Abstract: Modern sensor systems have and are continuing to acquire data which serve as valuable information sources for scientists in multiple research and application disciplines. The intrinsic complexity of image data and their large volumes makes their archiving as “file systems” difficult and inefficient. We propose a unified treatment of the archivation of very diverse image products from the point of view of content-based picture query and retrieval systems.

INTRODUCTION

The intrinsic complexity of image data and their large volumes makes the archivation as “file systems” difficult and inefficient. Remote sensing was a privileged area, were queries can be specified by geographic area, time of acquisition or sensor type [7]. However, the latest developments in sensor technology, image interpretation, the enlargement of remote sensing application fields and the huge immensity of data acquired by the most recent generation of sensors make the “classical” archivation approaches unsatisfactory. Meanwhile, the developments in archivation facilities, computation power, and data communications changed the philosophy of both image users and owners [4].

NEW PERSPECTIVES

Image archives require both database systems and “vision capabilities”, but a gap exists between these techniques. Classical databases, until recently, did not deal with multidimensional structures like pictures, and the vision systems were not designed to provide query and retrieval functions. Most existing image-databases have been created using some extensions of relational data models. Generally, the “content” of the images is described in a separate file and has a relational database representing the logical structures. The physical images are stored separately having, as a consequence, “rigid” manipulation systems. A better approach to deal with the image archivation problems is an integrated image analysis and/or pattern recognition sub-system in the retrieval system. The method is efficient for small archives and limited applications. The present trends in the field [3, 5, 8, 9] are mainly the inference of similarity measures for images, the integration of information representation and retrieval methods, and the synergy with cognitive systems.

The field of remote sensing, due to the very high image complexity and due to the huge volume of produced data, is one of the challenges of archivation technology. Only a few aspects of the query by image content have been approached and solved [1, 6].

Previous activities in remote sensing applications demonstrated that the main use of satellite data sets is for interdisciplinary, multitemporal or multisensor use. A frame of projects [11,12,13] was initiated with the goal to give solutions for several specific problems: presentation of comprehensive information about the data type leading the user to the right products for his application, easy access to thematic multisensor or multitemporal data, presentation of the information in an application suitable way, easy access to vaguely specified data, direct access to the original images, unified treatment of very diverse image products, easy and if possible fully automatic image database updating, substitution of archivation space with computation power for new products, elaboration of content-based picture retrieval systems.

The areas of investigation are: physical and logical representation of image data, image compression, stochastic and structural robust image feature selection, thematic image representation and understanding, pictorial abstract image representation, storage and access structures, definition of generic clusters and the associated algorithms for query processing, retrieval system specifications, interfaces and display of results, system architectures.
QUERY & RETRIEVAL BY IMAGE CONTENT:
PROBLEM FORMULATION

The problem formulation of the image content query and retrieval processes can be done from several perspectives and a short definition could not be sufficiently explanatory. For the goal of the present work we define it as the process to find in an image archive the data which best suit to solve the user application. It is an information retrieval problem and it is always a model based approach [10, 14]. We use the models as points of view over our data. Every model explains different features. A simple example is presented in Figure 1.

The query by image content is an inverse problem approached in a Bayesian way [2]. The 1st level of inference, model fitting, is implemented to extract the characteristic image features (Figure 1); the query by image content is the 2nd level of the Bayesian inference: the model selection. The query specification is analyzed and from a library of models the most likely ones to explain the query are selected (Figure 2). The prior evidence over the model space actually represents in an objective way the user interest in a certain application.

PROPOSED IMAGE ARCHIVATION SYSTEM

The methods for query by image content we are implementing rely on:

1) A pyramidal representation of the image features as the basic strategy to discard, during the query, non-interesting images in a time efficient algorithm.

2) A hierarchical modelling approach used to link the semantic level of the query to image content (Figure 3). Three levels are defined:

   a) modelling of the objective information content of the images; this is a pure signal processing approach;

   b) conjecture modelling is the level which defines the adaptation to specific user applications, it transforms the evidence over the model space objectively;

   c) the user application modelling explains the semantics of the query in the context of different applications.

The utilization of these strategies results in a scale dependent and user application dependent adaptive clustering of the archived images.

SUMMARY

We are developing image archives for remote sensing data, having as driving technology the methods of multidimensional signal modelling from an information theoretical perspective. The newly developed techniques are to be integrated in existing remote sensing image archivation systems with the aim to fill the gap between the logical and physical data representation.

REFERENCES

Figure 1: Information retrieval is always a model based approach. We use the models as points of view over our data. Every model explains different features. We exemplify how the utilization of two models (M1 [10] and M2 [14]) can explain the physically significant structures at multiple scales: pixel, pixel neighbourhood, and scene scale. The same scene is analyzed at several resolutions. M1, at coarse scale understands the image as being composed from large areas: agriculture, mountains, forest and lake. At intermediate scale, M2 recognizes the orientation of the agriculture parcels, and at the finer scale M1, again, explains this time, the pixel classes. The pyramidal representation of the image features is an important issue: it is the base for the strategy to discard during the query the non-interesting images in a time efficient algorithm.

Figure 2: The query by image content is an inverse problem approached in a Bayesian way. The previous example (Fig.1) is the 1st level of inference: model fitting; the query by image content is the 2nd level of the Bayesian inference: model selection. The query specification is analyzed and from a library of models the most likely ones to explain the query are selected. With high probability, the reader will select from the small collection of images in the left column the one having the highest visual evidence: Lena. The prior evidence over the model space actually represents in an objective way the user interest in a certain application.

Figure 3: A hierarchical modelling approach is used to link the semantic level of the query to image content. Three levels are defined: a) objective modelling of the informational content of the images; this is a pure signal processing approach (Fig.1); b) conjecture modelling is the level which defines the adaptation to specific user applications, it makes the evidence over the model space objective (Fig. 2); c) the user application modelling explains the semantics of the query in the context of different applications: i.e. the same images could have very different meanings in an ecological or military application. The result of this strategies in the image space is a dynamic scale/application clustering.