

Information theoretical approach for active learning : application to satellite images annotation.

Pierre Blanchart* (PhD Student), Mihai Datcu (Prof. Dr.)**
Ecole Nationale Supérieure des Télécommunications
Laboratoire de Traitement du Signal et des Images
46, rue Barrault, 75013 Paris
*** pierre.blanchart@enst.fr**
**** mihai.datcu@enst.fr**

Abstract :

Content-based image retrieval (CBIR), also known as query by image content (QBIC) and content-based visual information retrieval (CBVIR) is the application of computer vision to the image retrieval problem, that is, the problem of searching for digital images in large databases.

In CBIR systems, understanding the user's needs is a challenging task that requires integrating him in the process of retrieval.

Relevance feedback (RF) has proven to be an effective tool for taking the user's judgement into account. In this paper, we present a new RF framework based on information theory which allows to combine the advantages of a probabilistic formulation with those of using both the positive example (PE) and the negative example (NE) given by the user.

Among approaches that use information theory, we can mention the Knowledge Driven Information Mining (KIM) system developed by Gomez and Datcu [1].

In KIM, a hierarchy of information representation is defined in order to enable the communication between the image archive and the users : the image data is first processed for extracting the image primitive features. An unsupervised information clustering is then obtained defining a characteristic vocabulary of signal classes. User specific interests, that is, semantic classes, are linked to combinations of these vocabularies using simple Bayesian networks. Mutual information computations between image semantic classes and signal classes are performed a posteriori to assess the relevance of retrieved images.

In this work, we would like to introduce a novel approach that we refer to as active learning.

The idea is to model the whole hierarchy presented above as a communication channel

that is, a channel in which the output (semantic classes) depends probabilistically on the input (primitive features). More specifically, we apply information theory results to learn the transition probabilities in the Bayesian network linking semantic classes and signal classes.

The problem can indeed be seen as a lossy source compression problem : we want to summarize the primitive features extracted from the images into a set of semantic classes which captures only the relevant or meaningful information. The relevance is given by the user through a relevance feedback variable which is used as side-information.

We also try to figure out how to accelerate the learning process by controlling the order in which images are presented to the user in the relevance feedback process. Some works have already been done in this area : we can mention the work of Costache [2] which present a SVM-based CBIR system with a relevance feedback loop in which the images presented to the user are the most ambiguous one that is, those which are the closest from the SVM separation surface.

We present here a different approach based on mutual information which integrates naturally in the learning process mentioned above. We have thus a two-way system in which the relevance comes from the user but also from the machine through the order in which images are presented to the user during the retrieval process : we call this approach active learning.

The information theory finally enables us to find a trade-off between the accuracy and the complexity of the compressed representation (semantic classes) through the computation of theoretical rate-distortion functions.

The proposed approach is validated on satellite image databases. The diversity of structures in satellite images allows the definition of numerous semantic classes and thus is a typical example of the usefulness of an active learning approach in an information retrieval system.

References :

- [1] I. Gomez and M. Datcu. A Bayesian Multi-Class Image Content Retrieval. *IEEE International Geoscience and Remote Sensing Symposium, 2007. IGARSS 2007.*
- [2] M. Costache, M. Datcu and H. Maître. Categorization based relevance feedback search engine for earth observation images repositories. *IEEE International Geoscience and Remote Sensing Symposium, 2006.*