GIS and Aerial Photographs for Change Detection around New Highways in the Czech Republic

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Abstract: Road network is an important phenomenon creating a landscape. Its original purpose was to connect urban areas among themselves, and to allow reaching other important places – forests, fields, mines, etc. Due to long distances, places for refreshment appeared around roads to make traveling possible or more pleasant. The 20th century brought a new feature. Large business/industrial areas were built up alongside certain roads, or highways. CORINE data were used for selecting areas, which changed after new highways had been built up – starting parts near large towns as an enlargement of town areas – and other localities. These places will be compared to areas, which stayed untouched by human activities even though they are along highways, too. Reasons for large new built up areas will be discovered by GIS tools and by using aerial photographs showing developments of these areas before, during and after building with several years´ time difference since 50-ies of the 20th century.

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1. INTRODUCTION

The Department of Economy of the Faculty of Civil Engineering was awarded a grant Sustainable management in microeconomy and its socially legal aspects. The Department cooperates with another departments of the Czech Technical University – Department of Road Construction, of Social Sciences, Mathematics, and the Remote Sensing Laboratory and others. The Remote Sensing Laboratory There are nearly 30 hypothesis which are being analyzed during the project. One of them – Road network as a presumption land development and as a condition of the economical growth where the growth is calculatable according to the road network.

The goal of the project is to define relations among various civil constructions, their prices, life, maintenance costs and other features connected to constructions. Motivation of the project comes from different conception of benefit, usage, sustainability from the economic point of view and engineering point of view. Interaction of these two points of view is not unambiguous due to information loss in preparation and creation input data for resulting economical information.

The road network influence was changed after discussions with economists and civil engineers to highway influences. The Czech Republic owns about 400 highways. The first of them connected Prague and Brno as two largest towns of the country in 70-ies. This highway is an exception among highways being constructed as a completely new connection route unlike other highways, which are copies of before existing roads. There are two periods – one of them represented by state planned economy (till 1989), the second one after 1989. It was decided to study only the period since 1989.

2.THE PROJECT GOAL

The final project goal was divided into folowing steps:

1) to choose data suitable for time change detection
2) to find changes in certain distance from highway exits (highway buffer zones)
3) to detect new industrial units, business areas, and other human activity localities in the highway buffer zones from all found changes
4) to compare the anthropological changes with neighbor urban areas, with neighbor of already existing industrial or business enterprises, with neighbor of waterways
5) to compare price map values with the anthropological changes
6) to determine causes of localizing of these objects to assess whether the highways neighborhood was the necessary condition for localizing

3. DATA SELECTION

The data choice was based on three level data sets – CORINE data, SPOT data and aerial photographs.

CORINE data were the first data sets. CORINE data are land use data determined by individual European countries according to the same list of hierarchical set of classes. Two time level data were used for change detections – data from the beginning of 90-ies and 2000. The changes were determined in relations to highways. The relation was defined as the 15 kilometers distance from highways exits. The data represent 1 : 100 000 scale. The smallest mapped unit are 25 hectares. If expressed as a square area, it is 500 by 500 sq. meters. Smaller object information is excluded from the result. This fact caused that the second step of the analysis continued in other data – remote sensing data. Areas with important changes in buffer zones around highway exits were applied for two time level SPOT scenes.

SPOT data as the remote sensing data were used for the larger scale analysis. Panchromatic data with 10 m/5 m resolution were selected for the evaluation. Image processing for change detections allowed to chose final areas with pre-defined conditions: distance from highway exits, land use change where the change is from agricultural areas or areas with vegetation to areas used for industry, business purposes or housing. The SPOT data served as a tool for the final data selection – aerial photographs/orthophotos.

Aerial orthophotos as more detailed remote sensing data are being processed for the final change detection and form the third, last and most detailed data level.

4. METHODOLOGY

The methodology comprises both GIS evaluation, and remote sensing image processing. The GIS tool was used for two time level CORINE data where changes were determined as overlaid areas. Resulting areas were areas whose change was from agricultural land use or vegetation land use to urban land use – economical objects or areas for housing. The second condition for the selected areas was based on their size which had to be larger than 25 hectares and therefore equal to the smallest mapped unit in CORINE data. The second condition was combined with the third condition limiting optional shapes to shapes whose minimal width had to be longer then 30 meters.

Image processing approach was used for remote sensing data processing – satellite represented by SPOT image data and aerial orthophotographs.

The goal of the image processing was to detect changes between vegetated and non- or less vegetated areas.
Change detection forms an important in image processing. The methods can be divided into two groups – methods for monochromatic (panchromatic) image data and methods for multispectral image data. Image data division useful due to suppression of differences in solar angle or view angle is presented e.g. by Williams (1995). Another group of methods is based on subtraction. The subtraction can be performed for image digital values or recalculated image values. These methods are presented in many publications for image processing and remote sensing (Lillesand and Kiefer, 1987, Jensen 1986). Spectral change vector presenting two pairs of smallest and highest change in a certain thematic region is another possibility for change detections and was published by Singh (1989).

Change detection in presented paper were tested by several map algebra methods which were used and mutually compared. The best of them were applied for the both remote sensing data types. The list of methods comprises subtraction and its variations shown in Fig. 1.

5. RESULTS

The methodology was tested at B&W aerial photographs whose orthorectification was uncoditionally necessary.

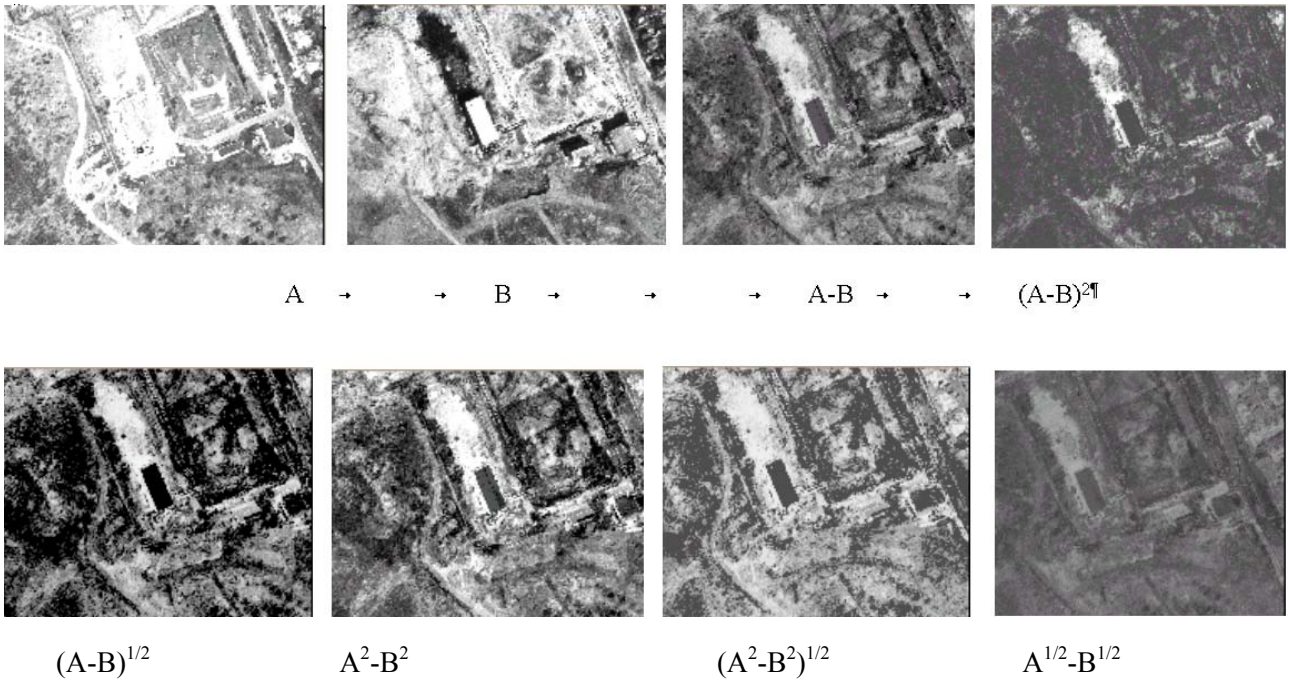

Figure 1. A and B aerial photos with time diference showing land use changes, other image are examples of map algebra applications. The images show differences in vegetation cover, in urban object occurrence.

The best results are in case of subtraction $A^2 - B^2$ where change detections of in vegetation areas (in areas with small differences in digital values) is slightly suppressed. Square root of the image $(A - B)^{1/2}$ is the most suitable for these small change areas. It is useful to control results for change detectio also by calculation of A - B, $(A^2 - B^2)^{1/2}$ a $A^{1/2} – B^{1/2}$ which should not be rejected. Other cases as log A – log B and $(A - B)^2$ or exponential functions are not suitable due to restrained information about changes. Changes in areas with very different recorded values beteween two time levels can be easily detected by log (A - B).

6. CONCLUSION

Methods using map algebra expressions ($A^2 - B^2$, $(A - B)^{1/2}$, A - B, $(A^2 - B^2)^{1/2}$ a $A^{1/2} – B^{1/2}$) will be applied in future project steps for time change detection both for SPOT panchromatic data and aerial orthophotos. The expression $A^2 - B^2$ will be used as the first step and other expressions will be used as controlling and verifying steps.

The results of image processing will be implemented in GIS where relations among other data and detected changes will be studied – neighborhood of towns, of other industrial or business areas, unemployment percentage, previous land use and prices from price map etc.

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