IMMERSIVE VISUAL INFORMATION MINING FOR EXPLORING THE CONTENT OF EO ARCHIVES

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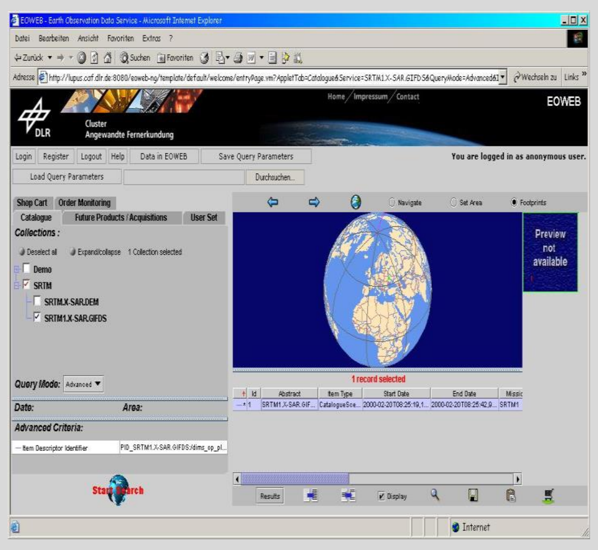
Challenge: Exploiting Huge Earth Observation (EO) Data Volumes

TerraSAR-X / TanDEM-X

Sentinel 1

Payload Data Ground Segment (PDGS)

Data Access via EOWeb

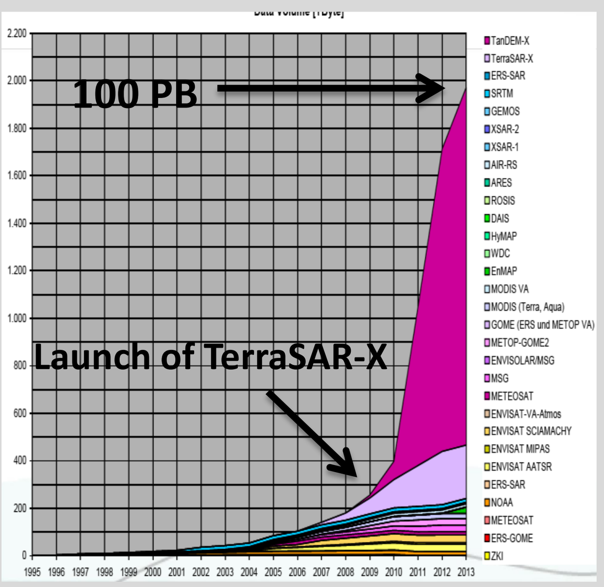


The Earth is facing unprecedented climatic, geomorphologic, environmental and anthropogenic changes which require global scale observations and monitoring.

The collected EO data volumes are increasing immensely with a rate of several Terabytes of data a day. With the current EO technologies these figures will be soon amplified, the horizons are beyond Zettabytes of data. The challenge is the exploration of these data and the timely delivery of focused information and knowledge in a simple and understandable format.

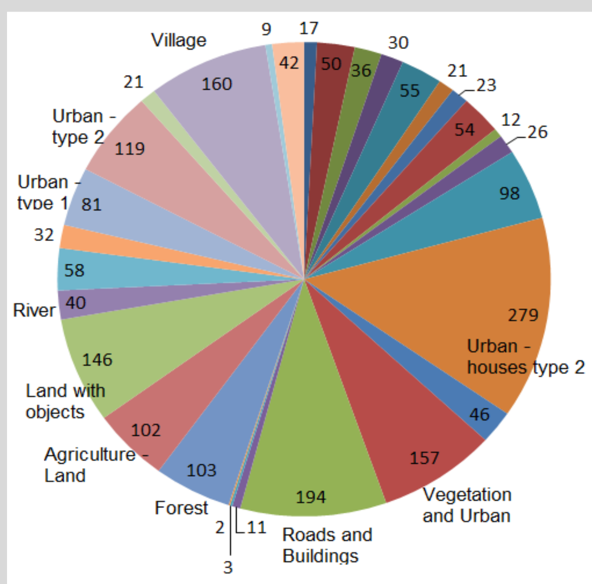
As users of EO data well know, image and data repositories are enormous, much too large to be scanned or analyzed thoroughly by humans. Practical approaches to use successfully such data and imagery must necessarily automate the retrieval of relevant images from a large repository.

DLR data archive: storage survey



Diversity of SAR image content

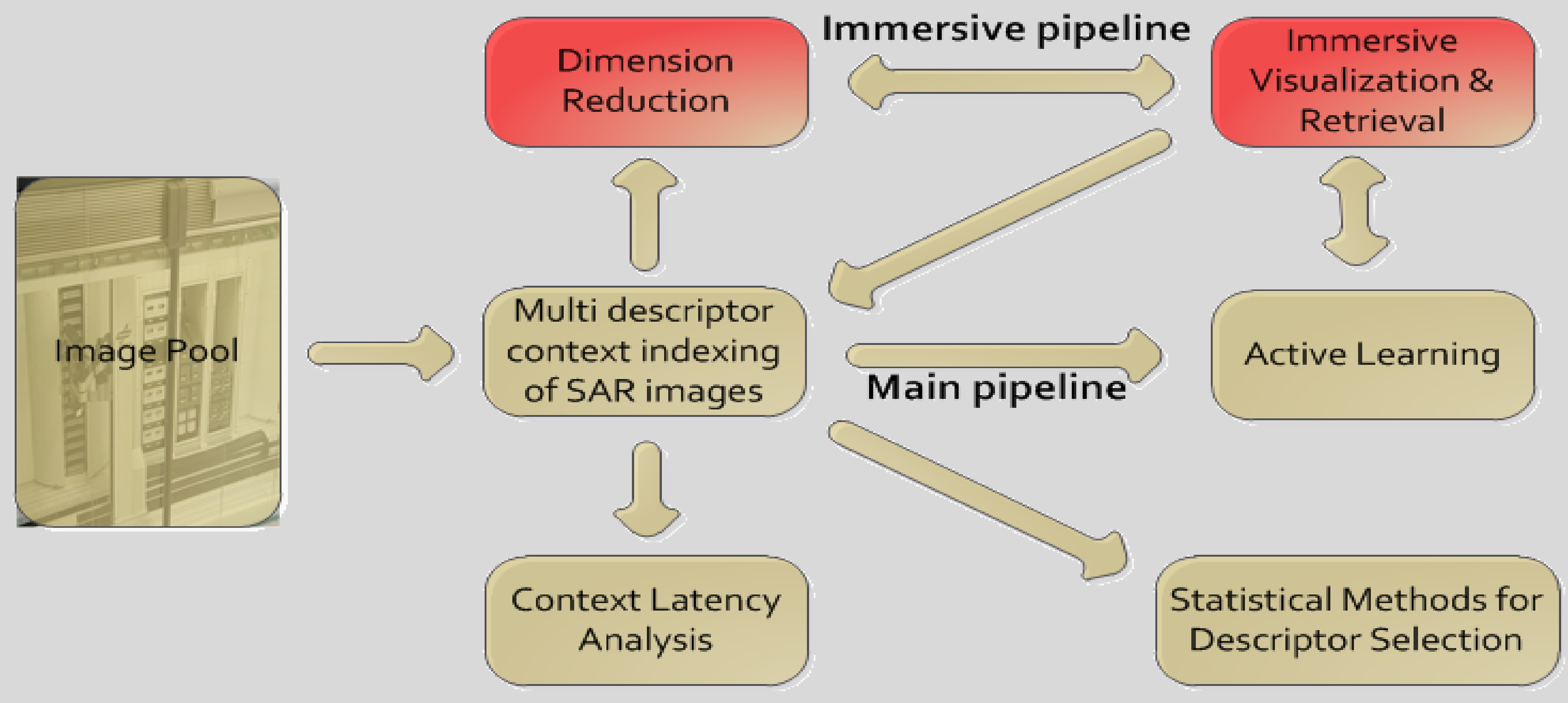
Semantic annotation for urban areas



The advent of very high resolution EO is rising a double challenge: the explosion of the data volumes and of the information content. The EO data content "meaning" comprises many facets. They carry quantitative information about physical, geometrical, or other types of attributes of the observed scene. The instrument (sensor) and image formation parameters lend understandability to the data. They also refer to geographical names as well as to geomorphologic, tectonic, and political categories. They have cartographic symbols, and last but not least, have ubiquitous names.

Concepts:

1. Immersive Visual Analytic System



Immersive visual information mining: the SAR data from the DLR EO Digital Library will be processed for **descriptor extraction**, the descriptor space will be analyzed **and projected adaptively in 3D space**, **visualized in the CAVE**, jointly with **multi-modal rendering of the images** and their content. The analyst, immersed in the CAVE, will be enabled to **interact with the data content** using learning algorithms and navigate, explore and analyze the information in the archive.

2. Feature Extraction and Assessment

In image retrieval and information mining, feature extraction and indexing are still challenging problems. The main objective of our research is to investigate the behavior of different feature descriptors in extracting the content of images. These descriptors represent the content of images based on their low-level features (e.g., shape, texture, color, etc). In this research a set of feature descriptors, representing image from various aspects, for multi-spectral and SAR data are used (e.g., spectral-SIFT, spectral-WLD, color-histogram).

Spectral SIFT and WLD are local feature descriptors. While SIFT is known for extracting lines and corner structures, WLD is mostly used for describing textural structures in images. Since human vision system is able to capture knowledge about the content of image data based on the frequency of different colors, in optical EO images color-histogram is extracted as a kind of feature descriptor. Color-histogram is produced by concatenating the local histograms of pixel intensity values for the three, RGB, channels.

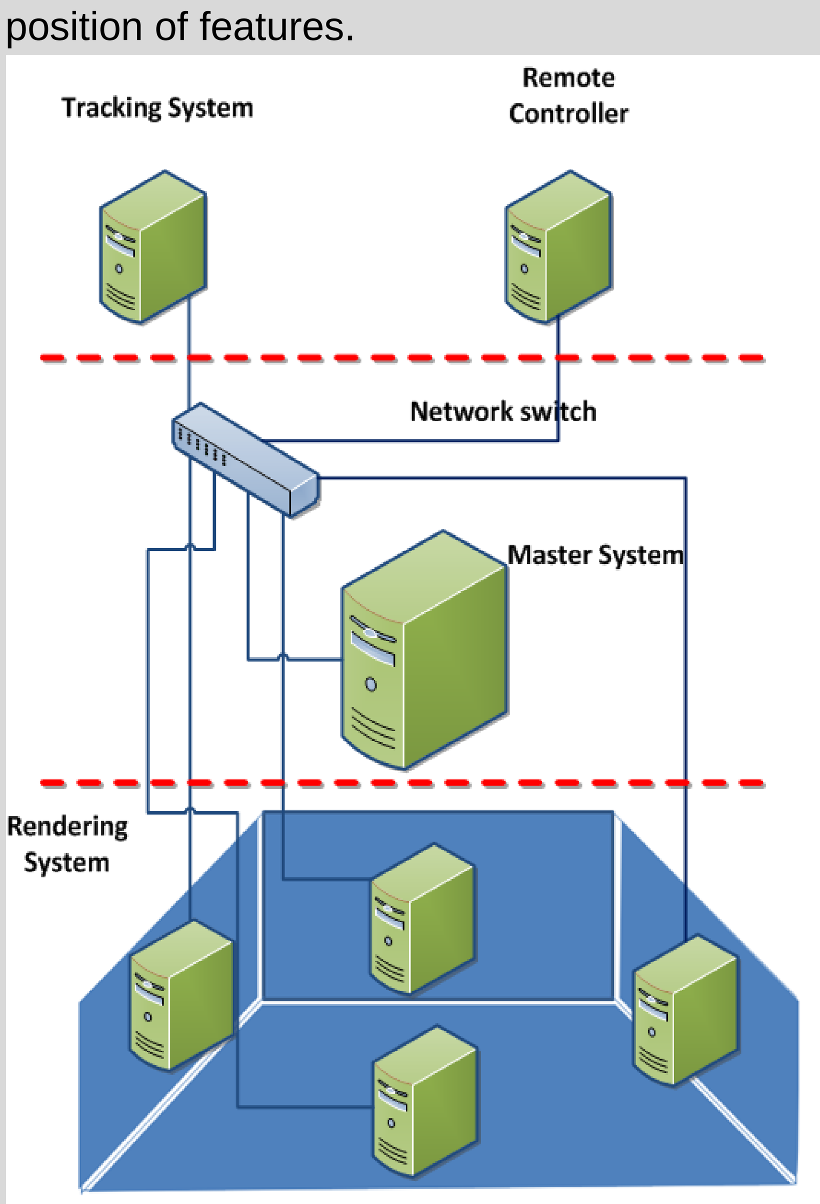
Exploring the feature spaces produced by different feature descriptors provides useful knowledge about not only the content of the data but also the discriminability of the features. This helps to develop more sophisticated feature descriptors which can be tuned to recognize a particular human-semantic concept. Moreover, they can be more general to group a collection of images into human-understandable classes.

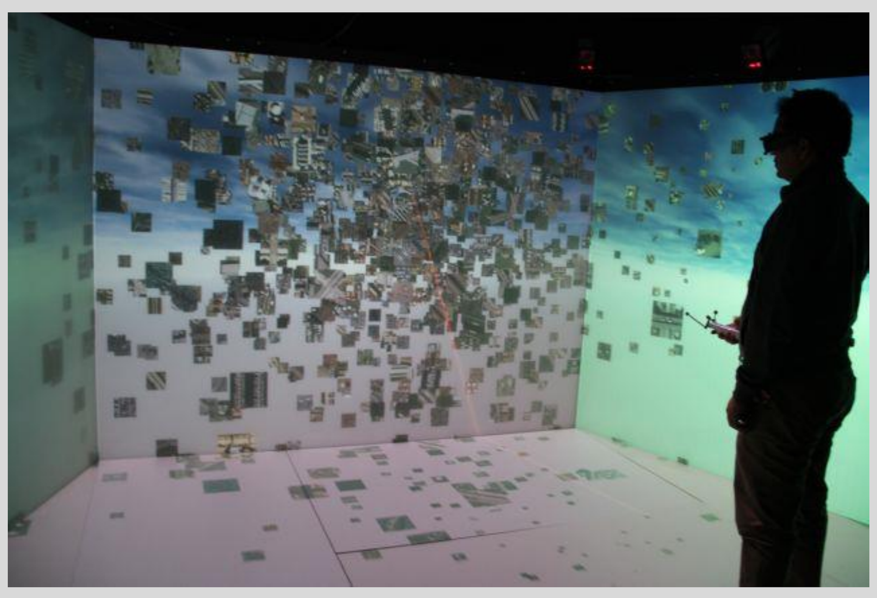
Implementation: Immersive Visualization System

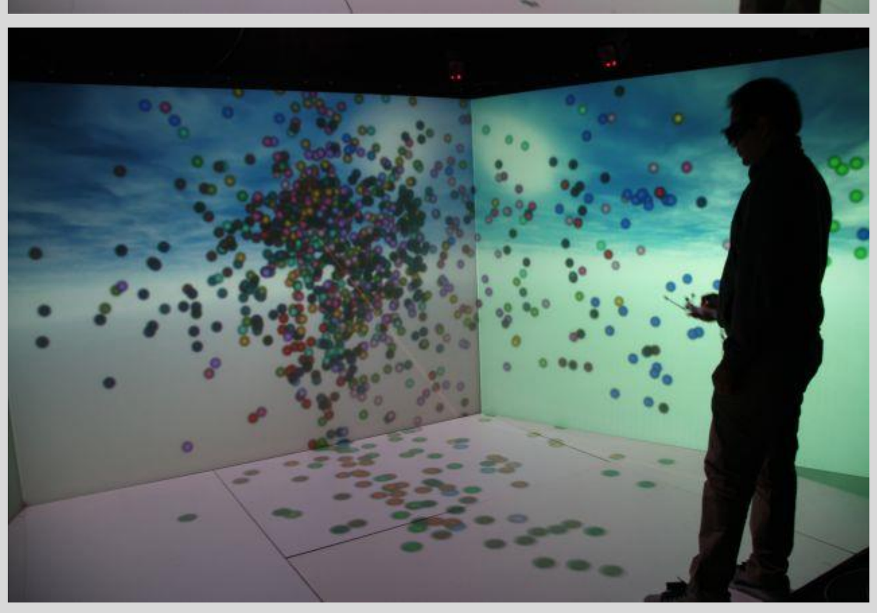
The real challenge is to combine machine intelligence with the power and potential of human intelligence. The goal is to go beyond current methods of information retrieval and develop new concepts and methods to support end users of EO data to interactively analyze the information content, extract relevant parameters, associate various sources of information, learn and/or apply knowledge, and to visualize the pertinent information without getting overwhelmed. In this context, the synergy of HMC and information retrieval becomes an interdisciplinary approach in automating EO data analysis.

CAVE

Images/features are represented in an Immersive environment, so called, CAVE. Physically, the CAVE is consisted of four walls as displays and a three-layer cluster of PC's. The first layer collects the motion and control signals and sends to the middle layer. Middle layer is responsible for receiving and sending control signals to other PC's; third layer comprises four Pc's rendering and displaying the scene on the walls. In this virtual environment, users are able to move and observe the data in different views. Furthermore, users can also manually cluster the data and change the position of features.



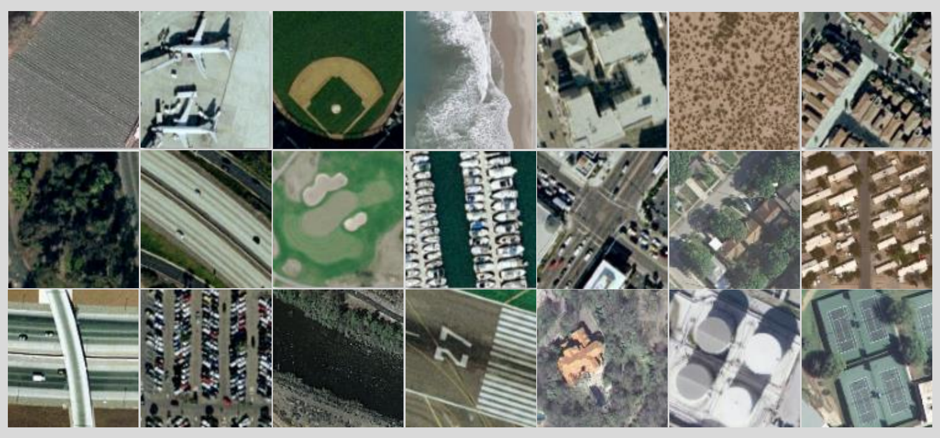




Results:

Assessment of Dimension Reduction Modelled as Communication Channel

Dimension reduction can be modeled as a communication channel where features from high dimensional space are transferred to lower dimensional space. Therefore, mutual information and entropy are able to present the quality of this channel.

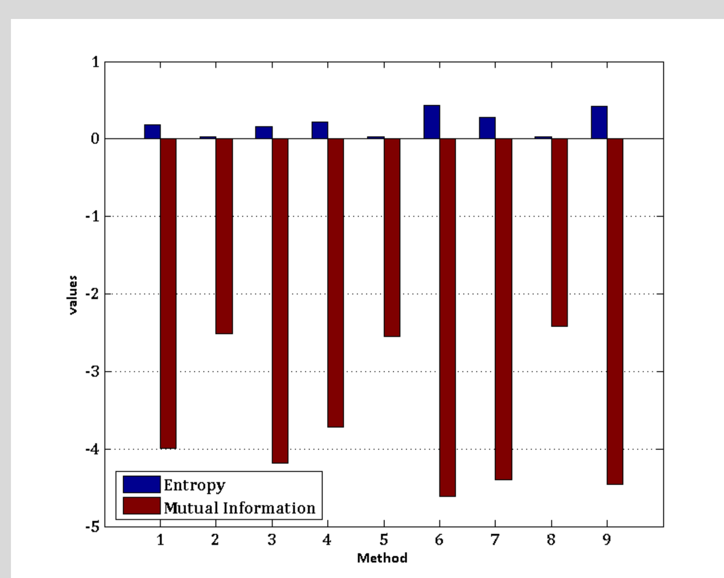


UCMerced_LandUse dataset: Multi-spectral test data, 21 categories, each contains 100 images.

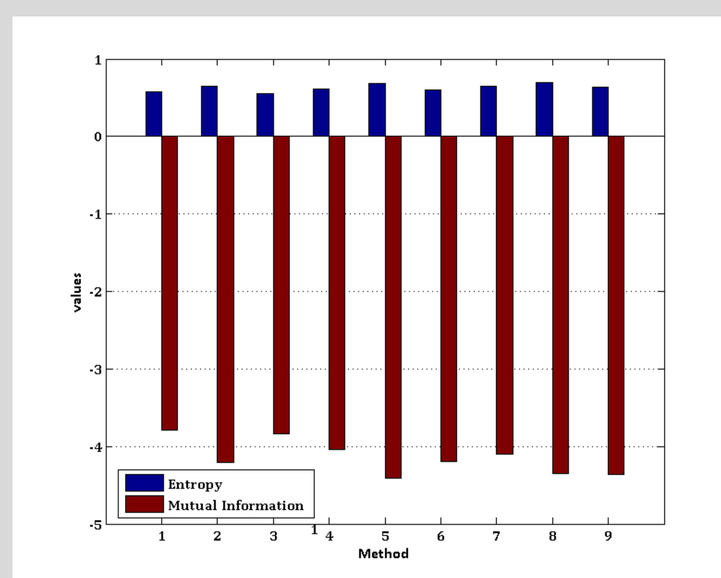
Corel dataset: Multi-spectral test data, 15 categories, each contains 100 images.

Evaluation and optimization of multi descriptors

- A collection of different types of features comprising: spectral Weber Local Descriptor (WLD), spectral Scale Invariant Feature Transform (SIFT), and Color Histogram, are extracted from each image
- A library of both linear and nonlinear dimension reduction techniques like: Locally Linear Embedding, Stochastic Neighbor Embeding, and Laplacian Eigenmaps are are used to transfer high dimensional features to 3D space for visualization.
- Distance preservence of features is kept in a co-ranking matrix. This matrix is modeled as communication channel to apply mutual information and entropy.



Results on UCMerced_LandUse dataset



Results on Corel dataset

Further Details:

•Lee, J. A., & Verleysen, M. (2009). Quality assessment of dimensionality reduction: Rank-based criteria. *Neurocomputing*, *72*(7), 1431-1443.

•R. Bahmanyar, M. Datcu, "Measuring the Semantic gap based on a Communication channel model", to be appeared in ICIP 2013.