Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian, Sharad Mehrotra, Nalini Venkatasubramanian
AAMAS'06, ATDM Workshop
Motivation: Testing IT in emergency response

• Efficacy of emergency response plays a key role in the consequences of the disaster

• Information technology (IT) can improve efficacy by delivering the right information to the right people at the right time

• Need for testing IT in the context of emergency response
  – Drills: realistic settings but expensive
  – Simulation: cheaper, but lacks realism and validation
DrillSim: A testbed

- DrillSim *simulates* a crisis response activity (e.g., evacuation)

- DrillSim allows testing IT solutions in the context of the *simulated* response activity
  - Plug-and-Play capabilities

- Translates IT metrics to response metrics
  - E.g., Bandwidth usage, time, accuracy to casualties, response time, risks taken
DrillSim: An augmented reality simulator

- DrillSim can simulate a crisis response activity
- DrillSim can also be synchronized with an on-going drill:
  - Simulated drill augments an on-going drill adding
    - Simulated people
    - Simulated communications infrastructure
    - Simulated sensing infrastructure

→ *Lowers cost of a real drill, adds flexibility*
DrillSim: An augmented reality simulator

- DrillSim can simulate a crisis response activity
- DrillSim can also be synchronized with an on-going drill:
  - Simulated drill augments an on-going drill adding
    - Simulated people
    - Simulated communications infrastructure
    - Simulated sensing infrastructure

  ➔ *Lowers cost of a real drill, adds flexibility*
  - On-going drill augments simulated drill
    - Real people
    - Real communications infrastructure
    - Real sensing infrastructure

  ➔ *Adds realism, allows for calibration of the simulated entities*
DrillSim: A Multi-Agent Simulator

• **One agent** simulates **one person**
• Multiple **roles**:
  – Evacuee
  – Floor warden
  – Building coordinator
  – Zone captain
  – Etc.
• Individual **profiles** (physical and cognitive abilities)
• Relationship between agents -> social networks.
• Agents involved in information flow
  • Collect information via their own **sensors** (e.g., eyes), or the devices they carry (e.g., PDA)
  • Analyze information (i.e., assimilate information, make decisions)
  • Share and disseminate information via their own communication **devices** (e.g., speech) or the devices they carry (e.g., PDA)
DrillSim Agent Model

- Information processing
- Clear interfaces between stages

Data:
- Hybrid World
- Data (Observed World)
- Information
- Decisions taken
- Plans

Process:
- Sleep
- Awareness acquisition
- Information abstraction
- Decision making
- Plan generation
- Action execution
Agent Role Editing

- A scenario is created by binding roles and profiles to agents
- An agent role is an instantiation of each information processing step
Come see the demo: Thursday May 11th, 12:05 - 13:25

Synthetic Humans in Emergency Response Drills
demonstrating DrillSim v0.2 (basic prototype)
Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian, Sharad Mehrotra, and Nalini Venkatasubramanian
Donald Bren School of Information and Computer Science
University of California, Irvine
Irvine, CA 92697, USA
{dmassagu, vbalasub, sharad, nalini} [at] ics.uci.edu

AAMAS'06 : ATDM workshop, Monday May 8th, 2006, Hakodate, Hokkaido, Japan

Supported by the National Science Foundation under Award Numbers 0331707, 0331690, and 0403433
Multi-Agent Simulation of Disaster Response

Daniel Massaguer, Vidhya Balasubramanian, Sharad Mehrotra, and Nalini Venkatasubramanian
Donald Bren School of Information and Computer Science
University of California, Irvine
Irvine, CA 92697, USA
{d massagu, v balasub, sharad, nalini} [at] ics.uci.edu
AAMAS'06 : ATDM workshop, Monday May 8th, 2006, Hakodate, Hokkaido, Japan
DrillSim v0.2 – basic prototype

- Response activity: evacuation
- 4th floor Cal(IT)2
- Grid representation
- A* algorithm + obstacle avoidance
- Stochastic decision making based on ANN
- Evacuee and floor-warden roles
- 2D/3D interface
- Human can control an agent
- Human can communicate with agents
- Simplified crisis model (spreading fire)
- Response metric: number of people in building vs time
Current status

• Achieved:
  – Role management

<?xml version="1.0" encoding="UTF-8"?>
<Role id="OfficeBuildingEvacuee">
  <profile>
    <visual>
      <mean>5.0</mean>
      <variance>0.5</variance>
    </visual>
    <hearing>
      [...]
    </hearing>
  </profile>
  <informationVariables>
    <var id="ROOM_FULL"></var>
    <var id="KNOW_ABOUT_HAZARD"></var>
    [...]
  </informationVariables>
  <decisionMaking>
    <decision id="KNOW_ABOUT_HAZARD">
      <NN_weights>
        <w dst="EXIT">1.0</w>
      </NN_weights>
    </decision>
    [...]
    <decision id="TOLD2EVAC">
      [...]
    </decision>
  </decisionMaking>
  <planners>
    <var id="evacuate"></var>
    <var id="exitFloor"></var>
    <var id="Default"></var>
  </planners>
  <socialNetsDependencies>
    <var id="trust"></var>
    <var id="waitFor"></var>
    <var id="informEvac"></var>
    <var id="informEvacFar"></var>
  </socialNetsDependencies>
</Role>
DrillSim v2.0: where we are going

- Campus-wide evacuation
- Plug-and-play architecture: integration with MetaSim
- Scalable architecture (O(100,000) agents)
- Integration with real world and real activities
- Realistic models for crisis, agent behavior, and initial scenario generator.
- Calibration of agent models
DrillSim: a *plug-and-play* system

- Plug models that drive simulation such as
  - human behavior,
  - spatio-temporal models (e.g., geography, class schedules)
  - crisis models,
  - response activity,
  - response plans.

- Plug IT solutions.
  - Response activity projected as information flow
    - Information is
      - Collected
      - Analyzed
      - Shared
      - Disseminated
    - IT solutions can be plugged at any of these points