UPDATING GEOGRAPHIC INFORMATION USING HIGH RESOLUTION REMOTE SENSING OPTICAL IMAGERY

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ABSTRACT: Remote sensing may be broadly defined as acquiring and then interpreting information about objects, which are away from the sensor. Geographic Information System (GIS) is a tool for integrating and analyzing spatially referenced geo-spati al data. The integration of remote sensing and GIS technology provides an opportunity for characterizing and analyzing dynamic environments so that any change of objects in terms of geometry, class and topology can be identified. Updating of the vector data of scale 1:25000 of Enschede Municipality, the Netherlands by using remotely sensed Ikonos imagery was performed by simultaneous viewing them using GIS tool. It is found that remote sensing high optical imagery are of promising characteristics in terms of capturing feature so that updating of vector is possible and database can be maintained easily and comparatively in less time than by using the field surveying techniques.

OBJECTIVES

i) To Apply of different techniques like image enhancement, image fusion (if necessary), etc. for proper discrimination of different classes and enhancement of interpretability of the image.

ii) To coincide the Remote-Sensing Image data with the GIS data of the same area (integration) and visualize on screen to detect change.

iii) To update the change detected, and add it to the parent data (replacing the old data).

PRE-PROCESSING

The first part of the image processing is usually known as pre-processing, since it must precede most other image processing operations. The amount of pre-processing required varies with the sensor type and the quality of the digital data. The following are the type of correction that is applied on the image to make them understandable. They are, System Correction, Radiometric correction, Geometric correction.

Here System correction and the corrections like error due to the satellite positions, the earth rotation correction is not applied as these corrections were expected to be applied by the provider of the imagery (by the distributor).

It has been commonly known that the Spectral reflection of an object is image specific. That is to say, it is dependent on the viewing angle of the satellite at the moment the image is taken, the location of the sun, weather conditions (like Haze) that are not same in the entire image. It is therefore these possible sources of errors are accounted for and corrections are applied on the multi -spectral image on all bands.

The mathematical relationship existing between the different parts of the radiometric correction is give by the equation below.
(i) Reflection detected by the sensor (O) (ii) Sun angle (S) (iii) Skylight (D) (iv) Sensor indicator (I) (v) The irradiance incident by the sun (T) and (vi) Reflection form the object/surface (R) and the relationship is

O = (T*S +T*D*I) R*I + H* I ……………………………………………………………………………..…..(1)

HAZE CORRECTION

Observing the function above reveals the fact that the haze effect (H) is contributing additively whereas the sun angle is supplying errors multiplicatively. It is due to this reason that the image has lower DN values than it should be. By applying correction, the haze value is approximated and the same value is deducted from each Pixel of the given image. The lower the value in the given image is estimated, the higher will be the correction of the image. The formula for the application of the haze correction used was

DN = Vw + Vh
i.e. Input DN Value(DN) = estimated lower value(if there were no atmosphere, Vw) + Haze contribution (Vh).
Therefore,
Haze contribution = Input DN Value minus estimated lower value (if there were no atmosphere)
……(2)

It is reminded that haze correction value 18 for band 1, has been obtained by estimating the value of the DN (here 2) as if there was no atmosphere present and using eq(2). The correction value is subtracted from all of pixels in band 1. The same procedure is applied for band 2. The lowest values in band 3 and Band 4 values were already near to zero so they did not need correction.

SUN ANGLE CORRECTION

Since an image of the same period is used for the entire study work the relative approach of sun angle correction is not applied in the sun angle correction but the "absolute" one. Using absolute approach, the sun angle correction is applied by the original DN values divided by the sine value of the Sun elevation angle provided by the distributor in the header files. Thus, DN′ = DN / sin (δ) i.e.
Output Pixel = input pixel / Sin (sun angle)
…………………………………………………………………………….(3)
Where sun angle i s measured in degrees.

The following list shows the data for the application of sun angle correction.

Image	Sun angle	Sin value
Band1	41.34205	0.66055

All of the haze corrected images are undergone through the sun angle correction by using the function eq (3).

It is noted that the resulting image after the haze correction is in image domain whereas the image after the sun angle correction is Value domain. (The necessary division converts this value domain image into image domain again carefully. Technically, the image domain is given emphasis since it is the only domain through which we can view color composite)

SKYLIGHT CORRECTION

The incoming radiance from a ground pixel to the sensor is affected by the two types of components. They are:

(i) The irradiance from surrounding pixels, which is more severe in the case of lower resolution images, but for higher resolution images, it is neglected. Hence for the images that are under used at present there was no correction applied and,

(ii) The path irradiance from the sky which is caused by scatter presents in the atmosphere by the dust, cloud etc. As the image under use is cloud free, the error possibly present by dust particles is neglected.

GEOMETRIC CORRECTION

Out of the two methods of the geometric correction, the method that involves the identification of ground control points (GCP) on the image was applied. Numerical values (Ground coordinates) were fed to these GCPs on the image. The accuracy achieved by geo -referencing the image was 0.73 of a pixel of 1- meter resolution (in case of the IKONOS Panchromatic Image). After geo-referencing (following the transformation), resampling was performed to move each digital value in the slave image to the new position of the new corrected image. In the case of the study work, bilinear interpolation was used which has better effect than nearest neighborhood and has less modification than cubic convolution.

SECOND STAGE IMAGE PROCESSING AND CLASSIFICATION

A range of techniques were applied to improve the appearance and interpretability of digital imagery directing particularly at final product, which was going to be subject to visual interpretation. Namely, image enhancement (either contrast stretching or color composite), filtering, Ratio images, principal components analysis as well as image fusion are prevalent for this purpose. These all activities were carried out to make the image better understandable.

IMAGE ENHANCEMENT

IKONOS images are provided with the dynamic range of 11 bit per pixel (2048 gray levels), where as the Image processing software facilitates the work using a dynamic range of 8 bits per pixel (256 gray levels) ranging from black = 0 to white = 255. Hence when image is imported, it seems to be readily black. To avoid this low contrast and low DN values the image is rescaled to the range of 0 to 255 immediately after the image is imported.

CONTRAST STRETCHING

Satellite images, particularly those at the optical range, often make use of a limited part of the dynamic range , especially when the sun illumination is low.(Reference no 3) For better interpretability, the image is transformed to occupy the full dynamic range. This is called contrast stretching(fig. 2). This expands the digital values to fill the dynamic range of the display system, producing an image of better contrast.

Fig 1, Band 1, IKONOS as provided

Fig 2, Contrast stretched image (IKONOS band 2)

When stretching the histogram as a whole, there are two techniques to enhance the contrast of an image (except piecewise-contrast stretch), linear stretching techniques and histogram equalization. Out of these two, histogram equalization was performed since the distribution of output gray levels is proportional to the frequency of the occurrence of the original DN values.

COLOR COMPOSITE OF THE STRETCHED IMAGES

Color images, when displayed on a monitor are normally composed of three bands, usually three different bands of an image taken at the same time (co-registered images). Each band is assigned to one of the color guns (red, green or blue). Apart from these composites, is also seen through the conversion of RGB to IHS.

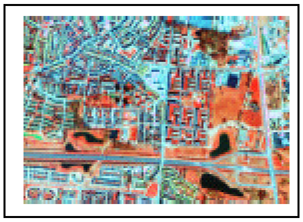

Fig 3, False Color Composite 4,3,1

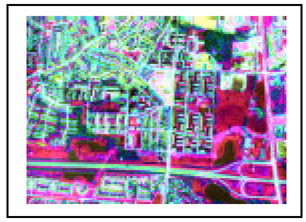

Fig 4, False Color Composite 4,3,1through HSI *system*

CHOICE OF BANDS FOR THE COLOR COMPOSITE

It is not by the random decision that three bands for a color composite were chosen. Allowable input bands for the color composite can be identified by statistical procedure. One such method is based on the selection of data, which have the highest variance. This method was propounded by Chavez et al (1982) called, Optimum Index Factor (Reference no 3). The higher the covariance the better the composite. Before introducing images to the monitor, Optimum Index Factor of the different combinations (in each combination there are three images) was calculated through the covariance matrix, which has been enlisted below.
OIF Index Highest Ranking was like 1: Band1 Band 3 Band 4 (129.22)
2: Band 1 Band 2 Band 4 (125.20) 3: Band 2 Band 3 Band 4 (111.95)
4: Band 1 Band 2 Band 3 (75.62)

As the image consists of mostly built up area, there are many linear structures like road lines. This linear structure could not be differentiated with the building or other details in the resulting color composite. Since many details cold not be visualized as clear as they could be result was not felt so satisfactory. Hence the processing was forwarded to the application of high pass filters (Edge enhancement).

APPLICATION OF MAJORITY FILTERS

When a close look was made on the image at bigger scale, noise was felt on some parts of the image where the distribution of details was more heterogeneous. It was due to mixing of pixel of values. Hence the majority filter was felt to be applied before edge enhancing filters.

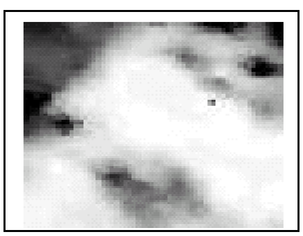

Fig 5, Image before majority filter applying

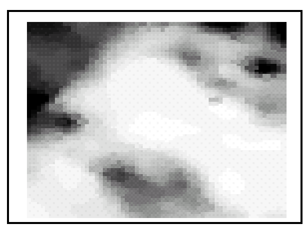

Fig 6, Image after majority filter applying

CLASSIFICATION

Principally, Classification techniques use a selection of spectral characteristics of objects in order to subdivide the imagery into meaningful classes of different land-cover types. By classification, the enhanced images are modified into different thematic classes. The choice of class depends on the objective of analysis, the spectral and the spatial resolution of the images under consideration. It was thought here that the objective of the study was to update a dataset to a scale of 1:25000. The following classes were pre -defined fo r the classification:
Built up area, Tree area, Open area, Water area, Road lines

It is here noted that by open area we mean the barren area, area of cultivation and grassland in a combined class. In the same way the industrial, sports grounds, residenti al and other constructions are comprised under built up area class.

SELECTION OF THE CLASSIFICATION TYPES

Since an updating of GIS data process is going to be undertaken after the classification of the image, Supervised classification procedure was selected for the classification purpose. It was also felt confident to classify by supervised method.

COLLECTION OF TRAINING SAMPLES

Considering the spatial resolution of the image, it was regarded that many more classes could be differentiated on the multi-spectra. A field visit was made for the collection of different training samples with the number of class more than just mentioned above. e.g. class like cultivation land with no crops, cultivation land with smaller crop, grass land, wetland etc. More than 30 f training samples were collected in the field for the purpose of classification.

FORMATION OF MAP LISTS

For classification using multi -spectral image, one need to define which combination of the bands are used for feature extraction. As the OIF of the given images showed the best combination for 3,4 and 1 band, these three bands were used to define the map list undergoing classification. (Noted that this is the first classification among many others that was performed during the analysis in which other combinations were also made).

DEFINING THE SAMPLE SET

As there are three scatter plots for this image because all three dimensions cannot be viewed simultaneously in the two dimensional monitor. When defining some sample sets, features of same class have different pixel values and they scattered very widely in the feature space. Because of this overlap, it was difficult to assign it to limited classes. Hence the number of classes was increased keeping in mind that after classification these features would be merged to a more general category again in the GIS analysis. Road features were divided as highway and road, bicycle track. Open area was divided to grassland, cultivated land etc. In the places where the building and road lines were seen to be mixed they were given name as X (unknown)

SELECTION OF THE CLASSIFICATION ALGORITHM

Out of different types of algorithms available for Classification and in spite of its simplicity, the box classifier was rejected because not all values pertaining to a certain class are arranged in a compact form so that they nicely fall inside a crisp boundary of an estimated rectangular box. When forcing such partition in the feature, low accuracy results. Similarly, the minimum Euclidian distance to mean classifier is also not chosen in the classification of the image because there is a danger of assigning a class to a pixel, which is far away from the mean. This can be avoided by assigning a distance but it is a value, which seems to be a biased and user sensitive.
The third, Maximum Likelihood Classifier, is more independent one, since it works on the statistical probability principle. The parameters like the cluster mean and covariance are taken into consideration in assigning a class to a pixel. This Algorithm was applied for the classification.

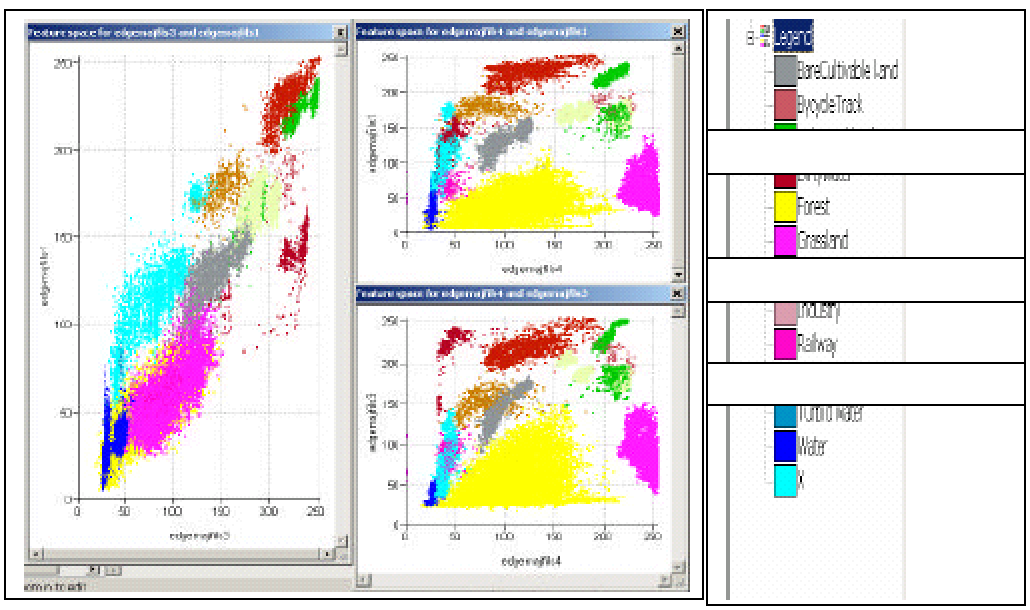

Fig 7, Three-Scatter plot using bands 4,3 and 1

PERFORMING THE CLASSIFICATION

After completing above steps for the classification, classification of the multi -spectral bands (using the map-list constructed already) was performed by using the sample set already defined, and using the algorithm as mentioned above.
The outcome of the classification was apparently very poor. Most of the buildings were seen to be classified as roads (highway). Some of the buildings (black roofed) have the same reflection as water in the image. Some tree areas are classified as water as well. The result of the first classification gave the impression that classification using the original bands of the image as they are could not procure a good result(fig. 8). That is why the image processing was forwarded to the application of arithmetic and other techniques to see whether the result would be better. The resulting image after these processing was found to provide good interpretability therefore better classification was expected.

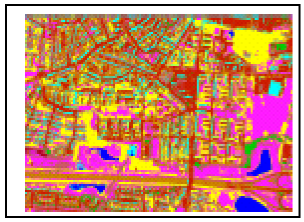

Fig 8, Classified image

APPLYING OTHER TECHNIQUES OF IMAGE PROCESSING

As the result of classification was not obtained satisfactory, other techniques of image processing were applied to see whether a better result would be obtained for the classification. For this different techniques were tested namely, Image arithmetic, Image Fusion and principal component analysis.

IMAGE ARITHMETIC

To solve the problem of spectral confusion, such as built up area and road networks, which got the same class in the previous classification, an effort was made to make them separate using band 4 because it consists of information more about vegetation. For this, piecewise contrast stretch was performed and the resulting image was inverted. But the result came up with the mingling of road feature and built up area. Hence the idea of inversion and piecewise stretching was abandoned.

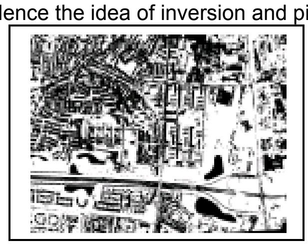

Fig 9, Piecewise stretched image of IONOS band 4 (65– 78)

Fig 10, Inverted image of fig 9.

IMAGE FUSION

Image fusion is defined as the combination of two or more different images to form a new image by using a certain algorithm (Genderan and Pohl 1994). The principles behind the image lie on the fact that it should increase accuracy as well as reliability thus reduce ambiguity. Three different approaches of image fusion were performed to peruse the best interpretable image. These are,
(i) Addition of the individual bands with the Panchromatic
(ii) Averaging of three bands and replacing the individual component by the panchromatic
(iii) RGB–IHS-RGB transformation

ADDITION OF THE INDIVIDUAL BANDS WITH THE PANCHROMATIC

Another effort made to rectify the image was the addition of the multi-spectral band with panchromatic one. For this the process involved is as below:
Let x, y and z are the three multi -spectral bands (Particularly 1,3,4 respectively)
Then Resulting Image after adding panchromatic band is given by,
Xnew = (x + panchromatic band)/2, Ynew = (y + panchromatic band)/2, Znew = (z + panchromatic band)/2
The color composite result is a promising one but the image processing is forward towards the image fusion by averaging techniques as described in the succeeding chapter to make a comparison to see which of the image will give the better result.

AVERAGING THREE BANDS AND REPLACING THE INDIVIDUAL COMPONENT BY THE PANCHROMATIC

This method was performed to see if the out coming fused image would be a better result. In this approach, three bands 1,3,4 were averaged. The average was divided by the each component separately and each time mul tiplied by the panchromatic one.
The formula used were ,
Int = (iko1 + iko3 + iko4)/3, I1 = (int / iko1) * pan, I 3 = (int / iko3) * pan, I4 = (int / iko4) * pan
There I1, I3, I4 are three resulting images. Finally the color composite of these images was prepared. The result was found to be better than the previous fusion. This combination was used to classify with the same parameter as mentioned in the first classification. But the result of the classification was poorer than the outcome that would come with the visual interpretation. Hence this classification result(fig. 11) is also rejected.

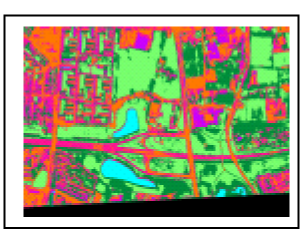

Fig 11, Showing classification using the fused image

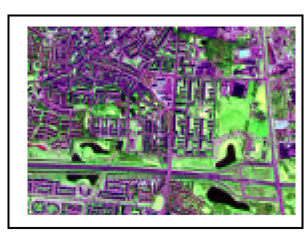

Fig 12, The image after RGB – IHS Transformation

RGB–IHS TRANSFORMATION

In this method, from colour composite (i.e. band 3,4 and 1) intensity, saturation and hue were extracted separately, each time resulting in new images. Out of these three Images, the image containing hue and saturation were again combined with the panchromatic image leaving the intensity image behind. In general, the idea to replace the intensity is to generate colour information at a higher resolution The HIS colour transformation effectively separates spatial and spectral information from a standard RGB image.
These three images are combined this time and visualized through the HSI channel(fig.12). But the visual impression was found to be even worse than the result achieved before. Hence this fused image is also rejected. No effort for automated classification was made with this fused image.

PRINCIPAL COMPONENT ANALYSIS

In this analysis, series of four bands of original data were converted to 4 new components, where the first components contains information least of the correlation between all the original bands, second components contain next lower correlation and so on in decreasing order. Statistically, the first principal component contains the main variance and is equivalent to topographical features and the information goes in the decreasing order. The first three components were combined and visualized as a color composite. The result seemed worse than the result obtained by the averaging. So this composite was rejected for classification.

REASONS FOR REJECTION OF THE RESULTS OF DIFFERENT ENHANCEMENT AND FUSION METHODS

In fact, the image under consideration consists of mostly built up area and less natural area of trees, open land or land of cultivation. In areas, where there is more landuse detail than land cover detail, the topographic features render complexity. In our case for example, shadows behind almost all the buildings. Moreover, in some case, water reservoir or ponds or lake in the urban area was more turbid than in other area. The roofs of most of the buildings have the same intensity levels as of roads. They look alike. Similarly, water areas absorb more radiation and therefore they have very low DN values, where as shadowy areas do not receive any radiation and send no response toward the sensor. Some of the industrial area, which has nearly black roofs, has almost the same DN values as those of water.

The classification results, in this case, are all rejected. Therefore, the option of automated feature extraction by classification was abandoned (taking time into consideration). Instead, manual feature extraction using visual interpretation was done. This is since human mind takes account of other factors like texture, pattern, form and more importantly association, which are not found in the automated system. The visual interpretation was made and accordingly changes in feature were picked up from the fused images obtained on averaging and addition method.

INTEGRATION OF VECTOR DATA WITH THE IMAGE RASTER AND UPDATING

The processed image was already co-registered with the un-updated original vector data, with the allowable error value (1 pixel). Updating was done overlaying features of one class on to the image and comparing these data with the image by visual interpretation. Interpretation elements like tone, texture, shape, size, pattern, site and association were taken into account. Simultaneous uses of the elements and by applying logical inference, many features were identified. A more detailed is like this: First, one of the classes of the generalized vector data was displayed in GIS. The image was already present in the same view. Any change in the feature is digitized and feature attributes assigned accordingly. If there is reduction in the feature area of a class then it means that, this changed area falls on the area of new feature. This changed part is also digitized and assigned a new attribute relevant to it. The process is continued on till all the features of all different classes are updated.

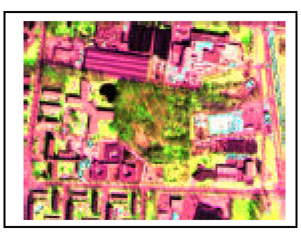

Fig 13 New Image

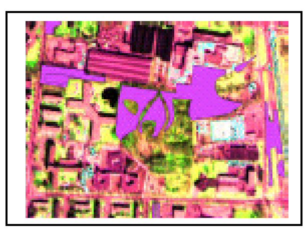

Fig 14, Old vector data showing partly forest

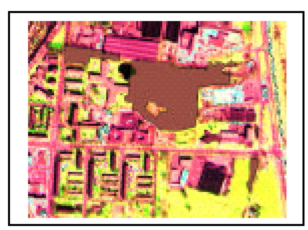

Fig 15,Forest updated

CONCLUSION

- Remote Sensing imagery of higher spectral and spatial resolution has been a promising source for information extraction.

- Remotely sensed data are seemingly more effective in terms of time and cost in updating GIS data. Feature extraction from RS data depend on the nature of geographic feature class e.g. from urban area in the image, it is difficult to extract information by classification because of low variance of spectral values (not statistically). But visual interpretation method is more efficient, less time consuming.

- It needs to be focused on the error analysis on the result of the integration of the vector and raster data.

- For a feature of highly undulated area or mountainous area, the integration of data must be associated with DEM. It is due to the flat geographic area, DEM was not considered in the work. In mountainous area, tilt and relief distortion makes the data displaced from their true position, so for hilly or elevated area, DEM must be accounted.

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