2D-3D MultiAgent GeoSimulation with knowledge-based agents of customers' shopping behavior in a Shopping MallT[1]

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Abstract. In this paper we present a simulation prototype of the customers' shopping behavior in a mall using a knowledge-based multiagent geosimulation approach. The shopping behavior in a shopping mall is performed in a geographic environment (a shopping mall) and is influenced by several shopper's characteristics (internal factors) and factors which are related to the shopping mall (external or situational factors). After identifying these *factors* from a large literature review we grouped them in what we called "*dimensions*". Then we used these dimensions to design the knowledge-based agents' models for the shopping behavior simulation. These models are created from empirical data and implemented in the MAGS geosimulation platform. The empirical data have been collected from questionnaires in the *Square One shopping mall* in Toronto (Canada). After presenting the main characteristics of our prototype, we discuss how mall's managers of the *Square One* can use the Mall_MAGS prototype to make decisions about the mall spatial configuration by comparing different simulation scenarios. The simulation results are presented to mall's managers through a user-friendly tool that we developped to carry out data analysis.

Keywords. Knowledge-based agent, MultiAgent System, GeoSimulation, Shopping mall, Shopping behavior, Spatial characteristics, Spatial behavior

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1 Introduction:

Geosimulation (Benenson and al., 2004) and more specifically the simulation of human behavior in space is an extremely interesting and powerful research method to advance our understanding of human spatial cognition and the interaction of human beings with their spatial environment. MultiAgent systems provide a computing paradigm which has been recently used to create such simulations (Frank and al., 2001). Several researchers used this paradigm to develop simulation applications that simulate different behaviors in spatial environments. For example, (Raubal, 2001) (Frank and al., 2001) presented an application which simulates a wayfinding behavior in an airport. (Dijkstra et al., 2001) simulated, using cellular automata, pedestrian movements in a shopping mall. (Koch, 2001) simulated people movements in a large scale environment representing a town. These applications successfully simulated certain kinds of behaviors, but they have some limitation related to the capabilities of the agents used in the simulation. For example, the agents of (Raubal, 2001) and (Frank and al., 2001) perceive and memorize their environment using the concept of information and affordance (Frank and al., 2001). (Dijkstra et al., 2001) and (Koch, 2001) use a message passing technique between the agent and the environment. These perception mechanisms do not allow agents to perceive the geographic characteristics of the environment which are important to take into account certain spatial behaviors. Furthermore, in these applications the agents do not have a memorization capability which can used to memorize the elements perceived in the environment. To develop more realistic applications that simulate human behavior in spatial environments, we need agents equipped with a more "*accurate perception*" and able to perceive all the components included in the environment and the changes that may occur to objects in the geographic space. Agents also need richer cognitive capabilities such as memorization.

In addition, the applications of (Raubal, 2001), (Frank and al., 2001), (Dijkstra et al., 2001) and (Koch, 2001) are only used to display on screens the behaviors to be simulated. To be more useful, simulation applications must be used beyond the mere visualization function: They should generate simulation output data which can be used by users in order to make decisions. In MAGS project (Moulin et al., 2003) we develop a method and a geosimulation platform in order to overcome some of the aformentionned limitations of exisiting geosimulations.

In this paper we present a multiagent geosimulation application which simulates customer's shopping behavior in a shopping mall in order to understand how shoppers interact with a mall and how they react to the changes of the mall's configuration and atmosphere. We use a *multiagent geosimulation* approach for the following reasons:

- The shopping behavior in a mall is an activity which is performed by a large number of shoppers (hundreds or thousands of shoppers). Hence, the use of a multiagent approach and a realistic simulation should take into account individual behaviors (Frank et al., 2001).
- It is, essentially, a spatial behavior carried out in an environment (shopping mall) in which the geographic and spatial characteristics are very important.

- Furthermore, we are interested in the behavior of customers who perceive, memorize, decide and navigate in the shopping environment. Hence, our agents should be equipped with some of these cognitive capabilities (Frank et al., 2001).
Furthermore, in our prototype we feed the simulation with data using specific tools that we developped for our work. In addition, our proptotype generates output data using software agents called *Observers* and we analyse this data using non-spatial and spatial analysis techniques. This analysis is carried out through a data analysis tool that we developped in *Microsoft Visual Basic 6.0*. Using our application, mall' managers (i) can visualize and understand how shoppers interact with the mall's environment (spatial or atmosphere aspects of the mall), (ii) can change the configuration or the atmosphere of the mall and see how virtual shoppers react to these changes and (iii) can identify the parts of the mall on which they need to concentrate their efforts in order to make their mall more confortable for shoppers and to seduce them.

This paper is organized as follows. In Section 2 we discuss the main properties of the shopping behavior in a mall. In Section 3 we present the characteristics of some agents' models that we designed to simulate the customers' shopping behavior. In Section 4 we present our multiagent geosimulation prototype of the shopping behavior. In the same section we present how mall' managers can use the prototype in order to evaluate different configurations and atmospheres of the mall. Finally, in Section 5 we discuss some related works and in Section 6 we present future works and conclude the paper.

2 The shopping behavior in a shopping mall

The shopping behavior that we consider in this research consists of all the activities that shoppers can carry out in a mall. These activities depend on the mall's characteristics. Hence, it is relevant to first study these characteristics.

(Roberts et al., 2000) presented five stages of the evolution of shopping malls. Furthermore, they identified the four critical components of malls: relatil, services, entertainment and social components. These elements are discussed in the following points.

- *Retail*: The retail component is the most dominant element of a shopping mall. It includes the stores and kiosks, the department stores, etc. Some shopping malls focus on a specific retail format to suit their particular area of specialisation. In this component we find the spatial configuration (layout and positions of the stores, kiosks, doors, etc.) and the atmosphere (music, lighting, odor, temperature, etc.) of the shopping mall.

- *Services*: The provision of services is a key element in shopping malls. Some malls provide outlets for the post office, laundromat, pharmacy, medical services, bank, wheelchair access, free child care services, community halls, a courtesy bus and parcel pickup, etc.

- *Entertainment*: Entertainment is a critical element in a mall and is perhaps the aspect that is remembered most by shoppers. Here are some examples of this component: fashion parades, live television broadcasts, cinema. Entertainment sometimes depends on the particular focus of the mall.

- *Social*: The social aspect of the mall relates to the idea of being a community meeting space. It allows people to participate in a community recreational activity, to seeing and being seen, to meet and passively enjoy the atmosphere. Ambient music, landscape and a wide variety of places to eat support this component. The social element is very important and a large number of people come to the mall not to purchase but to socialize.

Our literature review confirmed that the shopping behavior in a mall is affected by the four shopping mall's components discussed by (Roberts et al., 2000). These components represent, what is called in the literature, the "*external factors*" which come from the environment and affect the shopping behavior. Other studies present factors called "*internal factors*" (they are related to the shopper). Here are some examples of these *internal factors* : demographic variables (gender, age group, marital status, occupation, etc.), personality, values, attitudes, culture, social class, goals, preferences, habits, temporal factors, the financial status, the knowledge of the shopper, etc. (Duhaime et al., 1996).

After identifying these factors, we grouped them into several categories. Some of these categories belong to the shopper and the others belong to the environment (shopping mall). In this paper we refer to these categories by the term "*dimensions*".

- *The Shopper dimensions:* These dimensions represent a large number of factors belonging to the shopper. In our work we consider the following dimensions: The shopper Characteristics, the Shopper Knowledge, the Shopper Behavior dimensions.

- *The Shopping mall dimensions*: These dimensions represent several factors belonging to the environment (shopping mall) and affect the shopping behavior. In our work we consider the following dimensions: Space, Ambiance and the Information dimensions of the shopping mall.

All these dimensions are used to design the knowledge-based agents' models that are used to develop the geosimulation prototype of the shopping behavior in a mall. The detail of these dimensions and the agents' models are discussed in Section 3.

3 The characteristics of the multiagent geosimulation models of the shopping behavior in a shopping mall

In our work we use knowledge-based agents to simulate the shopping behavior. This section aims to present the agent-based simulation models that we used to develop the geosimulation prototype. The first agent model simulates the shopper. This model contains the shopper's dimensions which affect the shopping behavior in a mall. Furthermore, since we use this model to simulate human behavior, we integrate spatial and non-spatial capabilities that simulate those possessed by people such as perception, memorization, decision making, navigation, etc. In the second agent model we integrate the dimensions that belong to the mall and which affect the shopping behavior.

3.1 The characteristics of the Shopper agent's model

In the Shopper agent model the dimensions take into account several factors that can affect the shopping behavior in a mall and different processes that compose this behavior.

Characteristics **dimension**: In this dimension we distinguish two kinds of characteristics: Non-spatial and spatial characteristics. The *non-spatial characteristics* represent the Shopper agent's attributes. They can be either static or dynamic. The static characteristics represent the attributes that can affect the shopping behavior and do not change during the simulation. Here are some examples: *gender*, *age group*, *marital status*, *sector of employment* of the Shopper, etc. The dynamic characteristics represent the attributes that affect the shopping behavior and can change during the simulation. Here are some examples: *level of hunger*, *level of thirst*, *level of fear or stress*, *need to go to the restroom*, *emotional states*, etc. The *spatial characteristics* represent the physical attributes of the Shopper agent. We have both 2D and 3D representations of the agents. In a 2D mode the Shopper agent can be represented by a point, a triangle, a square (Fig. 1.a presents these representations). The 2D representations (point, triangle or square) can be chosen by the user of the simulation in order to distinguish between the simulation agents
In 3D it is represented by slightly animated figures of a man or a woman that can be young or old (Fig. 1.b).

Fig. 1.a. The 2D spatial characteristics of the Shopper agent

Fig. 1.b. The 3D spatial characteristics of the Shopper agent

***Knowledge* dimension:** The Shopper agent's knowledge obviously influence its shopping behavior and decision making such as choosing the type of stores or kiosks to visit, the path or corridors to follow during the shopping trip, etc. In our model we distinguish non-spatial and spatial knowledge. *Non-spatial knowledge* represents what the Shopper agent knows about the non-spatial characteristics of the environment (the mall). Here are some examples: The name and speciality of stores or kiosks, the products found in stores or kiosks. *Spatial knowledge* represents what the Shopper agent knows about the spatial characteristics of the environment. Let us mention for example the locations of stores or kiosks, of doors, of restrooms, of corridors.

***Behavior* dimension:** Shopper agents are autonomous and can perform different spatial aor non-spatial behaviors in the mall.

Non-spatial behavior contains the following processes:

-The Perception process: The Shopper agent can perceive the non-spatial information of the environment such as the types of stores or other messages that can be broadcasted in the mall (ads messages or others).

-The Memorization process: The Shopper agent can memorize the non-spatial information that comes from the environment such the type of stores or the kiosks.

-The Decision making process: The Shopper agent makes decision about its movements inside the mall. On the bases of its own characteristics, of what it perceives in the environment, of what it memorizes (its knowledge). For example, the Shopper agent can decide to go to a store, to go to a place where to eat, to go to the restroom, to play, to socialise with other people, to leave the mall.

Spatial behavior contains the following processes:

-The Perception process: The Shopper agent can perceive the spatial characteristics of the environment. The perceived elements (stores, obstacles, other agents, etc.) are used in the decision making process.

-The Memorization process: The Shopper agent uses this process in order to memorize the spatial elements perceived in the environment. In our simulation the Shopper agent can memorize the locations of stores, doors, corridors, and use them in the decision making process.

-The navigation process: The Shopper agent can move from one point to another in 2D and 3D modes (Fig. 2.a and 2.b).

Fig. 2.a. The 2D spatial behavior of the Shopper agent (navigation)

Fig. 2.b. The 3D spatial behavior of the Shopper agent (navigation)

3.2 The characteristics of the Shopping mall agents' model

The model of the shopping mall contains several dimensions. Unlike the Shopper's model which is represented by an agent, the shopping mall model is represented by different software agents. Each important element of the shopping mall such as stores, kiosks, restrooms, doors, is represented by a software agent. These agents cannot move, but they have all the other characteristics of agents. These agents represent the limits of the simulation, in the sense that we do not simulate in details what happens inside the stores. The behaviors associated with these agents enable us to model, using probabilistic models, the outcomes of the shopper agent's visits in the stores. For example, a behavior of a store computes the duration and the results of the visit of each agent entering in the store based on the agent's charactristics and some probabilities. Another store behavior broadcasts to agents located in it information about the items and ads displayed in the store window. In the shopping mall's model we consider *Space*, *Ambiance* and *Information* dimensions.

***Space* dimension:** It represents the geographic and spatial characteristics of the mall, and is taken into account by the spatial processes of the Shoppers agents (perception, memorization, navigation and movement decisions, etc.). Fig. 3.a and Fig. 3.b represent respectively 2D and 3D spatial representations of *Square One shopping mall* in which we carry out our simulation. To feed this dimension we use data manipulated with Intergraph's Geomedia Geographic Information System (Hhttp://www.intergraph.com).

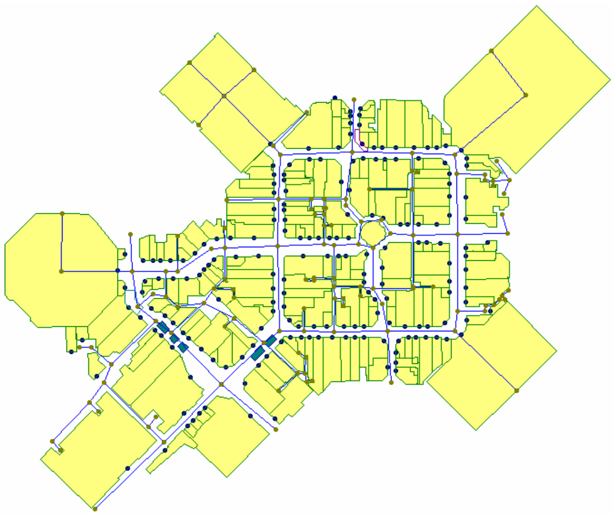

Fig. 3.a. The 2D spatial structure of Square One shopping mall

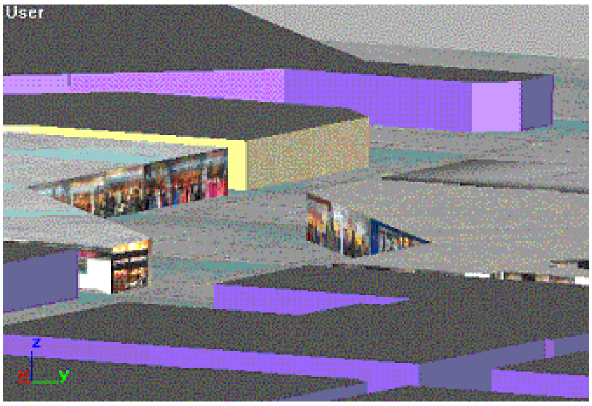

Fig. 3.b. The 3D spatial structure of Square One shopping mall

***Ambiance* dimension:** It contains the elements of the ambiance or the atmosphere of the shopping mall which can affect the shopping behavior. As example of elements we can cite the *temperature*, *colors*, *music*, *lighting*, etc.

***Information* dimension:** It represents the non-spatial information of the mall.

4 The geosimulation implementation: The case of the Square One shopping mall (Toronto)

4.1 The MAGS: The MultiAgent GeoSimulation platform

The simulation models presented in the previous section are used to develop a multi-agent geosimulation prototype using a geosimulation platform called MAGS (Multi-Agent Geo-Simulation) (Moulin et al., 2003). It is a generic platform that can be used to simulate, in real-time, thousands of knowledge-based agents navigating in a 2D or 3D virtual environment. MAGS agents have several knowledge-based capabilities such as perception, navigation, memorization, communication and objective-based behavior which allow them to display an autonomous behavior within a 2D-3D geographic virtual environment. The agents in MAGS are able to perceive the elements contained in the environment, to navigate autonomously inside it and react to changes occurring in the environment. These agents have several knowledge-based capabilities.

- *The agent perception process*: In MAGS agents can perceive (1) terrain characteristics such as elevation and slopes; (2) the elements contained in the landscape surrounding the agent including buildings and static objects; (3) other mobile agents navigating in the agent's range of perception; (4) dynamic areas or volumes whose shape changes during the simulation (ex.: smoky areas or zones having pleasant odors); (5) spatial events such as explosions, etc. occurring in the agent's vicinity; (6) messages communicated by other agents (Moulin and al., 2003).

- *The agent navigation process*: In MAGS agents can have two navigation modes: *Following-a-path-mode* in which agents follow specific paths which are stored in a bitmap called ARIANE_MAP or *Obstacle-avoidance-mode* in which the agents move through open spaces avoiding obstacles. In MAGS the obstacles to be avoided are recoded in specific bitmap called OBSTACLE_MAP.

- *The memorization process*: In MAGS the agents have three kinds of memory: *Perception memory* in which the agents store what they perceive during the last few simulation steps; *Working memory* in which the agents memorize what they perceive in one simulation and *Long-term memory* in which the agents store what they perceived in several simulations (Perron et al., 2004).

- *The agent's characteristics*: In MAGS an agent is characterized by a number of variables whose values describe the agent's state at any given time. We distinguish *static states* and *dynamic states*. A static state does not change during the simulation and is represented by a variable and its current value (ex.: gender, age group, occupation, marital status). A dynamic state is a state which can possibly change during the simulation (ex.: hunger, tiredness, stress). A dynamic state is represented by a variable associated with a function which computes how this variable changes values during the simulation. The variable is characterized by an initial value, a maximum value, an increase rate, a decrease rate, an upper threshold and a lower threshold which are used by the function. Using these parameters, the system can simulate the evolution of the agents' dynamic states and trigger the relevant behaviors (Moulin and al., 2003).

- *The objective-based behavior*: In MAGS an agent is associated with a set of objectives that it tries to reach. The objectives are organized in hierarchies which are is composed of nodes that represent composite objectives and leaves that represent elementary objectives which are associated with actions that the agent can perform. Each agent owns a set of objectives corresponding to its needs. An objective is associated with rules containing constraints on the activation and the completion of the objective. Constraints are dependent on time, on the agent's states, and the environment's state. The selection of the current agent's behavior relies on the priority of its objectives. Each need is associated with a priority which varies according to the agent's profile. An objective's priority is primarily a function of the corresponding need's priority. It is also subject to modifications brought about by the opportunities that the agent perceives or by temporal constraints (Moulin and al., 2003).

- *The agent communication process*: In MAGS agents can communicate with other agents by exchanging messages using mailbox-based communication.

The spatial characteritics of the environment and static objects are generated from data stored in Geographic Information System and in related databases. The spatial characteristics of the environment are recorded in raster mode which enables agents to access the information contained in various bitmaps that encode different kinds of information about the virtual environment and the objects contained in it. The *AgentsMap* contains the information about the locations of agents and the static objects contained in the environment. The *ObstaclesMap* contains the locations of obstacles, the *ArianeMap* contains the paths that can be followed by mobile agents, the *HeightMap* represents the elevations of the environment, etc. The information contained in the different bitmaps influences the agent's perception and navigation. In MAGS the simulation environment is not static and can change during the simulation. For example, we can add new obstacles, or gaseous phenomena such as smoke, dense gases and odors which are represented using particle systems, etc. (Moulin and al., 2003).

4.2 The Mall-MAGS prototype

Using the MAGS platform we developed a multiagent geosimulation prototype that simulates customers' shopping behavior in a mall. As a case of study we use the *Square One shopping mall* in Toronto (Canada). To feed the simulation models with data we carried out a survey in October 2003 and collected 390 questionnaires filled by real shoppers in the *Square One* shopping mall. This data belongs to two categories: Non-spatial data such as demographic information (gender, age group, marital status, occupation, preferences, habits, etc.) and spatial data such as preferred entrance and exit doors, habitual itineraries, well-known areas in the mall, etc.

In Fig. 4.a and Fig. 4.b we display 2D and 3D screenshots of a simulation that involved 390 software Shoppers agents navigating in the virtual shopping mall.

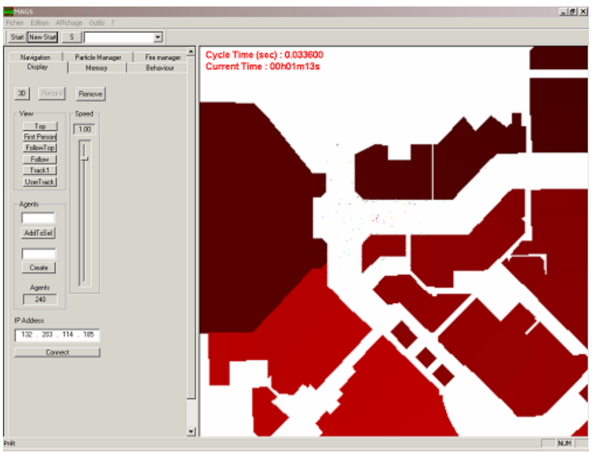

Fig. 4.a. The 2D simulation in MAGS platform (Square One mall)

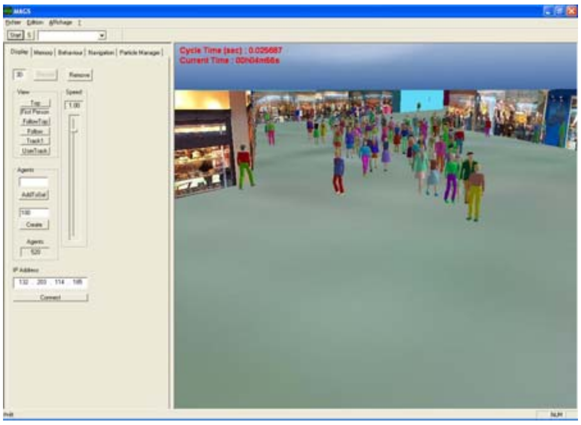

Fig. 4.b. The 3D simulation in MAGS platform (Square One mall)

In the simulation prototype the Shopper agent comes to the mall to visit a list of specific stores or kiosks that are chosen before the simulation on the basis of the agent's characteristics. It enters by a particular door and starts the shopping trip. Based on its position in the mall, its knowledge (memorization process), what it perceived in the mall (perception process), it makes decision about the next store or kiosk to visit (decision making process). When it chooses a store or kiosk, it moves in its direction (navigation process). Sometimes, when it is moving to the chosen store or kiosk, it perceives another store or kiosk (perception process) that is in its shopping list and that it did not know it before. In this case, the Shopper agent moves to this store or kiosk and memorizes it (memorization process) for its next shopping trips. The shopper agent accomplishes this behavior continually until it visits all the stores or kiosks or until it has not time left for the shopping trip. If the shopper agent has still time for shopping and some stores or kiosks of its list are in locations unknown by the agent, it starts to explore the shopping mall to search for stores or kiosks. When the shopper agent reaches the maximum time allowed to the shopping trip, it leaves the mall.

The Shopper agent can also come to the mall without a specific list of stores or kiosks to visit: It comes to the mall to explore it, to see people, or to make exercice, etc. In the exploration mode the Shopper agent takes its preferred paths in the shopping mall. In this mode the moving action of the Shopper agent to the stores, kiosks, music zones, odor zones, lighting zones, is directed by its habits and preferences. For example, if the Shopper agent likes *cars* and it passes in front of a car exhibition, it can move to this exhibition. To extend our simulation prototype we can simulate the shopper reactions to the mall's atmosphere. We can insert special agents that broadcast music, lighting or odor. If the shopper agent is in the exploration mode and likes the music or the lighting or the odor broadcasted by these special agents, the shopper agent can move toward them and possibly enter the store.

During its shopping trip the Shopper agent can feel the need to eat or to go to the restroom (simulated by a dynamic variable reaching a given threshold). Since these needs have a bigger priority than the need to shop or to play, the agent suspends temporarily its shopping trip and goes to the locations where it can eat something or to restrooms. In our geosimulation prototype the priorities of the activities of the shopping behavior are defined based on Maslow's hierarchy of needs (Maslow, 1970).

4.3 The use of the Mall_MAGS prototype

Mall_MAGS can be used by shopping mall managers to make decisions related to the spatial configuration of the shopping mall**.** A shopping mall manager can change the spatial configuration of the shopping mall (change a store location, close a door or a corridor, etc.). For each change the manager can launch the simulation and collect the results. By comparing these results he can make informed decisions about the impact of spatial changes in the mall.

To illustrate the use of the Shopping behavior geosimulation tool we used 2 simulation scenarios. In the first one we launch a simulation with a set of input data about the shopping mall (GIS) (see Fig. 5.a) and about a population of 390 shoppers. This first scenario generates for us output data about the itineraries that the Shoppers agents take in the shopping mall. In scenario 2 we exchange the location of a two department stores: *Wal-Mart* and *Zellers* (Fig. 5.b), we launch the simulation again and we generate the output data about the itineraries of the same population of Shoppers agents. By comparing the output data of the two scenarios we notice the difference of the paths that the Shopper agents followed to attend the department stores *Wal-Mart* and *Zellers* stores. The simulation output analysis shows us that corridor X is less frequented in scenario 2 than in scenario 1 (Fig. 6.a). However, corridor Y is more frequented in scenario 2 than in scenario 1 (Fig. 6.b). In these figures the flow of the agents Shoppers which pass through a corridor is represented by a line which is attached to this corridor. The width and the color of this line are proportional to the flow of Shoppers agents that pass through the corridor. If this flow grows, the width of the line grows and its color becomes darker. By a data analysis on the characteristics' dimension of the Shopper agent we can see that in scenario 2, most of the Shoppers agents that go through corridor Y are female and they come to the mall to visit female cloth stores. If the mall manager chooses the mall configuration of scenario 2, he may think of renting the spaces along corridor Y to female cloth stores. It is important to note that:

- The simulation output data are generated using software agents called *Observers*. The mission of these agents is to gather data about the Shoppers agents which enter their perception area. This data is recorded in files and analysed after the simulation.
- The data analysis of the geosimulation output (non-spatial and spatial data) is implemented in an analysis tool that we developped using *Microsoft Visual basic 6.0*. This user-friendly tool uses the data generated by the *Observers* agents in order to make multidimensional non-spatial and spatial analysis using an OLAP (OnLine analytical Processing) approach (Bédard et al., 2001).

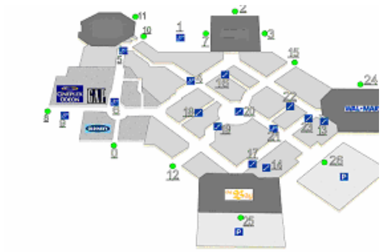

Fig. 5.a. The simulation environment in Scenario 1

Fig. 5.b. The simulation environment Scenario 2

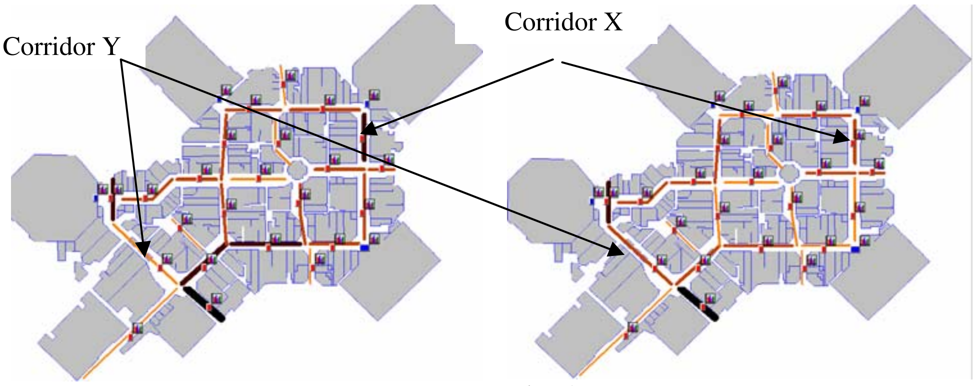

Fig. 6.a. The spatial data analysis in Scenario 1 **Fig. 6.b.** The spatial data analysis in Scenario 2

5 Related works

(Bandini and al., 2002), (Ulicny and Thalmann, 2001), (Sung and al., 2004) and (Batty, 2003) developed some applications that simulate pedestrian behavior in geographic environments using the agent technology. These works do not focus on the individual features and behaviors of each agent but aim to study the emergent behavior of crowds in the simulation. They also focus on the animation and gestural movements of the agents rather than their internal behavior. The shopping behaviors are very much influenced by the agents' internal factors (Duhaime et al., 1996). In order to simulate such behaviors, we need to deal with the individual structure and behavior of the agents. So the structure of our agent must contain the majority of the factors that influence the shopping behavior. The agent's behavior must be enough developed to contain the processes that compose the shopping behavior. We also need to take into account the collective level of the simulation (the crowd). Furthermore, the applications of (Ulicny and Thalmann, 2001) and (Bandini and al., 2002) are used to merely visualize the simulation in 2D and 3D. A simulation application is often used to make decision about the system to be simulated. Hence, it must generate output data that can be manipulated for different purposes. These outputs should be easily used by users to make decisions. In our simulation we take into account this important aspect of a simulation and we generate, using what we call observer agents, output data about the simulation which is used thanks to a user friendly interface, by the user to make decision about the system to be simulated (the shopper) or about the configuration of the simulation environment (the mall). In addition, our simulation is based on real data about the shopper and the simulation environment (the mall), which improve the realism of the simulation. This is not taken into account by the simulation applications mentionned above because they use data generated randomly or automatically using algorithms such as genetic algorithms.

6 Conclusion and future works

In this paper we presented how we can simulate the spatial shopping behavior of customers in a mall using knowledge-based multiagent geosimulation. We presented the factors that influence this behavior. Based on these factors we proposed different relevant dimensions that belong to the shopper and to the spatial environment (the shopping mall). Based on these dimensions, we discussed the agents' models that we designed in order to simulate the shopping behavior in a shopping mall. Third, we presented the multiagent geosimulation prototype that we developped based on these agents' models. This prototype is called Mall_MAGS whitch refers to Mall (shopping mall) using the MAGS simulation platform. Finally, we presented how the shopping mall's managers can use our prototype in order to make decisions about the assessment of the shopping mall configuration in order to make it more confortable for the shoppers. This decision making process is based on a non-spatial and spatial multidimensional analysis of the geosimulation output data. It is important to note that the simulation output data is generated using agents called *Observers* which use their perception capabilities to observe the simulation and store data about it in file structures.

In few months we plan:

- To enhance our prototype to simulate customers' entertainment activities if a Shopper agent feels the need to play or to entertain, it can move toward an entertainment zone such as merry-go-round in order to satisfy this need.
- To simulate the social aspect of the shopping behavior. So, if the Shopper agent does not like crowdy environments it can avoid them. If it perceives a store to be visited and it sees a large number of shoppers agents in front of this store or kiosk, it can decide to abandon its goal to visit to this store. However, if the Shopper agent likes to be in a crowd it can look for crowded areas around it and move toward them.
- To extend the usage of the simulator in order to help mall managers to make decisions about marketing strategies related to the changes of music or odor in a corridor, change of temperature, or wall colours in certain areas, etc. For each change they would execute the simulation and collect results. By comparing these results they can make decisions about the optimal marketing strategy to adopt. How to propose a systematic way to carry out these comparisons is still an open research area.
- To validate our geosimulation models, document our prototype and deliver a final version of the Mall_MAGS prototype to the managers of the *Square One* shopping mall in Toronto.

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Biography

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