Synthetic Humans in Emergency Response Drills

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ABSTRACT

Being able to realistically simulate humans in emergency response activities is a key challenge for advancing the field of information technology for emergency response. Building good human models enables testing information technology solutions in any emergency response simulated scenario. This paper presents an agent behavior model for mimicking peoples's behavior on emergency response activities. The accompanying demo demonstrates a concrete model for evacuations integrated with an emergency drill simulation environment.

Categories and Subject Descriptors

I.2.11 [**Computing Methodologies**]: Artificial Intelligence. Distributed Artificial Intelligence[Intelligent agents, Multi-agent systems]; H.1.2 [**Information Systems**]: Models and Principles. User/Machine Systems[Human information processing]; I.6.3 [**Computing Methodologies**]: Simulation and Modeling Applications; I.6.4 [**Computing Methodologies**]: Simulation and Modeling. Model Validation and Analysis

General Terms

Design, Algorithms, Experimentation

Keywords

Agents and cognitive models, agent-based simulation and modeling, applications of autonomous agents and multi-agent systems, artificial social systems, perception, action and planning in agents, synthetic, embodied, emotional and believable agents

1. INTRODUCTION

Information Technology (IT) enables better information flow from source to consumers. It changes the quality and amount of information humans have during emergency response and, thus, influences the decisions humans make. In order to evaluate the impact of IT solutions in emergency response, special attention on human models that emphasize the role of information in the decision-making process is needed.

We model the decision-making process as an information processing system [4]. In our approach, we determine the relevant information variables for each decision. The information abstraction process converts agent observations of the scenario (obtained via raw sensory data) into relevant information variables. Our agents use this information to make decisions. The decision-making model is tested and calibrated with an emergency drill simulation environment–DrillSim. The rest of the paper is organized as follows. Section 2 sets the context by introducing DrillSim. Section 3 presents our agent model. Section 4 describes how our model integrates and calibrates with DrillSim. The paper then concludes with the conclusions and future work.

2. DRILLSIM

DrillSim [1] is a multi-agent emergency response simulation system. The system consists of a multi-agent simulator and a pervasive space. The multi-agent simulator models an emergency response activity where each agent represents a person. The pervasive space captures a drill of the activity in the real space. The system allows both a real drill and a simulation of a response activity to be played out simultaneously. This way, the whole activity takes place in an hybrid world–the merging of the real drill and the simulation. DrillSim is a system for testing IT solutions for disaster response. This testing is enabled due to the plug-and-play capabilities of the system that allow plugging IT solutions for disaster response, thereby translating IT metrics (e.g., delay, QoS) to emergency response metrics (e.g., evacuation time, casualties).

3. AGENT BEHAVIOR MODEL

Each agent in DrillSim represents a person in the response activity. Agents are the key constituents of the activity and take decisions based on their awareness and their cognitive characteristics. Agent behavior (Figure 1) in our model is motivated by the information processing model of [4]. Agents take some action every t time units. For this purpose, an agent acquires awareness of the world around it (i.e. event coding), transforms the acquired data into information, and makes decisions based on this information. Then, based on the decisions, it (re)generates a set of action plans. These plans dictate the actions the agent attempts before going to sleep again. For example, hearing a fire

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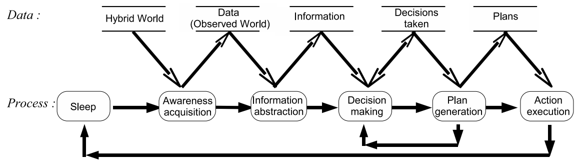

Figure 1: Agent Behavior process.

alarm results in the decision of exiting a floor, which results in a navigation plan to attempt to go from the current location to an exit location on the floor, which results in the agent trying to walk one step following the navigation plan.

Awareness acquisition: Awareness acquisition is the process of coding events into data, thus adding data to the agent's observed world. An agent's observed world is composed of the information it knows a priori (e.g., a map of the building) and the events it observes during its life.

Information abstraction: Based on its observed world, the agent translates the acquired awareness into information. Information is a set of variables that take values between 0 and 1. Note that, information abstraction is a cognitive process and varies between individuals. It depends on factors such as underlaying social networks [5] and the agent's cognitive characteristics.

Decision making: The decision making step is based on a probabilistic model over an artificial neural network [3] (i.e. a time-discrete recurrent artificial neural network). This allows for explicitly modeling the importance of each piece of information on each decision, setting the emphasis on the impact of information on decision making rather than on the reasoning process itself. The characteristics of the neural network parameters (i.e. activation function, weights matrix) are set according to the agent's role and calibrated through running real emergency response drills within the DrillSim environment.

Planning of actions and execution: For every decision an agent decides to take, the agent generates a plan of actions if no previous plan exists or if the previous plan is invalid. Planning may also involve taking further decisions. These decisions are also decided at the decision-making neural network above presented. After plan generation, the agent attempts an action from each plan. The most basic actions are walk and speak. For example, given a navigation plan, the agent walks one step more of the computed path.

4. INTEGRATION WITH DRILLSIM

An initial prototype of DrillSim with the agent behavior here described has been implemented in Java and JADE [2]. This prototype provides a GUI (shown during the demo) that allows real humans to observe and interact with the drill simulation. Figure 2 shows a snapshot of the GUI. In particular, it allows a user to start the simulation, pull the fire alarm, input a hazard, get an arbitrary view of the simulation in 2D or 3D, get a 3D view of what an agent is viewing, send messages to other agents, control an agent, and get statistics of the evacuation.

5. CONCLUSIONS AND FUTURE WORK

Providing realistic agent behavior for simulating emergency response activities will definitely catalyze information technology research in emergency response. Realistic agent behavior enables simulating emergency response activities for evaluating different information technology solutions. We propose to model agent behavior as an information processing system based on five steps: Awareness acquisition, information abstraction, decision making, plan generation, and action execution. This five-step process translates raw events observed by the agent to concrete actions. The agent behavior is integrated and demonstrated with DrillSim. The instrumented environment of DrillSim allows calibrating the decision-making model.

Thoroughly modeling agent behavior is a complex task and calibrating it using real data is indeed challenging. Our future work involves exhaustively calibrating our decision-making model and making it more comprehensive.

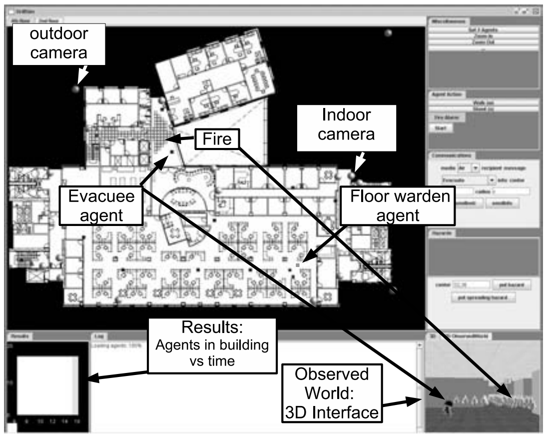

Figure 2: Snapshot of the prototype.

6. ACKNOWLEDGMENTS

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