FUSION OF HIGHT RESOLUTION AND MULTISPECTRAL SATELLITE IMAGES IN THE STUDY OF COASTAL ZONE. EXAMPLE IN HAI PHONG, VIETNAM

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ABSTRACT

The use of collateral remote sensing data sets provides additional benefits of redundancy and complementarily that are required by data integration and data fusion technique. SPOT data have been widely integrated among multispectral sensors especially PAN-XS fusion and PAN-TM fusion using technique such as Intensity – Hue – Saturation (IHS), principal components analysis (PCA) and high-pass filter (HPF). High resolution satellite images is very important for environmental study and detail mapping of the urban areas and coastal zones. LANDSAT and SPOT XS images have advantage of spectral and large dimension. However, their spatial resolution is not sufficient in comparison with IKONOS images that have disadvantage of extreme expensive and limited surface. It is first time, we make successfully in this study the fusion of SPOT MS and aerial photo. The spatial resolution increases 10-20 time in comparing with SPOT MS. Some fusion techniques are used such as Intensity – Hue – Saturation transform (IHS), high-pass filter (HPF. The fusion technique can also integrate among multispectral sensors with different resolution. SPOT data are integrated with RADAR data to enhance feature discrimination. Applying in Cat Hai coastal zone, the quality of SPOT MS imagery are intensively ameliorated so one can map small road of the villages, the disks, small salt marsh and shrimp basin. In other part, thank to the conservation of multispectral resolution, one can more understand the sedimentary transports in shallow and mangrove mapping. In Hai Phong area, one can map port bridge, container port and evaluate recent industrial affectation. SAR images of ERS-1, ERS-2 and RADARSAT satellite analyses to extract the wave pattern. Such information has been proved to be necessary to explain the beach erosion areas. Analysis of aerial photos of 1952 and 1993 completed by SPOT-HRV together with LANDSAT-TM satellite images allow mapping the erosion and sedimentation areas and to highlight the relation between these coastal geomorphologic processes and the wave patterns.

1. INTRODUCTION

The advantage of satellite data is well known. It provides at any scale, up to date, inexpensive information on digital form. Many tools, which allow to extract environmental data from satellite imagery have been developed. The study of coastal zone and environmental change demands a diversity of accurate observation. Observation of processes at earth surface plays an important role in assessment of natural hazards in reducing their negative effect. Remote sensing applications is at very young stage but its results have been quite considerable. For decades, Geologists have used satellite imagery to identify rocks and geological structures. Satellite imageries such as LANDSAT, SPOT and aerial photo are commonly used in geological mapping and exploration. Landsat have great advantage of large dimension, high spectral resolution and low price. However, in the study of coastal zone and environmental monitoring this type of imagery demonstrate its disadvantage of low resolution (25 meter of multispectral Landsat 7 and 15 meter of Panchromatic).

With the rapid increase in environmental preoccupation expressed by the international communities over the last decades the need for earth and environmental data has become more and more evident. The humanities have to face to global climate change, preservation of the biodiversity, desertification and natural hazards such as flood, typhoon, earthquakes, and landslides. With respect to all this subject, The use of high resolution satellite imagery contributes information, which is irreplaceable for the study of certain aspect of the problems. The use of high resolution satellite data in the study of coastal zone has been continuously developing since the launch of SPOT. The first generation of SPOT satellite with a 20 meter resolution in multispectral mode and 10 meter in panchromatic mode provide large information for natural resources assessment and coastal zone monitoring. The combination of high resolution SPOT imagery and ground observation has contributed to an increasing understanding and management of natural resource and environment. Although for long time the techniques used have been shown more by the availability of the technology than by actual need, there have been a gradual improvement in the way this readily accessible information is being used, mainly due to the growing capabilities of the developing countries. Important development with new generation of Indian satellite images IRS-C with 5 meter in Panchromatic. This high resolution satisfies to the demand for mapping of 1/50.000 scale in many countries. Spatial resolution of multispectral IRS-C limits at 20 meter as SPOT MS. The disadvantage of IRS-C is its price and limited cover. IKONOS imagery is commercial product from 2000. High spatial resolution of IKONOS with a 4-meter in multispectral mode and 1 meter in panchromatic mode is excellent for earth observation and environmental monitoring. This imagery meets to almost request of remote sensing application. However, IKONOS imagery has also its disadvantage. We know already that the repeat of observation is inverse proportional to the finest of the imagery. That is why one can not get easily the IKONOS imagery. In other side, This data is very expensive due to limited dimension and its price. If we can make successfully the fusion of aerial photo and other satellite imagery such us Landsat and Spot, we can have multispectral satellite imagery with high resolution and low price. This will open to great capacities in remote sensing application for coastal zone observation, urban mapping, environmental monitoring and natural hazard assessment. In this paper, we present at the first time our result of fusion between aerial photo and Spot imagery and discuss about the possibility of integration of multisensor data on the study of coastal zone such as the fusion of Radasat imagery with Spot. Our procedure can be applied for the fusion of Landsat imagery with NOAA imagery for environmental monitoring. In Hai phong area, we use also fusion technique to integrate SPOT with RADASAT imagery

2. FUSION TECHNIQUES

Fusion techniques are a new advance in remote sensing. If the RADAR interpherometry is a powerful tool for determining fault displacements and terrain movements of landslides with the precision of some centimeters (Masonnet et al., 1993), fusion techniques permits one to combine an image of high spatial resolution with an multispectral image but low spatial resolution for obtaining an other image in the same time rich in spectral and high spatial resolution. Various fusion techniques are used currently such as Intensity – Hue – Saturation transform (IHS), principal components analysis (PCA), high-pass filter (HPF) and wavelet transform basing on principle of fusion techniques, one can classify into 2 categories of fusion. The first one consists of fusion methods taking into consideration of all channels in the fusion process such as IHS and PCA methods. The last one treats individually the information for each channel such as HPF and Wavelet transform methods (Chaver et al.,

1991, Mangolini et al., 1993, Ranchin, 1993). The method of Intensity – Hue – Saturation transform (IHS) is most simple technique but it gives us effective result. From 3 parameters Red, Green, Blue of a multispectral image, one can transfer to Intensity – Hue – Saturation (IHS). These values IHS are characterised for the given multispectral imagery. If we replace Intensity in multispectral images by Panchromatic image of higher resolution, we will obtain new value IHS characterised for a new multispectral image. Re-transferring from IHS to RGB, we will get new image conserving spectral but high spatial resolution as old panchromatic image (Guyenne, 1988, Carper et al. 1990). The principle of High pass filter method is presented by its author (Chaver, 1991). Wavelet transform methods can be affected by various approaches (Ranchin, 1993, Garguet et al., 1994, Yocky, 1996, Zhou et al., 1998, Rakotoniaina et al., 1999). Almost workers make the fusion of Panchromatic and multispectral SPOT images having the different of spatial resolution of 2:1 (Chaver, 1991, Ranchin, 1993, Zhou et al., 1998, Rakotoniaina et al., 1999). The question is that can we make the fusion of panchromatic image with multispectral images having spatial resolution ratio more than ten time?

One of most important problem in the fusion is making georeferece of aerial photo and satellite image. Thank to our technique of registration from image to image, we can compare the centre of a pixel of aerial photo with a part of pixel of satellite image with dimension larger from 10 to 20 times. The registration is carried out by iteractively relative control points refining them through correlation, deriving transform coefficient and resampling the multispectral data to the panchromatic coordinates as reference.

3. RESULT

We test to integrate aerial photo of 1992 with SPOT multispectral in 1996. Using topographic map and control points in the Cat Hai region, we make firstly georeferece of aerial photo. We compare georeference of SPOT image with georeferece of aerial photo by using 15 control points. Some control points are situated in Cat Ba Iceland and in Dinh Vu, Hai Phong. in Cat Hai coastal zone, the quality of SPOT MS imagery are intensively ameliorated so one can map small road of the villages, the disks, small salt marsh and shrimp basin. In other part, thank to the conservation of multispectral resolution, one can more understand the sedimentary transports in shallow and mangrove mapping. For setting off the advantage of fusion image, we compare the fusion image with SPOT multispectral in 2 areas in Cat Hai. In North Hoang chau commune (figure 1), we observe more detail the structure of spring, the sand beach and houses in village. The landuse and salt marsh can be mapped in detail. Due to the change of mangrove distribution between the SPOT multispectral and aerial photo, western border of Hoang Chau commune is not fused in fusion image. Basing on the dimension of SPOT MS not to be fused, we determine the reduction of mangrove is about 20 meter. In the figure 2, we compare the fusion image with SPOT MS in southern part of Cat Hai region. Although the quality of fusion image is much higher than SPOT MS, one can judge that the integration between aerial photo and SPOT in this part is less than in Hoang chau commun. It can be explained that tiding area is much changed between aerial photo and SPOT MS. We compare the fusion image with SPOT in southern part of Cat Hai area. The distribution of vegetation cover is clear in fusion image. In particular, we could see the trace of spring in the sea. That means the erosion of beach. We estimate at least 60 m of beach erosion. Using the most simple classification, we show that the advantage of fusion image for regconising small object.

We present also example of the fusion of multisensor data. We test the fusion between RADASAT image, high resolution (12.5 m) with SPOT. This procedure have advantage to combine the advantage of texture of RADA with spectral of SPOT. Analysis of aerial photos of 1952 and 1993 completed by SPOT-HRV together with LANDSAT-TM satellite images allow mapping the erosion and sedimentation areas and to highlight the relation between these coastal geomorphologic processes and the wave patterns.

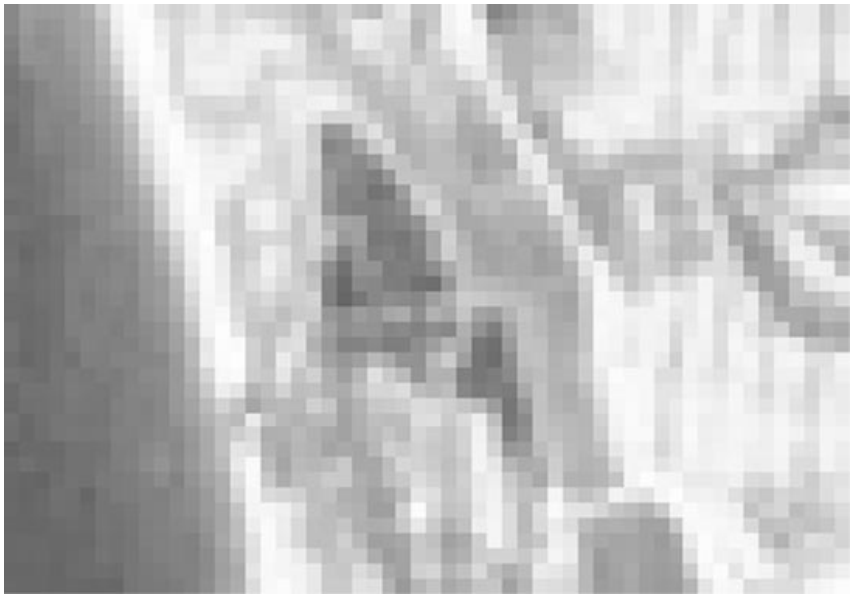

Figure 1. SPOT image in Hoang chau, Cat Hai , Hai Phong

Figure 2. Fusion between SPOT image and aerial photo in North Hoang chau, Cat Hai , Hai Phong

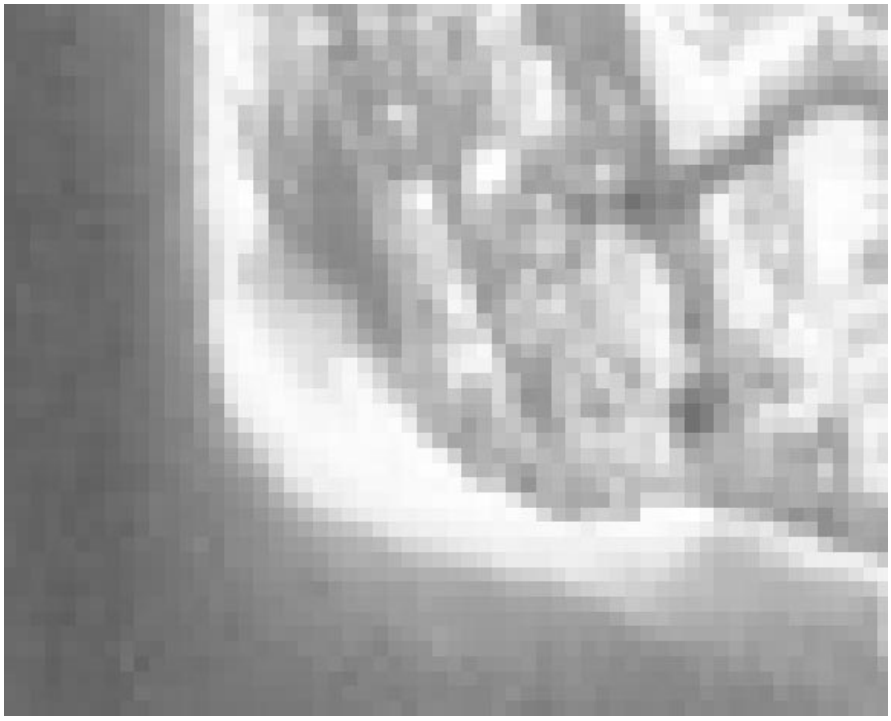

Figure 3. Multispectral SPOT image in south Hoang chau, Cat Hai , Hai Phong

Figure 4. Fusion between SPOT image and aerial photo in South Hoang chau, Cat Hai , Hai Phong

For evaluation of the spectral quality, we consider the histogram of original SPOT image with that of fusion image for each band. We compare also some land-cover classes. The average different is less than 10 % for 3 bands.

4. CONCLUSION

It is first time that we make the fusion of aerial photo with SPOT MS having the different of resolution of more than 10 time. This approach permit one to have large application in environmental observation.

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