IMAGE SEQUENCE ANALYSIS

Dana Klimešová, Tomáš Suk

Institute of Information Theory and Automation,
Academy of Sciences of the Czech Republic
Pod vodárenskou věží 4, 182 00 Praha 8, Czech Republic

Telephon: 42 2 6605 2247, 42 2 6605 2586
Telefax: 42 2 6641 4903
e-mail: klimes@utia.cas.cz

Commission V, IWG V/III - Image Sequence Analysis

KEYWORDS: Forestry, Analysis, Transformation, Algorithm, Multitemporal

ABSTRACT:

The contribution deals with temporal context information in the field of temporal image data sets processing. We propose the special comparative transform which make possible to evaluate the objects dynamics along the temporal axis. We present examples of forest dynamics analysis using aerial data sets from the last about fifty years.

1. INTRODUCTION

Multisource and temporal analysis represents a very effective method how to gain information about the state, dynamics and future trends of observed landscape objects and phenomena. Together with the technology of geographical information systems it is a powerful tool to provide a new quality of information. We used time series of aerial photos to monitor the changes during fifty years aimed at forest devastation, prevention process evaluation and at the mapping of the range of mining activity in the selected territory

2. TEMPORAL ANALYSIS

2.1. Temporal layers creating and preprocessing

Having in disposal temporal data sets from the observed territory we are able even visually recognize some significant changes but we are not able to quantify them and distinguish enough all changes and their dynamics. Usually we are dealing with data sets from different sources which differs in resolution and technology of scanning. In the case we have to use more than five temporal layers the problems usually occur because of control points selection. To cover the selected area it was necessary to consider 48 photos from 12 years. The first step we need to do was the geometric transformation of all images (digitized aerial data sets). The registration had to be done both inside one time layer and for all overlaying layers. Great changes of landscape in case of long period make impossible to use the same set of control points for corresponding temporal layers. This fact is more complicated when highly corrugated terrain is processed. The difficulties are simplified when suitable map layer is used as a reference image. We have to estimate the type and parameters of the mapping function. For the purposes of error estimation the translation, similarity, affine, projective, quadratic and surface spline transform have been applied with at least 20 control and 12 test points for temporal layer.

2.2 Error estimation

Error estimation in the number of points with respect to control and test points was as follows:

Type of transform	control points	test points
translation	39,362	87,034
similarity	4,544	4,669
affine	3,835	3,486
projective	3,909	3,643
quadratic	2,476	2,646
spline	0,000	1,925

It means that the error less then 2 pixels was only yielded by the surface spline transform.

$$u = a_0 + a_1 x + a_2 y + \sum_{i=1}^{n} f_i \, r_i^2 \ln r_i^2$$

$$v = b_0 + b_1 x + b_2 y + \sum_{i=1}^{n} g_i \, r_i^2 \ln r_i^2$$

where

$r_i^2 = (x - x_i)^2 + (y - y_i)^2 \quad i = 1,2,\ldots,n,$

n is the number of control points,

(x_i, y_i) and (u_i, v_i) are coordinates of control points in transformed and reference images respectively

(x, y) and (u, v) are coordinates of transformed and reference image.

The coefficients

$a_0, a_1, a_2, b_0, b_1, b_2, f_i$ and g_i

$i = 1,2, \ldots, n,$

we can obtain as solution of the systems of $n+3$ equations

$$u(x_i, y_i) = u_i \qquad v(x_i, y_i) = v_i$$

$$\sum_{i=1}^{n} f_i = 0 \qquad \sum_{i=1}^{n} g_i = 0$$

$$\sum_{i=1}^{n} f_i x_i = 0 \qquad \sum_{i=1}^{n} g_i x_i = 0$$

$$\sum_{i=1}^{n} f_i y_i = 0 \qquad \sum_{i=1}^{n} g_i y_i = 0$$

We decided to use this transform.

3. COMPARATIVE POINT TRANSFORM

Let us assume we have temporal data set of registered images $I_k(x,y) \quad k = 1,2,\ldots,n.$

Then we are able to gain temporal layers $T_k(x,y) = T_k$ classified with respect to selected object or phenomenon the dynamics of which we are going to investigate. See figure 1 as an example.

The reasonable range of temporal layers used to one comparative analysis is about 3-8, taking into consideration that the result has to be distinguished for human perception. In the case n = 4 layers it means we have 16 temporal states of object but for n = 5 layers it is 32 states to express.

We propose to define

$$I_R = a_1 T_1 + a_2 T_2$$

$$I_G = b_1 T_2 + b_2 T_3 + b_3 T_4$$

$$I_B = c_1 T_3 + c_2 T_4 + c_3 T_5$$

where T_1, T_2, T_3, T_4, T_5 are values of one pixel in each of the layer we suppose the binary images, I_R, I_G and I_B are values of the same pixel of the red, green and blue component of the result color synthesis. Coefficients a_l, b_m and c_p for $n = 4, 5$ are presented in table 1.

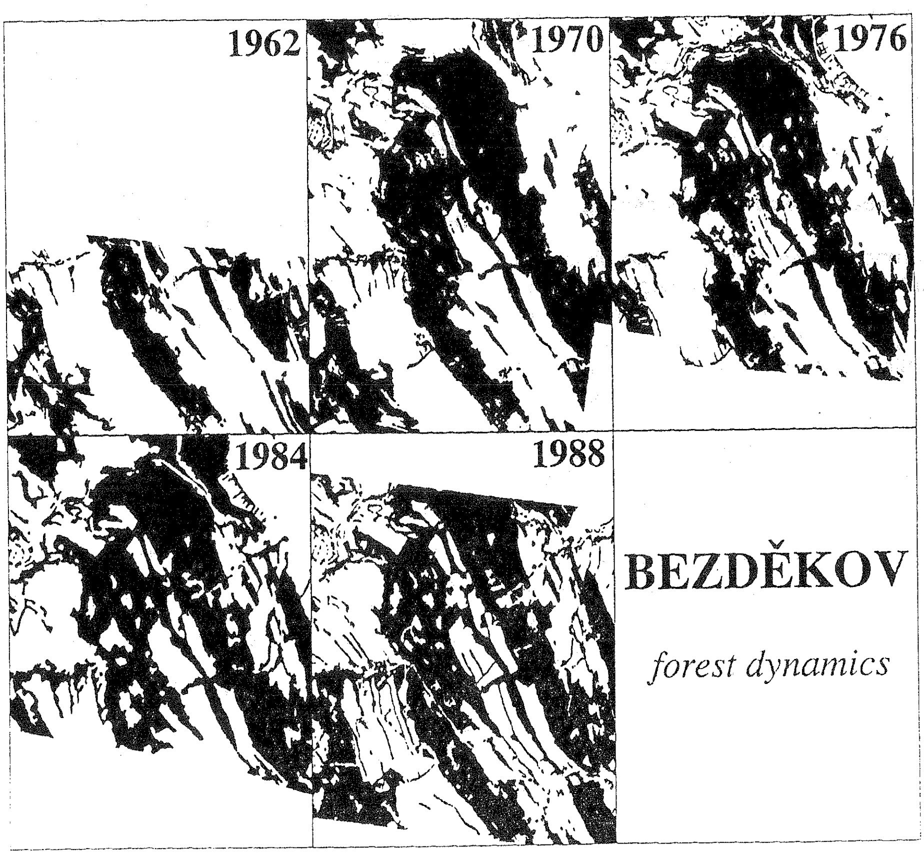

Fig. 1 Five temporal layers of observed area

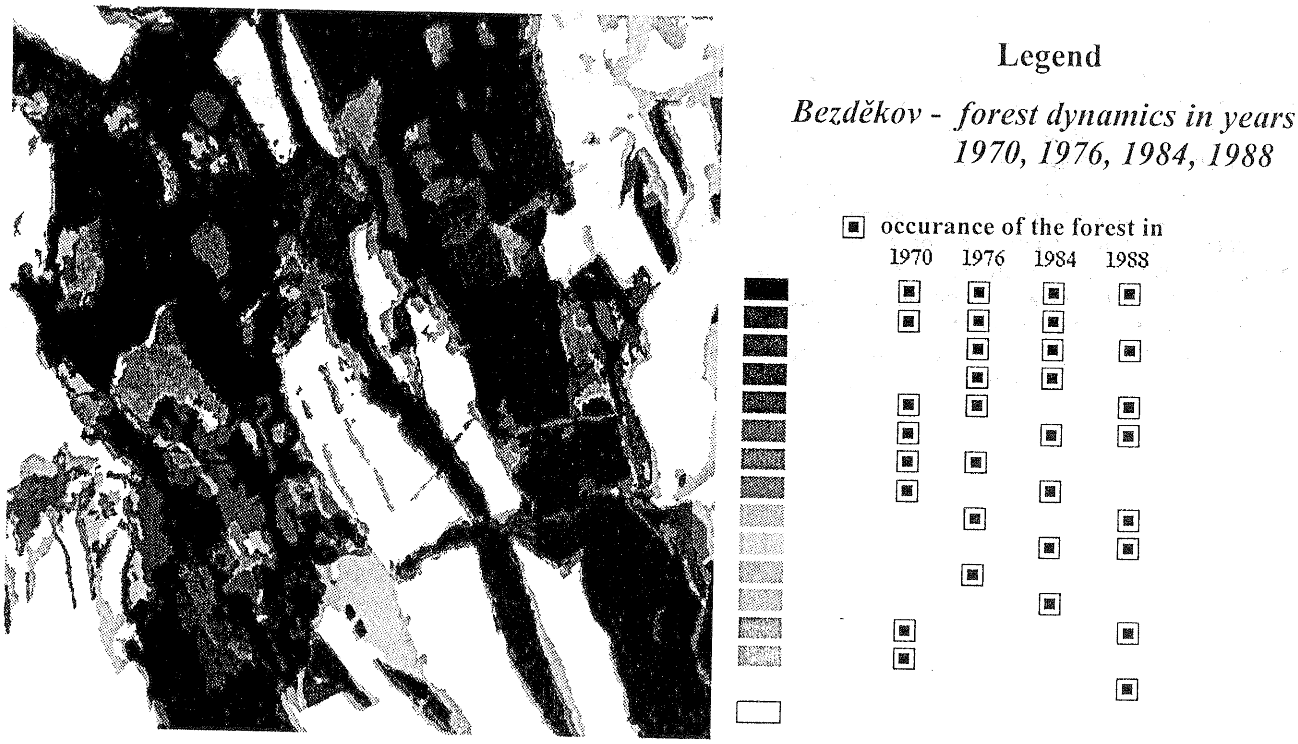

Fig. 2 Temporal analysis of the area Bezděkov

On the basis of the preceding considerations, it is possible to achieve the set of equations for n = 6, 7, 8. When 6 - 8 temporal layers are analyzed we must compose each component separately. It actually means:

$$I_c = \frac{1}{3}T_k + \frac{2}{3}T_{k+1} \quad , \text{ where } \quad k = 1, 2, \ldots, 7$$

for two layers per component and

$$I_c = \frac{1}{7}T_k + \frac{2}{7}T_{k+1} + \frac{4}{7}T_{k+2} \quad \text{for} \quad k = 1, 2, \ldots, 7$$

in the case of three layers per component, where I_c stands for I_R , I_G or I_B .

n	a_1	a_2	b_1	b_2	b_3	c_1	c_2	c_3
4	0,75	0,25	0,5	0,5	0	0,25	0,75	0
5	0,6	0,4	0,2	0,6	0,2	0	0,4	0,6

Table 1: Coefficients of equations for n = 4, 5

3.1 Statistical evaluation

The computerized process using comparative point transform enables to evaluate qualitative as well as quantitative the development of temporal object along the selected temporal layers.

year	%	decrement/increment compared with the year before		balance in %
1962	100			
1970	108	-10	+18	90
1976	92	-24	+10	76
1984	110	-21	+41	79
1988	121	-8	+18	92

Tab. 2: Bezděkov - statistical evaluation for 1962-1988 years in percentage - five time layers

year	number of pixels	decrement/increment compared with the year before		balance
1962	30 576			
1970	32 914	-3 029	+5 367	27 547
1976	28 164	-7 885	+3 135	25 029
1984	33 751	-6 010	+11 597	22 154
1988	36 966	-2 787	+6 002	30 964

Tab. 3: Bezděkov - statistical evaluation in the number of image pixels

4. COMPARATIVE RESULTS

The method of multisource and temporal analysis was applied in the north-east Bohemia district to monitor forest dynamics during the last 50 years and in the National Park Šumava to analyze the evolution of the forest and urban areas. 12 temporal data sets of aerial data have been processed and dynamics of selected objects was analyzed. Various combinations of temporal layers were evaluated with very interesting results, namely with respect to the territory where the aimed process of local protection was accepted twenty years ago to decrease the impact of the power station and existing mining activity (the area of Bezděkov). See Fig. 2 as an example.

5. REFERENCES

Flusser J., SuK T., 1994. A moment-based approach to registration of images with affine geometric distortion, IEEE Trans. on GRS, vol. 32, No. 2.

Klimešová D., Havel J., Saic S., 1992a. Regional planning an d control using satellite data, Proc. of the International Space Year, Munich.

Klimešová D., Havel J., Saic S., 1993. Multitemporal and multisource analysis, image analysis and synthesis, R. Oldebourg, Vienna, Munich.