Computer Models For Fire and Smoke

Model Name: BGRAF – A Stochastic Computer Simulation to Model the Behavior of People in Fires: An Environmental Cognitive Approach

Version: v2

Date: 1984 - 1991

Model Actively Supported?: No

Classification: A stochastic decision model of human behavior in fires

Very Short Description: Models the decision making process of the occupants of a building in fire emergencies. It is based on the episodic nature of human behavior in fires, with an active library of actions people can take. A CAD model (called CAED) that defines building spaces were used to defined the built environment in the simulation.

Modeler(s), Organization(s): Prof. Filiz Ozel is currently at the Design School, Arizona State University. At the time the model was developed, she was at Un. Of Michigan and New Jersey Institute of Technology. CAD system mentioned above was developed at Un. Of Michigan as part of a funded project by the US. Army Corps of Engineers.

User's Guide: Not available

Validation References:

"Computer Simulation of Human Behavior in Spaces", Chapter published in "Environmental Simulation", (Ed.'s R. Marans & Dan Stokols), Plenum Publishing Co. 1993.

"Simulation Modeling of Human Behavior in Buildings", Article published in "SIMULATION", Periodic publication of the Society for Computer Simulation, Summer 1992.

"Calibration of Computer Model BGRAF: A Nursing Home Fire", The Proceedings of BUSRU (Building Use and Safety Research Unit) Conference, Portsmouth Polytechnic, Portsmouth, UK., July 1988

"Simulating West Chase Hilton Hotel Fire: An Application for the Calibration of Computer Simulation BGRAF", the Proceedings of the CIB'86 Conference, Washington,DC, Sept. 1986.

Summary:

Data regarding human behavior in over 500 fires were collected and reported by Dr. John Bryan in 1980's and early 1990's, funded by NIST, Center for Fire Research. This report was studied by this author and different action types as well as different goals were identified. As a result of the real world data provided by this study, probabilistic decision trees were developed for the occupancy types of Nursing Homes and Hotels. These probabilistic decision trees were used to define the decision model in BGRAF during the validation study. John Bryan's study also provided the timeline for fire and smoke spread for each fire event. A nursing home and a hotel fire were selected from Bryan's study for simulation in BGRAF (please see references above). The fire itself was modeled as an event driven model as well as a local fire spread model. The results of the simulation which were measured in exit time for the occupants, how many reached safety etc. closely matched those of their real world counterparts.

Availability: Not available

Price: N/A

Necessary Hardware: Runs on mainframe computer as well as on Apollo computers.

Computer Language: Fortran

Size:

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Detailed Description:

1. BGRAF is primarily a probabilistic decision modeler/simulator. The simulation user is provided with tools to define a probabilistic decision model where multiple occupant groups can be defined and associated with different decision trees and the probabilities for each branch of the tree. For example, in a hospital, staff may be assigned a different probabilistic decision tree than patients or visitors. The decision tree is a goal oriented tree where goals are associated with physical actions by the simulation user. For example, a simulated person can go to a door to alert others, or can go to the same door to head to the stairs.
2. The fire event itself is modeled as a single point fire and smoke spread model as well as an event driven model. It interacts with human behavior. For example if people decide to close a door, then the smoke does not spread beyond that door. Also if people stay in a smoke area for a specified length of time without successfully exiting the building, then they become incapacitated.

3. The building itself is defined as rooms, walls, doors and windows through a CAD system developed for the Army Corps of Engineers. The data structure of the system recognizes building components and spaces (similar to the present day BIM systems) as opposed to other CAD systems where building drawings are simply comprised of graphics entities. Therefore, simulated people and fire/smoke that occupy building spaces are cognizant of building configuration and behave accordingly. A travel algorithm was developed and implemented where people can only go through doorways and other openings. Analytical geometry was employed extensively to identify the exact location of each simulated occupant in the building as they move through building spaces. Travel routes were not pre-determined since cognitive factors were also modeled as explained below. Exit routes and spaces along them such as corridors, stairs etc. were defined by the simulation user for each building modeled.
4. Additionally, BGRAF includes a cognitive model of human behavior in fires where environmental cognitive factors were incorporated into the action libraries of the model. Physical distinctiveness (such as for an atrium) and visual access are among these cognitive factors. For example, when go-to-exit action was implemented, the simulation checked to see if a staircase was visible to the simulated occupant, if yes, then the occupant would start moving in that direction. If a staircase was not visible to the occupant at any point in time as he/she moves in rooms/corridors etc., then a familiarity factor comes into play based on the predefined familiarity of the occupant with all the stairs. Familiarity factor is defined by the simulation user for each occupant group probabilistically. If they are not familiar with the location of any stairs, then the direction of the occupant movement is randomly selected. Otherwise, the occupant probabilistically decides which one to use based on his/her familiarity level. For example, the stairs next to a garage entrance may be assigned a very high familiarity which will increase the likelihood of that staircase being selected by a simulated occupant during a fire emergency modeled using BGRAF, but they will not automatically head in the direction of that exit or the closest other exit.