ON AN INTERACTIVE SYSTEM TO SUPPORT THE MANAGEMENT OF INDUSTRIAL RUBBER TREE (HEVEA) PLANTATIONS

Souleymane KOUSSOUBE
James louis NDOUTOUME
Roger NOUSSI

Institut Africain d'Informatique[1]
P.O. BOX 2263
Libreville (GABON)

ABSTRACT

The use of remote sensing and Geographic Information System (GIS) for the needs of industrial plantations management, has occupied more and more important place during the last years. In the case of the hevea culture, this can be explained by the need expressed by agronomists to achieve development, inventory, maintenance and farming operations, on the plantations, by means of aerial images, topograph. and descriptive data. Most of these operations integrate decisional procedures using models from Statistics, Operational Research and Artificial Intelligence. The DSS presented here has been designed in this context. Its main particularity rest on the fact that most of the decisional procedures implemented need a simultaneous use of the three types of data cited above. Our approach uses a modelization of the user's conceptual space in the shape of a state graph. A session in the system may be viewed as a partial exploration of that graph. The control of this exploraton is completly left to the user. Furthermore the system provides the user with a set of operators allowing him to generate new states from the current one, and a set of functions based on some decisional models for the evaluation of the generated states.

Keywords: DSS, GIS, Remote Sensing, heuristic search

INTRODUCTION

The management of industrial plantations of hevea involves (among other things) the operations of installation of sites, inventory, maintenance and exploitation. An hectare (100 m^2) of hevea planted, counts in average 550 plants. Consequently, a modest plantation of 5000 hectares would contain about 2 500 000 plants. Note that the life time of a plant of hevea is about 35 years. During this period, the heveaculture practitioner regularly supervises its growth and its phytopathological conditions. These conditions are often watched througout the textural analysis of the leaves. Besides, the hevea plantations are organized in blocks which are disposed according to a matricial configuration. Each block is then marked out in band-line and in band-column to the intersection of which it is located. On the same principle, a block is organized in lines and in columns whose intersections point out potential plantable positions. Adjacent blocks having the same type of hevea (clone), the same cultivation year and the same mode of planting, are grouped in plots according to some precise criteria. Moreover, in order to organize the harvesting of latex in a plantation, adjacent plots are grouped in plates according also to some precise criteria. This description of the field of an industrial plantation of hevea points out some essential features of the information system; that are:

1) the important volume of informations induced by the necessity to supervise individually each plant in a block;
2) the importance of the covered area (in Gabon for instance, a plantation of hevea covers in average 1 000 ha);
3) the diversity of georeferenced objects (structuring elements of the plantation) which

- villages which are living areas for plantations workers. Moreover our system will take into account in subsequent version, the program of villagers rubber tree plantations;
- roads and hydrographic networks.

a.2) Image data are organized in pixel matrixes. These are usually aerial photographic pictures. Satellite pictures can also be used. Image data are important in the survey of the phytopathological and growth condition of rubber trees. Collating image data upon topographic data necessitates preliminary processing such as texture analysis and classifying [REVI 92]

b.) Descriptive data

Each geographic object of the GIS is linked to a set of descriptive informations. In our system, they are organized following the relational model [ADIB 82][GARD 83]. Most of these descriptive data have no intrinsic space location, as in the example of material and human resources: their association with a geagraphic object depends on either they are in storage or in use.

contrary to the approach of many GIS, association of geographic objects and descriptive informations follows a dynamic line. Here is succintly presented the matching system to this effect.

I.2°) Associative relationship of descriptive and (geo)graphic data

Flexibility in structuring descriptive data has become possible through disjunction in the designing process of descriptive and (geo)graphic data. To make possible the integration of the two types of data, we have to describe the possibilities of association existing between the information plans forming the (geo)graphic model and the relationships constituting the descriptive model.

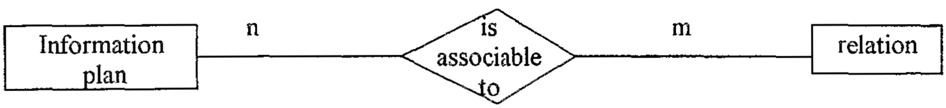


figure 1 : conceptual scheme of associative relationship between descriptive and (geo)graphic

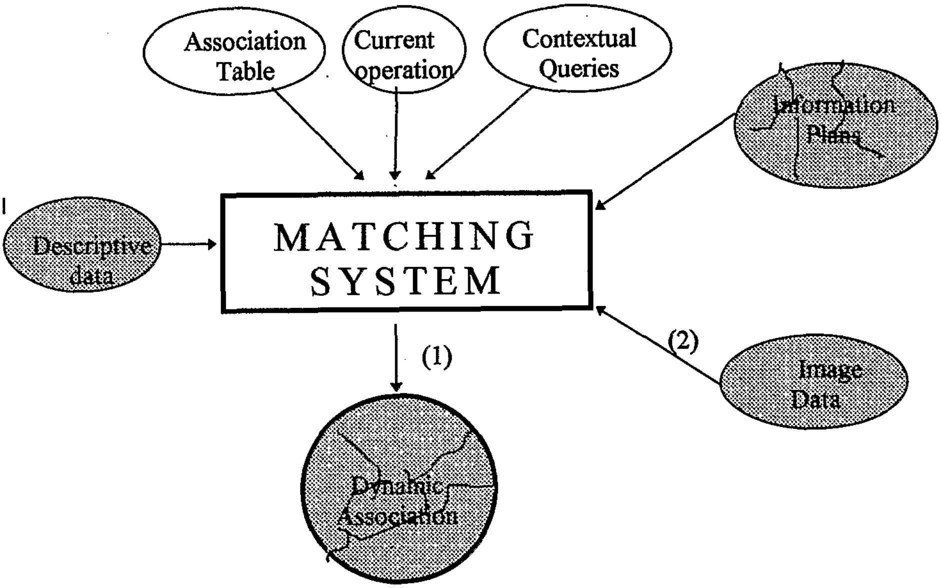


figure : Dynamic association system

(1) synthesis or joint
(2) image analysis followed by update of georeferenced data (data with spatial attributes)

II.) AN EXAMPLE OF DECISIONAL MODEL IMPLEMENTED

In order to emphasize the main particularity of this DSS, we present here, one of the implemented decisional models. This one is dedicated to provide aid for spatial organization of blocks in plots, in plates or in clones under some precise criteria. In order to perfom this task, the heveaculture practitioner may carry out a multidimensional analysis. The data used are generally in the shape of a matrix X(n,p) in which objects «blocks» are on line position and variables (observable parameters) are on column position. The relevant parameters for this analysis are for instance, the area, the growth state, the yield, the quantity of fertilizer used, the spatial position, and the health state of blocks. The large number of observable parameters used in the spatial example, is intuitive while in the case of correspondance analysis, it is necessary to identify the interpretation rules. This is a difficult task in spite of the suggestive character of the representation obtained. The working scheme of the decisional model in the spatial organization of blocks may be described by the following sketch :

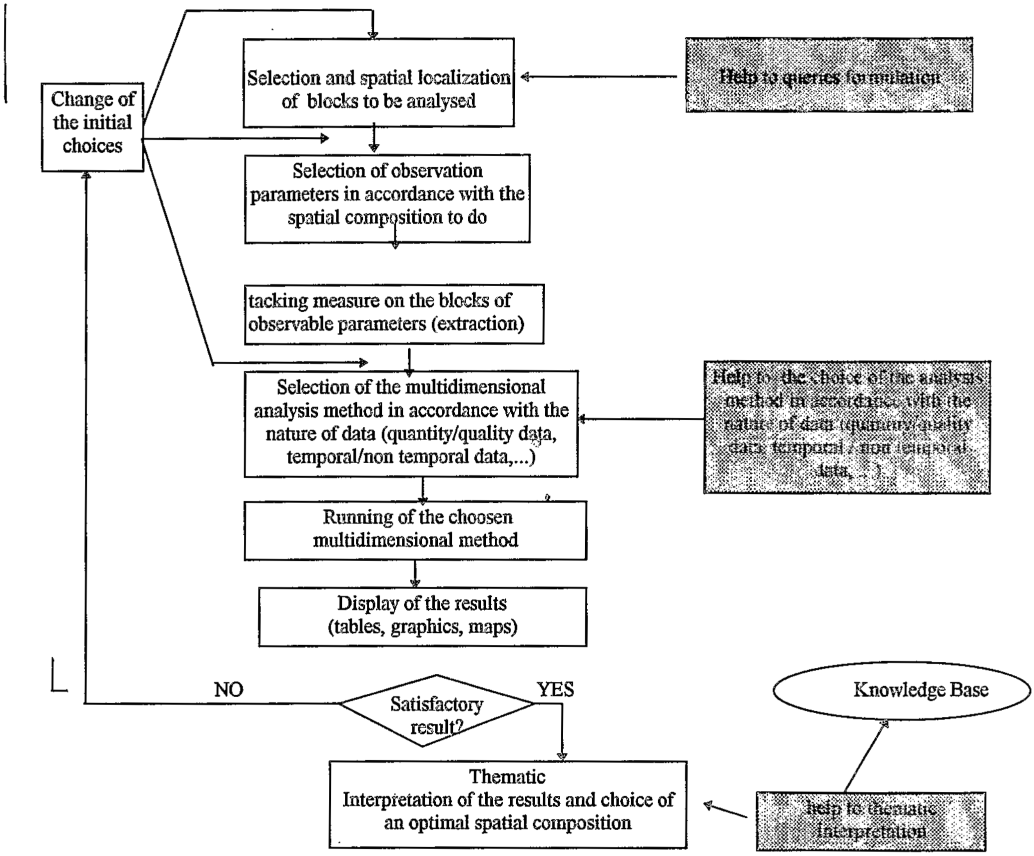


figure 3: working scheme of the decisional model used for the spatial organization of blocks

III) MODELIZATION OF THE USER'S CONCEPTUAL SPACE

[redacted]

exploration on this graph. The nodes of this graph are the representations of the plantation materialized each one by a map.

The system provides the user with a set of functions for the valuation of each state in accordance with his target and a set of operators allowing him to generate new states from the current one. A link between the nodes S1 and S2 corresponds to the existence of an operator O such that O(S1) = S2. The initiative for the valuation of a state or for the generation of a new state is completely left to the user.

II.1°) Description of a state

A state in the user's conceptual space is a map composed of information plans taken in the following set of basic plans:

C = { block, plot, plate, clone, garden, village, contour }

The initial state on which the system starts may be represented by:

Eo = [block, plot, plate, clone,road, contour]

This writing denotes the map that is composed of the information plans ' block', 'plot', 'plate', 'clone', 'road', 'contour' as well as the tables relating to these informations plans.

In the list of the plans that compose a card, one distinguishes a particular plan viewed as the active plan and on which decisional models (state valuation functions) are applied. The other information plans are mainly useful for the display.

III.2°). Evaluation of a state

The user can perform three kinds of valuation on a state :

1) A visual valuation (completely abstract and subjective) resulting in feelings or ideas the displayed map inspires him.

2) Quantitative and numerical evaluation which consists in applying on the current state E, one of the decisional models (issued from statistical and operational research models). The working scheme of one of these models is presented in figure 3 above.

3) A symbolic evaluation (expert system) which consists in applying on the current state, an expert system performing backward chain inferences on a user's goal.

This module can, for instance, be used during the creation of a block in order to specify its limits by taking into account some pedologic or climatic knowledge or the history of surrounding blocks.

III.3°). Change of a state

The present DSS has been designed in order to allow the engineer to investigate a situation in a non imperative way. Thus after having performed some valuation on the current state, he can choose to analyse a new state (that he finds) more promising.

The state change operators provided are :

- Selection which allows to generate a new state by selecting in the current state, objects that meet a given criteria ;
- Union which generates a new state by bringing together objects appearing in two states which are already processed;

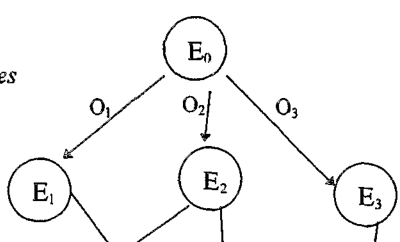
- Intersection which allows to generate a new state by performing the intersection of objects that appear in two processed states;
- Symmetrical difference of two states;
- Integration of new information plans;

III.4°) Management of the state space

The state space is potentially infinite as in most problems of research in a states graph [redacted] of the steps which have lead to the generation o f the current state, the system manages a [redacted]

Suppose that, at a given instant, the set of generated states be described as follows :

figure 4 : generated states



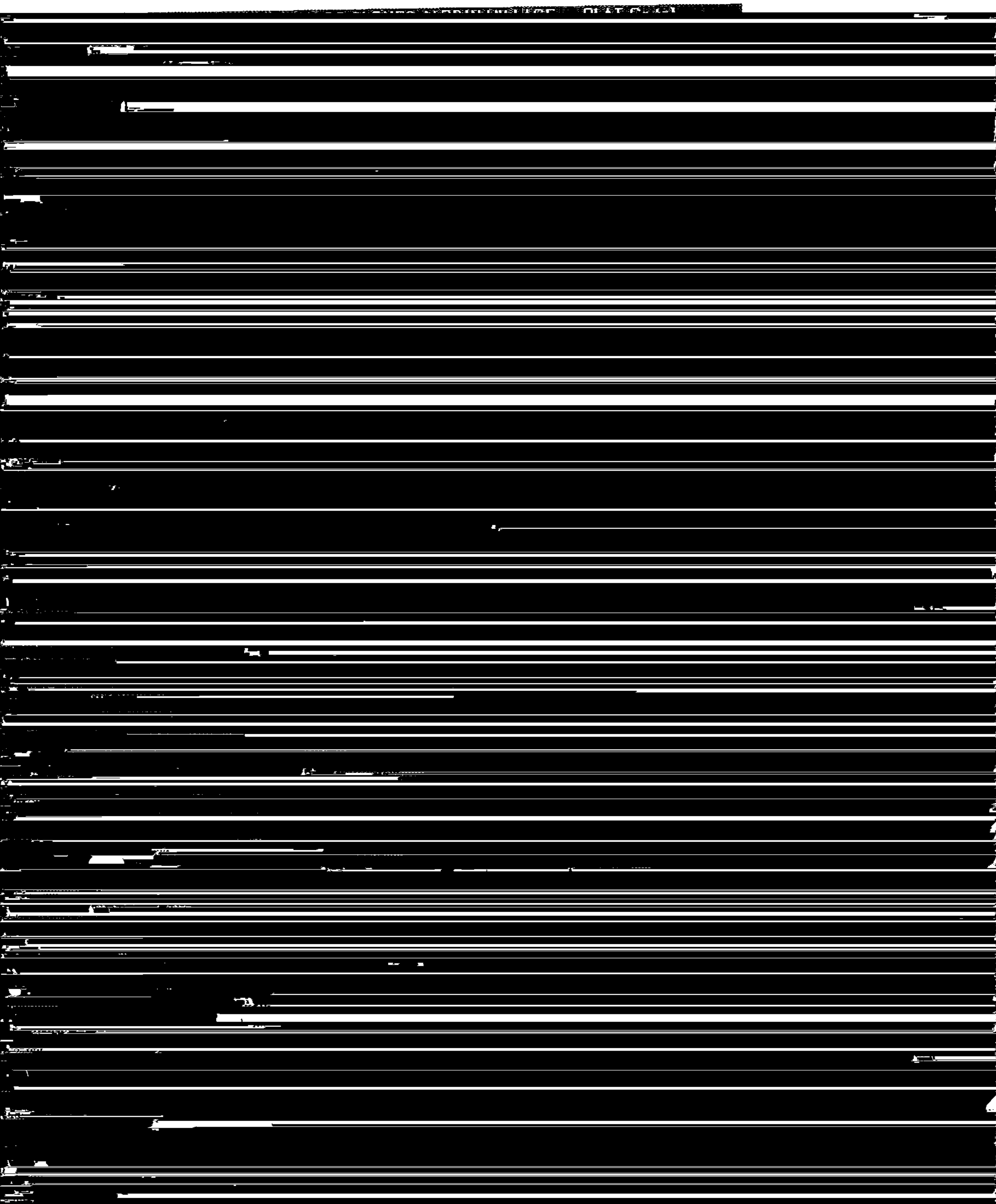
IV°) THE SYSTEM'S INTERFACE

One of the main features of a DSS is its interactive character[LEVI 90] [ANDR 83]

IV.2°) Support to the execution of decisional procedures

The interface of the system provides a menu with different statements allowing to start the execution of decisional procedures. Some of these statements use additional data coming from the relational data base. An assistance in writing the queries is proposed to the user in this case.

The result of th execution of decisional procedures are given in the shape of graphic in the form of cipher information displayed in a form.



- the use of a user-friendly GIS interface;
- the use of decisional models with varied data sources.

This system is effectively used by engineers in industrial hevea plantations in Gabon. Its utilization in industrial hevea plantation in Cameroun and Côte d'Ivoire is envisaged in the short term.

An interface adapted to the use by high level decision makers based on the notion of sub-language[KITT 89] is in study.

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