SMACH: Simulation of Realistic Human Behaviors and Electrical Consumption

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Abstract. The SMACH platform allows the modeling and simulation of multi-agent based simulations of virtual humans' behaviors. It is focused on the behaviors taking place inside the housings, and it is able to deduce the load curve of electrical consumption of each electrical appliance in the housing. The simulations are entirely configurable: housing (type, surface, insulation, etc.), household (type, number of humans, relations, etc. virtual humans, electrical appliances, heating system, weather forecast, etc. It can simulate quickly any household for any period of time, from minutes to years.
It has been demonstrate that we are able to produce realistic humans' behaviors and accurate electrical consumption, and we have a collection of scenarios which have been validated by the real humans that are modelled in the simulation.

1 INTRODUCTION

Energy efficiency and consumption reduction is a major challenge for our society. According to the EEA (www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-9), more than 25% of the final energy consumed in Europe is used within the residential sector. The study and reduction of residential energy consumption is a crucial issue, but it is a complex one, because of the significant role played by individuals' behavior on that matter. Several models able to simulate this consumption already exist, but in their large majority they are based on statistical approaches [1,2], and try to represent an "average" family and life scenario (which doesn't exist in real life). More generally, a recurrent problem in computational approaches to human behavior simulation is their lack of realism due to a lack of knowledge about human activities.

2 OUR APPROACH

SMACH is a collaborative work between researchers and experts from different fields of research (multiagent systems, artificial intelligence, human behaviors, housing thermal design, electricity, and ergonomics), that aims at simulating household activity and electrical consumption. Our approach is based on ergonomic methods of interviews and observations, human behavior studies and data collection in households. We simulate the individual activity and its dynamics at a fine grain-level, and we integrate unexpected events (that cannot appear in "average" simulation) and consider particular lifestyles. Each human of the simulation is an agent with its own actions and preferences. Agents communicate to synchronize their activities through group or individual behaviors. SMACH also offers a model of personal thermal comfort, derived from air temperature, clothing, and activity. The actions have durations and rhythms, which allows us to design specific lifestyles, with their own repetitiveness and variability (each simulated day is different from the others, although they could share the same rhythm). The meta-model is shown in figure 1.

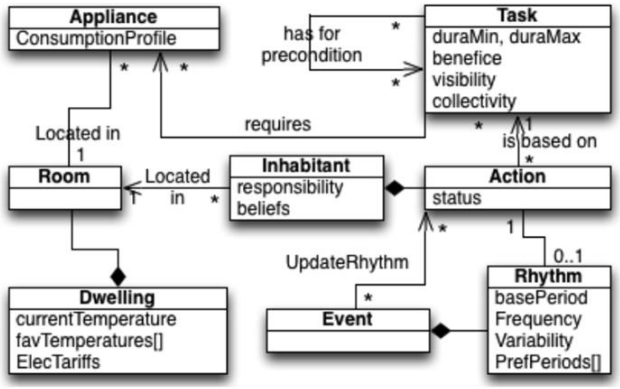

Figure 1: SMACH meta-model

3 VALIDATION

The multiagent simulation of human activity has been validated by experts in ergonomics and through participatory simulations. The SMACH software also produces fine-grained load curves of all electric appliances in the housing (from light bulbs to heaters, and including washing machines, hot water tanks, etc.), thanks to consumption models and co-simulation with a realistic thermal model. The two main outputs of our system are the global activity tracking table, in which we can see every actions performed by each inhabitant in the simulation, and the electrical load curve, which can be separated appliance by appliance. This is illustrated on figure 2.
We have a particular interest in the validation of our model for both human behaviors and electrical consumption. We have validated our ability to produce real human behavior by modeling 10 real households (after a couple of hours of interview with the inhabitant at home). Then, we confronted them with simulations of their own lives, and asked them whether the simulations were fitting their real life. The participants also had the ability to change the avatar's behavior. All finally agreed that the simulations were appropriate enough to represent their lives. In addition, we

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confirmed that the electrical consumptions that SMACH produced for these households were similar to the real ones (15 weeks of real and simulated consumptions were compared).

Figure 2. Activities and consumption analysis screen

4 CONCLUSION

Our software is able to answer a difficult question within the electrical consumption field: explaining household's consumptions by putting humans and their activity in the center of the picture. Therefore, we are able to reproduce, explain and predict *consumption peaks*. These peaks are one of the biggest problem encountered by electricity producers, and represent an important source of pollution because of the additional and temporary productivity power needed [3]. The SMACH platform provides great tools to test and simulate the impacts of different methods aiming at the reduction of these peaks such as specific tariffs, smart energy controllers, smart grids, etc. Several hypothesis have been studied and reported in previous papers [4-9].

Another benefit is the capacity to predict the impact of different modification in the housing, for example insulation and/or renovation works, investment in low-energy appliances, ecological gesture, modifying target temperature, etc. This makes SMACH an interesting educational and pedagogical tool towards the consumer awareness to cost and carbon emissions.

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