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MONITORING THE CHANGES OF A SUBURBAN SETTLEMENT BY REMOTE SENSING

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Abstract

Satellite images and aerial photos support settlement surveys and provide valuable information of their physical environment. Aerial photos are excellent tools to overview large areas and simultaneously provide high-resolution images making them efficient tools to monitor built-up areas and their surroundings. Aerial photos can also be used to collect complex spatial data as well as to detect various temporal changes on the land surface, such as construction of illegal edifices and waste dumps. The 10 to 30-meter resolution SPOT and Landsat images are usually insufficient for site specific data collection and analysis. However, the recently available 0.5-meter resolution satellite images have broadened the scope of monitoring and data collection projects. Beyond environmental and urban monitoring, the new available high-resolution satellite images simplify the everyday work of local authorities and will facilitate the development of governmental databases that include spatial information for public utilities and other communal facilities.

Keywords: remote sensing, GIS, urban geography

1. Introduction

Aerial photographs have been widely used in various studies, in the fields of e.g. archeology, and localization of subsurface pollution, illegal waste dumps, and soil erosion. Aerial photos are also feasible for the estimation of crop yield, determining the health of natural cultivated vegetation, and temporal changes of glacier mass balance (e.g.: Braasch, 1997). Remote sensing and GIS methods have been used for the detection of various physical phenomena by several authors (Gyenizse et al. 2005; Gyenizse et al. 2007; Czigány et al. 2008).

To determine the environmental impacts and the available natural resources of urban and semi-rural areas, we need to study the mutual interactions between the settlements and their physical environment. On the one hand, the differences of physical environment determined the development of settlements with both dense and diffuse population distributions. On the other hand, over time, socio-economical processes reacted with the physical environment, and sometimes changed it dramatically (Balassa et al. 2008). We get important data and information from historical geography (Frisnyák, 1995; Kőszegfalvi, 1997; Lovász

1982; Somogyi, 1996), building up a modern database that is necessary to explain the socio-economic changes in different settlements in Hungary. The effects of the infrastructural and regional development of spatial processes of the urbanization were first discussed by various socio-geographical studies (Kőszegfalvi, 1997; Tóth, 2007; Szebényi, 2006; Timár, 1994; Timár and Váradi, 2001). The analysis with conventional methods usually predicts negative results for large settlement and positive development for small ones. The research based on GIS and numerical methods give more objective results. Settlements have different physical environment, but while some have very similar physical surroundings, the development and the interaction between the socioeconomic and physical environment could be totally different (Lóczy, 1989).

To analyze the various ecological conditions, we need to select the appropriate physical variables to get correct input data for the GIS analysis. Formerly, we studied the magnitude of human impacts on settlement environments using decision support systems. We also considered landscape planning, and our environmental investigations were based on quantitative methods. Typical property maps include the location and shape of permitted structures; unfortunately, these maps do not capture information about any illegal (non-permitted) structures. Aerial photos are useful, and in the long run, cheap tools to track such changes. However, tracking of such changes can be easily done with a large scale satellite image.

Nevertheless, aerial photos and satellite images need to be digitized and digitally analyzed for administrative control purposes. In the present paper we compare three digital analytical methods to track changes of built-in areas on a test area in SW Hungary.

Aerial photos, however, have not been excessively used for urban and administrative purposes and to detect the temporal changes between the physical and urban environment. Thus, the objectives of the present study are summarized as follows:

- to explore the temporal and spatial structural development of selected settlement by the mean of aerial photos,
- to provide a general historical overview of the changes of settlements and their natural environment based on selected case studies,
- to select relevant information from aerial photos (such as roofs) with digital methods,
- to analyze the natural and social factors with GIS and numerical methods,
- to compare the results of three methods of supervised classification modules in GIS software environment.

2. Materials and methods

In a new town like Kozármisleny (town declaration on July 1st, 2007), SW Hungary (Fig. 1), there are many new estates, and house expansions which are almost impossible to be controlled by the local authority.

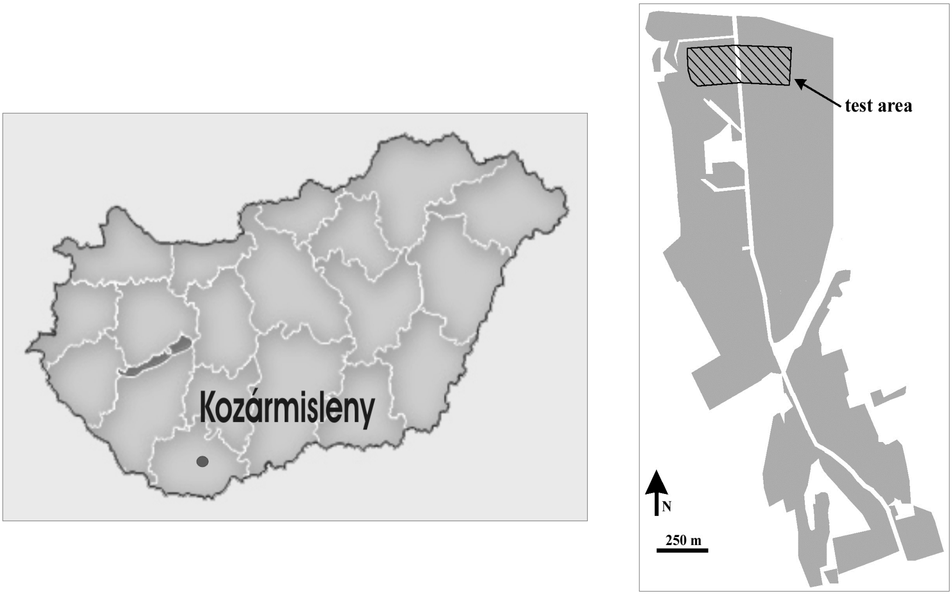

Fig 1. The test area the new town Kozármisleny, S-Transdanubia

The study area is a new development in the northern part of Kozármisleny. The area is divided into two separate parts with different characters. One fourth of the estate development consists of built up with new houses with colorful (usually reddish) roofs, while the rest of the area is older with roofs covered by dust and moss.

Given that the tiles are new, the same color, and not contaminated by dust or moss, tiles on the new houses are made at about the same time, thus their intensity is quite similar, as they are usually not contaminated by dust and moss. Due to their similar color intensity, they are suitable for identification by digital methods. This test area with intensive red roofs helped to separate the buildings' pixels from the surface pixels. For the more appropriate separation, we covered the satellite image with the layer of the plot boundaries.

Aerial photos from Kozármisleny, Pécs and its surroundings were taken in 2000 as part of the MADOP (Digital Ortophoto Program of Hungary) program. These 1-

meter resolution digital orthophotos were obtained from the Hungarian Institute of Geodesy, Cartography and Remote Sensing.

These photos were then imported into IDRISI 32, a GIS and image processing program. The aerial photo was split into three band, an RGB composite image, which can be used for cluster analysis (Eastman, 2003). From the composite RGB image we could determine, even with visual interpretation, the deviation of tiles from, natural colors. In the methodological part of the present study we primarily intended to delineate these non-natural roof areas. However, older tiles are less vivid reddish than more recently built roofs. Thus, we had to teach the program to identify dull and worn-out roofs as well (Fig. 2).

Fig. 2. Different hue of the roofs on test area for supervised classification. Note that if roofs are deselected based on one pixel intensity, certain roofs are not deselected, denoted with red arrows

We also imported digitized and georeferenced 1:10000 scale topographic maps. We obtained a map (2003) of all known buildings and properties from the local government of Kozármisleny (Fig. 3).

The initial classification method we used was unsupervised classification. The classification with cluster analysis produced the worst result because both within and outside the test area almost everything was identified as a red roof area.

We maximized the number of the clusters in ten. The automatic process of the cluster method showed a noisy picture which is not allowed of an adequate analyses.

Since this unsupervised classification method did not work well, we moved on to supervised classification methods. We initially digitized training sites for three classes of roofs, roads, and vegetation. We analyzed the image using two IDRISI modules: (i) the Minimum Distance (MINDIST) (based on minimum pixel distance to a mean) and (ii) Maximum Likelihood (MAXLIKE) (based on maximum similarity).

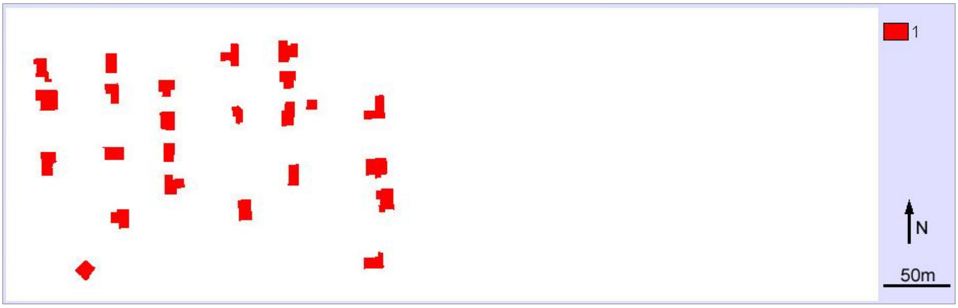

Fig. 3. Control area for new redroof-houses sign on digital map of the Local Governmental Database
Legend: 1. Areas of the red roofs houses

3. Results

As mentioned, the unsupervised classification produced the worst result.
Fig.4. shows the results of the minimum distance (MINDIST) classifier. Table 1 is the confusion matrix. As can be seen, the accuracies for the three roof classes are red and green roof, and old roof. Most of the inaccuracies are between the three classes and roads.

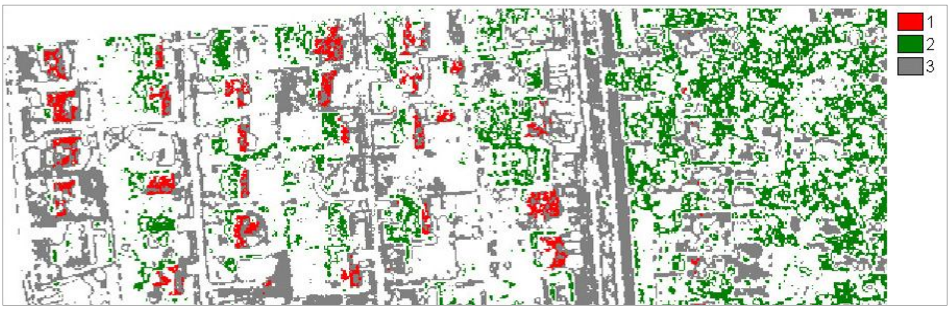

Fig. 4. Controlled classification with MINDIST method
Legend: 1=new (red) roof, 2= new (green) roof, 3= old roof

The present study shows the comparison results of two GIS modules used for analysis of aerial photographs. We compared the MINDIST and MAXLIKE classification system.

All three methods are faster and more efficient than the conventional manual analysis; however they are burdened with significant errors (see Table 1). We found large differences among the two methods, but for proper operation all of them would require higher resolution (submeter) input data.

Table 1. Correspondences between the different controlled classes and the land register map red roof houses area

Controlled GIS classification system	The area of the red roof houses on land register map (pixel area m^2)	Pixels located at their true locations based on land register maps (%)	Pixels located at their false locations based on land register maps (%)	The rate of the true and false pixels
PIPED	465	9.6	2.9	1:2
MAXLIKE	2571	53.3	29.2	1:3
MINDIST	3042	63.1	297.9	1:5
AREA ORIGINATED FROM LAND REGISTER MAPS	4821	100	0	0%

With higher accuracies, this method would be suitable for detection of temporal extension of roofs, but is also for tracking and controlling the changes of the extension of private and public areas. Furthermore, it would increase public safety through administrative awareness of the exact location and extent of changes.

Discrepancies from local urban planning in certain cases may jeopardize public health and safety, cause interpersonal conflicts (noise and light pollution, accessibility of public utilities or health issues) or may produce environmental pollution. The new freeway section M60 could generate investments in the south part of Kozármisleny. During the research we found lot of advances of environmental evaluation with GIS methods. The rapid development of Kozármisleny generated the growth of the population and brought along the development of new building estates. The council of the town pointed the places of the new estates to take notice of environmental thematic maps for land evaluation with GIS. Orthophoto analysis may decrease the involvement of in situ field by as much as 90 per cent (Akbari et al. 2003). The process of development of Kozármisleny is a model for long-lived sustainable growth.

The results based on a ten-year research and data collection. The results of the conventional research methods (Nagyváradi, 1998) are in good correlation with the applied GIS model. Such models can be extended to the future and be applied to other settlements. Model predictions are in good correspondence with the observed settlement development trends. Models generated from the applied methodology are suitable for analysis of other settlements.

4. Summary

In some cases, GIS and numerical methods produce more objective result of the analysis of the physical and social factors. The digital analysis of aerial photographs in Kozármisleny, however, did not work as well as traditional, manual methods. The tested methods of classification illustrated the need for either better software or data.

In summary, the presented image classification method provided promising results, however, the error is too high for practical use. For future applications, high resolution multi (or hyper) spectral data might improve the accuracy.

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References

Ádám, L. (1989): Physical geographical land evaluation based on agroeconomy. *Földrajzi Értesítő* **38**: 243-262.

Akbari, H. – Rose, L.S. – Taha, H. (2003): Analyzing the land cover of an urban environment using high-resolution orthophotos, *Landscape and Urban Planning* **63**(1): 1-14.

Balassa, B. – Nagyváradi, L. – Szebényi, A. (2008): A specific way of a settlement development on example Kozármisleny. II. Confenece of Landdevelopment, DDRFÜ Kht. Kaposvár. pp. 120-124.

Braasch O. (1997): Bemerkungen zur archäologischen Flugprospektion in West und Ost. In: Oxele, J. – Gojda, M. (ed.): Aus der Luft-Bilder unserer Geschichte, Dresden pp. 28-37.

Czigány, Sz. – Pirkhoffer, E. – Geresdi, I. (2008): Environmental impacts of flash floods in Hungary. In: Samuels, P. - Huntington, S. - Allsop, W. – Harrop, J. (eds.): Flood Risk Management: Research and Practice: 1439-1447; Taylor & Francis Group, London

Detrekői, Á. – Szabó, Gy. (2002): Introducing GIS. Nemzeti Tankönyvkiadó, Budapest. 380 p.

Eastman, J. R. (2003): IDRISI Kilimanjaro: Guide to GIS and Image Processing. Clark Laboratories, Clark University, Worcester, USA.

Farkas, Gy. (1996): Using local governmental GIS systems. *Térinformatika* **4**: 21-22.

Frisnyák, S. (1995): Geographical history of Hungary. Nemzeti Tankönyvkiadó, Budapest, 213 p.

Geresdi, I. – Lovász, Gy. (2000): GIS in physical geographical researches. In: Lovász, Gy. - Szabó, G. (eds.): Regional development – regional researches. PTE TTK Földrajzi Intézet. Pécs pp. 303-310.

Griffiths, P. et al. (2010). Mapping megacity growth with multi-sensor data. *Remote Sensing of Environment* **114**(2): 426-439.

Gyenizse, P. – Szabó-Kovács, B. – Sebők, M. (2005): Hidrological impacts on the social and economic processes over the Dráva flood plain - Geographical Review. *Földrajzi Közlemények* **54**: 67-72.

Gyenizse, P. – Nagyváradi, L.- Pirkhoffer, E. – Ronczyk, L. (2007): Aesthetic assessment of a man-made landscape. *Geografia física e dinamica quaternaria* **30**: 175-178.

Kertész, Á. (1997): GIS adaptations. Holnap Kiadó, Budapest, 240 p.
Kis, É. – Lóczy, D. (1985): Geomorphologic mapping for environmental qualification. *Földrajzi Értesítő* **34**: 475-482.
Kőszegfalvi, Gy. (1997): Urbanity, Urbanization, Urban development. JPTE, Pécs, 203 p.
Kraftné, Somogyi G. (1993): Environmental problems of the recreation areas near urban territories in Hungary. *Specimina Geogarphica* **3**: 35-41.
Lovász, Gy. (1982): the role of the physical environment of the urban construction. *Településfejlesztés* **2**: 17-26.
Lóczy, D. (1989): Land ecological theories, methods and practice. *Földrajzi Értesítő* **38**: 379-393.
Lóki, J. (1999): Digital thematic mapping. Kossuth Egyetemi Kiadó, Debrecen. 205 p.
Marosi, S. – Szilárd, J. (1963): Theoretical and methodical aspects of the land evaluation based on physical geography. *Földrajzi Értesítő* **12**: 393-414.
Márkus, B. (2001): Introducing GIS. Nyugat-Magyarországi Egyetem, Székesfehérvár, 40 p.
Mezősi, G. – Bárány-Kevei, I.- Mucsi, L. - Balogh, I. (1993): First results of GIS based geoökological mapping. *Acta Geogr. Univ. Szegediensis* **31**: 71-82.
Nagyváradi, L. (1998): The effects of the physical environment in the urban development of Kozármisleny. *Földrajzi Értesítő* **47**: 189-196.
Nagyváradi, L. – Szebényi, A. (2008): Kozármisleny – a prosperous town in Baranya county. In: Csapó T. - Kocsis Zs. (eds.): Villages and small towns in geographical field. IV. Urban geographical Conference Szombathely pp. 264-277.
Czigány, Sz. – Geresdi, I. – Pirkhoffer, E. (2008): Modeling of flash flood events in small low-mountain watershed in SW Hungary. In: Challanges in Hydrometeorological Forecasting in Complex Terrain Join 2nd MAP D-PHASE Scientific Meeting & COST 731 Midterm Seminar, 19–22 May, Bologna, pp. 64–65.
Somogyi, S. (1996): The geographical environment and it changes of the Carpathian basin during the settlement of the Magyars.. *Földrajzi Közlemények* **120**: 111-118.
Szebényi, A. (2006): The study of the specifications of the suburbanization around Pécs in 2005. In: Csapó, T. - Kocsis, Zs. (eds.): Agglomeration and suburbanization in Hungary. Savaria University Press, Szombathely pp. 196-215
Timár, J. (1994). The Main Features of Suburbanization in the Great Hungarian Plain, *Landscape and Urban Planning,* **22**(2-4): 177-187.
Timár, J, - Váradi, M. M. (2001). The Uneven Development of Suburbanization during Transition in Hungary. *European Urban and Regional Studies* **8**(4): 349-360.
Tóth, J. (2007): Little settlements in the agglomerations. In: Csapó, T. - Kocsis, Zs. (eds.): Urban geographical Conference Szombathely, pp. 38-48.