Cost analysis of the application of various photointerpretation techniques to land use classification

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ABSTRACT

When facing land use classification by photointerpretation, an initial decision-taking process happens regarding the technique to apply to get the best results from the source of information. Some factors are taken into account like adaptation to the photograph properties and flight parameters, as well as ground relief and coverage. Not less important have to be the economic variables involved regarding the equipment, personnel and other resources involved.

A comparative study was carried out in a study area to measure the effectiveness of each of the available techniques using a cadastral parcel map-based approach, and with the goal of building a spatial database.

Once the stages to be followed for each of each procedure have been defined, a test area with a mixed inland-coastal character within the whole study area was selected. The three approaches applied were map shading-tablet digitising-tesselation coding, map coding-digital parcel coding, photo scanning-georreferencing-digital parcel overlaying-land use extraction.

When having the original photographs on which digital parcels were drawn the most efficient working approach is the third. In other circumstances the second has demonstrated a higher efficiency and an alternative. Then this method was extended to the whole study area and measured the work times for the several subareas, since difficulties arise when having varied topography, mixed land uses and non-updated cadastral map. Results show varied costs with the same technique in non-homogenous areas in the range of 1.2-7.5 hours.

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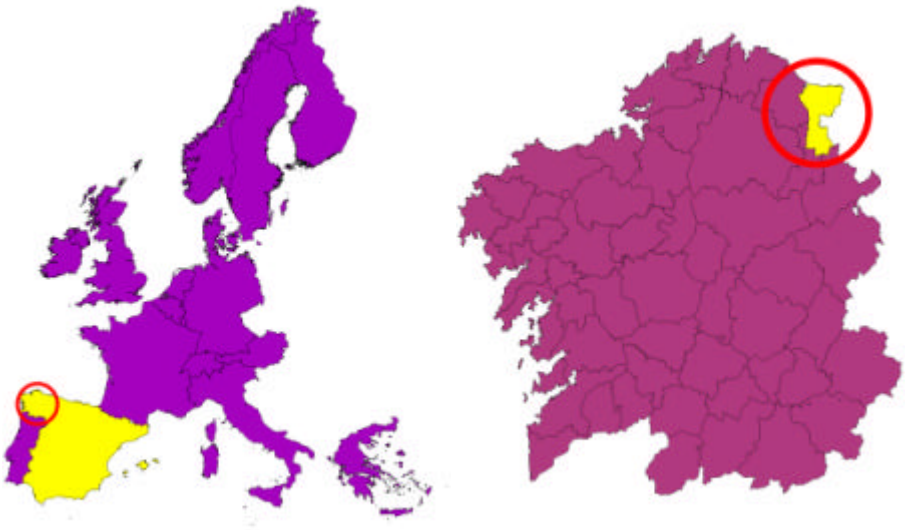
INTRODUCTION

Interpreting an aerial photography implies to examine the spatial features with the purpose of identifying them, define their category, limits and relationships with the environment (Serra, 2002). The identification of vegetation by means of aerial photography is very dependent on the appearance and plant characteristics in the area (Murtha, 1997). To assist the task of carrying out an interpretation with a high resolution, this is the technique used to analyse land use (Campbell, 1997). Numerous processes have been developed to generate land use information, but there are not enough studies comparing the different methodologies using technical and economic criteria.

Figure 1 – Study area location



OBJECTIVES

The main objective is to compare the methods available and to develop a process of photointerpretation and codification of land use, minimizing costs and offering a sufficient accuracy for the requirements of forestry planning at the municipal scale.

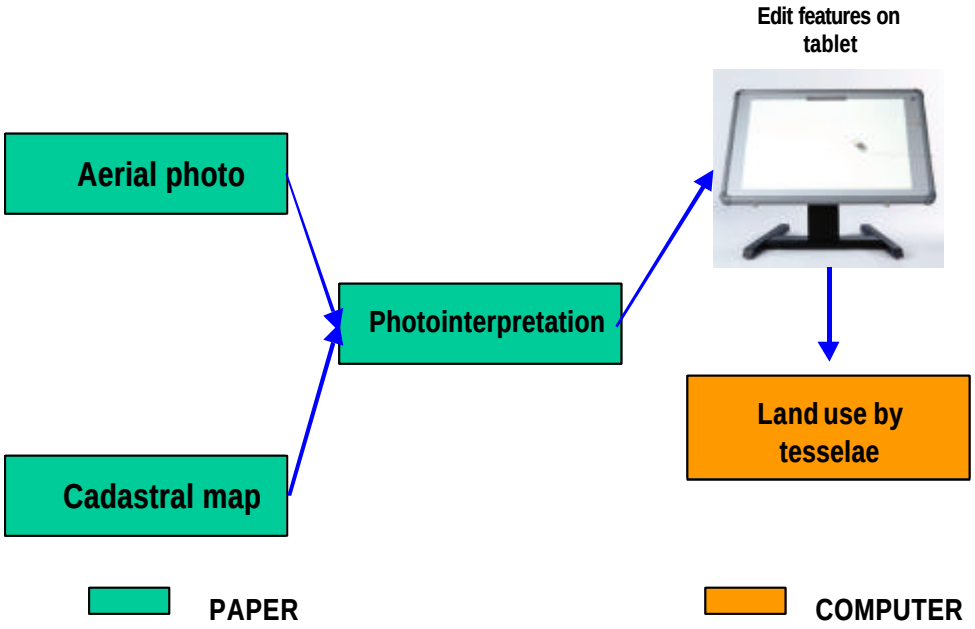
METHODOLOGY

There are two main components of the study, photointerpretation and data entry. The procedures are tested in a municipality of the district of Eastern Mariña in the NW of Spain, and then extend the analysis to the whole district. The equipment used in the Laboratory of the Territory (LABORATE) of the University of Santiago de Compostela is that commonly available in any company working in the filed of land use planning, so that the procedure selected is feasible to be applied in the whole region.

Three methods were used and their results evaluated according to their performance based on quality and time invested in the tasks completed.

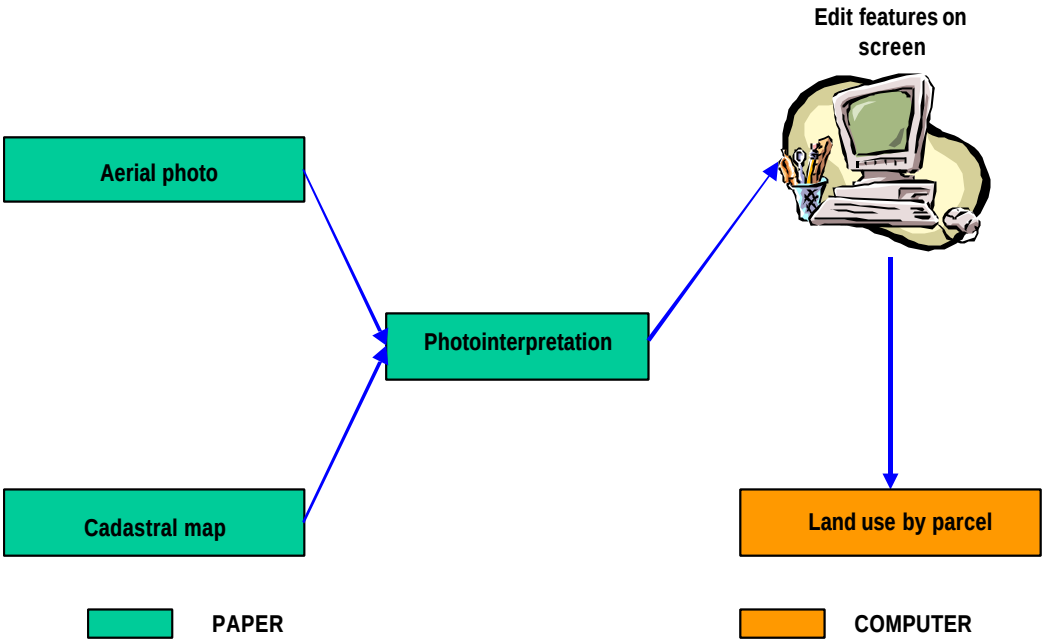
The **first procedure** handles information –photographs and parcel map- in paper format; and the technician accomplishes a land use tessellation with the highest level of disaggregation of the legend. The operation of colouring is carried out to facilitate the subsequent task of digitising and generate a file with land use tessellae. Figure 2 synthesises the main steps.

Figure 2 - Procedure 1



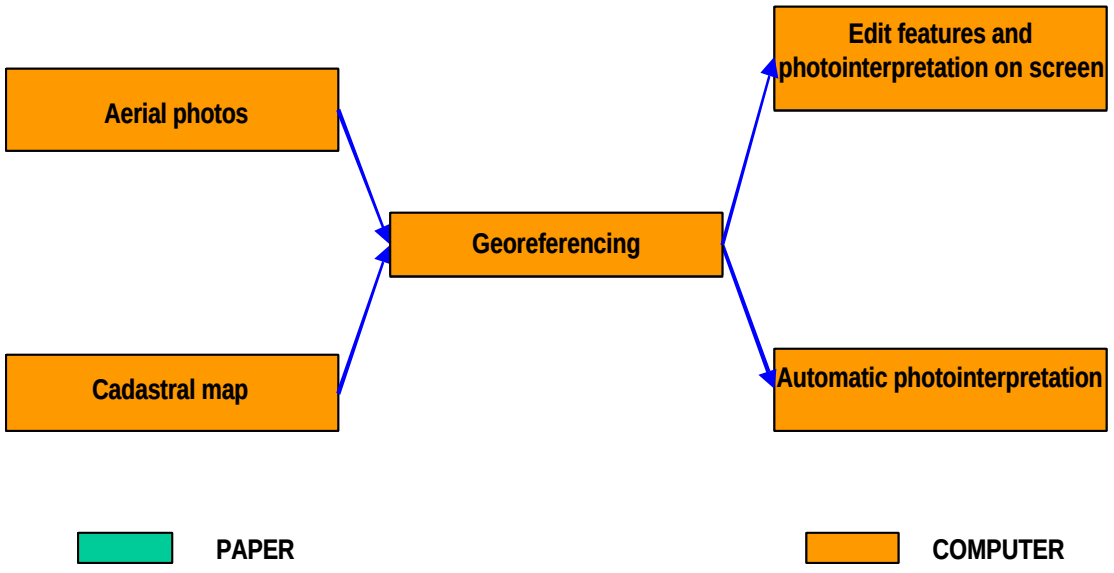
The **second procedure** handles the same kind of information but land use tessellation is accomplished by coding the parcels according to a key linked to the legend. Tessellation is finished when delineating land uses as shown in figure 3. Tessellae codification is done in a GIS, supported by the digital parcel information and building the thematic attribute table.

Figura 3 - Procedure 2



In **procedure 3** –figure 4- operations handle only digital information. Aerial photographs have been scanned with a resolution of 300 dpi and ground coverage of 1.53 and georreferenced to be then overlaid on the cadastral map. Further interpretation is carried out on the screen by identifying land uses or by using image processing software for classification.

Figure 4 - Procedure 3



Once the model has been chosen, it is applied in the whole district and evaluated the economic and technical issues involved. Since the district has four diverse

municipalities, it allows to compare the results of the three methods in each municipality, and extrapolate conclusions to other areas.

Zone I comprises the municipalities of Ribadeo and Trabada, their size and land use complexity are similar, and represent the coastal and inland areas.

Zone II only includes the municipality of Pontenova, it has a high relief and land use complexity, particularly caused by land use tessellation and the small size of both crop and forestry parcels. The cadastral map was elaborated in 1994 and has not been renovated after a land consolidation process has occurred, which involved not only the parcels but also the road network. Aerial photography belongs to a different year and season.

Barreiros is the municipality in **zone III**, with a coastal area and low relief and land use complexity, a large coverage of agricultural land and low forestry coverage. The working support is the cadastral map elaborated in 2000, as well as aerial photographs of the same year. The analysis is carried out in the municipalities of Barreiros and Pontenova.

The methodology applied has followed these steps:

- Selection of a time measurement system. The unit will be the hour, phases will be measured separetly.
- Points of verification. Within the quadrats sized 250x250 m used to validate the information obtained by photointerpretation (Marey, Crecente and Fra, 2003)
- Process.
- Final calculations. The results for each sample point will be measured separately, distinguishing between photointerpretation and codification. Total verification time will be divided by 100, aggregating the result to each sample point. Finally, the total cost will be estimated for every municipality.

RESULTS

We may differentiate between two groups, those obtained for each procedure that allow to select the most appropriate, and those obtained by applying the procedure selected for the whole district. The results obtained from the selection of the model are:

Procedure 1

***Advantages*.** The model does not present any comparative advantage to reach the goals of the study.

***Disadvantages*.** Time invested in colouring the photographs to assist digitising. Deformations of the map used for interpretation and errors in georeferencing produce differences between the information obtained by digitalisation and the base cadastral map.

This procedure has commonly been used, but is not adapted to the objectives of this study. The most important drawback is the loss of positional information limiting the overlay of the results. The time cost of colouring the tessellae in the paper map implies an improvement in the process of digitising and codification, however the efficiency is not the expected.

Procedure 2

Advantages. Reduction of the tessellation time and a higher accuracy in assigning uses to parcels.

***Disadvantages*.** Dependence on the drawing tools of the GIS for the tessellation of subparcels. Loss of accuracy in the delimitation of the tessellae not matching the parcels.

This procedure turns out to be more appropriate for the objectives of the study, since both tessellation and codification of land uses are done in the parcel map. This advantage is more valuables when there are a number of adjacent parcels with the same use. The tessellation of those parcels with mixed uses is done by drawing lines in the paper map and are a reference for tessellation on screen. The shortcoming is the loss of accuracy. Land use codification is based on the edition of the attribute table. The final result is a parcel map with information on updated and disaggregated land uses.

Procedure 3

***Advantages*.** Reduction of times spent in photointerpretation and tessellation and the potential application of the process to larger areas.

***Disadvantages*.** Loss of accuracy of the results.

The procedure presents advantages like saving time and allowing the application to larger areas. The main disadvantage, like in the first model, is the loss of accuracy of the results. Although georeferencing is accurate, cadastral map and aerial photograph do not match at the parcel scale, independently of the class of photointerpretation accomplished, since they are different sources. Comparing the results from the three procedures, it has been found that the **second** is more adequate for both processes.

Results of the application of the procedure selected

In zone III, corresponding to the municipality of Barreiros, there are 12 sample points which represent 75 ha, the 1.02 % of the municipality. As we can observe in table 1, the average time invested in each interpreted point is 4 minutes. This is considered to be a very short time, due to the straightforward process of interpretation, the low complexity of land uses and the quality of data sources. Codification consumes less time –the same as interpretation- for having a parcel map that matches real features, reducing time cost. Globally, the cost for the municipality of Barreiros is 5,647 minutes, equivalent to 11.7 working days.

Table 1. Timing for photointerpretation and codification in zone I

	Photointerpretation (minutes)	Codification (minutes)	Total (minutes)
Point 1	1.81	0.38	2.19
Point 2	1.55	0.29	1.83
Point 3	5.94	0.95	6.89
Point 4	5.16	0.86	6.02
Point 5	6.45	1.14	7.59
Point 6	3.87	0.76	4.63
Point 7	4.90	0.67	5.57
Point 8	6.19	1.33	7.52
Point 9	4.65	0.95	5.60
Point 10	1.81	0.86	2.66
Point 11	2.58	0.67	3.25
Point 12	3.10	0.76	3.86
TOTAL	48.00	9.60	57.60
Mean	**4.00**	**0.80**	**4.80**

In zone III, corresponding to the municipality of Pontenova, there are 20 sample points which total 125 ha, the 0.55% of the municipal area. Contrasting with the former case, difficulties for interpretation are significant, average times increase sharply, for a single point represents 10.73 minutes, a 268% higher.

The factors influencing the process are the following:

- Characteristics of the area. Complexity does not come out from the number of categories of land use but from the mixture making it difficult tessellation.
- Relief of the area. Steep slopes and deep valleys create shadows which do not allow to differentiate land uses.
- Photograph characteristics. Photographs belong to different flight lines, seasons and years. This makes it difficult to establish criteria to differentiate types as a function of colour, tone or texture. Pictures taken in spring are more suitable than those taken in fall.
- Parcel information quality. Information from the parcel does not match the information taken from the photographs, because of the inconsistent dates. The effect is perceivable in the consolidated lands and road network which are not shown in the parcel information, which makes complex the transfer process.

Table 2. Timing for photointerpretation and codification in zone II

	Photointerpretation (minutes)	Codification (minutes)	Total (minutes)
Point 1	6.40	3.63	10.03
Point 2	4.00	3.53	7.53
Point 3	12.33	5.99	18.32
Point 4	10.72	5.74	16.46
Point 5	13.56	6.66	20.22
Point 6	8.50	5.20	13.70
Point 7	10.27	5.09	15.36
Point 8	12.90	7.45	20.35
Point 9	11.35	5.99	17.34
Point 10	5.36	5.56	10.92
Point 11	6.56	4.88	11.44
Point 12	7.23	5.37	12.61
Point 13	8.43	6.69	15.12
Point 14	16.26	6.48	22.74
Point 15	9.93	7.44	17.37
Point 16	15.84	8.10	23.94
Point 17	19.68	8.40	28.08
Point 18	6.98	5.34	12.32
Point 19	14.28	5.04	19.32
Point 20	14.05	7.50	21.55
TOTAL	214.65	120.07	334.72
Mean	**10.73**	**6.00**	**16.74**

These difficulties entail more fieldwork to verify the data for the tessellae and coverages, increasing the time cost. As for the codification, it presents similar problems, as property fragmentation makes necessary to divide the polygons of the cadastral parcels. The mismatching of the cadastral map and the real world for a certain date implies to make editing operations in with the use of GIS is more problematical. The total cost of the processes of interpretation and codification for the municipality of Pontenova is 60,858 minutes, equivalent to 126 working days.

CONCLUSIONS

The selection of the process to apply and produce a land use map implies testing several procedures and carry out a comparative analysis. It is very dependent on the objectives of the study and the data source quality and properties. In this case, the former factor has been decisive to prevent the use of the second procedure yet giving the best technical and economical results. Once the model has been selected and applied, local factors have a significant influence. It has been observed how the elements intervening in both testing areas make results to differ, despite the process applied has been the same. When making thematic mapping, the first step is to consider the objectives of the study, then test the procedures and select the proper model and, finally, analyse the results in some sample areas before applying it to the whole study area.

REFERENCES

CAMPBELL, J. B. (1997). Land Use and Cover Inventory. In: **Manual of Photographic Interpretation** (pp. 335-364). Bethesda: ASPRS.

MAREY, M., CRECENTE, R., and FRA, U. (2003) **Stratified land-use classification with aerial photography and remote sensing.** Arizona: ACSM -APLS Conference.

MURTHA, P. A. (1997). Vegetation. In: **Manual of Photographic Interpretation** 2nd Edition (pp. 225-251). Danvers: ASPRS.

NERO, M. A. (2.000). **Estudo comparativo de metodologias de digitalizaçao de mapas e seu controle de qualidade geométrica**. Sao Paulo: Escola Politécnica da Universidade de Sao Paulo.

SERRA, W., CEBALLOS, G., LUNA, S., and QUINTANA, F. (2002). **Fotointerpretación, fotogrametría y teledetección**. http://www.efn.uncor.edu