KOMPSAT – Urban Application Center

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Abstract: KOMPSAT-2, to be launched in 2005, will be a long awaited addition to the existing high-resolution satellite sensors. The use of download facilities in Europe will greatly increase its capacity without loosing any coverage over Korea. In this paper the concept for an *Urban Application Center* is presented. It is part of the proposed Regional Application Center which is dedicated to archiving and distributing KOMPSAT-2 images. The *Urban Application Center* will offer services derived from KOMPSAT-2. Its aim is to promote the use of KOMPSAT-2 data and increase the general awareness and acceptance of satellite data.

Keywords: KOMPSAT-2, Fusion, Segmentation, Classification

1. Introduction

The availability of KOMPSAT-1 - and in the near future KOMSAT-2 - data is a great asset to the remote sensing community both on a scientific as well as on an administrative and commercial level. Especially KOMPSAT-2 with its 1 m spatial resolution in the panchromatic band and 4 m spatial resolution in the four multispectral bands (blue, green, red, near infrared) will fill a gap in the field of high-resolution satellite data. At the moment this market is covered by IKONOS-2 and QUICKBIRD but both have their limitations as to availability of data, copyright restrictions and pricing policy. A first step towards assuring that the capacity of KOMPSAT-2 can be increased without reducing the workload necessary for accomplishing its original mission has been undertaken by ensuring downlink capacities over Europe [1]. While the ability to record and download data is a prerequisite for any further uses, it is by no means a guarantee that the data will be accepted and used by the community. In Europe a data archiving and retrieval system for KOMPSAT-2 data is currently under development. This catalogue will also be linked to meta-catalogues as are run by the European Space Agency (ESA), to ensure an even wider coverage [2]. The next step is the establishment of an *Urban Application Center* in Europe. Aims are not only to provide data in its raw or pre-processed state but to offer enhanced products which can be accessed directly by the user. In this paper the basic principles of the *Urban Application Center* will be outlined and examples given for products and services that will be provided.

2. Principles for Services provided by the *Urban Application Centre*

The aim of the *Urban Application Center* is to offer enhanced products derived from KOMPSAT-2. These services will be based on the principles of high degree of automation, easy access to data and services and availability to both expert and non-expert users. In the following sections these principles will be discussed in more detail.

2.1. Automation

Processing will be carried out with a high degree of automation, ideally without any interaction by a human operator. This way the data can be generated online, on demand or directly after reception. If any human interaction is necessary or should be made available in order to enhance the quality of the results this should be provided by the user requesting the data. The results of this automated processing will probably not match those that can be obtained by custom made processing and they are not meant to replace them. They will however be sufficient for many applications requiring a fast overview over an area and offer enhanced products to those who do not have the means to carry out the tasks themselves.

2.2. Easy Access to Data and Services

As already pointed out in the introduction, easy access to data is crucial for successful data dissemination. While access to data has been very much improved in the past few years finding suitable data is still cumbersome as numerous portals have to be searched and querying of archives is often limited. The need for better access to data has already been recognized and currently a number of developments are taking place that will hopefully improve the situation in the near future. From a European point of view the *Service Support Environment* (SSE)[1], currently under development by ESA promises to be a very attractive platform. It will comprise a large number of services and catalogues among which are eoPortal[2] and MASS[3] (Multi Application Support Service System). The eoPortal already offers access to the catalogues of ESA and NASA. MASS is a demonstrator for an e-business architecture and should become the ESA standard interface for thematic applications. It offers services that can be modeled by the different service providers and either offered free or as payable services, depending on user access restrictions. The benefit of using this kind of architecture is that the user can draw on different services and even create new products to suit his/her own needs by a process called *chaining.*

2.3. User Groups

So far the use of satellite images has been limited to expert users who have the technical know how and equipment to access and process the data. This has also limited the acceptance of the use of satellite data in administration and other institutions. By making satellite data more accessible and by reducing the necessity to invest in software and time to learn the handling of it, the acceptance and number of uses can be greatly increased. With the internet being more and more part of our everyday lives, many barriers have already been removed and, provided that access is easy enough, satellite images could be enjoyed by a wider audience.

3. Services to be offered by the *Urban Application Centre*

The services provided by the *Urban Application Center* are divided into three categories: image transformation, segmentation and classification. The differences are in the way the data is handled and the uses that can be derived from them. For all services it is assumed that standard pre-processing as well as geocoding has already been performed. High-resolution imagery has its own demands on processing. A number of routine applications for image processing already exist, but they all rely on medium to low resolution data. Examples for these are, to name a few, weather monitoring, fire monitoring and vegetation monitoring. These very often use data from sensors specially dedicated for these purposes. Especially ENVISAT [2] offers a host of sensors for monitoring special physical properties on the ground and in the atmosphere. So far, high resolution data has not been available at a level where the automatic generation of products, to be made available to a wider audience, has been an issue. The services, which are currently being developed for KOMPSAT-2 are complementary to those offered by MASS and, although they are initially developed specifically for high resolution data, might be of interest for use with other datasets as well. In exchange, services which have already been developed such as selection of subsets, calculation of NDVI and so forth are of interest for use with KOMPSAT-2 data and can be accessed as well. In the following section the three types of services offered by the *Urban Application Center* are briefly described.

3.1. Image Transformation

In the context of this paper image transformation refers to the integration of two images in order to create a new one which contains characteristics of both images, a process also called image fusion. In our case the aim will be to use the multispectral bands together with the higher resolution panchromatic band to create high resolution color images. Various algorithms have been developed and for the planned services the emphasis will be on two which offer very different advantages to the users. One is called adaptive image fusion (AIF) [3], the other is a Hue-Saturation-Intensity (HSI)-transformation [4].

The AIF applies a modified sigma filter [5] to the panchromatic image with a given window size. At each position the two sigma range related to the central pixel is calculated and all pixels that fall into that range are selected. The position of the selected pixels is then transferred to the multispectral band where an averaging of these sub-pixels is performed. As by this process no spectral information is transferred from the panchromatic image to the multispectral bands, the spectral information is not significantly changed. This allows the resulting high resolution images to be used for classification purposes just as the original multispectral images.

The AIF leads to results that are spectrally very close to the original but not necessarily very suitable for visual interpretation tasks. For this purpose other methods have been developed such as the HSI-transformation. This technique converts the red, green and blue color bands into hue (dominant wavelength of the color), saturation

[1] http://earth.esa.int/rtd/Events/SSE_2004/index.html
[2] http://www.eoportal.org
[3] http://earth.esa.int/rtd/Projects/MASS/index.html

(degree of purity of a color) and intensity (measure of brightness of color). In order to create a high-resolution multispectral image, the intensity band is replaced by the panchromatic band. While this method delivers good visual products its uses are limited to three bands and it is not suitable for further multispectral processing although very well suited for visual interpretation tasks.

3.2. Image Segmentation

Satellite data with high spatial resolution as provided IKONOS-2, QUICKBIRD and, in the near future, KOMPSAT-2 pose new challenges where data processing and classification routines are concerned. A high spatial resolution not only means more detailed images but also more complex images with many unwanted artifacts. One way to reduce this complexity and also create a basis for further processing is image segmentation [6]. The aim is to separate the image into homogenous regions. Size and shape of these regions depends on parameters selected for the segmentation. As it is planned to have as much automation as possible the initial segmentation parameters are calculated from the image based on its heterogeneity. On this the second segmentation is built by combining neighboring segments based only on color differences. This results in a segmented image were large homogenous areas, e.g. grassland, water bodies and clouds form large segments and heterogeneous areas such as urban areas remain divided into smaller segments. Based on features calculated for teach segment describing color, shape, neighborhood, and so forth classifications can be carried out. A number of routines have been developed for the purpose of image segmentation [7], although at this stage processing is limited to using eCognition[4] for segmentation and classification experiments.

3.3. Image Classification

The third category of services is the creation of thematic products, i.e. converting data into information. Traditional classification schemes such as the Maximum Likelihood Classifier tend to perform rather poorly on high resolution data, leading very often to an unwanted salt-and-pepper effect [7]. In the past few years, segmentation based classification procedures have proofed to be more suitable. Starting point for the classification provided by the *Urban Application Center* will be a segmentation as described in section 3.2. At this stage it is planned to concentrate on 6 classes (vegetation, sealed areas, arable land, water, shadow and clouds) although the proposed procedure makes it easy to add new classes if that is feasible. The classification is carried out on the bases of the segmented image. Features, which are calculated for each segment, are used to assign one of the six classes. These features draw on spectral as well as shape and neighborhood characteristics and are selected in such a way that they are as typical as possible to describe the classes in a very general way. As one of the premises for this center is high automation of services, it is the challenge to find parameters, or better yet, derive them from each image that lead to satisfactory results.

4. Application Example - Classification

As the AIF has already been presented in another context [8], results of the first classification experiments will be presented here. As a substitute for the type of data that may be expected from KOMPSAT-2, an IKONOS-2 scene, recorded over the city of Vienna on September 1st, 2000 was selected for the classification example (see Fig. 1.). The study area covers approximately 5 x 5 km.

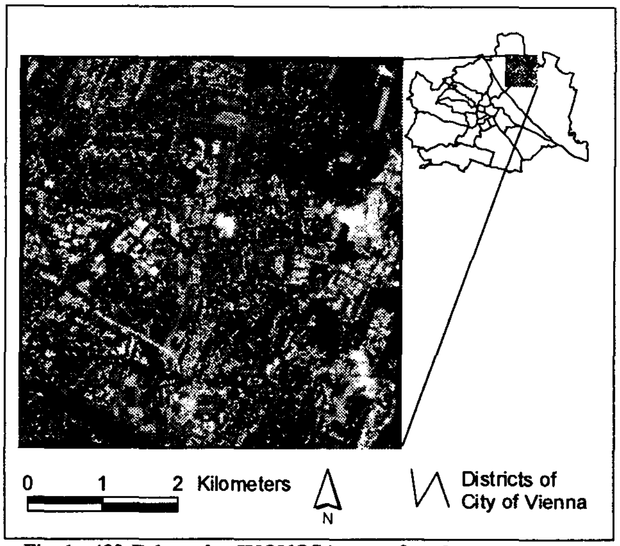

Fig. 1.: 432-False color IKONOS image of study area

For the classification experiment both the multispectral and panchromatic images were segmented together on two levels using eCognition. On the first level a combination of form and color parameters were used (scale 10, shape 0.1, compactness 0.9). These segments were merged together on a second level on the basis of color difference between neighboring segments, using a threshold of 40 pixel-values. This leads to larger homogenous areas, without changing heterogeneous areas.

For the classification, 6 classes (vegetation, sealed areas, water, arable land, shadow and clouds) were defined on the basis of selected features which are calculated for each segment. Table 2 gives on overview over the type of features used for each class. Ratio is defined as the mean value of an image segment divided by the sum of all spectral layer mean values. Brightness is the spectral mean value all selected bands (here all bands were selected for the calculation of brightness) of an image object. The number of features was kept to a minimum in order to ensure that the classification can be easily transferred from one image to another. If the features are selected correctly then a transfer should only involve ad-

[4] www.definiens-imaging.com

justing the parameters governing the functions for each selected feature.

Table 1: Features used for classification

Class	Feature
Vegetation	Ratio of near infrared
Water	Ratio of near infrared
Sealed urban	Ratio of near infrared
	Std.dev. of near infrared
	Std.dev. of green
Shadow	Brightness
Clouds	No class of the above
	Brightness
Arable	No class of the above
	Brightness

Fig. 2. shows the result of the classification. The density of urban structure (red) can be seen clearly in contrast to vegetation (green) and arable land (brown). Water bodies (blue) were classified as well as clouds (white) and shadows (black), cast either by buildings and clouds. Misclassification occurs where some shadows have been mistaken as water and where the contrast of roofs is very low, especially in areas with small individual houses.

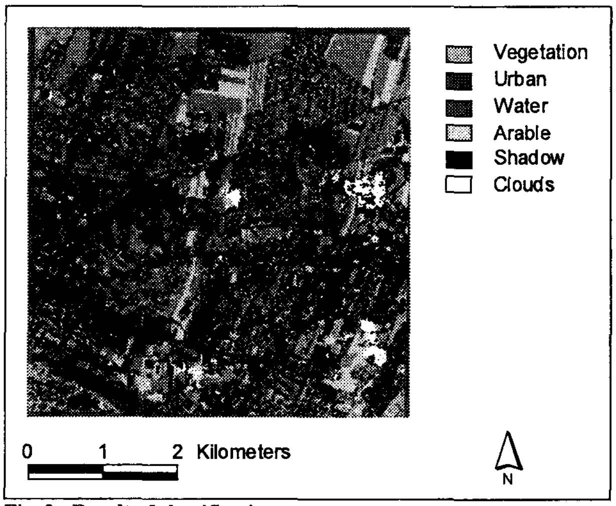

Fig. 2.: Result of classification

5. Conclusion and Outlook

With KOMPSAT-2 the remote sensing community will have an important addition of high-resolution satellite data at its disposal. Past experiences have shown that the acceptance of a sensor depends very much on the access users have to the data. This depends one the one hand on the capacity the sensor has to record and download the images. With the possibility to receive data in Europe this capacity should be greatly increased without interfering with the original mission of KOMPSAT-2. The next factor is availability, i.e. how easily can the user have access to data and what restrictions are associated with it, both in monetary as well as in ownership terms. Easier access also means having intelligent ways of querying the data beyond geographic coordinates and cloud cover. The third factor is information policy: do the users get the information about the sensor characteristics they need to make full use of the data. A fourth factor may be added and that is how non-expert users can benefit from the data. By adding thematic information to the data within the framework of the *Urban Application Center* intelligent query mechanism as developed within data mining can be used the speed up the search process. The acceptance of the use of satellite data can be improved by offering off-the-shelve enhanced products, as created by image fusion and thematic classification. The results of the mostly automated enhancement and classifications routines cannot substitute custom made products but might be an introduction into using satellite data both on an administrative but even commercial level. Satellite data that is easily available might create completely new uses within but also outside the remote sensing community.

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