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14. Abstract/Notes

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THE USE OF IMAGE REGISTRATION TECHNIQUE IN BRASÍLIA'S URBAN GROWTH MONITORING

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ABSTRACT

This paper describes the use of an Image Registration Program in the studies of the urban growth. The program implemented in the Image-100 (Multispectral Images Analyzer) permits a quick identification of growing areas by means of the overlap of the same scene in two or three different dates, and the use of adequate filters. The city of Brasília, Brazil, was selected for test area. The dynamics of Brasília urban growth was analysed with the overlap of scenes dated June 1973, 1978 and 1983. The results show the utilization of the Image Registration Technique for the monitoring of the urban growth.

1. INTRODUCTION

One of the most relevant information for the urban planning process is related to the dynamics of the urban growth. This kind of information is essential for analysing the tendencies of urban growth, considered in its spatial and temporal dimensions, and is useful to the decision making process related to the reorganization of urban structure.

In this work, the urban growth of Brasília, Brazil, within the last ten years, was analysed with a special emphasis on the utilization of orbital remote sensing data and automatic image processing. The urban spatial structure and the monitoring of its temporal changes were focused in a comprehensive and dynamic way by the utilization of MSS LANDSAT images.

In order to aid data interpretation, a registration algorithm implemented at the Image-100 was used, aiming at the merging of multitemporal images. The utilization of appropriate color filters, combined with the merging of the images, produced colored compositions in which specific colors identified areas of possible urban growth and oriented the field check towards their localization.

The analysis of the color composites, complemented by the interpretation of photomosaics from different dates and field checking, allowed an evaluation of the urban growth of Brasília from 1973 to 1983. This evaluation was done taking as reference the Pilot Plan elaborated by the urbanist Lucio Costa in 1957-1970) for the construction of this planned city. The city was inaugurated in 1960 as the new capital of Brazil in an effort to lead Brazilian national deve

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lopment towards inland.

Figure 1 shows the test area which was delimitated in accordance to the working scale of the images and the purpose of the present paper as well.

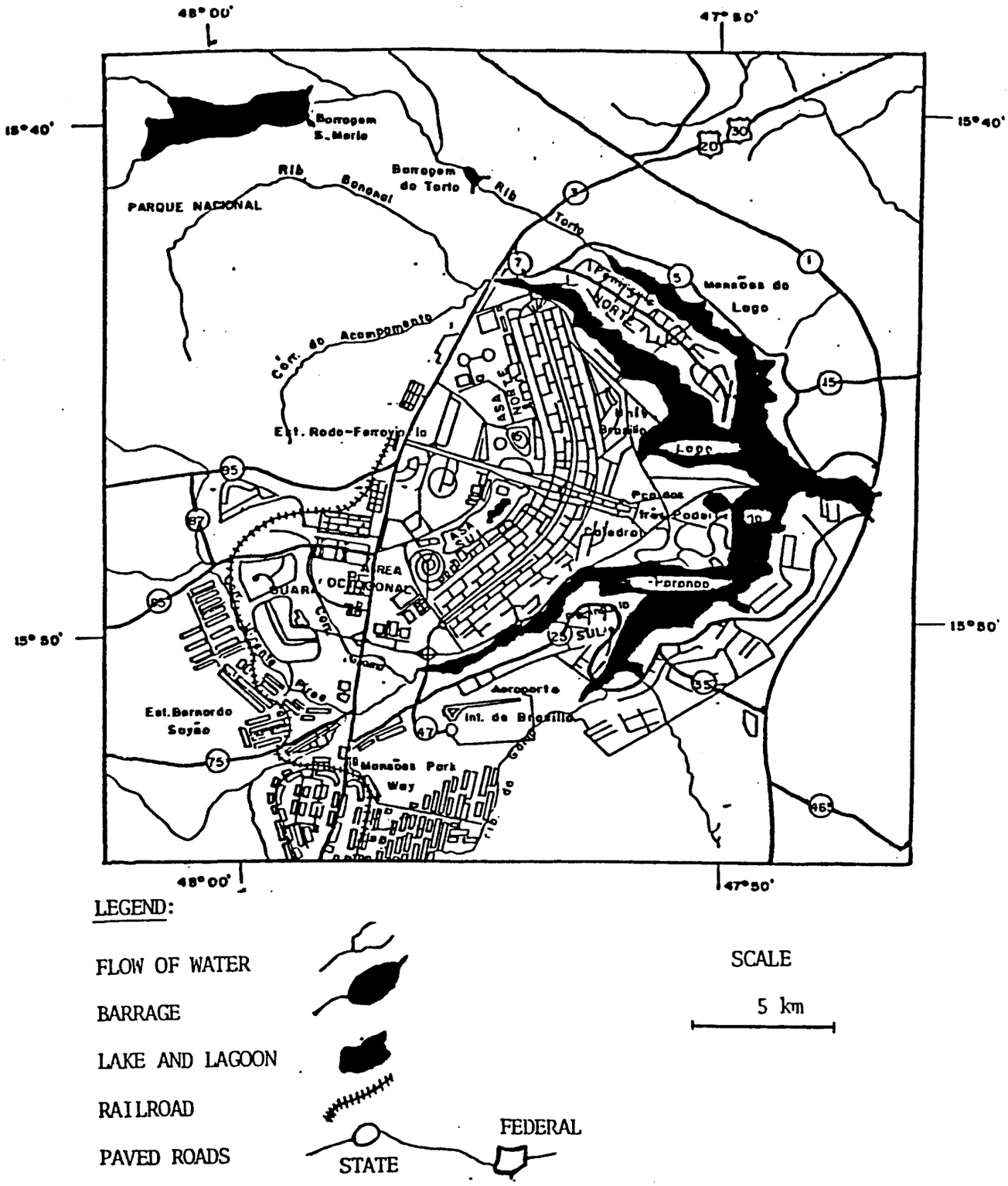


Figure 1. Test Area - Brasília, Brazil

2. METHODOLOGY

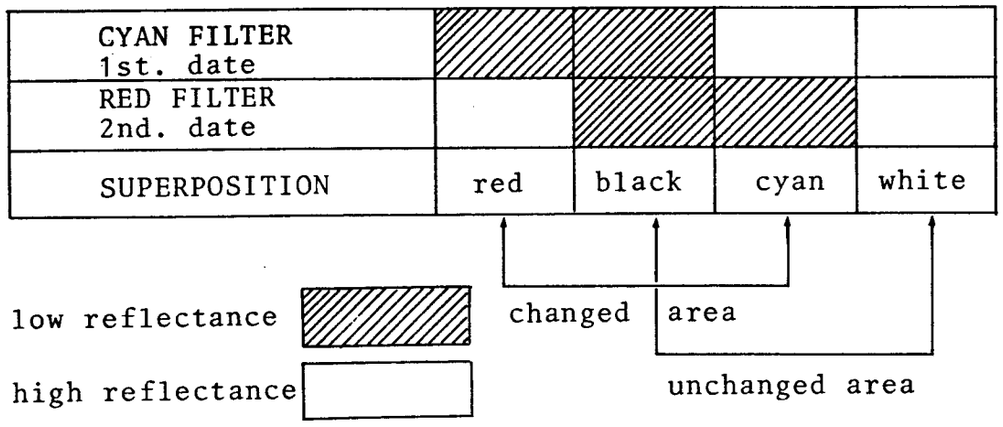
Viewing the objective of the present study and due to the available supply f MSS/LANDSAT data, it was possible to use 1973, 1978 and 1983 MSS/LANDSAT igital data of the test site. The three selected dates (June for all of them) correspond to the regional dry season. A 5-year interval between the data was onsidered highly appropriated to the nature of the present study - the identi ication of urban growth.

In this study it was used an Image Registration Program developed by the igital Image Processing Laboratory at CNPq/INPE. Through this program the mage-100 superposes the time-progressive-taken images and performs the neces sary geometrical transformations to correct the differences between the MSS nages produced by different satellites, in order to coincide the corresponding icture elements (pixels). Through the use of this program and of appropriate color filters, a set of multitemporal color composites were obtained.

Using the channel 5, at the 1:100,000 scale, corresponding to the 1973, 1978 and 1983 images, three color composites resulting from the registration of 1973-1978, 1978-1983, 1973-1983 images pairs, and one color composite result ng from the registration of 1973, 1978 and 1983 images simultaneously, were obtained.

The color composites related to the merging of two images were obtained ssociating the blue and green (cyan) filters to the former image, and a red filter to the later image of the pair.

Figure 2 shows the procedure to obtain this color composities.



igure 2. Multitemporal color composite obtained with the automatic registra tion of two scenes and color filters (adapted from Eyton, 1983).

The resulting image on the screen of the Image-100 is a color composite, analysed as follows:

a) As the unchanged areas receive the same amount of complementary colors, hey fall into a gray scale, in which the brighter gray values correspond to urban areas or bare soil, while the darker gray values correspond to vegetation over or water surface.

b) The changed areas are represented by cyan or red. When they are shown in cyan, it means that the changes were from a high to a low value of target reflectance between the two dates, and so one concludes that bare soil was substituted by vegetation. The red areas correspond to changes from low to high values of target reflectance, which are related to the substitution of vegetation for bare soil or urban area.

As an alternative procedure to evaluate Brasília's urban growth, it was produced a color composite from the merging of three images, associating the blue, green and red filters to the first, second and third images, respectively.

Figure 3 shows the results expected from this color composite

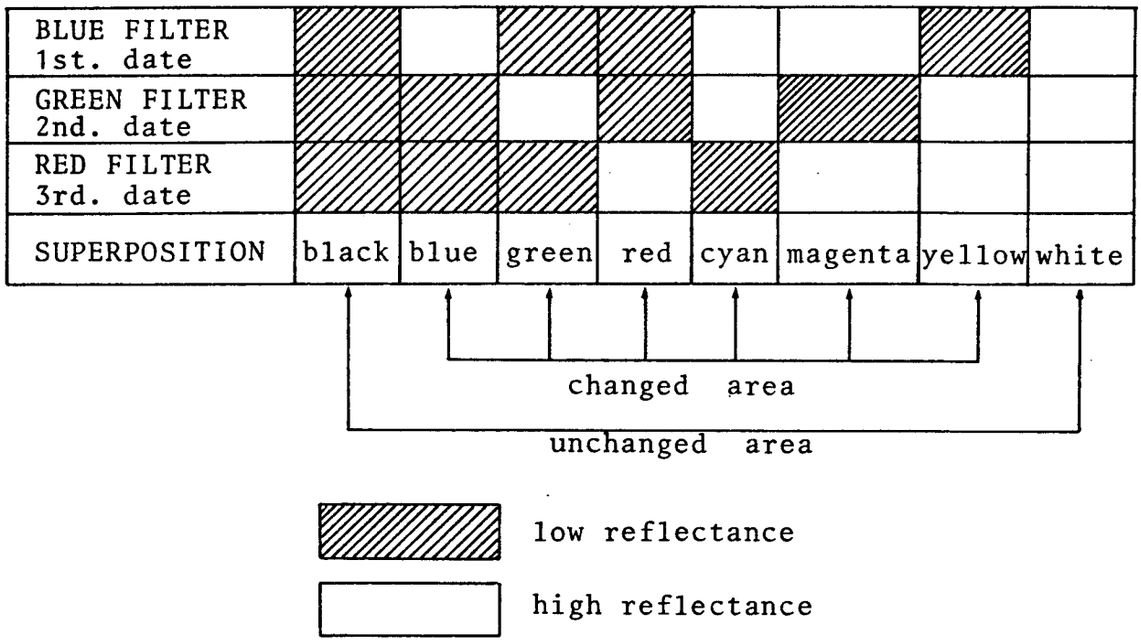


Figure 3. Expected results from the multidate color composite obtained by digital registration and color filtering (adapted from Eyton, 1983).

The resulting image in the screen of the Image-100 is a color composite to be analysed as follows:

a) The enchanged areas, considering the three passages of the satellite, are presented in a gray scale in which the bright gray values correspond to urban areas or bare soil, while the dark gray values correspond to vegetation cover or water surface.

b) The changed areas are shown in blue, green, red, cyan, magenta or yellow. The different colors are consequence of the process of substitution of land-use, leading to the transformations of the target reflectance values from high to low and vice-versa in the image. The color differences facilitate the discrimination of most of the land-use changes within the scene at different dates. An important feature observed in the results is the fact that the yellow color represents areas that at the scene of 1973 were occupied by vegetation, and the red color may represent areas in which the vegetation, present in 1973 and 1978, was substituted by urban land-use at 1983 scene.

The theoretical models presented in Figures 2 and 3 are based on the fact that the unchanged areas (with similar reflectance values in the three scenes), result in gray levels when the blue, green and red filters are associated to

ach date at Image-100 screen; and that the changed areas present different colors as a consequence of the sequence of changes in land-uses in the analysed scenes.

These models require some control over the dynamic range of the gray scale in the different images.

In this work, the selected images showed gray scale variations, probably as a result of change in sensor characteristics of the different satellites (LANDSAT 1, 2 and 4), atmospheric effects or data recording.

To minimize those variations, the following procedure was applied:

a) the best image to define the Brasília's urban area was chosen as tandard image, with no change in the gray levels of this pixels;

b) the gray levels of the other images was changed applying the following inear model:

$$N_s(i,j) = aN_e(i,j) + b,$$

where:

$N_e(i,j)$ represents the gray level of the picture element i, j in the image to be changed;

$N_s(i,j)$ represents the gray level of the pixel i,j of the changed image;

a and b are constants obtained using the mean and variance of the sample gray levels of the image to be changed and of the standard image in each defined land use class.

The analysis of the color composites, complemented by photointerpretation of mosaics from different dates and field checking allowed the determination of the Brasília's urban growth from 1973 to 1983 and the confirmation of the method as a tool for urban growth monitoring.

3. RESULTS AND DISCUSSION

The visual interpretation of the three color composites, resulting from the registration of the 1973-1978, 1978-1983, 1973-1983 pairs of images, helped the identification in each one of these composites of the unchanged areas, which appeared in shades of gray, and of the areas where there could be urban development between the two passages which appeared in red color.

The analysis of the multitemporal color composite, resulting from the merging of the images of 1973, 1978 and 1983, also helped the evaluation of Brasília's urban growth during the period of interest.

According to the model presented at Figure 3, and the analysis of the data obtained through this composite, it was possible to identify the growing areas which appear in yellow and red tones, corresponding to the growth observed from 1973 to 1978 and from 1978 to 1983, respectively.

The areas of bare soil for agricultural use or for extraction of material for building purposes (quarry), which were largely evident in Brasília's environment, appear in the same colors as that of urban growth. The precise discrimination between these areas and that ones was done through the interpretation of photographic mosaics and/or later field works.

The unchanged Brasília urban area from 1973, 1978 and 1983, with high reflectance in the three analysed images, was shown in the multitemporal color composite in white color, according to the theoretical model presented in Figure 3.

Through the use of the multitemporal color composite resulting from the merging of the 1973-1983 images, it was possible to identify:

1) the diffuse residential densification in certain areas such as "Peninsula Norte", "Península Sul", and "Mansões dos Lagos";

2) some blocks of constructions in "Asa Norte";

3) the expansion of the urban nucleus in the outskirts called "Guará I" and "Guará II";

4) the growth of the urban invasion (slum) in the area of "Barragem do Paranoá", which became twice as large as it had been;

5) the settlement of the housing area "Octogonal", which had not been formerly proposed in the Pilot Plan elaborated by Lucio Costa.

Using the two multitemporal color composites resulting from the merging of 1973-1978 and 1978-1983 images, or alternatively the multitemporal color composite resulting from the use of the three images simultaneously, it was possible to identify more precisely the occasions of these events.

The resulting color composite from the superposition of 1973-1983 images enhanced the urban growing tendencies, as well as other ground changes, also shown in the other intermediate paired composites, such as the environmental alterations caused by the urban growing of Brasília, the extraction of material for building purposes and the soil erosion caused by it. In temporal analysis, some land-use changes were better identified by the intermediate paired composites or by the three date multitemporal color composite. For example: the largest urban invasion in Brasília, which happened in "Barragem do Paranoá", must have occurred in the period of 1978-1983, since no growth in this area was presented in the 1973-1978 image.

The same is true with relation, for example, to the settlement of the housing area "Octogonal", which was clearly settled after the 1978 overflight of the LANDSAT satellite. This fact is promptly identified through its red color in the three dates color composite.

The advantage of the merging of 1973, 1978 and 1983 images, in relation to the paired composities, is that it permits the analysis of the urban growth in each one of the time intervals between the dates using only one multitemporal composite.

4. CONCLUSIONS

The Image Registration Technique complemented by the use of adequate filters prove to be useful to obtain analytical data about a city dynamic growth.

The color composites easily identified when and where there was the change of a low reflectance target for a high reflectance target, which corresponds to the urban growth process. By the color discrimination, those areas where this change took place were spotted from those where no change occurred.

The bounding of the altered areas of Brasília in the analysed period, by the registration of the satellite data, reduced the fieldwork which could be directed to those specific sites to verify whether they really corresponded to the urbanized areas.

During the present study there were some difficulties which are to be approached in future researchers. Firstly, to compare the Brasília urban structure in the mentioned periods, LANDSAT 1, 2 and 4 data were used, which made difficult the superposition of the images, which took longer due to the geometrical differences in the results of the MSS sensor system. Secondly, urban area and the areas of bare soil, for agricultural use or for extraction of material for building purposes, are displayed in the same color because of their high reflectance. It would be desirable in future works to test some procedures for discriminating between these two targets.

It is also important to mention that the choice of Brasília as test area may have simplified the use of the method described, because Brasília is a planned city, with a rational urban network. It is advisable to apply the method to a nonrational organized city.

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