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AN APPROACH TO DEVELOP INTERPRETATION KEYS FOR THE ANALYSIS OF SINGLE BAND BHASKARA SATELLITE TV-DATA


ISRO-Space Applications Centre
Ahmedabad, India

P. SENCHAUDHURI

Indian Institute of Management
Ahmedabad, India

I INTRODUCTION

Bhaskara, the first Indian Earth Observations Satellite was launched on June 7, 1979. The two primary payloads onboard the Bhaskara satellite were two Television cameras (TV Camera) and two frequency Satellite Microwave Radiometers (SAMIR). The salient features of the TV camera and SAMIR payloads are summarised and given in Table 1.

Since the Bhaskara TV data is having a low resolution and as the data was acquired in only one band, namely, 0.54–0.66 μm, the utility of the data from the point of view of information extraction on earth resources is limited. Moreover, because of its orbital characteristics the data is acquired at different times of the day and thus under various illumination conditions.

This note discusses an approach that is designed to increase the scope of utilisation of this data. This approach is developed using both digital and photographic techniques with a view to arrive at a standard set of keys for analysing and interpreting the TV data. The basis of the digital technique is the frequency distribution of gray tones (reflectance values) for identifying major cover types, classifying them and generation of new data sets by assigning pseudo grey codes to the classified data. The pseudo gray coded data is then used to generate photographically colour codes for each of the cover type. Each pseudo data set is turned into a photographic film transparency and is assigned the colours red, green and blue respectively. The colour composite made using these transparencies is the new colour coded thematic ground cover picture from Bhaskara.

II METHODOLOGY

Let \( Z = \{ z_i | i = 1, \ldots, n \} \) be the data set corresponding to an image frame, where \( N \) is the total number of pixels and if \( f_k, i = 1, \ldots, n \) be the frequency for the frame corresponding to the gray value \( i \), then

\[
N = \sum_{i=0}^{n}\frac{n_i}{6}
\]

where \( n_i+1 \) is the number of gray levels recorded by the slow scan TV vidicon camera. Also, let

\[
I = \{ m_i | 0 \leq m_i \leq n \}
\]

be the sequence of relative minima and

\[
J = \{ M_j | 0 \leq M_j \leq n \}
\]

be the sequence of relative maxima for the frequency distribution given in equation (1). From these two sequences \( I \) and \( J \) form the two sequence \( I' \) and \( J' \) of stable minima and maxima respectively such that

\[
I' = \{ i | i \in I ; f_{i-1} > f_i < f_{i+1} \} \quad \ldots (2)
\]

and

\[
J' = \{ j | j \in J ; f_{j-1} < f_j > f_{j+1} \} \quad \ldots (3)
\]

where, \( f_{k-1}, f_k, \) and \( f_{k+1} \) are the frequencies at the three consecutive relative minima and maxima.

The sequences \( I' \) and \( J' \) are used to identify the clusters existing in the data set \( Z \) on the basis of the hypothesis that there exists at least one stable maximum between two stable minima. The limits of the clusters are obtained in the following way

Let

\[
I' = \{ x_1, \ldots, x_m \}
\]

and

\[
J' = \{ y_1, \ldots, y_m \}
\]

are the sequences of stable minima and maxima respectively then

\[
C_i = \bigcup_{j=k}^{l} \{ x_j, x_{j+1} \}
\]

where, \( y_j \in [x_k, x_{k+1}] \) and \( x_{k-1} \) is the upper limit of \( C_{i-1} \), \( C_i \) is the \( i \)-th cluster whose grey values lie between the range \( x_k \) and \( x_{k+1} \).

Then a lookup table is generated with the clusters and their limits. This table is used to classify the data set \( Z \).
The classified data set is assigned pseudo codes, one code for each cluster, where values are assigned by taking into consideration the light reflectance properties of the objects represented in the clusters. Three such data sets with three different grey coding for each cover type are generated and photographic transparencies are generated on a film recording system. Finally a colour coded imagery is generated photographically by exposing under controlled conditions with the three primary colours, namely, blue, green and red. The colour tones generated out of this product can be used as keys for classifying and interpreting the data for extracting resources information from Bhaskara TV Camera data.

III. ANALYSIS OF DATA, INTERPRETATION AND THEMATIC MAP KEY GENERATION

A typical Bhaskara TV imagery over Himalayan region in India was chosen for testing this approach.

The reseau marks in the imagery were blocked by counting the positions of the scan lines and pixels as there was no consistency in the location of reseau marks in the frame.

The methodology mentioned in the previous section was then applied to the imagery in order to check the consistency of the result and thereby to standardise the colour coding scheme for a single band TV data.

A. TEST SITE

The data for the test site whose coordinates are (29°50'N, 77°16'E), (31°45'N, 75°E), (31°30'N, 80°E) and (32°45'N, 77°45'E) covers an area of 329x329 sq kms on the ground and is shown in figure 1. The data was analysed by using the method discussed earlier in section II. The analysis gives eight distinct clusters. The distribution of population in each of the clusters and the range of grey values of each cluster is given in Table 2. From the clustered data set three separate photo-thematic transparencies/maps were generated by giving three sets of pseudo grey codes. One such photo-thematic-map is shown in figure 2. Using these three photo-thematic-maps, a colour coded picture is generated as discussed in section II.

For the above test site, the broad landcover information is available from the 'Forest Atlas of India' and is shown in figure 3. By comparing figure 3 and the colour coded picture it is possible to establish a correspondence between colour tones generated in the picture and the existing landcovers. Table 3 gives the range of gray values for the different clusters, their tones (keys) in the colour coded picture and the names of the landcovers.

It is observed from figure 3 and Table 3 that arable land shown in the existing map shows two colour tones in the colour coded Bhaskara imagery, namely, greenish, blue and orange, which may correspond to fallow/barren land and vegetated lands respectively. Again dull green tone is observed for both tropical moist deciduous forest as well as for Himalayan dry temperate forest. Also, for dry alpine scrub two tones, namely, brown and pinkish violet are seen in the colour coded Bhaskara imagery which may be because of the different dryness conditions. The light pink tone appearing in the picture could not be related with any ground cover and this may be appearing due to some mixed signatures from forest and snow. It is also noticed that water in Bhakra Nangal dam gives similar signature as snow. This may be due to specular reflectance of sun illumination from the dam water. This is difficult to distinguish from snow, probably because such high reflectance value is close to the levels corresponding to snow cover and both may be falling in the saturation region of the TV sensor response curve.

The above mentioned procedure was extended to the imagery obtained over two more test sites with a view to verify the consistency of the approach.

B. GENERATION OF KEYS

The test results from all the three sites mentioned above were combined to define keys that could be used consistently for the interpretation of all Bhaskara TV data. These keys in the form of colour tones, as explained before, were generated on the basis of clusters obtained from the spectral reflectance properties of various ground covers and by making use of available ground truth information. Table 4 gives broad ground covers and their interpretation keys.
IV. CONCLUSION

This approach of identifying clusters on the basis of a definition of relative maxima and minima in a data set and identification of a stable maximum between two minima seems to offer reasonably consistent interpretation keys for broad categories of land covers. The variations observed in the colour tones for similar ground covers may be attributed to, among other things, the omission of radiometric corrections required in the data due to the non availability of radiometric calibration information on TV data as well as acquisition of this data under different illumination conditions. These broad categories of land covers could be further sharpened, if one looks at the data along with the latest landcover maps and reference data. One major advantage of this approach is the exact delineation of a broad cover and its quantification as illustrated in Table 2.

It seems that the TV data when analysed using the above approach fulfils, to some extent, mission objectives of SEO, namely, the utilisation of Bhaskara TV data in the fields of forestry, hydrology (snow cover) and broad landuse.

V. REFERENCES


VI. ACKNOWLEDGEMENT

The authors wish to thank their colleagues in Sensor Development Division and Image Processing and Analysis Division of Remote Sensing Area of Space Applications Centre, ISRO for their cooperation and useful discussions in this work. Thanks are also due to Chairman of the Remote Sensing Area and Director of Space Applications Centre for providing facilities and encouragement to carry out this work. The support provided by Shri Naresh Bhatnagar in typing this manuscript is thankfully acknowledged.

Table 1

<table>
<thead>
<tr>
<th>Bhaskara Orbit and TV Sensor specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhaskara Orbit Specifications:</td>
</tr>
<tr>
<td>Altitude : 525 kms (nominal)</td>
</tr>
<tr>
<td>Inclination : 51°</td>
</tr>
<tr>
<td>Type : Near circular (non-sunsynchronous)</td>
</tr>
</tbody>
</table>

| TV Payload specifications:                 |
| Type of camera : Slow Scan Vidicon, Two   |
| bands (0.54–0.66 μm and 0.75–0.85 μm)     |
| Ground Resolution : 1 km (approx.)        |
| Ground Coverage per frame : 340x340 km²   |
| Quantisation level : 7 bits               |

SAMIR Payload specifications:

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>19.1</th>
<th>22.235</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Bandwidth (MHz)</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Brightness Temperature Resolution (o_K)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Spatial Resolution (kms)</td>
<td>150</td>
<td>230</td>
</tr>
</tbody>
</table>
### Table 2. Statistics of clusters

<table>
<thead>
<tr>
<th>Cluster No.</th>
<th>Cluster interval</th>
<th>Population</th>
<th>% of total area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9 - 52</td>
<td>9,645</td>
<td>6.18</td>
</tr>
<tr>
<td>2</td>
<td>52 - 60</td>
<td>8,896</td>
<td>5.70</td>
</tr>
<tr>
<td>3</td>
<td>60 - 64</td>
<td>7,534</td>
<td>4.83</td>
</tr>
<tr>
<td>4</td>
<td>64 - 72</td>
<td>16,864</td>
<td>12.08</td>
</tr>
<tr>
<td>5</td>
<td>72 - 87</td>
<td>27,638</td>
<td>17.72</td>
</tr>
<tr>
<td>6</td>
<td>87 - 111</td>
<td>17,864</td>
<td>11.45</td>
</tr>
<tr>
<td>7</td>
<td>111 - 123</td>
<td>4,784</td>
<td>3.05</td>
</tr>
<tr>
<td>8</td>
<td>123 - 127</td>
<td>58,478</td>
<td>37.49</td>
</tr>
<tr>
<td>9</td>
<td>0 - 9</td>
<td>2,315</td>
<td>1.50</td>
</tr>
</tbody>
</table>

### Table 3. Correspondence between clusters, colour tones and land cover. Class/Cover type in the test site.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Original Grey Values Range</th>
<th>Colour-Code</th>
<th>Possible Class/ Cover type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9 - 52</td>
<td>Red</td>
<td>Himalayan moist Temperate Forest</td>
</tr>
<tr>
<td>2</td>
<td>52 - 60</td>
<td>Brown</td>
<td>Dry Alpine Scrub</td>
</tr>
<tr>
<td>3</td>
<td>60 - 64</td>
<td>Pinkish Violet</td>
<td>Dry Alpine Scrub</td>
</tr>
<tr>
<td>4</td>
<td>64 - 72</td>
<td>Dark Green</td>
<td>Tropical moist deciduous forest and Himalayan dry Temperate forest</td>
</tr>
<tr>
<td>5</td>
<td>72 - 87</td>
<td>Orange</td>
<td>Arable Land (with vegetation)</td>
</tr>
<tr>
<td>6</td>
<td>87 - 111</td>
<td>Greenish Blue</td>
<td>Arable land (Barren/Fallow)</td>
</tr>
<tr>
<td>7</td>
<td>111 - 123</td>
<td>Light Pink</td>
<td>Unclassified (mixed signature)</td>
</tr>
<tr>
<td>8</td>
<td>123 - 127</td>
<td>Light Blue</td>
<td>Snow</td>
</tr>
</tbody>
</table>

### Table 4. Keys for interpretation of Bhaskara-TV data

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Colour Tone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>i) Moist temperate forest</td>
</tr>
<tr>
<td></td>
<td>ii) Dry Alpine Scrub</td>
</tr>
<tr>
<td></td>
<td>iii) Tropical moist deciduous forest, Himalayan dry temperate forest</td>
</tr>
<tr>
<td>Water Body</td>
<td>i) Deep sea water</td>
</tr>
<tr>
<td></td>
<td>ii) Coastal sedimenated water</td>
</tr>
<tr>
<td></td>
<td>iii) Sedimented water</td>
</tr>
</tbody>
</table>

**Parren/Fallow land** Greenish Blue

**Vegetative Arable Land** Orange

**Snow or cloud** Light Blue

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Fig. 1: Original Bhaskara TV-data for the Test Site

Fig. 2: Pseudo coded photo-thematic-map from figure 1

Fig. 3: Broad Landcover map for the Test Site

TROPICAL MOIST DEciduous FORESTS
TROPICAL DRY DEciduous FORESTS
TROPICAL THORN FORESTS
SUBTROPICAL PINE FORESTS
SUBTROPICAL DRY EVERGREEN FORESTS
HIMALAYAN DRY TEMPERATE FORESTS
MOIST ALPINE SCRUB
HIMALAYAN MOIST TEMPERATE FORESTS
AIRBÉL LAND

SCALE: 1:2000000

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Dr. K. L. Majumder obtained his Master of Science degree in Applied Mathematics in 1968, got Diploma in Non-Linear Mechanics in 1971 and Doctorate degree in Interval Interpolation in 1975 from IIT Kharagpur, India. He joined Space Applications Centre, ISRO in November 1974 and is working in the Image Processing and Analysis Division. His current interest is in pattern recognition and handling of remotely sensed data for the extraction of resources information.

Shri A. K. S. Gopalan obtained his Master of Science degree in Physics in 1964 and Master of Electronics degree in 1966. He was working with the Department of Electrical and Electronics of Birla Institute of Technology & Science, Pilani, India from 1966 to 1970 and joined Indian Space Research Organisation in 1970. Since then he has been working in projects on satellite communications and image processing of airborne and satellite imageries from the point of view of information extraction on earth resources.

Shri D. S. Kamat studied physics at the University of Bombay, India and later at University of London, U.K. He has worked on Computer Science and Applications at the Indian Statistical Institute, Calcutta and Tata Institute of Fundamental Research, Bombay. He is Head of Image Processing and Analysis Division and Co-Chairman, Remote Sensing Area, Space Applications Centre, Ahmedabad and his current interest is in the use of remote sensing for information and management of resources.

Shri A. N. Patel got his Bachelor of Science degree in Chemistry. He joined Space Applications Centre in 1978 and have been working in the Photographic Products generation laboratory at the Centre. He has specialised in generating both colour and black and white data products required for analysis and interpretation of remotely sensed data.

Shri P. Senchaudhuri passed his Master of Science degree in Pure Mathematics in 1973. Diploma in Computer Science in 1977 and joined Space Applications Centre in 1978 and was developing systems software in an interactive digital image processing system. At present he is working at the Indian Institute of Management, Ahmedabad as a Systems Analyst.