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Simulating and Monitoring Children Activity related to Injuries

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Abstract. Simulating children injuries related to everyday activities has been the focus of our research for a while. This research stream has developed a comprehensive approach to the full modeling of human behavior. In this paper we describe methods that intended supporting mothers in the day-to-day care for their children, and also analyze children's behavior, in order to estimate these methods' efficiency. The prototype components that we are describing here are based on a 3D developmental environment that we have developed for efficiently managing the inputs from the real world events in real time, and ultrasonic sensing technology developed in house. An AI based methodology combined with presence and warning interface, for the intended users, is further discussed among other solutions that we have considered in this applicative framework. Finally we draw conclusions on different services offered through integration of ubiquitous sensing and visual/multimedia solutions indoors.

1. Introduction

We have been successfully applying our behavior modeling related to child accidents in different previous related works [1, 2]. Interest of this research was mainly focused on child behavior sensing and modeling. We were using an ultrasonic sensing environment [3] that for experimental purposes has been developed from a small experimental room, to a full house with the entire necessary living infrastructure, down to the slightest detail.

It is an imperative that the solution we were aiming must be packaged in such a form that the end user can understand and live/interact/interface with it in harmony, and support his own modifications through simple-to-use shape, texture and behavioral situations. This is where yesterday's Virtual Reality was not successful. This is where applied gaming used in the right context, gives the i3D (interactive 3D) community a second chance [4]. With no lack of ability to perform accurately in real time, an ultrasonic sensing environment can articulate objects and action representations in such a way that can properly affect the virtual world. In addition, they can relate their dynamics to knowledge structure.

The absence of evidenced support, lack of efficacy, and cost benefits are some barriers that we have been trying to avoid while adopting these solutions into mainstream commercial and educational practices.

We do expect our results to be responsive to a multitasking environment (which is usually the case for the average housewife, who has to take care of her children while pursuing

everyday activities), corresponding to a typical mother in today's Japanese society, in relation to her visual attention and scale of being conscious about existing dangers.

However, the essential part of the discussion that adds value to this research is the efficiency when preventing child injuries. Under the constraints we have applied for our task we want to have a realistic reaction that will bring the living commodities created inside the house to a better level.

Other researchers [5] have introduced formal models of interactive object behavior using Petri Nets. To our advantage, their work describes interactions within the kitchen environment, with different appliances in a virtual world that constitute an environment similar to a real kitchen. We have previously investigated similar situations [12] and under a revised form this result has served for the setting of future experiments.

Overall, there is a growing interest in describing high-level object behaviors to support more complex problem solving, or the "procedural" generation of interactive content. One challenge appears to be the integration of object behavior into an overall environment behavior supporting a mission which has been seen as an emerging task from other researchers too [6]. In other words, crediting real life experiences—events that can be considered as a warning step in the virtual world—might be a good way to reinforce caution/attention dedicated to children (from their mothers) when they are indoors.

In addition, we thought that from a controversial point of view, we should focus more on *the mother* herself, given the fact that her support and involvement have been inclusive [2].So in other words, while the passive component of her behavior has been well measured, wanted to see the active component of her interaction. And accordingly, we have compiled an interleaved behavior chart, which tries to explain children's explicit behavior model representation, in the mother's presence. We do believe that she is the key to solving this problem and therefore all the developed applications should be supporting her.

The proposed approach has a specific interest in indoor wellbeing applications, in particular the possibility of re-incorporating physical child behavior under the direct control of a visual injuries simulator. Similar to Interactive Storytelling [7], this brings the possibility of dynamic, imminent injuries generated from the physical behavior of the indoor environment. Badler et al. [14] was the first to give the concept of action's representation in supporting/training virtual environments. This is a generic similarity, with our approach, when it comes to behavior associated with objects and functionality, although not a classic Artificial Intelligence technique.

Different stages of causality related to child injuries consist of reactions, under the control of a context AI, which has to determine the proper response similar to [1].

The kitchen is also the most dangerous space in the home and a good place to test whether common sense is improving real world scenarios [15]. Contextual awareness observation of child behavior is needed to understand intention and offer functional aid in avoiding some common mistakes and to understand the way problems can be solved.

BlueRoof Technologies Company [10] is offering different combined services inside a house, providing high quality living commodities, especially for those parts of the society which need support in everyday life. The main goal for our service based research is to integrate different backgrounds, young and old people into self-supporting communities,

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and with the help of technology, be able to solve the few persistent challenges which they have to face.
In the next several sections, we describe different technologies baseline for prototyping, which can control different objects' behavior from a global environment perspective (ultrasonic location sensors involved), using relevant analysis of potential dangerous situations.

2. Solutions for Real-Time Actuators

An early system version (the basic principle) for the implementation of a real time sensing living environment was assembled beforehand. Though created for experimental purposes, the system was able to extract directly, the measured child behavior/location and map it in a virtual environment (Figure 1). A good feature of this system is that it can also visualize all the previously recorded location/direction data available in a database, which have been created. The reconstructed behavior patterns were the same, or similar, to those measured from the experimental behavior sensing sessions with children and their mothers.

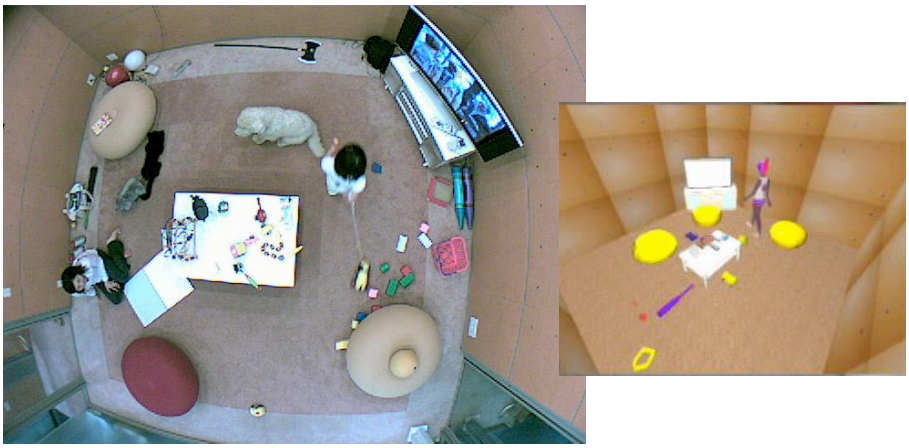

Figure 1. Two images, of a fish-eye camera that observes the environment for experimental purposes only, and the corresponding character behavior in the VR envorinment, which follows synchronously the behavior of the moving subject in the real world.

There is a one-to-one correspondence between the real objects and the virtual ones, whose position is tracked continuously (notice their time and space synchronicity in Fig. 1.). The system can sample events (playing, interaction with objects and people, etc.) in the real world (with a frequency that matches that of a normal behavior), for the interaction of the child with the objects, or even different object's interaction triggered by the child. Not only can we classify different types of interactions that a child is able to perform, but we can also combine different primitives, given the properties and physical parameters of the surrounding objects themselves.

Nowadays, different home appliances makers (e.g. Toshiba) are able to wirelessly report different intrinsic functional data about their device's functional status (ON/OFF), or their physical state (OPEN/CLOSE), as well as other parameters about their usage. These appliances can be more interactively integrated into the unified computing environment, [15]. A combined solution, with the sensing technology already mentioned on [3] can be efficient for the above purpose, while VirTools® developmental environment seems to fit it and support the implementation of interactive 3D visual contents. It can also serve as a general C++ development platform. The realistic impact of events, child movements, and setting of objects, along with the scenarios to follow, are technically easily to handle through this prototyping tool. The next section takes a look into the techniques intended for this purpose.

3. Sophisticated Behavior Set for Real Life

Figure 2. Different simulated children injuries' scenes incorporated in a behavior MATRIX structure, that represents different accident scenarios Experimental settings and the action flow in the course of time (the red circles show the subjects and objects of interest)

This system's AI baseline has been derived partially from our previous VR environment implementation of causal injuries. Overall, the system represents an interactive environment, which shows, according to the events, a fictional situation related to an accident, clearly simulating a potential, dangerous situation [12]. Since accident simulation, which for instance favors a certain type of accident protection, can be flexible, that is why this system can also be considered as a third-person game (in spite of serious gaming applications [11]).

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The number of injuries is limited to those which were already created for a cooperative project with Benesse Company [9], in which a wealth of data from mothers were sought through internet research. However, quite a few special accidental situations have been considered. Since the navigation of a child in a physically complex environment generates different hazardous proximity zones, which bring forward different possible events, we compute situations that maximize the threat to a participant, i.e. the child (Figure 2). Attributing casual connections among different events, which can happen in the virtue of the participant, plays an important role in the impression of an emergent accident generated and properly viewed time-wise by the mothers. When thinking of a "virtual simulation" offered for the injury prevention, we must allow for the creation of alternative sequences, which might be possible in the course of time and space available. Since the representation of the actions is somehow subjectively related to a pre-existing accident animation, the causal principles that we have retained should be well defined for new developments. The similarity of consequences, with respect to injuries, still tends to create an environment very sensitive to accident predictions, at any rate.

While the Bayesian Networks has been used efficiently for human behavior analyzing and modeling [13], and a Behavior Matrix developed in house, can be proven successful for the targeted system.

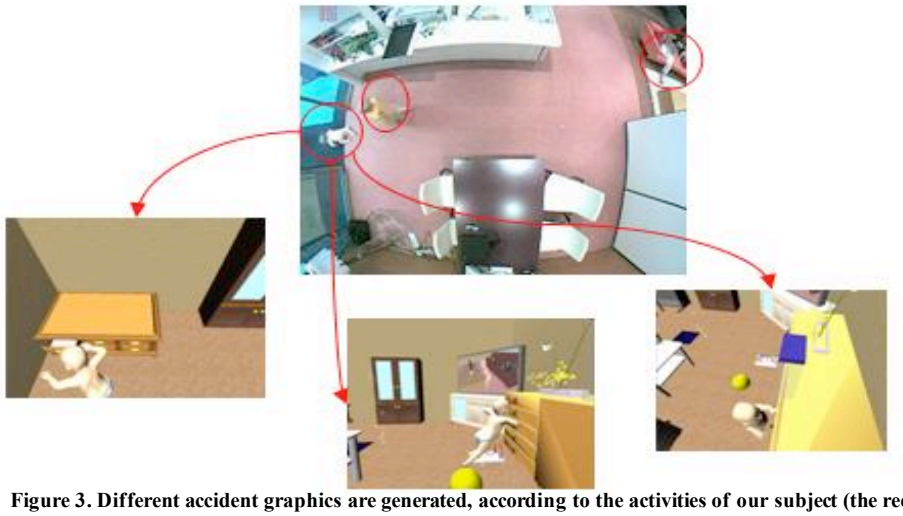

Figure 3. Different accident graphics are generated, according to the activities of our subject (the red circles show the subjects of interest, i.e. children and mother) inside a sensorized living environment.

As any physical object around the child, can take part in some elementary actions (such as falling over, tilting above or sliding toward), there is a need to limit the number and type of actions considered. This is achieved in part by considering the contents of the accident animations available for display. Considering the consequences (or after-conditions) of the actions previously generated for each object will somehow increase the possibilities for injuries. For example (Figure 3, on the lower right), liquid containers breaking or tilting over will spill out their contents, which could create electricity conductive areas, flammable

areas, slippery areas, according to the type of the liquid and related to the initial damage caused. If we additionally map these conditions, we can easily suggest possible injuries according to their likeliness to happen.

Unknown
Deleted:

4. Discussion

Usually the system is counting on the behavior ontology of possible actions that will lead to a certain injury. The injury potential of an object's state can define the injuries pending in the environment. A color coded scheme (Fig. 4.) can help in identifying these dangerous details that we probably know in the objects, but miss most of the time in the everyday life. Still under the process of a formal evaluation we can either measure mother's activity and her behavior when dealing with different situations, or a cost/feasibility on average for all the dangerous situations. Her mother's feedback is probably the most valued data we are looking forward to collect and therefore map it later, as a parameter, back into the system. A graphical representation of the mother and child in their living environment and also their interaction (Fig. 4.) can be a hint to solving different hazardous situations.

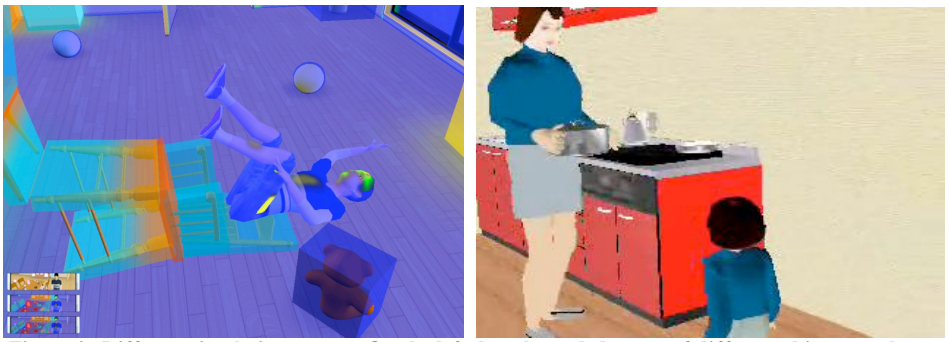

Figure 4. Different simulation aspects. On the left the color coded zones of different objects are shown related to the danger level, and on the right an accident scene where mother is involved.

The real time integration of knowledge representation intends to open interpretations and conditioned interactions, which constitute a good experimental ground to address other mothers' support services.

Seeing the kitchen as a dangerous environment (Fig. 4.), but not exclusively, as injuries can happen anywhere/anytime, brings a competitive situation with other areas around the house. As a consequence, the actuators to match such situations are diverse and composed of different interaction patterns (active and passive). Figure 5. shows children interacting with a robot we have developed for this purpose [8], along with a full set of display abilities and interaction patterns. Different children's ages and developmental levels have been taken into consideration when developing this robot in trying to actively prevent children from being involved in dangerous situations. From the experimental measured interaction and observed child behavior we have confirmed its efficiency in actively interacting with children, though this interaction is multifold and needs to be disseminated further. Nevertheless, this "watchful eye" with which we have experimented, has the potential of

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offering an effective service for the discussed purpose, though the developmental status of the robotics field is still immature, to fully support services offered to humans. Finally, more needs to be done to standardize different actuators that will have the same goal—assisting in a particular service (i.e. child injuries prevention)—and being able to integrate them into a central computerized control hub. Relevant alarm and personal awareness systems to third parties interested in using these services are of importance too. In a different perspective, social issues like living in a community, multiple-child families, the human/machine interface, etc., have to be carefully considered.

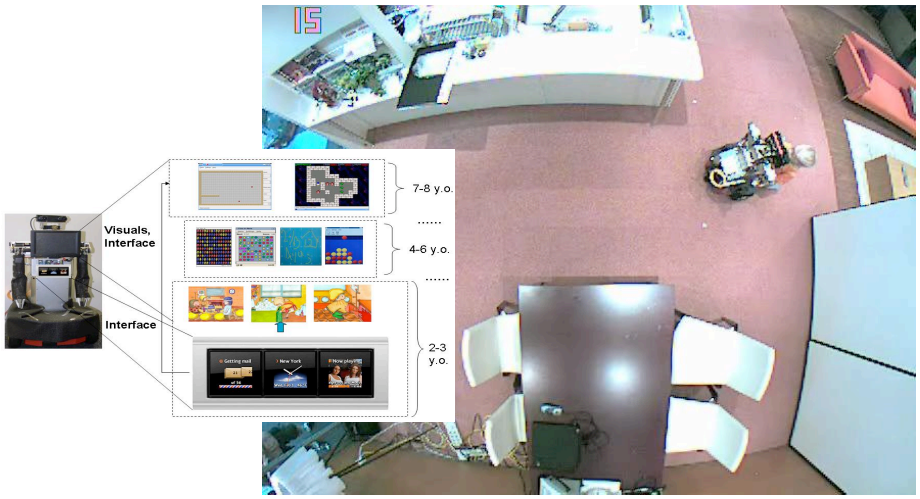

Figure 5. Actively adapting ways of interaction with the robot (according to children age/developmental stage), when this actuator is trying to actively intervene and passively interact with children, and avoid injuries. The LCD touch panel and OPTIMUS keyboard serve as optimal interfaces for children.

Fundamental and technical issues due to the difference in representation between computer graphics interfaces and knowledge-based systems have brought to our attention that only through rich experimental data sets we can successfully offer the results to the public.

5. Conclusions

Above we have discussed different prototypes in using a consistent framework, in preventing child ijuries. While mentioning guidelines and actual stages of development which are parts of a strategic approach towards a successful solving of this problem, we address some of the important steps of this evolving work. Letting the environment play a crucial role in a featured virtual injuries simulating system, we give a chance to different AI techniques to extend/adapt their benefits, in accurately interpreting the phenomenon. By keeping a constant awareness of potential dangers, these implementations are intended to perform, while remaining of moderate complexity. The incorporation and well rendition of different components, that would provide a high level control in simulating/monitoring and avoiding children injuries, will be very important to settle all the crucial factors of causality

in these cases. The visualization component still falls behind, if compared to large accident knowledge databases and yet allows exploring the context of interactive and dynamic multimedia. It might be early for the real time performance of this system to live up to our expectations; however, parts of its architecture have suggested that it might still be compatible with the desired accident response time.

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