A METHODOLOGY FOR A LARGE SCALE OLIVE TREES INVENTORY

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Abstract : In order to establish a methodology for the determination of olive trees area and number in cadaster parcels, several methods were compared: black-and-white aerophotography, color infra-red aerophotography, multi-spectral scanner imagery. Human photointerpretation, automatic processing were applied to the main categories of olive trees fields. The results of these experiments are presented and the sources of errors are analyzed.

1. INTRODUCTION

In 1975, the Council of Ministers of the European Communities adopted a regulation on the establishment of a register of olive cultivation in the Community.
In accordance with an article of the Council Regulation, the register must furnish among other information for each olive cultivation holding in the Community the total olive growing area together with the cadastral reference numbers of the parcels comprising it and the total number of olive trees. Because the area to be inspected is large ($\sim$ 80.000 km^2), conventional ground surveys cannot be considered. The Services of the Commission decided to test the more advanced and rapid methods. Under the responsibility of the Directorate-General of Agriculture, a pilot experiment was organized in 1976 in Southern Italy. The experiment was coordinated by the J.R.C. and several national Institutes were in charge of the different methods to be tested.

The results were submitted by the Directorate-General of Agriculture to a group of independent experts and a common methodology was derived.
The Commission adopted this methodology (ref. 1).

2. METHODS TESTED

2.1. General Criteria:

Olive cultivation can take very different aspects:

- density of the trees
- type of distribution (square, delta, random, lines and hedges)
- hight of the trees
- diameter and shape of the crown (due to age or cutting mode)
- density of the leaves
- association with other trees (almond, orange, etc) or with meadow or with crops (vegetables) or with natural vegetation
- nature of the soil
- presence of irrigation (mainly for production of table olives)
- lie of the land (flat, slope, terrace)
- state of cultivation (neglected or well maintained)

Due to the large variability of the aspects of olive trees cultivation, it was necessary to organize a complex experiment with several methods, several scientists and several test-sites in order to obtain significant results and conclusions.

2.2. Test-sites:

Three test-sites were chosen in one of the most productive area of Southern Italy (Apulia) near Bitonto, Fasano and Palagiano where most of the aspects indicated above could be met.

2.3. Reference method and ground-truth survey:

In order to compare the results obtained by each method to a reference, 52 parcels of about 1 hA were observed by a well-trained team of technicians. Cadastral maps showing the location of 12.197 trees (from this total 7.027 olive trees) were established using reference grids.

The time necessary to make this survey was measured, in order to determine the comparative cost of a ground inventory.

A part of the results was communicated to the scientists testing the various methods in order to provide them with interpretation keys (ground truth), the other part being used as a check of the quality of their determination.

2.4. Flight survey:

A flight covering 2 strips of about 70 x 2 Km, N.W- S.E and N.E-S.W, was done in July 1976 by a company with an aircraft equipped with a metric camera and an 11 channel BENDIX Multispectral Scanner delivering digital data.

The scale of the aerophotographies in black and white and in color-infra-red was 1/10.000 and 1/18.000. at the corresponding flight altitudes of 1500 and 2500 m, the instantaneous field-of-view of the M.S.S. was 3,75 m. and 6,5 m.

2.5. Photointerpretation methods:

2 Groups operated in parallel using conventional (human) photointerpretation and automatic photo-interpretation (Fig. 1).

The criteria which were then used to define the interpretation keys were mainly tonality, morphology, structure and texture.
Automatic photointerpretation started from the decomposition of the false colour image into 3 (blue, green and red) components (Fig. 2) and its digitalization.
In addition, an experiment of photointepretation using directly the restitutor was done, allowing to produce a cadastral map with the location of trees in each parcel.

Photointerpretation experiments were also done using the video diplay of an interacting system visualizing the MSS tapes (3 best channels or 3 first principal components).

2.6. Digital methods:

Experiments were made on ratioing (for example $\frac{\text{Channel 9 - Channel 5}}{\text{Channel 9 + Channel 5}}$), on level slicing, on clustering and classification algorithms.
With a resolution at ground of only 3,75 m, experiments were only partially successful.
An interesting method for the counting of the trees started from a digitized aerophotography. Three operators, the Laplacian (operator which measures the individuality of a pixel by contrast with neighbouring pixels), the local minimum (operator characterising all the points having a value lower than that of the eight neighbouring points) and the gradient (operator giving the direction towards which the values of the neighbouring points increase) were combined in order to produce a detection method by local texture (Fig. 3).

3. RESULTS:

Detailed tables were produced for each method and each category of olive cultivation showing the accuracy and the time necessary for the determination (cost element): 3 geographic situations multiplied by 11 types of olive trees gave 33 conditions.

The following conclusions were common to all experts:

- Scale between 1/8000 and 1/10000
- Orthophotography is indispensable even in flat zones
- B & W aerophotography is indispensable to complement coulour-infra-red
- All methods produce good results when the conditions are favourable (flat ground, evenly spaced big olive trees) and give accuracies of the order of a few percent.
- Where conditions are very difficult it is necessary to use several supplementary methods (slope, terraces, high tree density, association, etc.)
- The M.S.S. was not considered as a competitor in its actual performance
- Any method has to be followed by a final human control (staff member highly trained)
- It was not possible to determine if there was an advantage to fly in July (full vegetation) or in October (advantage: olive trees have permanent leaves and some associated trees loose their leaves in autumn, but disadvantage; larger shadows).

The proposed method is represented in fig. 4.

4. ACKNOWLEDGEMENTS :

The documents listed in the references 2 to 9 have been used to write this paper; we express our gratitude to all scientists who have made this study possible, and to our colleagues of the Directorate-General of Agriculture of the Commission of European Communities, in Brussels, Dr. Schiratti, Dr. Lucheti, Dr. Cassotta for their support and understanding.

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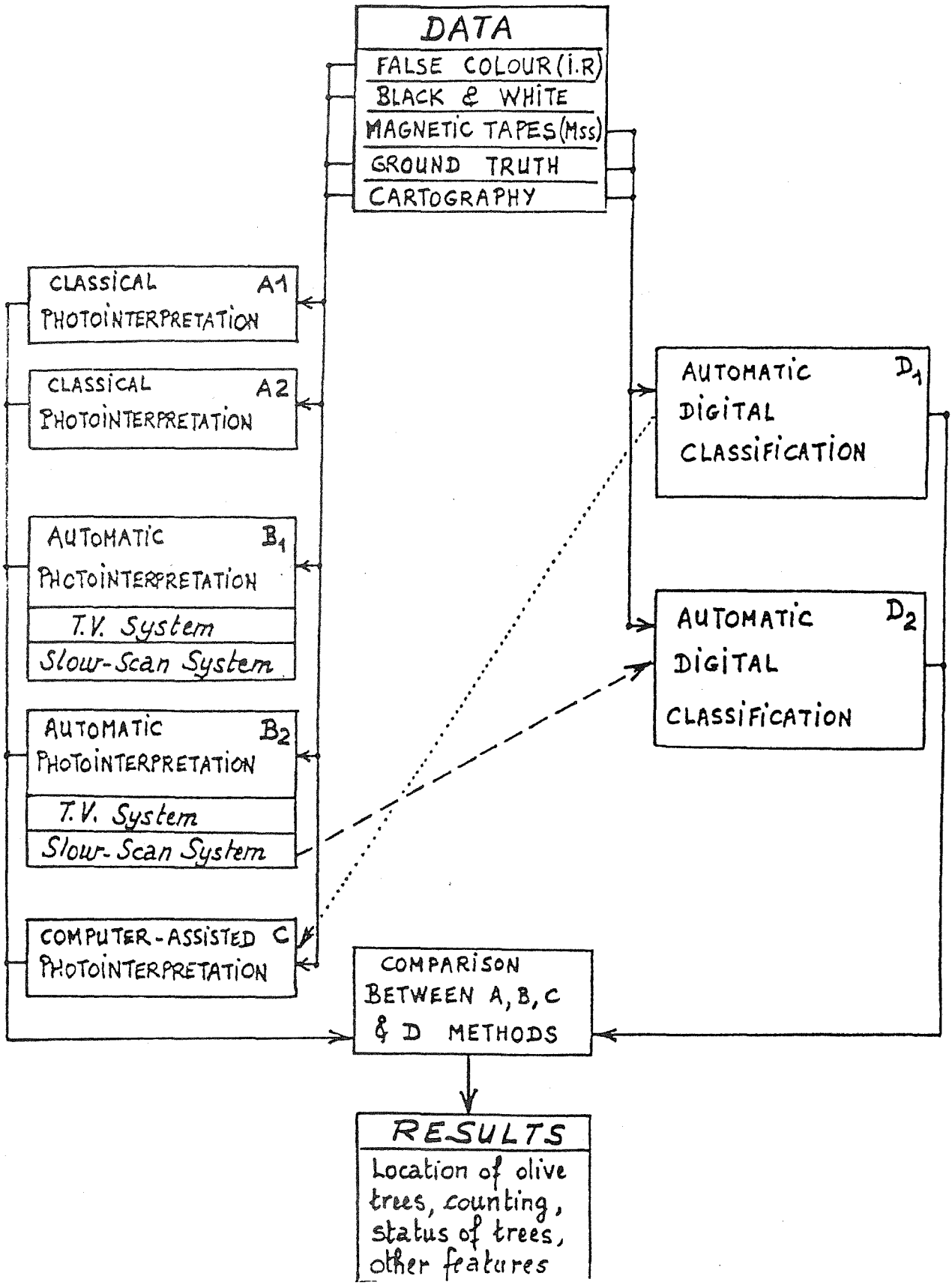
Fig. 1.

DIAGRAM "PHOTOINTERPRETATION and DIGITAL PROCESSING"



PHOTOGRAPHIC DIGITAL RECOGNITION PROCEDURE

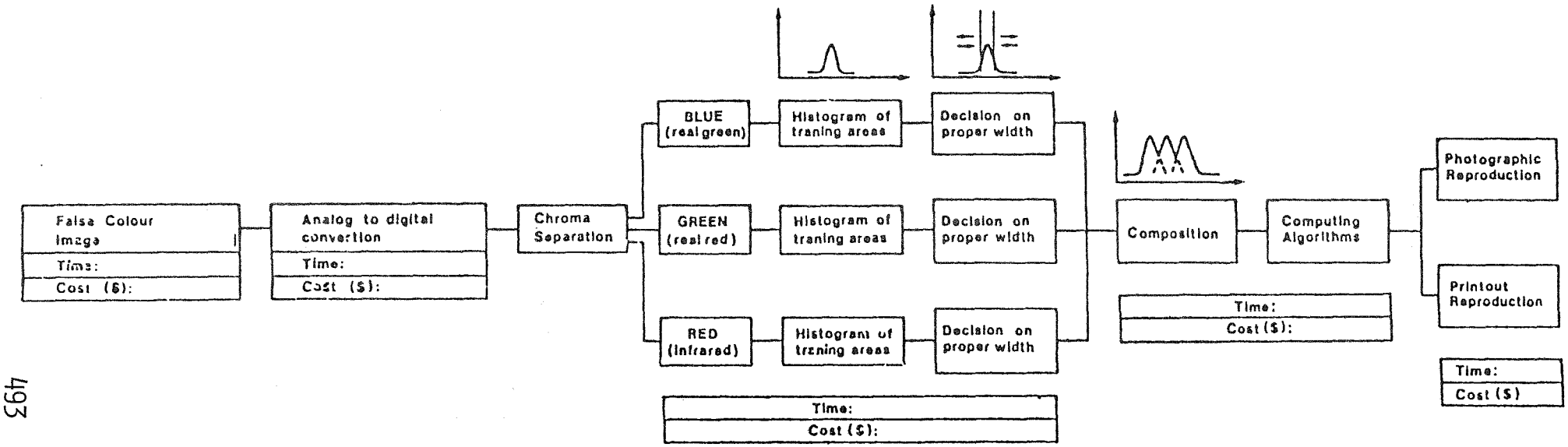


Fig. 2

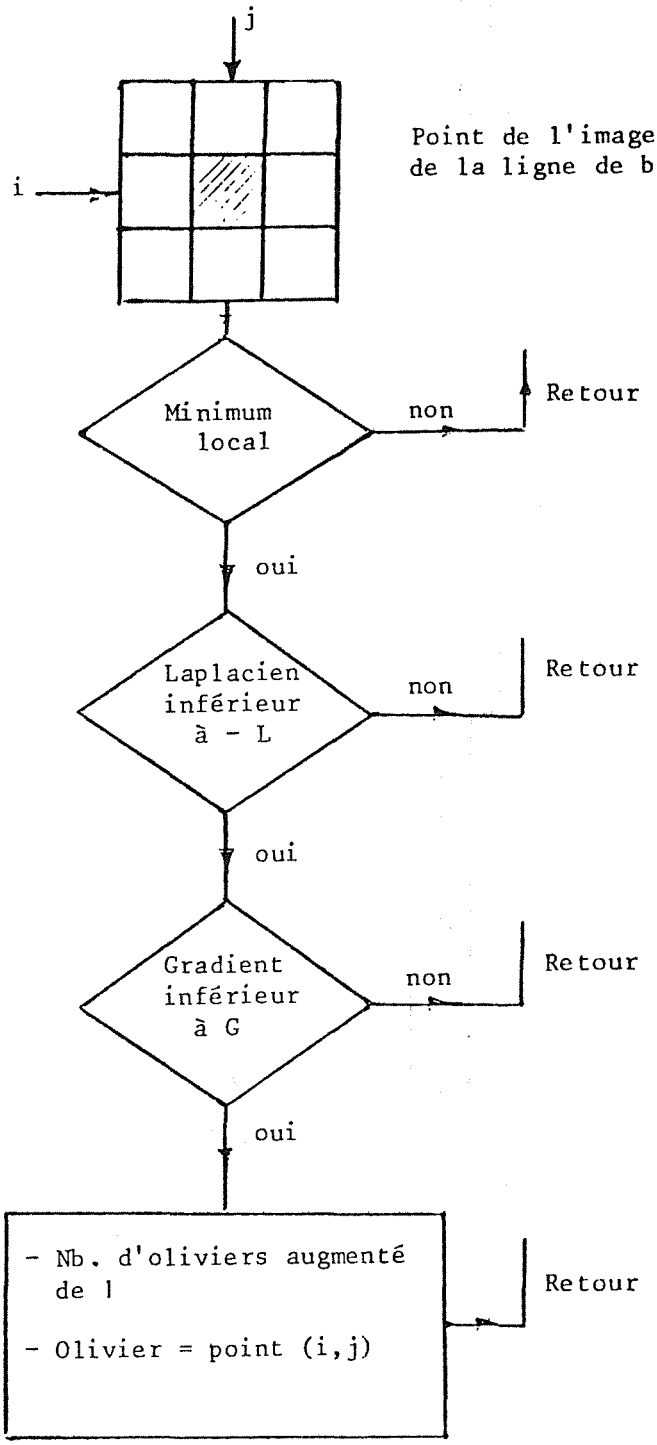
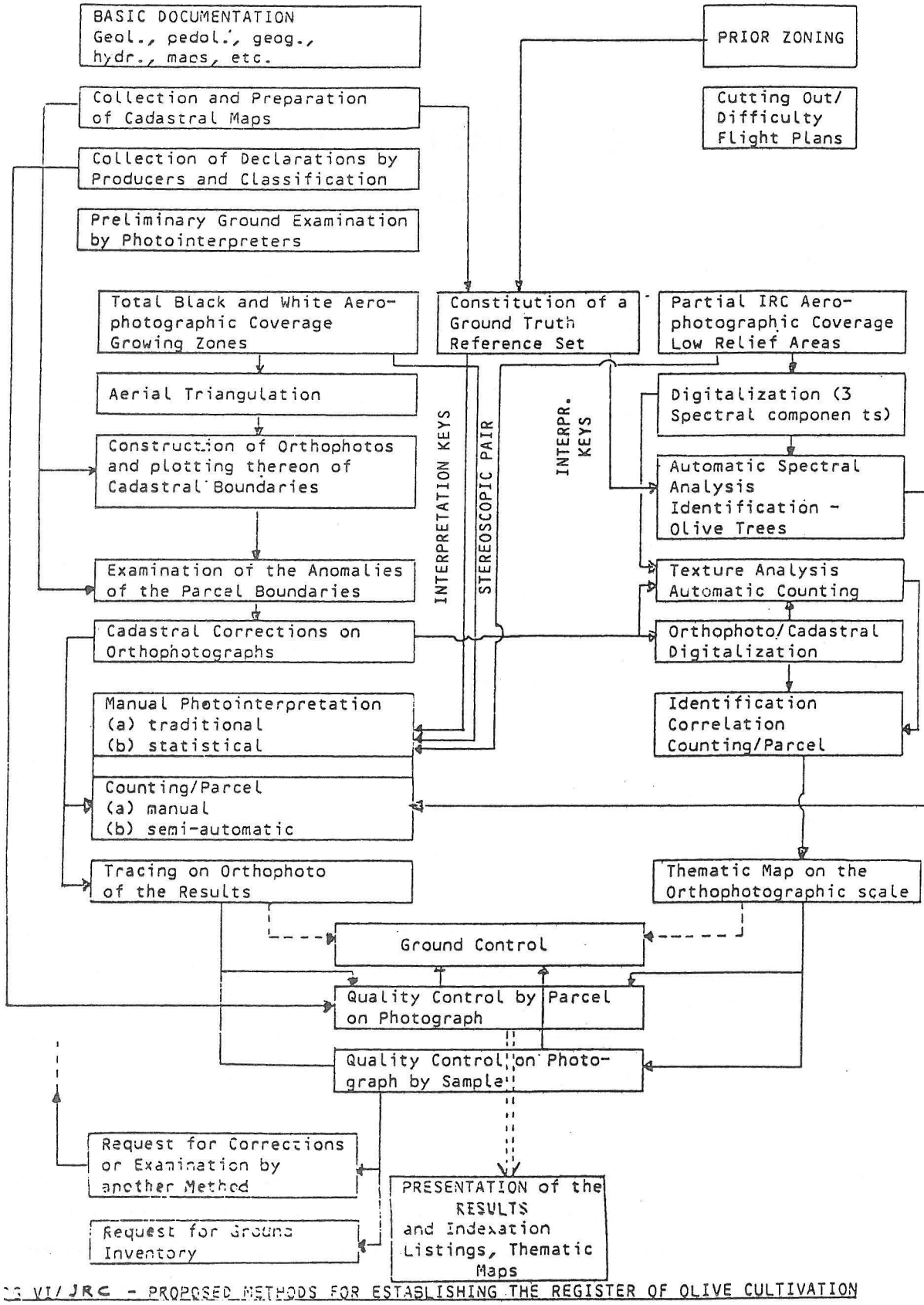


Fig. 3 - Organigramme de détection des oliviers utilisant les propriétés de texture locale.



G VI/JRC - PROPOSED METHODS FOR ESTABLISHING THE REGISTER OF OLIVE CULTIVATION

Fig. 4