Detailed mapping of agricultural plots using satellite images and aerial orthophoto maps

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ABSTRACT: Satellite images and aerial orthophoto maps are widely used for administration and control of area-based agricultural subsidies in EU countries. The need for preparation of functional systems causes intensive development of this area also among candidate countries.

There are two main applications where satellite images and aerial orthophoto maps can be used: building and updating of reference geodatabase (Land Parcel Identification System – LPIS) and the control with remote sensing. The main requirements concerning the satellite or aerial data depend on the application. LPIS has to be based on the data meeting minimum requirements of geometric accuracy specified in the European Commission technical documents. It is also important that the data should be recent and easily available. The control with remote sensing is focused mainly on the area of declared parcels and the crop identification. There is a space for the use of many different data sources such as digital aerial orthophoto maps as well as a wide range of satellite images (panchromatic, multispectral or radar).

In the Czech Republic, different satellite and aerial data have been tested for detailed mapping of agricultural plots. The testing has been done during several previous years. Various data sources and different methods were used. The paper compares various approaches when different variables such as the spatial resolution, recent acquisition, vectorization team knowledge and experience or the vectorization scale are changing. Also, the influence of independent data verification on achieved results using information given by farmers or terrain measurement was observed.

The tests results were applied during the LPIS building in the Czech Republic. The process itself was also generating new experience. Finally, intensive testing on new data sets gives more complex view on this problem.

The influence of mentioned parameters on the final product is significant. Not only the geometric accuracy and spatial resolution of aerial or satellite data, but also the recent acquisition and the availability of the data, the methodology chosen for creating the geodatabase and the staff background and experience are very important.

1 MAIN CHARACTERISTICS OF THE LAND PARCEL IDENTIFICATION SYSTEM

The Land Parcel Identification System (LPIS) is a reference geographical database of agricultural plots which is used as a reference set of data for the administration and control of area-based agricultural subsidies in EU countries. Due to expected EU enlargement in 2004, LPIS must be developed and implemented in the time of accession also in candidate countries.

LPIS can hold different reference objects. The most detailed object is agricultural parcel which is defined as a continuous piece of land cultivated by one farmer with a single crop. Less detailed object, farmer block, is defined as a continuous piece of land cultivated by one farmer with a single land use type (e.g. arable land, permanent grassland, vineyard, etc.). The third level is represented by physical block: continuous piece of land surrounded by permanent boundaries (e.g. road, stream, forest, etc.). Each member state or candidate country can decide for the type of reference object in LPIS database (Léo, Kay & de Roeck 2002).

LPIS should be based on data sources meeting minimum requirements specified in certain EU legislative and technical documents. Use of GIS technology is compulsory (at the latest since 2005), use of aerial or satellite ortho images as a source of spatial information on agricultural plots is recommended. Minimum requirements on geometric accuracy of graphical data are specified as at least equivalent to cartography at a scale of 1:10 000.
(Reg. 1593/2000, Reg. 2419/2001). Practically this means that pixel size of orthophoto maps must be less or equal 1 m and absolute RMSE of each orthophoto map less than 2,5 m. (Léo & Lemoine 2001). Ortho images used as a data source must also be of a suitable date - maximum 5 years old (Kay 2002).

LPIS holds information about reference parcels – first of all unique ID and area. Some national systems hold also information on farmer, land use type, irrigation, organic farming, etc. LPIS is used as a reference for declaration by farmers, for administrative and cross-checks, and for on the spot controls (including control with remote sensing).

2 CONTROL WITH REMOTE SENSING

The control with remote sensing is focused mainly on the area of declared parcels and the crop identification. There is a space for using of many different data sources including digital aerial orthophoto maps and a wide range of satellite images (panchromatic, multispectral or radar).

Minimum of 5% of all declared parcels must be controlled every year (Pedersen 2002). Control with remote sensing is used in 13 of 15 current EU member states according to methodology prepared and approved by JRC Ispra (Loudjani 2002, Common Technical Specifications 2002).

3 MAPPING OF AGRICULTURAL PLOTS IN THE CZECH REPUBLIC

In the company Ekotoxa Opava, different satellite and aerial data have been tested for detailed mapping of agricultural plots. The testing has been done in several previous years. Creating of the Czech LPIS in years 2000-2002 was the most important processed project (Trojáček 2002). Manual vectorization based on visual interpretation of an orthophoto map is the dominant method used for practical applications in this area. Various data sources and different methods were used.

Following part of the paper is focused on different factors affecting final results: spatial resolution, recent acquisition of data, vectorization scale, knowledge and experience of the staff providing the vectorization. Also, the influence of independent data verification on achieved results using information given by farmers or terrain measurement results was observed.

4 FACTORS AFFECTING FINAL RESULTS

4.1 Spatial resolution

The same area is shown in Fig. 1a) and 1b) whereas image used differ by the extent of displayed detail. That also effects final vector drawing of agriculture land borders. For the use of reference geodatabase for administration and control of agricultural subsidies, the resolution of 10 m is quite unsatisfactory, especially for small plots that are difficult to recognize.

![Figure 1. Spatial resolution of images. (a) Satellite image SPOT, panchro, 10 m, 1997; (b) Aerial orthophoto map, B&W, 0.5 m, 2000.](a)

4.2 Recent acquisition of data

The examples in Fig. 2a) and 2b) represent the same area in the period of two years. To be able to guarantee the credibility of the whole system it is necessary to update the LPIS database regularly. Frequency of orthophoto maps updating should not be higher than 5 years.
Figure 2. Recent acquisition of data. (a) Aerial orthophoto map, B&W, 0.5 m, 2000; (b) Aerial orthophoto map, color, 0.5 m, 2002

4.3 Vectorization team knowledge

Vectorization of block boundaries at the first case (Fig. 3a) was done by the operator, that accomplished visual interpretation of images without consideration to common agricultural practice in the countryside. Plot boundary lined with trees accurately copies particular pixels on the image. As for the second case (Fig. 3b), the interpretation was done by experienced operator, who evaluated the situation correctly.

Figure 3. Vectorization team knowledge. Satellite image SPOT, panchro, 10 m, 1997. Vectorization done by two operators with different level of knowledge and understanding

4.4 Method of vectorization

Selected method of vectorization is usually given by technological feasibility. The first picture (Fig. 4a) represents the option, where the drawing is done on transparency over the printed map using exactly set scale (in this case 1:15 000). The result is then digitised using automatic or semi-automatic procedures. At the second picture (Fig. 4b) is displayed the workspace for vectorization on the screen. This enables to use other available digital data. If the situation on orthophoto map is not transparent in chosen standard scale, it is also possible to display it in detail.

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4.5 Verification of results – terrain measurement

Visual interpretation of orthophoto maps done by operators can be difficult especially where the border to be drawn is not clear enough or is hidden (usually by the tree crown). In this case, it is important to have suitable methodology that helps the operator to decide where to place the line.

The dotted line in Fig. 5 shows the border measured using D-GPS. The continuous line was created by the operator. The difference in this case can rise up to several meters, which significantly affects resulting area.
4.7 Vectorization scale

The chosen scale of vectorization directly influences character and homogeneity of resulting vector geographic database. It is supposed to be selected in compliance with resolution of orthophoto maps and with requirements concerning the final product. For the same type of image, an unified scale must be set up for all involved operators.

5 CONCLUSION

Manual border vectorization of agricultural plots based on visual interpretation of aerial orthophoto maps represents the main method used to establish large reference geographical databases - Land Parcel Identification Systems (LPIS) in particular European countries. Subsequently, these databases are used as reference systems within the processes of administration and control of area-based agricultural subsidies.

To achieve satisfactory results it is necessary to keep in mind all mentioned factors. Each of them can significantly influence the quality of final database and subsequently also the quality of the administration and control process, which affects thousands of farmers in Europe.

REFERENCES


