Understanding Townscapes through AI Approaches to the Study of Human Living in Space

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ABSTRACT
Spatial environments have been studied by many scholars in different disciplines, and the present study aims at contributing to the broader discussion from an urban-planning viewpoint. Indoor and outdoor townscapes, because of their dynamic complexity, seem to offer ill-structured holds to the typical spatial behaviour of an agent, particularly when spatial behaviours are analyzed in mainstream AI robotics. Therefore, a question arises about the ‘fundamentals’ of townscapes from the point of view of the needs of living agents, having to live in and move through them in resilient and intelligent ways.
In this context, the subject of the present paper is the diagnosis and the control of a structured simple space, geometrically intended as the minimum arc of a graph. Conditions, situations, elements, behaviours are explored and partially analyzed in their spatial-temporal dimensions, subsequently aiming at setting up a system architecture to let spatial agents control their de-structuring impact.
The research makes use of text analysis and interpretation, both applied to an in-class questionnaire survey, exploring low level (movement orientation) and high level (memories and fantasies) behaviours in human interaction with a space. The experiment is developed by relying on a large class of students from the Technical University of Bari, daily using a long and apparently amorphous corridor to reach lecturers’ offices for advice, exams and explanations.

Keywords: Spatial conceptualization, Townscapes, Environmental planning, Multi-agent systems, Decision support systems.

1. INTRODUCTION
Landscapes and townscapes have been studied by many scholars over time: the present study aims at contributing by addressing a specific issue to the broader discussion. It raises out when considering that townscapes and cityscapes are the prevalent, knowledge-intensive, meaningful spaces and entities that the human adapt for their life. Because of their dynamic complexity, they seem to offer ill-structured holds to the typical spatial behaviour of an agent, particularly when trying to simulate spatial behaviours in mainstream AI robotics. Therefore, a question arises about the ‘fundamentals’ of spacescapes from the point of view of the needs of living agents, having to live in and move through them in resilient and intelligent ways.

In fact, on one side, it seems commonsense to think that well designed space architectures or furniture make space more meaningful for the human to use – to live in – when compared with amorphous spaces. Conversely, discipline experts maintain that the drama of social marginality in cities largely depends on the abundance of landmarks and symbols that characterizes the city cores, which are inappropriate and alienating to poor people. Yet, on the background of these points, there is a potential naivety in speaking about spacescape ‘fundamentals’ as opposed to spacescape ‘additional’, ‘ornamental’ qualities, in a world where no clear practical and theoretical distinction can be made between content and form.
Understanding the way in which human agents think and operate in given spaces – i.e., space ontology, from a perceptual point of view – is commonly essential for AI robotics. In turn, because of the well known circularity between AI and cognitive science, the development of AI robotics devices help in understanding spatial human behaviours. Therefore, the comprehension/identification of space fundamentals by human agents can be of great interest in strategic planning, in that they may represent structures, pillars, invariant, resilient characters of the environment, on which to build/plan the development of towns.
Basing on the above points, the present paper deals with space conceptualization by humans according to the cognitive approach that is mainstream in AI robotics, by using at the same time the expert domain knowledge of outdoor and indoor artificial spaces that are analyzed and designed by architects and planners. The research makes use of text analysis and interpretation, both applied to an in-class questionnaire survey, exploring low level (movement orientation) and high level (memories and fantasies) behaviours in human interaction with a space. The experiment is developed by relying on a large class of students from the Technical University of Bari, daily using a long and apparently amorphous corridor to reach lecturers’ offices for advice, exams and explanations.
The paper is structured as follows. After the present introduction, in the second section the main scientific issues connected with the conceptualization and representation of space are reviewed and discussed, as foundations of the present study. The third section synthesizes the results of the questionnaire experimentation, with a discussion of the resulted knowledge base. Section four presents and example of a basic navigation-support module to help students’ move in the corridor. A general discussion and conclusion remarks are drawn out in the fifth and last section.

2. SPACE, COGNITION, ORGANIZATION
The present work aims at exploring the mode of conceptualizing and representing the space by human agents in finding out a way to reach a spatial objective through it.

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5 The present study was carried out by the authors as a joint research work. Nonetheless, chapter 2 was written by D. Borri, chapters 1, 3, 4 and 5 were written by D. Camarda. The authors are grateful to A. Celino and M. Patano for their support, help and critical contribution to the review of the paper.
The scientific context of reference is the engineering of intelligent artificial systems, oriented to plans and organizations involving biotic as well as abiotic agents.

On the side of planning and organization studies, the space is dealt with either as environment and tank of human actions (whose characteristics are considered only from the viewpoint of its adaptability to humanization—anthropization), or as a relevant, active entity per se (an agent, we could say), whose analysis and modelling reveals parts of human behaviour dependent on it [7] [18] [22].

On the side of spatial cognition studies the space—as abiotic entity—is largely dealt with not per se, again, but from the point of view of biotic agents who use it to better adapt some of their behaviours that cannot ignore the space. An example in elementary actions could be the search for food in a space, whereas in higher-level actions an example could be the enjoying of a spatial beauty [6] [20].

There are integrations of the two sides of study, especially where theories and actions of planning and spatial organization—as strongly occurred in recent years—are influenced by knowledge acquired from other domains [8] [19].

In our specific ‘cognitivist’ research perspective, still theories and theorems from the mathematic, geometric and topologic domains are almost entirely to be explored. Yet, some promising milestones from both classical tradition and recent developments appear among them [2] [13] [17].

The problem that we put down in the present work is connected with the general mechanism of spatial cognition-perception-decision, operating in a human agent who ‘navigates’ through a given indoor space-environment, for the execution of a specific task. The task is in our case the reaching of a localized objective, namely the finding out of a professor, presumably at work in her room, by a student who needs some clarification on her course of lectures.

In general, we know that there is a problem of orientation and movement in navigation, which is diffusely studied in the broad interdisciplinary field of cognitive sciences [5] [11]. However, in the present work we will bring up the specific problem of the role played in helping the navigation by different components of the space-environment in which the navigation develops. In particular, we will study the role played by its ‘structural’ components, made up by ‘substances’ or ‘essences’ such as the walls that limit the space, and by its ‘ornamental’ components, made up by everything integrates the structure from other—different-functional viewpoints, such as furniture.

In expressing this problem, we were inspired by some intriguing logical arguments by Goodman [12]. Even if they do not concern directly and analogously our pretended distinction between ‘substances’ and ‘forms’ and relevant navigation-helping roles in a given space-environment, such arguments face the dialectics between the theme and the way of developing the theme itself. In particular, the arguments put down the dilemma of the impossibility and possibility of discriminating primary and secondary components in human agents’ perception of reality. Goodman’s thesis, even with many contextual shades and exceptions, is in favour of a non-discriminability, whereas large robotics literature seem to prefer discriminability (particularly in the difference between navigating in ‘structured’ or in ‘ill-’ or ‘non-structured’ spaces) [1].

It is a remarkable dilemma, which crosses the problem of the potentially infinite identification-description of the characters (attributes) of a given space-environment with respect to a cognition agent who must use them to live in the space. They are attributes (and consequently ‘sub-attributes’, to be identified-described for each attribute, as an infinite ‘waterfall’) in fact non-numerable, for which there is a possible task of ‘selection’. The non-numerable dimension of the identification-description, as well as the hierarchy dilemmas evoked by the necessary selection can be found out, for example, in some solutions to the problem showed by naive physics [14]. They introduce the frame concept-mechanism, which the agent instantly builds up about the situation—contextualized—of that space-environment, for the task that she wants to execute. Also, the same agent will surely avoid breaking the frame in parts, if it is not needed for a different—e.g., analytical—task, so as not to hamper the primary task.

The robotics distinction between structured and ill- or non-structured spaces mainly recalls the distinction between spaces with simple or complex geometries. The former are characterized by elementary geometries, rare unexpected events, rare secondary components, rare decision exigencies. The latter are characterized by composite geometries, frequent unexpected events, frequent secondary components and situations in which decisions are needed [3]. In the former, the robot’s movement and related learning would be easier than in the latter, and then connected to a recognizable cognitive configuration. This would occur even if they characterize a major part of the real worlds and even if in fact particular difficulties for an human agents passing from a structured to a non-structured world seem to be reasonably absent.

An indoor space—e.g., an hospital— in which an human agent crosses a well identified section of it, geometrically simple, and empty (a long and desert corridor, characterized only by a sequence of doors and/or windows on sides and by an origin and an end without any lateral branch) is in fact rather simple to be navigated and does not require any particular attention from the human agent.

A outdoor space—e.g., a community fair— through which a human agent moves randomly, in a highly crowded context, without any easily recognizable geometry, form, origin, end, requires in fact particular attention. In it, it is often possible to be carried away by the moving crowd through unclear paths, in which we are afraid of getting lost, or loosing some friend or person perhaps inexpert of moving in such complex space-environment (e.g., a child who is not (self-)trained for the task).

In it, a shrewd agent tries anxiously and previously to identify and memorize characteristic signs—such as a ‘beacon’ or a ‘monument’— replacing a ‘structure’ or a ‘geometry’ that are nonexistent or not perceivable [4] [9] [13].

In a corridor of a school or university building the human agent-navigator moves routinely. If she had been already there, at least once (hopefully more than once, better off every now and then), the relevant space-environment and some ‘objectives’ are already in her memory, reinforced by iterated experiences. In this context, (i) the task of reaching an objective belonging to the group of possible known objectives in that space-environment is executed without particular helps, but (ii) the task of reaching an objective not belonging to the group of possible known objectives in that space-environment is executed with some the help of some ordinary helping agent or through retrieval (context-dependent or independent) mechanisms. In this case, she will probably try several times until being successful, and will give up only basing on a rational calculation (time spent, presence of other commitments, possible and not known change of location etc.). If she has no memory of having been there, then the task is executed as in (ii).

Some elements are used in order to help human agents in navigating indoor environments—even fully structured, and then simple—that are not well known to them. They are: (a) other human agents-advisers, usually placed in striking locations that
are strategic for the navigation in those environments (clearly indicated and in any case evident entrance locations); (b) maps placed in full evidence, in which the location of the navigator is indicated (‘you are here’), highly useful in the absence of agents-advisers, but also to be used by human agents-navigators who are exploratory or at the opposite too shy to ask for help; (c) characteristic signals. In a university building corridor where multiple professors’ rooms are aligned it is easy that those signals are nameplates on or near the doors.

However, even in the absence of every possible help, a human agent carrying out a navigating task in an indoor environment with a given –even very low- structuring level, with the right age for the task and non-disabled in some basic abilities for navigation tasks (psychological-perceptive and moving abilities), is able to manage the task. In the end, that agent is able to carry out the navigation task without particular risk for her safety and sanity. Here, the scientific debate between innate and learned knowledge, on the existence of cognitive primitives, becomes essential and intriguing reference.

The labyrinth is an exception to the above. In fact, it is a cornerstone of the human environment for a biological organism. However, it is evident that the learning of the navigation in whatever indoor environment by the human agent starts soon after her birth (but the experience of the organism’s being and moving in a confined space can precede the birth) and develops with the conceptualization (categorization-abstraction) of spaces. These ones are founded on the progressive growth and maturation of some fundamental biological components and functions, as well as on the accumulation and the memorization of experiences.

The parent’s accompanying a child by the hand in her navigation in the space-environment, besides its being an expression of cautiousness, is a form of teaching the adaptation to the ill- or non-structuration, from which dangers to life may rise out. In fact, the hand will be dropped off when the child will be in a space that is familiar or low-risk, according to the parent. Therefore, structuration is not a characteristic of our surrounding environment, but it is due to the ability of mind to bring a given system back to a known model.

Let’s now go back to the aforementioned task of the navigation by the human agent in the structured space-environment of a university corridor, which is aimed at driving students, e.g., to some professor rooms. Let’s go back to the research objective in our present work to reflect –being aware of Goodman’s scepticism- on a possible distinction between ‘essence’ and ‘ornament’, in both an individual and a social (multi-agent) perspective in that space-environment. In this context, we believe that the most interesting experiment should be the behaviour of the human agent-navigator who had never been in that space-environment. In fact, as soon as she has been there and has memorized the execution of the task, the problem is solved, and rather generates other interesting problems, e.g., concerning the management of the spatial memory connected to that task.

It is evident that the individual perspective is that of a carrying out of the task by an isolated agent, whereas the social (multi-agent) perspective is that of carrying out a task by a non-isolated agent, assisted by a adviser-agent and therefore immersed in an organization of spatial learning. The finding out of the corridor that serves professors’ rooms in an university department –a well structured space-environment in our experiment- by the human agent-navigator can be instantaneous or can require some time. It can be instantaneous because the building shows up to the navigator with its structure of rooms served by a corridor, without any intermediate environment among the external space from which the agent originates and the internal space of agent’s destination. Yet, it can require some time to understand the layout of the building and the relationship between its part devoted to professors’ rooms and other parts (e.g., the entrance). In cases of a localization of the corridor that is not immediately perceivable by external comers, as well as of an absence of a human agent-adviser at the departmental entrance, the task will be executed by the human agent-navigator with a trial-and-error method. She will be wandering ‘actively’ in the space-environment of task execution, even if the presence of a map in the department entrance would surely facilitate the task execution (for a non-disabled person, at least).

Now we need to generalize a position problem. In fact, a big building could have a multiplicity of corridors, each of them serving a number of professors’ rooms, and in that case the agent should previously find out the right corridor among that multiplicity. However, once the right corridor has been entered, and if it is simply shaped (i.e., the corridor is not crossed in its midway by another transversal corridor with other rooms), the agent can perform simple actions. At the beginning of the corridor, she can ask to an occasional agent-adviser the location of the desired room, and then she can walk through the entire corridor in order to find the room and the professor. Alternatively, if the human agent-navigator prefers to avoid asking to a adviser, she can look at the usual series of nameplates with the name of each professor (particularly if doors are closed) or follow a previous direction by friends, or use a map available in loco, or find the professor with an active navigation –perhaps by glimpsing him through an ajar open or by hearing his voice- or ask to occasional professors or persons in the corridor. Obviously, a normal context rationality will prevent the navigator from using the mere intuition, dream, fantasy, or a dice throwing after numbering all rooms.

However, what appears interesting to our aim of distinguishing ‘essence’ and ‘ornament’ in a space-environment in order to navigate intelligently in it, is that some categories of actions can be drawn out from the above framework. They are: (i) self-driving of the navigator through active navigation (meet the professor), (ii) self-driving of the navigator through localized signals (nameplates at the doors), (iii) self-driving of the navigator through geometrical signs (the department map with professors’ names and rooms), (iv) driving the navigator through the help of a fixed or occasional human agent-adviser. In category (ii), an ornament (the nameplates) makes it possible to find out the essence (the room) in a ‘continuous’ (the corridor) which otherwise would not be usefully qualified for the task execution. The agent-adviser at the beginning of the corridor, if the nameplate is missing, could suggest the navigator to number the rooms in her searching, because the desired room is number x on the left. The adviser could also indicate the room through the ornaments on the professor’s door, so as to distinguish the room from all the possible rooms.

In this case, the ornament is a non-secondary attribute with reference to the specific task, even if it may be a secondary attribute with reference to the general conceptualization of the task.
3. DESCRIPTION OF THE EXPERIMENT

The questionnaire layout

The organization of the questionnaire is reported in figure 1. Although questions were all of interest of the study, some of them were developed with the practical aim of better addressing and focusing agents’ attention on the major themes to be investigated.

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**QUESTIONNAIRE**

**Situation A:** You are at DU (Town Planning Dept) and decide to visit a professor in that department, crossing the space in between.

**Question A:** Describe in detail the ‘substantial elements’ of the space in which you move, being of help or obstacle for your reaching the professor of your interest. (“substantial elements” are intended as spatial elements and their physical qualities, or substances such as materials, dimensions, physical barriers/halos etc.)

**Question B:** Describe in detail the ‘ornamental elements’ of the space in which you move, conditioning the actions in your reaching the professor of your interest (“ornamental elements” are intended as objects, shapes, colours, lights, ornamentals etc.)

**Situation B:** You are at DU and decide to visit professor Delicate in his room, crossing the space in between.

**Question A:** Describe in detail the ‘substantial elements’ of the space in which you move, being of help or obstacle for your reaching professor Delicate.

**Question B:** Describe in detail the ‘ornamental elements’ of the space in which you move, conditioning the actions in your reaching professor Delicate.

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The questionnaire survey involved 260 students of the course program, from October 2008 to February 2009, aging about 20. The questionnaire was delivered through an Internet homepage linked to the institutional didactical portal of the Town Planning Department at the Technical University of Bari, and related answers were delivered by email.

Up to today, answers to questionnaires are 180 (96 women and 84 men), i.e., about 70% of the whole student population involved.

Some aspects of the resulted knowledge base

Following literature on spatial representation and ontology (e.g., Goodman [12]), a major aim of this exercise was to find out information on some important issues needed to navigate in such a simple spatial environment as an university corridor. The analysis of the answer protocols was carried out using a double-level approach, essentially aimed at achieving a reliable robustness of results, given the quantity of data gathered. The first approach was a statistical analysis of the texts of answers, the categories of questions and the gender profiles of respondents. ‘Structures’ or ‘essences’ and ‘ornaments’ were purposely singled out from answers delivered under the different ‘known target’ (type-A answers) and ‘unknown target’ (type-B answers) perspectives. Also, they were further cross-analyzed with the categories of ‘landmark’ and ‘beacon’, as put down by recent studies [16], in order to retrieve significant clues. The analysis was carried out by using ad-hoc text-mining software (particularly Concordance 3.2 and WordStat 5.0), essentially focused on the frequencies, the deviations, the grouping, the clustering of keywords in texts. However, this approach was clearly not able to ensure a minimization of the typical biases due to word excerpting from discourses [21]. For this reason, a second, complementary analysis approach was used, aimed at contextualizing the findings of the former statistical analysis in the text of the answer protocols. This approach was carried out visually, with no software support but a traditional page-by-page reading and rescue of answers.

Due to the large quantity of texts and keywords, only the statistical analysis was developed on the entire population of the database elements. On the contrary, text fine-reading was carried out as an iterated random check on population samples.

Within this general approach, an initial analysis aimed at understanding agents’ interpretations of spatial elements in navigating the environment. In particular, the ‘essence’ or ‘ornament’ nature of the elements was first investigated [12]. In this concern, responses to questions A3 and B2 (essence), as well as A4 and B3 (ornament) were analysed and statistically described. A preliminary check revealed that separate A3/B2 and A4/B3 comparisons were not significant in this investigation. Therefore, essences and ornaments were analyzed as keywords occurrences in two aggregate groups, and subsequently verified in the actual response context.

A number of spatial elements occur in both groups with similar frequency. However, a check with the response context reveals that some words are used by agents just as a general reference to better explain/locate listed essences or ornaments. Examples of such cases are sentences like “…the entire wall of the corridor is an essence”, or “…pictures on the wall are ornaments”. Admittedly, this situation is intriguing per se, particularly highlighting the risks of acritically identifying lexical/logical ontologies with spatial ontologies.

The above situation, together with a search for similar words and lemmas, induced a simplification in the list of keywords, which is reported in table 1.

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<table>
<thead>
<tr>
<th>Concept</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALLS</td>
<td>3.35</td>
<td>0.95</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>DOORS</td>
<td>4.10</td>
<td>0.75</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>WINDOWS</td>
<td>4.00</td>
<td>0.60</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>FLOOR</td>
<td>3.50</td>
<td>0.95</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>PILLAR</td>
<td>3.00</td>
<td>0.75</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>TABLE</td>
<td>4.50</td>
<td>0.50</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>TABLEAU</td>
<td>3.75</td>
<td>0.75</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>CHAIRS</td>
<td>4.25</td>
<td>0.60</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>CORNER</td>
<td>4.00</td>
<td>0.75</td>
<td>180</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1 – List of essences (left) and ornaments (right)

The table illustrates the results of an analysis clustered on the gender profiles of respondents. Such descriptors as standard deviation show that the two groups generally disagree on the nature of spatial elements, as statistically expected. This seems to be basically independent from the nature itself, except a slightly lower disagreement on ornaments, perhaps due to a misleading text in the questionnaire (figure 2).
In general, it can be observed that the preferences expressed by the two profiles are not substantially different from one another, particularly in identifying ornaments. In a more focused detail, perhaps one can find out a slight presence of more ‘traditional’ essences in women (wood, frames, glasses) rather than in men. As an overall view, a top-down ranked list of spatial elements can be reported in table 2.

Table 2 – Main essences and ornaments.

<table>
<thead>
<tr>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doors, models, walls, notice board, chains, furniture, rooms, light, wood, floor, tables, windows, pictures, plants, glass.</td>
</tr>
<tr>
<td>Wood, doors, glass, frames, corridor, steel, handles, enquiry room, space, rooms, library, walls, offices, hall, furniture.</td>
</tr>
</tbody>
</table>

It is possible to note that a number of elements occur in both lists (in bold), even if lists themselves have been previously corrected to minimize above-mentioned biases. Admittedly, by looking at those single elements, one may well expect that they can serve as ornaments but also as essences, given there major role in structuring built spaces.

A further analysis was carried out, to investigate if functional and geometrical features had been used to describe the elements in the protocols, within a context of other argumentative and/or qualitative features (figure 3).

Geometrical features are prevalent on functional ones, with a significant –perhaps even ‘traditional’- prevalence in dealing with essences. However, it is interesting to note that the failing of using geometries in dealing with ornaments seems to be particularly due to women protocols, where geometrical features appears to be really marginal. A sample analysis of protocol texts reveals that in fact qualitative features are used more frequently by women to identify and argument on ornamental elements of space.

The last analysis implemented in the study has concerned the landmark/beacon (L/B) character of spatial elements [16]. This features had not been intentionally considered when the questionnaire text were prepared. However, after looking at the responses, some important similitudes emerged with a number of experimentations recently carried out on similar subjects or situations [10]. Therefore, it seems interesting to highlight some aspects at least linkable to that dichotomic issue, particularly concerning the role of elements perceived by agents in navigating spatial environments. The fundamental question to be addressed will then concern the possibility that (perceived) spatial elements are somehow credited to L/B features.

Because of the lack of explicit question contexts for L/B characters, it was decided to rely on indirect proxies to investigate such issues. A basic difference between A and B questions proved to be useful in this perspective, because in situation ‘A’ the target (a professor in her/his room) was surely known to respondents, who had chosen her/him in answer A2. The corresponding question in situation B is B1, but the target professor is mandatory and, in many cases, unknown. This situation is reflected by the elements used by agents in the different cases, reported in table 3.

Table 3 – Proxies used to identify ‘landmarks’ and ‘beacons’

<table>
<thead>
<tr>
<th>Proxies</th>
<th>Situation A</th>
<th>Situation B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplates</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Direct knowledge</td>
<td>35%</td>
<td>15%</td>
</tr>
<tr>
<td>Enquiry desk</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>Students</td>
<td>35%</td>
<td>45%</td>
</tr>
<tr>
<td>Map</td>
<td>5%</td>
<td>10%</td>
</tr>
</tbody>
</table>
In order to find out possible beacons for the target, situation ‘A’ seems then more suitable, with particular reference to occasional students (35%) and nameplates (15%). Both of them can reasonably play beacon roles for the navigating agents, even with clearly different features. It is interesting to note that whereas nameplates are mentioned as ornaments by a small part of respondents in previous contexts, students encountered in the corridor are significantly cited in the essence list, particularly by men. Situation ‘B’ may conversely show interesting characteristics in the identification of landmarks for the navigation. In fact, since the target is mostly unknown by agents, signs and indications can represent critical clues to reach it correctly. In this case, the enquiry desk (20%) and occasional students (45%) are most cited addresses for the target quest, followed by nameplates (10%) and departmental map (10%). Like occasional students, also the enquiry desk is cited as an essence in previous contexts, with greater emphasis. The departmental map, instead, is not included in the above lists: in fact, the answer texts reveal that it is looked up but without any help received, because professors are not indicated on it.

4. A BASIC NAVIGATION-SUPPORT MODULE

From the observation of outcomes, it is possible to draw out some interesting insights for the definition of an embryonic layout to support the target-oriented navigation of students, based on a simple system of IF-THEN-ELSE logical rules. The above discussion suggests that navigating agents recognize some characters of the simple environment investigated as basic ‘essences’ able to structure the space, as well as simple ‘ornaments’ of the same space. Therefore, following table 2, it is possible to use such indications to feed an expert system based on logical trees of rules. The general layout of such system can be represented in figure 4.

The layout is a simplified version of a more complex one, in order to enhance its readability. However, the assumption is that the system is divided into two parts, addressing the main activity, i.e., navigation support, and the needed environment maintenance. Let’s assume that the user selects her position as a navigating agent, then the system asks her gender. This decision rhomboid is put down because of the differences found in women/men protocols, e.g., concerning the identification of essences and ornaments. The subsequent steps should then take into consideration such differences in dealing with the attributes of the space, addressing specifically the gender of the navigator.

However, because of the basic nature of this study, this feature has not been fulfilled yet and a unique gender profile has been instead considered. The navigator then declares her target (a professor, in our study), and the system gives her access to the knowledge base previously built on the survey protocols. In order to facilitate the search for effective navigating hints, the system asks if the agent prefers to know and avoid obstacles toward her target, or to receive direct hints and signs to reach it. A probable circumstance in the first condition is an agent with information on her target, wanting to avoid time-wasting (beacon-like condition). In the second condition, instead, information is less and then a close support is more needed (landmarks-like condition). Let’s look at the beacon-like condition, by making reference to the actual web-browser aspect of the interaction module (figure 5).

In fact, after the selection has been made, the agent is driven toward a selection of conditions of obstacles that can be envisaged in her navigation. Each of these statements are intrinsically connected to the lists of space attributes –i.e., as ‘essence’ or ‘ornament’ nature- that have been previously put in the knowledge base. Of course, in order to avoid possible influences, misinterpretations or misleading clues, attributes’ nature is not revealed to agents, but remains nevertheless associated to keywords as hidden characters in the knowledge base.

The need for keeping the essence/ornament difference is connected with the different actions to be carried out in subsequent steps. However, if the selection operated by an agent reveals the need of an improvement or a repair action by maintenance units, then the systems stores the selection itself in a ’to-do’ database, so as to let environment administrators perform the related activity in due course.

After identifying the obstacles feared, the system looks at the contexts in which these elements had been conceptualized in the survey protocols, from the knowledge base. This action can be performed as an automated or semi-automated routine, by using ad-hoc software for text mining, such as Concordance or Wordstat. This routine is useful to identify in particular rapid clues and suggestions overcome the obstacles, taking them from the protocols themselves (see figure 4). If the hint cannot be found out, then the system recognizes the lack of information and then automatically addresses the agent to the second support condition, i.e., help needed (figure 6).
The landmarks-like condition support process is rather similar to the previous one. In the last stage, if the navigator cannot find help from the automatic routines scanning protocols, then it identifies a number of possible agents to make enquiries (enquiry desk, students etc.). Of course, in both conditions, clues and suggestions may come from other databases or from experts in different knowledge domains (sociology, psychology, engineering, architecture, etc.) previously connected and/or contacted. Also, in both conditions, the process can be iterated for different conditions and elements, until the navigator decides to end it up.

If the agent is an administrator, then the process develops toward maintenance-oriented paths.

At the moment, the layout is being based on an architecture built on Corvid Exsys 5.0, integrated with text-mining software (Simstat 2.06 with Wordstat 5.0) and fine-tuned with Dreamweaver 8.0 in its html interface.

5. BRIEF CONCLUDING REMARKS

The paper aims at investigating some ways of conceptualization and representation of the space by human agents. The contextual aim is the finding out of a way to reach a spatial objective in a simple spatial environment, i.e., a university corridor. The space considered is supposed to be simple, in that it is highly structured and does not induce disorientation and consequent difficult decisions to the navigating agent. In this condition, it is possible to draw out indications on the nature of some attributes of the space, and check if spatial ‘substances’ and ‘ornaments’ play significant roles in helping (or hindering) the navigation.

The study seems to confirm that the conceptualization of the corridor space is highly tributary to the existence of the two separate categories, whose presence, scarcity of lack is able to make more or less executable the navigation task. Ornament and essence elements come out rather clearly from the analysis, at times using the same words for different categories. It was evident that generally ornaments allowed the finding out of the substance looked for (the professor’s room) and enhanced the structuring degree (usability) of the corridor for the task execution.

By looking at questionnaire responses, some considerations can be drawn out, concerning the question of structuration of the space-environment. Classical literature on robotics reports that an environment in which a robot can perform its activities is considered a structured space [1]. The degree of structuration of the space in the present research is pretty high, in that it is a long simple corridor, but some elements where highlighted by respondents, able to decrease the degree of structuration significantly. In the experimentation, the most evident one is certainly a geometrical element, such as physical obstacles (doors, furniture, chairs) or physical shapes (recesses, narrowings, deviations). However, also evident are some intrinsic features of the environment. In fact, respondents report a corridor’s structuration modification in feature changes, such as floor material (“this section is not slippery because of the linoleum”), or wall colour (“this warm colour allows a better orientation”), or light (“where doors are not vitreous, the corridor is dark and disorienting”). In general, geometrical, non-geometrical, qualitative characters seem to define the real degree of structuration of the environment. This would stress the commonsense difference in the general mechanism of spatial cognition-perception-decision, between a robot and a human agent who ‘navigates’ through a given indoor space-environment, for the execution of a specific task. Also, this would stress the importance of emphasizing (instead of reducing) the complexity of environmental elements in spatial decisions.

The aim of the paper has not been to build up a decision-support system for the navigation toward the reaching a professor’s room. However, the study made it possible to single out logical if-then rules, and the drawing out of a navigation-support layout to help the reaching of a spatial objective.

In this context, the building up of an actual system architecture to support spatial navigation in simple environments could be a fair future perspective for the present research.

6. REFERENCES


