

Human Behaviour under Fire Situations – A case –study in the Portuguese Society

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ABSTRACT

Among possible emergency situations, those that very likely will mostly affect human behavior are the ones related to fire, due to the many reasons associated with its initiation.

The prediction of the human behavior in the reply to a fire situation requires an integrated system that involves the people, the building and the fire. It is expectable that people will answer differently to distinct and varying fire situations, which will depend on a diverse range of factors.

This paper summarizes a case-study on the human behavior under fire situations, based on the analysis of data collected through a questionnaire, applied to the Portuguese population nationwide. There were 14 questions related to fire, to which 225 answers were obtained. Within these 225 answers, 50 originated from people that actually experienced or were involved in a fire situation.

The study was already able to point out some trends in the behavioral analysis. However, it is not ready to fully support the development of a simulation model capable of estimating the pre-movement time. With this purpose, other questionnaires are being designed, which will be associated with results gathered from the observation of a number of real-life simulated evacuation scenarios.

1. INTRODUCTION

The analysis of the implications of people's behavior under fire conditions has been studied for several years ^{[1] [2] [3] [4] [5] [6] [7] [8] [9]}.

Some years ago the development of a buildings fire risk analysis model, called MARIE, was started in Portugal, consisting of eleven partial models ^[10].

Although a complete implementation of MARIE is still far from being a reality, some preliminary work has been done, highlighting the descriptor of the building model (DEM) and the evacuation model (MMO). As regards the MMO at the time of its development some aspect were not considered, or they were treated with extreme simplicity, among which are those related to people's behavior. When considering a building evacuation it can be considered the existence of three distinct phases. The first phase begins when the fire starts until it is detected. The second phase is related with the time between the occupants being aware of the fire and their decision to leave the building. Finally, the third phase starts when the evacuation process itself begins and ends when every occupant has left the building. The

MNO simulates in detail the third phase, but ignores what happens before the occupants have deciding to leave the building.

For this reason it was considered important to initiate a study that could lead to the construction of a model that simulates the second phase to be integrated in the MMO.

In a review of different simulation models of evacuation there are some who seek to model human behavior, but the methodology used in most cases is extremely simple, by introducing some rules that don't make a real modeling of people's behavior according to their characteristics and knowledge ^[12]. This behavior depends on the characteristics of the occupants themselves (physical, psychic and cognitive characteristics), of the buildings (type of use, geometrical characteristics, the existence of an organization and security management) and of the fire (visibility conditions, radiation, temperature and toxic gases concentration).

The analysis and the prediction of human behavior in response to a fire situation require an integrated system that involves people, the building and the fire. People respond in a distinct way to different fire situations, depending on several factors.

Although there is some randomness in the human behavior in a fire situation, it is possible to implement standardization according to some factors.

- The knowledge of human behavior under a fire situation may be attained by resorting to the following methods:
- appropriate questionnaire;
- fire drill analysis;

In the following chapter, the main conclusions of this first phase of the study are summarized, both about the sample's characterization and the actions/reactions of the respondents.

2. SUMMARY OF THE INVESTIGATION ANALYSIS^[2]

2.1. Characterization of the sample

2.1.1. Overall characterization

In this first phase of the study the sample in question, formed by 225 respondents, has some characteristics that, in a way, are adjusted to the Portuguese reality, namely gender, age group and fire safety training.

Thus, relatively to gender, the sample is formed from 50.2% of women and 49.8% of men. Relatively to the age of the respondents, it is verified that they are between 17 and 78 years old, with an average of 35.96 years old, meaning that the sample is in accordance with the national trend (in the last census, the national average was 39.09 years old). On the other hand, in the universe of the 225 respondents, only 72 have training in fire safety and just 19 make an annual recycle, fact that is also in accordance with the Portuguese reality.

It must be noted that there are some aspects of the sample that deviate from the Portuguese society characteristics. Regarding education levels, the sample does not represent the country's reality, because more than 50% of the respondents have university education, a percentage that far exceeds the national reality.

It will be necessary to evaluate, in later stages of the study, if this incongruence with the actual population influences the final conclusions and seek which new surveys reflect with more reliability the education level of the national population.

2.1.2. Characterization in subjects related with fire safety

Result of the publication of new legislation in the area of the fire safety, Portugal is experiencing important modifications regarding the organization and management of the fire safety in buildings and the generalization of training and awareness of the occupants, fact that can have consequences in their future behavior.

Regarding fire safety training it was found that a significant percentage of the respondents (65%) don't have any training in this area.

Still reflecting the current state of the organization and management of fire safety in the country, it was concluded that 63% of the respondents are unaware of the evacuation plans of the buildings they attend; which may be explained by the fact that the generality of the buildings have not yet implemented these plans. Concerning the ability of the respondents to identify the emergency exit it is verified that 96.89% state that they are capable of that identification, percentage that significantly drops regarding its localization in the buildings they attend, because only 55.56% declare to have that knowledge.

Finally, we emphasize the fact that 50 of the 225 respondents had already been confronted with a fire situation, a fact that is relevant to establish correlations with those who have never had such an experience.

2.2. Influence on the reactions of the relation of the respondents with the building

In this first phase of the study a general analysis to the answers received was conducted. An additional analysis was also carried out in which the influence of certain characteristics of the respondents (gender, age, fire safety training and education levels) was evaluated.

Before initiating this study we had the idea that the reaction of the occupants during a fire could be influenced by the relation they have with the building, fact which was not confirmed in this first phase of the study, because 52.89% of the respondents said they would have the same behavior, while 44.00% stated that it would be different.

Regarding the respondents that had already been involved in a fire, 54% reported that their reaction would be the same, even if they were on the building they lived, or in the one they worked or in any other building.

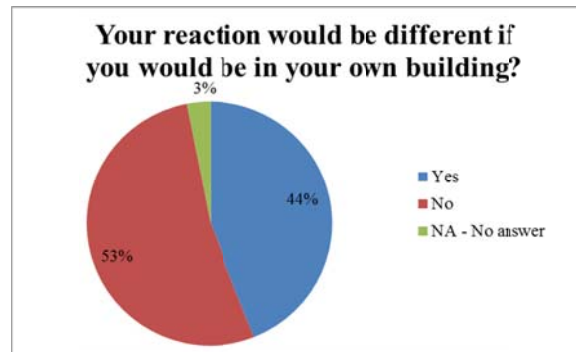


Fig. 1. Your reaction would be different if you would be in your own building?

2.3. Knowledge of the evacuation plans, escape routes and emergency exits

The implementation of certain procedures in matters of organization and management of the fire safety in buildings that the country is now entering upon as well as an increase of training, may be reflected on the behavior of the occupants in the fire safety, so were asked some questions regarding this matter.

Thus, trying to understand whether the respondents are aware of the evacuation plans of buildings that they attend, it was found that 141 responded negatively, with a percentage very similar to the masculine and feminine gender.

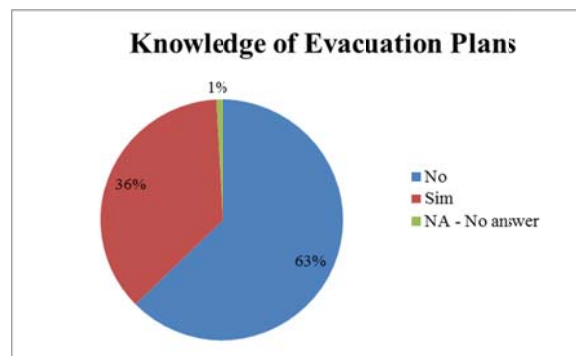


Fig. 2. Knowledge of the evacuation plans

Regarding the relation between knowledge of evacuation plans and training in fire safety verifies that, regardless of whether or not training in fire safety and their gender, a little more than 35% are aware of evacuation plans.

The same applies to the knowledge of escape routes; there is no great difference between respondents who have training in fire safety and those without.

On the other hand it was found that 96.89% said that can identify the emergency exits, that percentage drops significantly with regard to its location in the buildings that they attend, since only 55.56% declared to have this knowledge.

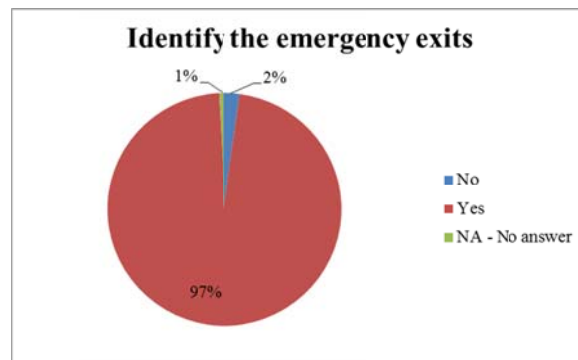


Fig. 3. Identify the emergency exits

Trying to understand if the respondents are concerned to identify the emergency exits when entering a building, the survey had a question on this subject. The conclusion reached was that when respondents have no training in fire safety, only 37% the female gender and 38% the masculine gender have this concern. When respondents have training in fire safety such percentages increase significantly, reaching 70% the female gender and 50% the masculine gender.

Trying to understand if there is any relationship between the concern to know where to locate emergency exits and knowledge of escape routes, it appears that 76% of respondents seeking to identify emergency exits know the escape routes and 63% of respondents who do not know the escape routes do not bother to identify them.

In this study it was verified that of the 72 respondents with training in fire safety 36 choose, in an emergency situation, the path they use in normal situations. Of the 153 respondents who haven't training in this area, 79 also choose the path they normally use to leave the building. These results seem to indicate that the influence of safety training in the fire behavior is not decisive, in the choice of escape routes in an emergency situation, because about 50% of respondents would choose the paths that make usual, independent they have or not training.

2.4. Chance of panic referred by the respondents

The result of some news related to incidents that occurred panic, makes the idea that it is very common and widespread. However, some researchers consider that, in a significant number of emergency situations, such it is not verified ^{[13] [14] [15]}.

According to the results obtained on the survey, 93.33% of the respondents consider that in a fire situation there will be panic.

In order to evaluate the influence of the characteristics of the occupants relatively to this interpretive ability an additional analysis was made by gender, making the intervention of the fire safety training, age, education levels, previous experiences with a fire, concluding that the influence of gender, education level and training in fire safety only slightly alter the percentage of responses prevails always, unmistakably, the conviction that the panic will be present.

The possibility of panic in a fire situation among the respondents is confirmed by the answers given by those who have experienced it, having stated that the trend is very similar to the one

before. In fact, from the 50 respondents that had already experienced it, 48 mentioned that people panic.

2.5. Spirit of helping others in a situation of emergency

Helping others can be crucial especially for disabled occupants. From the overview of the answers to this question reveals that 60.89% mentioned that it exists, while 38.22% think that is not the case.

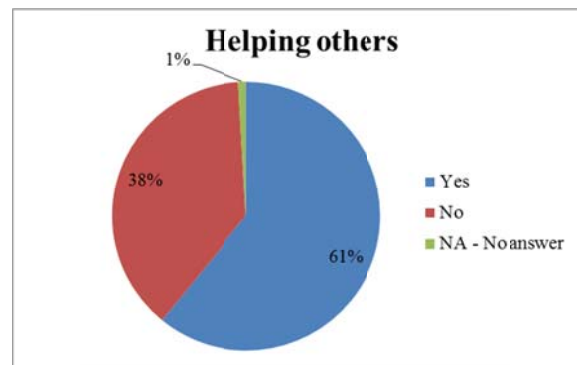


Fig. 4. Helping others

Trying to evaluate the occupants' characteristics on this interpretive capacity, an additional analysis was made on the basis of gender, training in fire safety, education level and also the previous experience with fire, comparatively to the answers obtained with the resultants from the overall analysis.

This additional analysis showed that 66.67% of the female respondents with training in fire safety and 50% of men consider that in a fire situation there is the spirit of helping others.

Regarding the influence of education level it appears that, regardless of these, more than 50% of the respondents consider that there is a spirit of helping others, with emphasis on the female gender who expresses a greater belief in that spirit than men, especially when the education level corresponds to the high-school level.

2.6. Ways to know about the fire referred by the respondents

One of the objectives of the survey was to know how people are aware of the existence of a fire. From the overall analysis of the respondents it was found that the most mentioned factor was the "Smell of smoke", with 36%, followed by the "Alarm", with 29%, while the third was concerned with the "Visualization of smoke", with 15%, and finally, the "Unusual movements of the occupants" and "Strange noises", both with 10%.

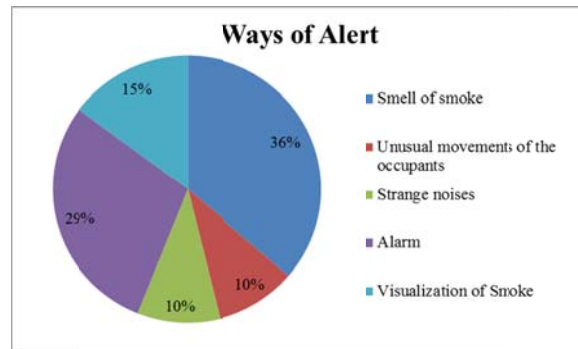


Fig. 5. Ways of Alert

With reference to the three most frequent responses in the overall analysis was conducted an additional study, relying on the several characteristics of the respondents.

That analysis shows that the most frequent answers are the same, regardless of gender and of previous experience with a fire, varying only the percentages relative to each one of them.

The same is not verified when the analysis is done regarding the training, revealing a change on the results of the overall analysis for the third most referred answer, that, for the respondents with training, is “Strange noises” instead of “Visualization of smoke”.

The analysis by age has also introduced some changes to the sequence obtained in the overall analysis, namely the respondents aged up to 20 years old and those between 30 and 40 years old. Thus, for the age of 20 years, the “Alarm” was the most referred (35%), followed by “Smell of smoke” (31%) and “Visualization of smoke” (17%). For the age of 40 years there is a change regarding the overall analysis, verifying that the “Alarm” is in first place (41%), followed by “Smell of smoke” (36%) and “Visualization of smoke” (18%).

Regarding the possible influence of education level it is noticed that, for the respondents with high school qualifications, the second and third most frequent responses are, respectively, “Visualization of smoke” (27%) and “Alarm” (18%).

2.7. Action of the respondents to the alarm

Another issue of the survey is to identify the reactions of the occupants after being aware that something unusual is going on, not knowing if it corresponds or not to a fire.

From the analysis of the responses it was observed that 36% refer “Investigating what was happening”, while 33% indicate “Leave the place on his own initiative”. Followed by “Warn others” with 27% and “Wait to be told what you should do” with 3% and, finally, 1% said “Continue to do what he was doing”.

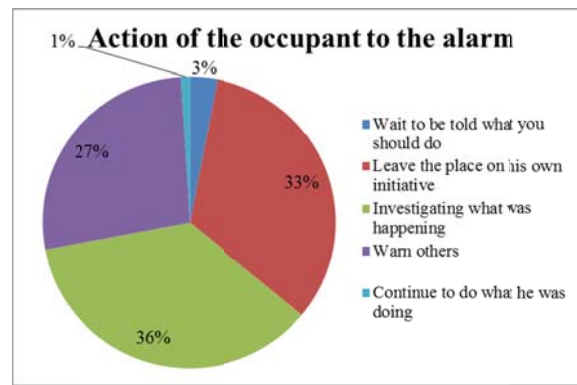


Fig. 6. Action of the occupant to the alarm

An additional analysis of the data showed that the gender has no significant influence on the responses, with the general analysis unchanged, albeit with some slight changes in the percentages.

Regarding the influence of fire safety training it was found that it introduced some changes to the overall analysis especially concerning the second reaction most indicated by respondents with no training which is "Leaving the scene on their own initiative", with 33%.

Regarding the influence of age groups it appears that this factor is significant in some cases. For the respondents aged 20 to 30 the most given response was "Leave the place on his own initiative" (34%), followed by "Investigating what was happening" (32%) and "Warn others" (32%). For the respondents aged 30 to 40, the most given reaction was "Leave the place on his own initiative" (38%), followed by "Investigating what was happening" (34%) and "Warn others" (21%).

Regarding the influence of education levels, it is noted that respondents with high school education point "Warn others" as first reaction (36%).

Previous involvement in a fire also showed significant influence as those who have experienced it pointed "Investigating what was happening" (43%) as first reaction, followed by "Warn others" (30%) and only then "Leave the place on his own initiative" (23%).

2.8. Interpretation of the alarm signal

The existence of alarm signals is now becoming widespread in many Portuguese buildings, but for these systems to represent an additional help it is crucial that occupants can identify the hazard associated to this alarm.

From the general analysis of the responses given, it is seen that 40% of the respondents indicate "In the uncertainty it's considered as fire", whilst 27% presume being before an "Exercise of Evacuation", 13% that the alarm is the result of "Operations of Maintenance" and 12% that it is due to a "Real fire".

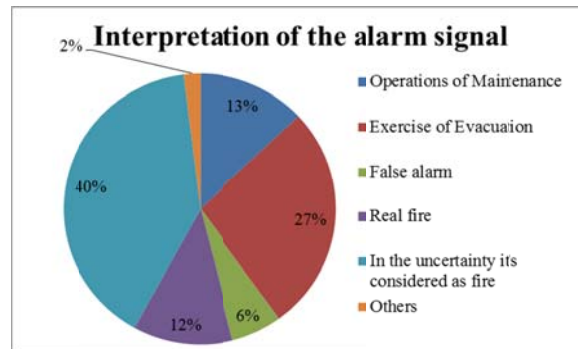


Fig. 7. Interpretation of the alarm signal

In order to evaluate the influence of the characteristics of occupants on this interpretive ability an additional analysis was carried out introducing variables such as gender, fire safety training, age group, education levels, and previous experience with a fire.

This way, with reference to the three reactions most mentioned in the overall analysis, it was found that gender, fire safety training and previous experience with a fire do not introduce any change to the order previously obtained only varying the percentages of each interpretation. Regarding the influence of age it is seen that there is a change compared to the overall analysis by respondents aged 30 to 40 years old, who indicate as the first interpretation "Exercise of Evacuation" followed by "In the uncertainty it's considered as fire."

The analysis regarding the education levels shows a difference compared to the overall analysis, as for the respondents with high school qualifications the second most pointed interpretation was "Real fire".

2.9. Reaction of Respondents to the Alarm Signal

The efficacy of an automatic fire alarm and detection system depends not only on the correct interpretation of the signal, but also on the reaction that the occupants have to the alarm.

From the general analysis of the responses given, it is seen that the predominant reaction was "Find out what is happening", with a percentage of 65%, which far exceeds all others, followed by "Leave the place to leave the building", at 15%. All other responses have merely residual frequencies.

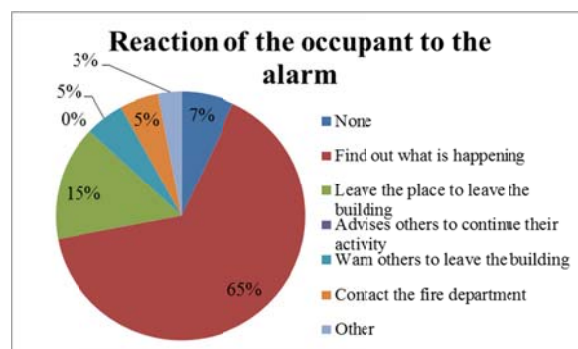


Fig. 8. Reaction of the occupant to the alarm

In order to evaluate the influence of the characteristics of occupants on their reaction to the alarm signal, an additional analysis was carried out introducing variables such as gender, fire safety training, age group, education levels, previous experience with a fire, having as reference the two most given responses.

This additional analysis showed that gender, age group, and previous experience with a fire have no significant influence on the responses, with just a slight change in the percentage frequencies. The most significant variations are relative to the residual actions, but, as such, these are not significant on the overall results.

Regarding the influence of education levels, it is seen that the second response most given is, for those with high school qualifications, “None” (14%).

2.10. Reactions of respondents due to the presence of smoke

In order to understand the influence of low visibility on evacuation pathways, due to smoke, on the behavior of occupants, the inquiry contained a question on this matter.

Only 204 respondents answer to this question. Of 204 responses given, 65% show as most frequent reaction “Try another way to get out of the building”, followed by “Investigate to fight the fire” with 26%, with all other responses having merely residual percentage frequencies.

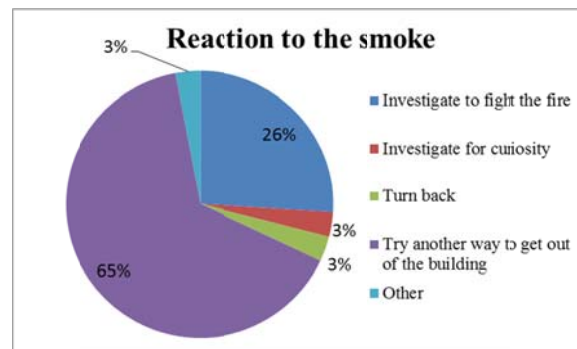


Fig. 9. Reaction to the smoke

In this question, it is noted that gender, age group, education levels and previous experience with a fire do not have a significant influence on the responses given.

Respondents with fire safety training have some different reactions, when compared to the overall analysis of responses. 56% of those with training gave the response “Try another way to get out of the building”, while 32% preferred “Investigate to fight the fire”. Regarding respondents without fire safety training, the most given response was also “Try another way to get out of the building”, with 70%, and in second place “Investigate to fight the fire”, with 23%.

Regarding the education levels, it is seen that respondents with high school qualifications, present a pattern of responses significantly different from all the others, but that might be due to the small number of such responders in this particular question.

2.11. Reactions of respondents face to a direct contact with the fire

The behavior of people when confronted directly with a fire will not be, most likely, the same as when they only know about the fire by hearing an alarm signal, by somebody else's warning or even by seeing smoke or flames.

Trying to evaluate such influence on behavior, the inquiry had a question on that matter. It is seen that 57% of respondents would react to that direct contact by "Try other way to get out of the building", followed by "Ask for help" (22%) and "Fight the fire" with 17%.

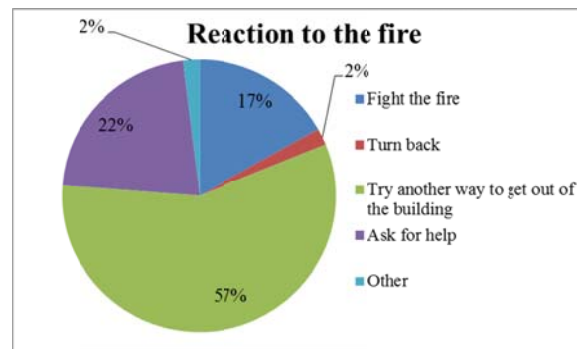


Fig. 10. Reaction to the fire.

The additional analysis shows that gender, fire safety training, age group and education levels have little influence on the responses given to this question, whilst gender and previous experience with a fire show more influence.

Regarding gender, it is seen that the most given response by women is "Turn back", followed by "Ask for help" while for men it is "Fight the fire" followed by "Try another way to get out of the building".

3. CONCLUSION AND FURTHER STUDIES

When knowing that a fire is taking place, not all occupants decide, immediately, to leave the building, rather having reactions whose consequences will increase the evacuation time.

However, although this behavior is well known, there haven't been studies to determine the time lost due to such actions, in spite of the fact that some simulation models try to consider this issue introducing a time delay at the beginning of the evacuation, which nonetheless is not supported quantitatively by any evidence on scientific studies.

For the development of a simulation model that quantifies this time delay, it is necessary, even with the uncertainty there is, that the behavioral pattern of occupants be understood, being this study the first step in Portugal towards such goal.

This initial phase of the study is focused exclusively on the analysis of an inquiry to people used to office buildings (workplaces), and it shows several patterns on the Portuguese population, some of them different from those expected, which are now enumerated:

- The high probability of panic occurring during a fire.
- The little relevance of the fact that the occupant knows the building or not.
- Some consequences of age in the reaction to some situations.

- Little influence of fire safety training on the knowledge of evacuation pathways.
- Little influence of fire safety training on the choice of evacuation pathways during a fire.
- Little influence of fire safety training on certain reactions by occupants during a fire.
- Prediction of an almost certain widespread panic during a fire.
- Little influence of the fact that the occupant knows the building or not on their reactions during a fire.
- Little influence of previous experience with a fire.

The results presented here must be read carefully, because they only represent the actual state of the study and are therefore still far from what can be considered to characterize the Portuguese behavior in relation to fire safety, being clearly insufficient to achieve the desired simulation model of people's behavior in case of fire and not to quantify the time wasted on the actions developed by the occupants before deciding to leave the building.

Thus, it becomes necessary to expand the universe of analysis, with the development of new campaigns for data acquisition.

To follow up this study the original survey was reformulated and it was initiated a second round of data collecting that evolved users and staff of two big shopping centers of the city of Lisbon and the fire drill analysis that will, later on, be analyzed.

The study will be extended to different kinds of buildings so that we can collect enough information to make the model of general use and not just to a particularly application.

Therefore, there will be the need to distribute the survey to buildings like hotels, health related, education related, sports related and others, in addition to analyzing simulations that may occur in those buildings.

Finally it is stated that another study is being developed, in Portugal, based on multi-agent systems, using the concept of serious games with an interactive virtual environment that allows collecting user's profiles and that will afterwards be used as towards the behavior model.

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