PhD Thesis Proposal

Classification using sparse representation and applications to skin lesion diagnosis

I. Description

In only a few decades, sparse representation modeling has undergone a tremendous expansion with successful applications in many fields including signal and image processing, computer science, machine learning, statistics. Mathematically, it can be considered as the problem of finding the sparsest solution (the one with the fewest non-zeros entries) to an underdetermined linear system of equations [1]. Based on the observation for natural images (or images rich in textures) that small scale structures tend to repeat themselves in an image or in a group of similar images, a signal source can be sparsely represented over some well-chosen redundant basis (a dictionary). In other words, it can be approximately representable by a linear combination of a few elements (also called atoms or basis vectors) of a redundant/over-complete dictionary.

Such models have been proven successful in many tasks including denoising [2]-[5], compression [6],[7], super-resolution [8],[9], classification and pattern recognition [10]-[16]. In the context of classification, the objective is to find the class to which a test signal belongs, given training data from multiple classes. Sparse representation has become a powerful technique in classification and applications, including texture classification [16], face recognition [12], object detection [10], and segmentation of medical images [17], [18]. In conventional Sparse Representation Classification (SRC) schemes, learned dictionaries and sparse representation are involved to classify image pixels (the image is divided into patches surrounding each image pixel). The performance of a SRC relies on a good dictionary, and on the sparse representation optimization model. Typically, a dictionary is learned for each signal class using training data, and classification of a new signal is achieved by associating it with the class whose dictionary allows the best approximation of the signal via an optimization problem that minimize the reconstruction error under some constraints including the sparsity one. It is important to note that the dictionary may not be a trained one [12]. In [12], the dictionary used for the face recognition is composed of many face images. Generally, the classification methods consider sparse modeling of natural high-dimensional signals and assume that the data belonging to the same class lie in the same subspace of a much lower dimension. Thus, the data can be modeled as a union of low dimensional linear subspaces. Then a union of a small subset of these linear subspaces is found to be a model of each class [19]. More advanced methods take into account the multi-subspace structure of the data of a high dimensional space. That is the case when data in multiple classes lie in multiple low-dimensional subspaces. Then, the classification problem can be formulated via a structured sparsity-based model, or group sparsity one [13, 20]. Other approach proposed to increase the performance of classification by using multiple disjoint sparse representation for the dictionary of each class instead of a single signal representation [21].

II. Objective

In this study, we focus on a highly accurate classification methods by sparse representation in order to improve existing methods. More specifically, we aim to improve the result of classification for
computer-assisted melanoma diagnosing, performed on skin lesion using epiluminescence microscopy images [22]. Malignant melanoma has the fastest growing incidence of all cancers. On the other hand the mortality rate significantly drops if melanoma is detected and treated early. It is important to propose an efficient system in clinical use for early melanoma detection.

It is a challenging task to automatically classify images of skin lesions due to the fine-grained variability in the appearance of skin lesions. In computerized diagnosing methods, a set of extracted lesion features [22]-[25], is used in the classification of skin lesions into malignant or benign lesions. Until now, support vector machines (SVM) is widely used as classification method for skin melanoma recognition [22], [26]. Recently, deep neural networks (Deep Learning) [35] have shown promising results on a wide variety of pattern recognition tasks. Note that these neural networks, trained on a given dataset, may learn features that can be successfully used for other classification tasks. Thus, one can use a given deep neural model, trained during weeks on huge databases, and use it as a sophisticated feature extractor, feeding a classifier trained on (relatively small) set of labeled images representative of the task.

It is hence interesting to propose novel sparse representation-based and Deep Learning methods for skin lesion classification. The proposed methods will be compared with other leading state-of-the-art methods. Moreover, we will propose a scheme for mobile app (iOS/Android) integrated with proposed methods. This system can help people to detect and prevent skin lesions by themselves. With the result obtained from this system, people can ask their dermatologist for a clinical diagnosis and an early melanoma detection. Therefore, this system can potentially provide low-cost vital diagnostic health care.

The research project will be supervised by Prof. Emmanuel Viennet (L2TI) and co-supervised with Asc. Professor Marie Luong (L2TI), in collaboration with Asc. Prof. Sébastien Guérit (LIPN), Prof. LE Tien Thuong (Institut Polytechnique de HCM-Ville ou HCM University of Technology (HCMUT), National University) and Prof. Nikolay Metodiev Sirakov (Department of Mathematics and Computer Science, the Texas A&M University-Commerce). Asc. Prof. Sébastien Guérit (LIPN) will collaborate on deep learning, while Prof. LE Tien Thuong (HCMUT) will give support on theories of classification and sparse representation. Prof. Nikolay Metodiev Sirakov will provide data of skin lesions and extracted features for classification of skin lesions in collaboration with Dr. Richard Selvaggi, M.D. (Live Oak Professional Center, Texas, USA). All these collaborations are already established and led to joint publications in the domain of sparse representation (Prof. LE Tien Thuong of HCMUT) and in segmentation and melanoma diagnosing system (Prof. Nikolay Metodiev Sirakov).

III. Plan of works
1. State-of-the-art study of sparse representation-based classification ([11]-[19]) and deep learning classification ([33]-[35]).
2. Implementation of leading state-of-the-art methods using some public databases for texture classification (using some datasets such as the well-known Brodatz texture dataset [27],[10]), face recognition (e.g. using Extended Yale Face Database [28], Labelled Faces in the Wild dataset, Japanese and Caucasian Facial Expressions of Emotion dataset), object detection using visual object recognition datasets for natural images such as PASCAL [29], Caltech 101 [30], Caltech 256 [31], COIL 20 [32], COIL 100 [32]), and comparative study.
3. Development of a novel sparse representation-based method and a novel deep learning-based method, both adapted for skin lesion classification.
4. Performance evaluation on skin images and other medical images and comparisons with other leading state-of-the-art SRC methods, SVM and Deep Learning approaches.
5. Elaboration of a smartphone compatible scheme for a mobile app (iOS/Android) integrated with the proposed methods:
   5.1- Firstly, we need to construct a database that is compatible with smartphone condition.
   5.2-Then, a smartphone compatible application will be proposed: embedded pre-processing / classification (with offline learned model).

At the end of the thesis, we would ask for an internship of engineer or a contract (CDD) via for example, a project BQR to code the application on iOS or Android.

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V. References


[27] http://multibandtexture.recherche.usherbrooke.ca/original_brodatz_more.html


