Firefighter Training Virtual Environment (sketches_0264)

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The Firefighter Training Simulation is a virtual environment being developed at Georgia Tech in collaboration with the Atlanta Fire Department. The VE user is a commanding officer trainee who instructs teams of virtual firefighters to perform different actions to help put out virtual fires. This simulation was developed using the Simple Virtual Environment (SVE) Library, an extensible framework for building VE applications[1].

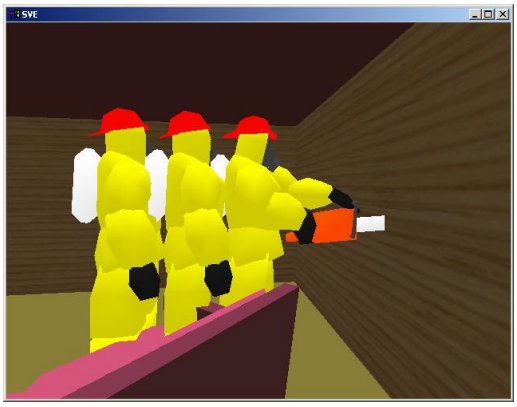
The VE includes a furnished single family home, a fire truck, a fire hydrant, various firefighting tools, and firefighters. To put out the fire, the user issues low-level task commands to the virtual firefighters of the form "team# task destination". For example, typing "1 chop 2" will instruct the fire team 1 to chop at location 2. The firemen execute keyframed animations to display their assigned task being carried out. The command entry to the system is performed by an operator who translates the verbal command from the trainee user into the appropriate syntax for the system.

We created a small motion database of firefighter character animations that includes cutting with a chainsaw in various positions, chopping with an ax, walking, crawling, climbing a ladder, carrying various tools, carrying an injured person, connecting and pulling the hose, and spraying the hose. We are currently using path finding and collision detection algorithms to find paths for the firefighters and avoid collisions with walls of the house.

Fire Simulation

We are using NIST's Fire Dynamic Simulator (FDS) to compute realistic physical fire and smoke behavior. FDS is a computational fluid dynamics (CFD) model of fire-driven fluid flow. It numerically solves the Navier-Stokes equations appropriate for low speed, thermally driven flow with an emphasis on smoke and heat transport from fires. We model the house offline with FDS and extract fire and smoke data for the entire house volume at one-second increments. We use this pre-computed data to visualize and animate the fire and smoke in our simulation.

To draw fire and smoke, we are implementing a voxel-based splatting renderer, which uses the FDS smoke density to control the opacity and color of each screen-aligned splat. Our splat–based Doppler radar[2] renderer runs in real-time, so we are confident that this smoke and fire rendering will also yield real-time update.



For interactive simulation, we must have data available for every sequence of actions that the firefighters can perform. When a firefighter sprays water on the fire, the blaze should subside and more smoke/steam should be produced. Therefore we must use FDS to simulate every possible scenario. We create a decision tree, which loads the appropriate FDS data corresponding to the sequence of the actions performed. We will limit the amount of actions being performed in order to keep the size of the tree and the amount of data needed manageable.

To minimize storage requirements for volumetric fire and smoke playback, we have developed a volume compression technique that quantizes the smoke density, temperature, and heat values to 8 bits per voxel, and applies hyperdimensional prediction and differencing to achieve lossy compression rates of 90 to 95%.

Conclusion

In collaboration with the Atlanta Fire Dept, we have developed a prototype VE simulator for the training or evaluation of trainee fire commanders. The AFD is enthusiastic about the current prototype, and plans to start using it by the Fall of 2002.

References

[1] D. Kessler, D. Bowman, L. Hodges. *The Simple Virtual Environment Library: An Extensible Framework for Building VE Applications.* Presence: Teleoperators and Virtual Environments, 2000. 9(2): pp. 187-208.

[2] Jang, J., W Ribarsky, CD Shaw, N. Faust. *View-Dependent Multiresolution Splatting of Non-Uniform Data*, Proc. IEEE VisSym 2002, Barcelona.