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Editorial

Similarity-based pattern recognition

The challenge of automatic pattern recognition is to develop computational methods which learn to distinguish among a number of classes represented by examples. Traditional pattern recognition techniques are centered around the notion of "feature". According to this view, the objects to be classified are represented in terms of properties that are intrinsic to the object itself. Hence, a typical pattern recognition system makes its decisions by simply looking at one or more feature vectors fed as input. The strength of this approach is that it can leverage a wide range of mathematical tools ranging from statistics, to geometry, to optimization.

However, in many real-world applications a feasible feature-based description of objects might be difficult to obtain or inefficient for learning purposes. This is typically the case when experts cannot define features in a straightforward way, when data are high dimensional, when features consist of both continuous and categorical variables, or when the objects to be classified are represented in terms of graphs or structural representations. In these cases, it is often possible to obtain a measure of the (dis)similarity of the objects to be classified, and in some applications, e.g., shape recognition, the use of dissimilarities (rather than features) makes the problem more viable. It is therefore tempting to design a pattern recognizer which, unlike traditional systems, accepts as input a matrix containing the similarities between objects (and no other information) and produces class labels as output. This allows one to develop algorithms that are independent from the actual data representation, allowing the use of non-metric similarities. Interestingly, such an approach is supported by the fact that (dis)similarities can be considered as a connection between perception and higher-level knowledge, being a crucial factor in the process of human recognition and categorization.

Indeed, recently, there has been a renewed interest in similarity-based techniques, both in developing and studying new effective distances between non-vectorial entities, like graphs, sequences, structures, and in proposing alternative distance-based paradigms. These methods typically keep the algorithm generic and independent from the actual data representation, allowing the use of non-metric similarities (thereby violating the triangular inequality). Further, they make the approaches applicable to problems that do not have a natural embedding to a uniform feature space, such as the clustering of structural or graph-based representations or the analysis of sequences. Finally, these representations are well suited to both supervised and unsupervised classification. The literature of pairwise algorithms includes, among others, kernel methods, spectral clustering techniques/graph partitioning, quadratic optimization, self-organizing maps, etc. These techniques are successfully applied to very diverse problems like object classification, image retrieval by content, color quantization, image segmentation, perceptual grouping, and bioinformatics (gene alignment, gene classification or phylogenetic analysis).

The goal of this special issue was to solicit and publish high-quality papers that bring a clear picture of the state of the art in this area. We received 71 submissions, confirming that this topic arouses lively interest in the field of Pattern Recognition and Computer Vision. Each paper was reviewed by at least two reviewers, with most being reviewed by three. This meant that we needed the assistance of some 200 reviewers which we thank for their invaluable assistance. Further, each paper was checked out by the editors. Based on the reviews, and giving authors the chance to revise their papers in the light of reviewers, comments, we selected the 10 papers that appear in the current special section, together with five papers that will appear in subsequent regular issues. The papers span a diverse set of methods and applications.

The first paper presented in this special issue is "On the Information and Representation of Non-Euclidean Pairwise Data", by Laub et al. The authors analyze the context of non-Euclidean pairwise data, i.e. relational pairwise data for which embedding in Euclidean space is not easily computable. Various approaches presented in the literature are inserted in a common framework and extended, showing that metrics violations could carry valuable problem specific information.

In their paper "Experimental study on prototype optimization algorithms for prototype-based classification", M. Lozano and colleagues address the problem of the dissimilarity-based classification. The authors analyze and

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experimentally compare different methodologies to choose the prototypes—namely the reference objects from which compute dissimilarity—aimed at reducing the computational burden still maintaining good classification performances.

Gosselin and Cord, in their paper "Feature based approach to semi-supervised similarity learning", address the problem of learning the semantic similarities between digital documents by grouping the underlying concepts in a semi-supervised manner. Concretely, starting from an incomplete set of partial labels, the method optimizes the feature vectors by moving elements that belong to the same concept closer to one-another.

In their paper "Edit distance based kernel functions for structural pattern classification", Neuhaus and Bunke use edit distance to define a kernel on strings and graphs and use it to train a support vector machine. The experimental evaluation confirms the effectiveness of the approach for supervised classification of data represented in terms of strings or graphs.

Verbeek and Vlassis, in their paper "Gaussian fields for semi-supervised regression and correspondence learning", propose the use of Gaussian fields for dimension reduction and semi-supervised regression and classification. Similarities are used to learn model and the authors provide an active-learning strategy that allows to minimize the model entropy.

In the paper "Fast multiscale clustering and manifold identification", Kushnir et al. propose a novel multiscale clustering based on algebraic multigrid techniques. The presented approach simultaneously detects clusters identifiable by their multiscale nature, separates clusters with different densities and solves intersection between clusters.

Theoharatos et al., in their paper "Multivariate image similarity in the compressed domain using statistical graph matching", propose to assess the similarity of JPEG images by applying the non-parametric multivariate Wald–Wolfowitz test, to the Discrete Cosine Transform (DCT) parameters in the compressed domain. The experimental evaluation confirms the effectiveness of the approach for image classification.

In their paper "Relaxational metric adaptation and its application to semi-supervised clustering and content-based-image retrieval", H. Chang and colleagues propose a non-parametric method for learning global metrics for content-based image retrieval. The approach is based on pairwise side information and is local in the sense that it allows locally adaptive metrics and global since long-range effects are possible on the metric adaptation process.

In their paper "Similarity-based analysis for large networks of ultra-low resolution sensors", Wren et al. present an application of similarity-based techniques to the analysis of information streams gathered from a network of motion detectors. In particular, the signal similarities are used to automatically calibrate the network geometry, increasing the robustness to structural changes. Moreover, an efficient methodology for temporal pattern discovery is proposed, able to effectively describe the activity occurring in the scene.

Finally, in the last paper "Specific object retrieval based on salient regions", Shao and Brady present an image retrieval technique based on salient regions that are invariant to geometric and photometric variations, and use correlation between these features as a measure of similarity between images for content-based image retrieval.

The large number and the high quality of the submitted papers demonstrate that the topics covered by the special issue are of sure interest in the Pattern Recognition community. We hope that this collection of papers will provide a timely and interesting sample of research in the field of similarity-based pattern recognition and that will prove useful to practitioners in the field.

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