PhD Position 2 - Sparse-based Image representation

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**Location:** Synchromedia Lab, ETS, Montreal, Quebec, Canada  
**Starting Date:** September 1st, 2014  
**Keywords:** Patch-based representation, Sparse Representation.

**Context**
Ancient manuscripts constitute a primary carrier of cultural heritage globally, and they are currently being intensively digitized all over the world to ensure their preservation, and, ultimately, the wide accessibility of their content. Critical to this research process are the legibility of the documents in image form, access to live texts, and similarity between document image within huge collections (big data). Several state-of-the-art methods and approaches have been proposed and developed to address the challenges associated with processing these manuscripts. The key issue to be tackled to face these challenges is the learning of prior representation of the document images that can be used in many computer vision and image processing algorithms.

Document collections contain huge amounts of data (big data problem) in which the relevant information is often difficult to find out. Sparse representations, in which few coefficient can reveal the information we are looking for, make the processing faster and simpler. Sparse representation is based on decomposing the input image’s patches into a few other patches in the form of a dictionary. The key question is to search for the optimal or ideal sparse transform that may adapt sparse representation to image properties, such as spatial relations, and then to derive efficient processing operators.

Sparse representations have therefore increasingly become recognized as providing extremely high performance in many image processing applications (pattern recognition, compression, denoising, image segmentation and classification, super-resolution, feature selection, etc.). Sparse representation principle also is considered as the base of the foundations of wavelet denoising and methods in pattern classification, such as in the Support Vector Machine and the Relevance Vector Machine, where sparsity can be directly related to learnability of an estimator.

**Objective**
This PhD position/proposal focuses on the patch-based and sparse representation of document images in order to pursue development of new models and methods toward data-driven document image enhancement, restoration and similarity. In particular, non-local patch representations and also various Component Analysis approaches could be considered. This is along our in-house Non-Local Patch Means (NLPM) methodology, and will expand the performance of patch-based non-local approaches using patch spaces as the foundation of the modeling. Although denoising and restoration with respect to pixelwise degradations have been widely studied using the sparse and patch representations, this research/proposal pushes the limit toward correcting those degradations that are more common on ancient manuscripts and document images, such as bleed-through interferences. This would require fundamental modifications and generalizations to state of the art mathematical formulation of sparse representations and their associated optimization problems.
Research Question
What would be a sparse representation of document images with enough capacity to perform: i) image processing (bleedthrough correction) or ii) image retrieval tasks? How could this representation be enhanced using non-local patch and component analysis concepts?

Domains
Image Processing; Signal Processing; Machine Learning; Sparse Representation; Optimization; Mathematics; Scientific Programming;

Requirements
The candidate must hold a M.Sc. in Computer Science (or equivalent). He/she must very good skills in image processing, statistics, pattern recognition, algebra, optimization, and matlab (and C/C++) programming. The candidate should have good writing skills in English. He/she must be highly motivated, independent, with a real ability to organize and follow a schedule.

References
[8] Farrahi Moghaddam, Reza; Cheriet, Mohamed; Beyond pixels and regions: A non-local patch means (NLPM) method for content-level restoration, enhancement, and reconstruction of degraded document images, Pattern Recognition, 44(2), 363-374, 2011.