unseen shapes, hence delivering a dense point-to-point correspondence with competitive results on challenging correspondence benchmarks.
Shape-from-Operator: Recovering Shapes from Intrinsic Operators

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Shape-from-X is an important class of problems in the fields of geometry processing, computer graphics, and vision, attempting to recover the structure of a shape from some observations. We formulate the problem of shape-from-operator (SfO), recovering an embedding of a mesh from intrinsic operators defined through the discrete metric (edge lengths). Particularly interesting instances of our SfO problem include: shape-from-Laplacian, allowing to transfer style between shapes; shape-from-difference operator, used to synthesize shape analogies; and shape-from-eigenvectors, allowing to generate “intrinsic averages” of shape collections. Numerically, we approach the SfO problem by splitting it into two optimization sub-problems: metric-from-operator (reconstruction of the discrete metric from the intrinsic operator) and embedding-from-metric (finding a shape embedding that would realize a given metric, a setting of the multidimensional scaling problem).
I will present our recent work in which we introduced tools traditionally used for sparse coding of signals and images into the analysis of deformable shapes. I will show how these methods can be used to achieve very high performance in intrinsic shape correspondence problems, and discuss their relations to other interesting recent works in the field.