A Multiagent System for the Study of Populations

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1 1. Abstract

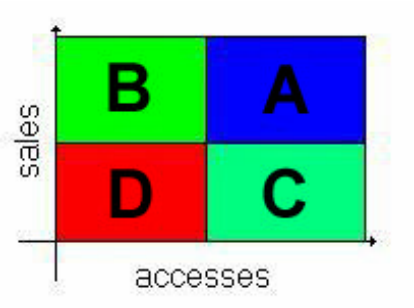
In this work we will confront the design of a system (based on agents) that takes charge to carry out tasks of surveillance or a population's supervision. Among their responsibilities they will be those of classifying the individuals, to control the appearance or disappearance of these and also to observe their evolution (for evolution we refer to the state changes).

Due to the nature of the problem, the system will have a high grade of autonomy. It would be also advisable to endow him of certain intelligence so that can adapt to the population's changes.

2 2. Introduction

From a purely commercial point of view, to know the demographic distribution of your clients is a vital question. This is due to that this knowledge allows to design much more precise and more e¤ective commercial strategies. If for a moment we notice the publicity, soon after we realize that each announcement (a marketing action) has a public that we will call" objective" public, to which was thinked. If we also carry out an historical study, this knowledge will provide us information about the evolution of the clients inside the system, what supposes that we can know the tendencies and the attitudes of the clients, such as the grade of satisfaction ...

Let's see a more concrete example. Let us suppose that we own a store and we want to study the clients in function of the number of times that they come into the store (to this variable we will refer as accesses) and in function of the gain that they generate (to this varable we will refer as sales). Therefore we could establish the following classi…cation:



Area A: Clients that visit many times the store and they also generate many revenues.
Area B: Clients that visit few times the store but that they generate many revenues.
Area C: Clients that visit many times the store but that they generate few revenues.
Area D: Clients that visit few times the store and that they generate few revenues.

Therefore, the …rst task to carry out will be the one of obtaining the position of the di¤erent users inside the system, or what is the same thing, to obtain the coordinates associated to each user. For example, if an user has visited 20 times the store and it has consumed 200 Eurus, we will represent it for (30,200). This will be the classi…cation process inside the system.

We will also add the date of the classi…cation, with what the representation would be of the type (01/01/2001 14: 37,30,200). Once …nish the classi…cation process, we have reduced the problem to the study of the estates of one "cloud of points." For this new task we will use several agents specialized in tasks characteristic of DataMining, as they can be:

a) Clustering: Obtaining of groups, in this problem, "similar" users should have near "positions."
b) Historical: Using the date of "evaluation of the user", tendencies or attitude patterns can be lo
c) Surveillance: custom "pursuit" of groups or individuals.

To implement the answers of the agents, we will use a system based on rules. For example:

$$if\ x\ 2\ R\ then\ do\ C;\ with\ x\ 2\ R^3 y\ R\ ½\ R^3$$

To each one of these rules we will denominate them Actions.

Lastly, we will make a classi…cation of the agents in function of their tasks:

a) Observer Agents. They will be the in charge agents of" translating" the information to the syst
b) Storage Agents: they will be in charge of storing the data.
c) Action Agents: they will be in charge of analyzing the changes in the users. Also they have to r
d) Coordination Agent: In charge of assigning the tasks to the di¤erent agents.

3 3. Formal development

De…nition 1 Coordinate C: Numerical form of one characteristic of the population.

We can asume, without loss of generality, that $C \subset N$. In the some cases, like qualitative values (in example "red","blue" ..), there is one injective funcition $f : V \to N$ where V is the set of possible values. We can also suppose, without loss of generality that a metric d that measures the vicinity among values exists. It will usually be the Euclidean metric, but in the variables of qualitative type you could use the discrete metric.

Be N the number of characteristic to study.

De…nition 2 Space E: $E = \prod_{i=0}^{N} C_i$: Is the topological product of all the coordiantes.

The space E is the set of possible users, since it represents all the possible combinations of values of the individuals. However, we can still …nd a wider space in the one that to carry out our study. To this new space will call it normal universe.

De…nition 3 Normal Universe U: $U = R \times E$: The normal universe is obtained adding the temporal coordinate (the date when the individual is analyzed).

In this set we can de…ne a distance D in the following way:

$$D(x;y) = \underset{i=0::N}{Max} \{d_i(x;y)\} \text{ where } d_i \text{ is the distance in the i coordinate:}$$

De…nition 4 Clasi…cation rule: Every function $f : \{\text{World values}\} \to C_i$ with C_i coordinate, is a clasifation rule for the coordinate i.

De…nition 5 Action a: Let $R \subset U$ be a set, C an algorithm. We will say that the couple $a = (R;C)$ is an realizable action by an agent Ag; if this agent can execute C taking every $x \in R$ as input: Let A be the set conatining all the actions:

$$A = \{(R;C) \mid R \subset U \text{ y } C \text{ algorithm}\}$$

De…nition 6 Knowledge K: Is the set of valid associations betwenn agents and actions.

$$K = \{(Ag;a) \mid Ag \text{ agent y a relizable action by Ag}\}$$

4 4. Group Management

Due to the characteristics of the problem, it can be necessary to pay special attention to certain individuals or individuals' groups. To achieve this objective, besides the previously aforementioned characteristics, for each user a responsible agent will settle down (to the one that we will denominate supervisor). This agent will be the in charge of "watching over" the individual, or what is the same thing, of responding to the events produced by the individual. These supervisor agents will have implemented communication mechanisms, since if the agent cannot apply none from the action rules to an user, it will look for an alternative solution, like to request help or to be declared incompetent for that individual's administration (Although It could always execute a random action).

In this way we will have a variable quantity of supervisor agents. With those we will control the movements of the individuals. Starting from this, the necessity of having an agent that coordinates the di¤erent supervisors and be devoted to solve the possible derivative problems of the induviduals assignment, arises. This problems can be:

1. No supervisor accepts an individual.
2. To change to supervisor's individual (This fact comes associated to the idea of group change).

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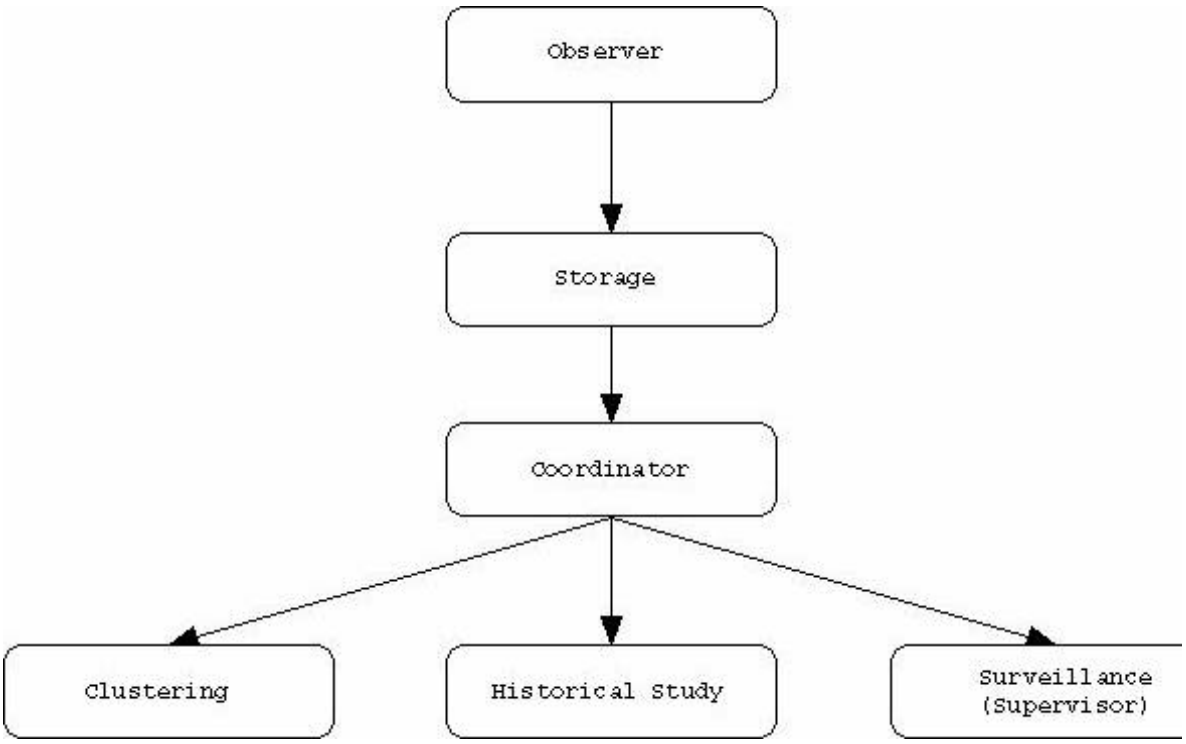
5 5. Organization and the agents' description



Now we are going to describe all the agent types in the system.

a) Observer

Description: : Agent in charge if translating the information from the individuals to their coordinates in U.

Objectives: To observe the changes taken place in the environment.
To obtain the user's new coordinates.

Notes for the implementation:

Here is where the functions f_i will be implemented.

To avoid waits in the time of classi…cation, the system should have several agents of this type working in parallel.

b) Storage

Description: Agent that handles the storage of the data. Usually it will be a database like Oracle.

Objective: The management of the data.

Notes for the implementation:

This agent should be able of communicate in a direct way with the rest of the agents.

c) Coordinator

Description: Agent in charge of coordinating the di¤erent action agents.

Objectives: To coordinate the di¤eren action agents.
To negotiate the assignment of supervisor agents
To negotiate the population of supervisor agents.

Notes for the implementation:

This agent has as subordinates the action agents, that is to say, these they will accept the decisions taken by the coordinator.

It is highly recommended to create only one agent of this kind, but if they are needed, there could be some coordinators with a hieratical relationship between them.

d) Action agents: Agents in charge of carrying out the answer from the system to the di¤erent situations. There are three basic subtypes:

1) Supervisor:

Description: Agents in charge of carrying out the inmediate response to the events in the system.

Objectives: To give an answer for all change detected in the individuals thar are under its responsability.
To help other agents on their duties.

Notes for the implementation:

The events can be so much events related with the individuals like routine tasks of the system.

This agents should have implemented an algorithm like:

Let $x \in U$
for every $a \in A$ do
f
if $x \in R_a$ then $C_a(x)$
g

2) Historical study:

Description: Agents with the same commitment as the supervisors, but these are oriented to study the behaivors of the individuals.

Objectives: To give an answer to speci…c behaviors.
To help other agents on their duties.

Notes for the implementation:

This study can be carried out from two very di¤erent perspectives:

2.a) Set theory perspective: It is enough for us to de…ne regions using the temporal coordiante.

2.b) Mechanical perspective: In this case we have to obtain curves that represents the "movement". This curves can be obtained with point interpolation techniques.

Also, this agents should have implemented an algorithm like the preceding.

3) DataClustering:

Description: Agent in charge of the managment of the groups of individuals.

Objectives: To discover new groups of individuals.

To detect changes in the ownership from the individuals to the groups.

To give an answer to the events related with the groups.

Notes for the implementation:

These agents should have implemented a construction algorithm of groups like:

Let x be an individual; $\varepsilon > 0$:
Let $G = \{G_i \; i = 1::M\}$ set of groups
for $i = 1$ to M do
    if $d(x; G_i) < \varepsilon$ then $G_i = G_i \cup \{x\}$ ¤
    stop;
f for
$M = M + 1$; (if x don$'$t belongs to any group)
$G_{M+1} = \{x\}$

We can extend the distance between point to a distance between a point and a set, in the usual way, like:
$d(x; Y) = \min\{d(x; y) \; j \; y \in Y\}$:

6 6. Resolution of objectives. Intelligence and learning

We can assume that for each individual, a region of the space exists that will call region objective O that it represents their good form, or what is the

same thing, their "optimal" state. For what the global objective of the system will be to reduce or to maintain in zero the distance from the individual to its objective region.

To endow from intelligence to the agents of the system we will use a model based on reinforcement. The intensity and the type of reinforcement it will be determined in function of the variation of the distance to the objective region. Be R the reinforcement:

$$R = d(x;O) \text{ ¡ } d(y;O)$$

where x is the individual's original position (before the agent carries out the action) and y is the following position of the individual.

7 7. Some Results

We can remark some results:

1. The consequences of the actions of the agents can be measured. When incorporating the temporary coordinate, we can observe the individual's state before and after carrying out the action.
2. The behaviors or the trajectory of the individuals can be measured by means of a study of the temporary series formed by their coordinates. This aspect you can use to carry out predictions on their behavior.
3. Unwanted changes in the ownership to groups can be avoided. If we consider the group like a set of points, this has a frontier (for example the convex closing of the set). Coarse with studying the distance of the individual to this frontier, if the distance is very small, the agent can carry out some action in consequence.
4. The "intentions" of the individuals can be measured. Using statistical techniques, and given an individual, if we calculate the vectorial average of all the natural changes of position (that is to say, we limit ourselves to observe how the individuals change, without acting on them), we obtain the tendency of an individual's change that is in that position.

8 8. Conclusions

This paper shows the the design of a multi-agent system that takes charge to carry out tasks of surveillance or a population's supervision. Among their responsibilities they will be those of classifying the individuals, to control the appearance or disappearance of these and also to observe their evolution (for evolution we refer to the state changes).

9 9. References

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