Crowd Human Behavior for Modeling and Simulation

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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14. ABSTRACT

Modeling and simulation of crowd behavior is currently a focus of several entities. This presentation falls under the presentation topic area of "understanding human behavior" and "model validation and verification" and will focus on modeling and simulation of crowds from a social scientist???s perspective. The differences between crowd modeling for training versus research purposes will be explained. Then a social science conceptual framework will be presented for guiding modeling efforts. Identification of critical factors and parameters in the crowd situation will be presented, including environmental and social elements, weapon and procedural factors along with an explicit articulation of underlying assumptions commonly evident. Use of data from various sources for incorporation into behavioral models will be discussed. Finally, the presenter will outline suggestions regarding model validation and verification of crowd modeling applications, for example the ideas of internal and external validation.

15. SUBJECT TERMS
crowd, modeling and simulation, validation, verification, behavioral model, data, internal validation, external validation.

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Why Crowd Modeling and Simulation?

- To Test Effectiveness of Non-lethal Weapons and Systems
  - "Testing with real humans can't be done"
  - "Testing with humans is expensive and time consuming"
  - "To extrapolate model from crowd laboratory findings"

Laboratory Crowd Behavior

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Conceptual Framework

- Based on the work of Kurt Lewin
- *Field Theory in Social Science (1948)*
- *Principles of Topological Psychology (1936)*

Conceptualization of Behavior

- B=f(P,E) Behavior is a function of the Person and the Environment
- Behavior can be expressed in mathematical terms
  - Easily imported into modeling and simulation exercises
- The challenge to researchers is to identify the totality of relevant factors and the elimination of extraneous factors

The Person

- Crowd member's behavior is influenced by what is thinking and feeling
- What a crowd members is thinking and feeling is influenced by what is seeing and hearing
- Other people in the crowd and the control force are what the person is seeing and hearing
- The physical environment mediates what the persons sees and hears from the others in the crowd and the control force.

The Key to M&S of Crowds

- Modeling and simulation of what the crowd member is PERCEIVING is critical to modeling COGNITION, EMOTION, & BEHAVIOR
- What each person in the crowd is seeing and hearing is critical to predicting the crowd's behavior

TBRL

Factors in Crowd Response to Non-lethal Weapons and Systems

- **Weapon Variables:**
- Visibility (can you see it)
- Predictability (can you tell where it's going to hit)
- Controllability (can do something to avoid being hit)
- Ability ("Effects" damage to persons)

- **Environmental Factors:**
- Cover
- Escape Routes
- Barriers

- **Individual Psychological Factors:**
- Motivation toward forbidden goal
- Competing motivations

- **Crowd Social Factors:**
- Organizational Hierarchy
- Interpersonal Attraction
- Alignment of motivations (do they all want the same thing) Communication Ability

Malcolm Baldrige National Quality Award 2007 Award Recipient

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M&S for Decisions vs Training

Decision Making

- Predictive/Normative M&S
- Validation and Verification of Model is Critical
- Third Person
- Efforts directed at gathering data to maximize validity of model

Training

- Descriptive M&S
- Perceptual Realism is Critical
- First Person
- Efforts directed at making user interface as perceptually rich as possible

How social psychologists make models

- Decide variable of interest "predicted"/"independent variable"/OUTPUT
- Propose a lot of factors that may be important in predicting that variable "predictors"/"dependent variables"/INPUT
- Find ways to measure each variable or identify repositories of data on these variables
- Subject data to statistical procedures that generate association among variables

Data Crunching Yields Specific Algorithms and Constants

- GATHER DATA
  - Metrics for input variables
  - Metrics for output variables
- Conduct preliminary exploratory analyses
  - Remove factors that don't predict
  - Check for interaction effects
  - Identify possible moderators
  - Identify mediators

Data Crunching Yields Specific Algorithms and Constants

- GATHER EVEN MORE DATA
- Conduct confirmatory analyses
  - Test hypotheses based on exploratory analyses (or theory or previous work…)
  - Derive equations that may reliably predict the behavior

Algorithms for M & S

- $y=\beta_1 x_1+\beta_2 x_2+ \beta_3 x_3+\ldots\beta_{12} x_1 x_2\ldots+\varepsilon$

- "Behavior is a weighted function of variable x_1, x_2, x_3 their interactions, and error."
- y is Output
- x are Inputs (Weapons, Environment, Individual, and Crowd Social Factors)

x1

Programming Individual Agents

- $y=\beta_1 x_1+\beta_2 x_2+ \beta_3 x_3+ \beta_{12} x_1 x_2 ...+\varepsilon$

y= how fast person is running away (Individual Output Metric)

x_1= how afraid of pain person is (Individual Psych Input)
x_2= how many friends present (Crowd Social Input)
x_3= walls present (Environmental Input)
x_4= can perceive weapon (Weapon Input)
$x_1 x_2$ = how afraid of pain he is when with friends (Interaction)
β=how much this variable matters
ε=error term

Verification of Crowd Model

Verification is defined as:

The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.

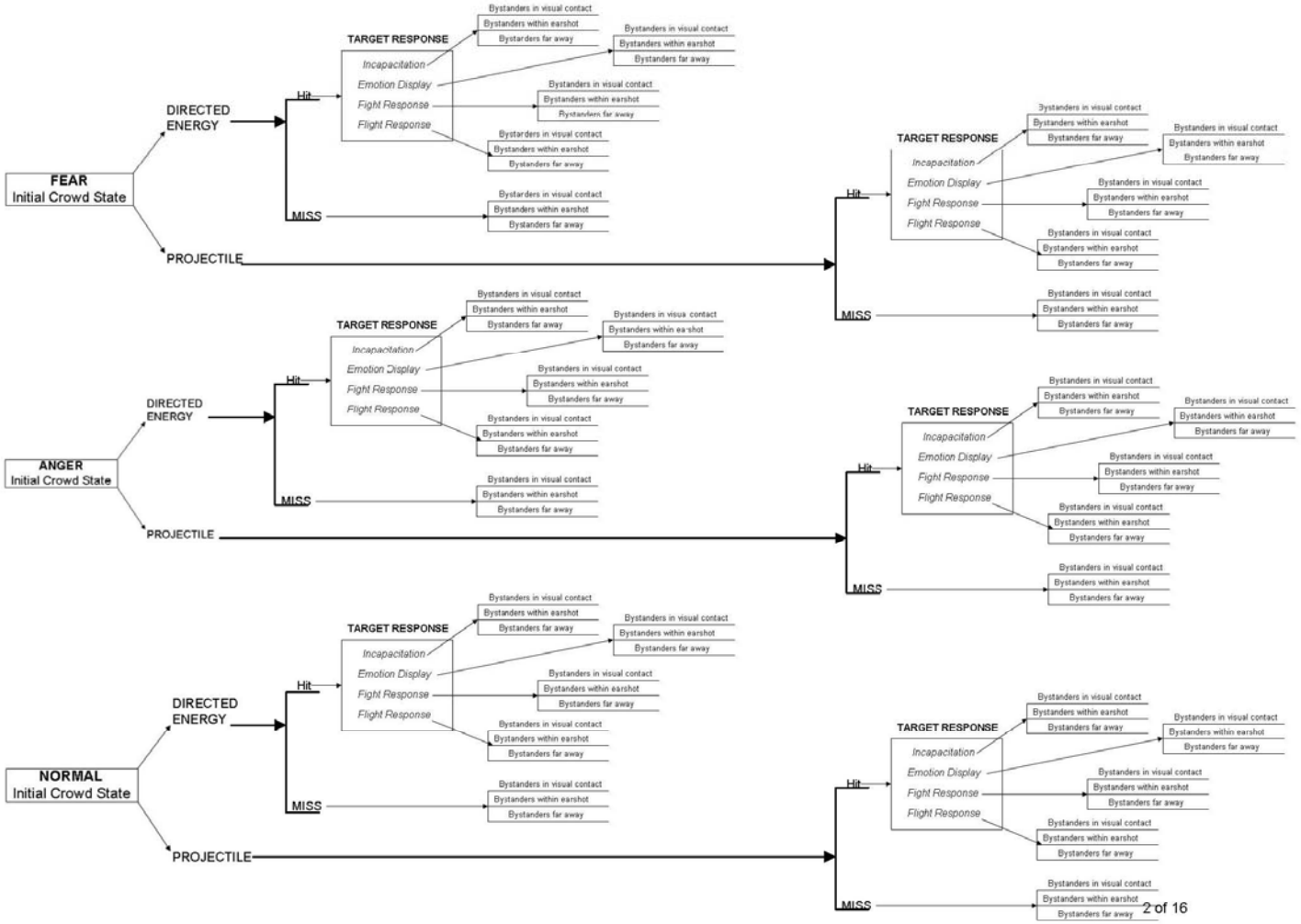
In short, verification addresses the question "Have we built the model right?"

Cook & Skinner, 2005
The Journal of Defense Software Engineering

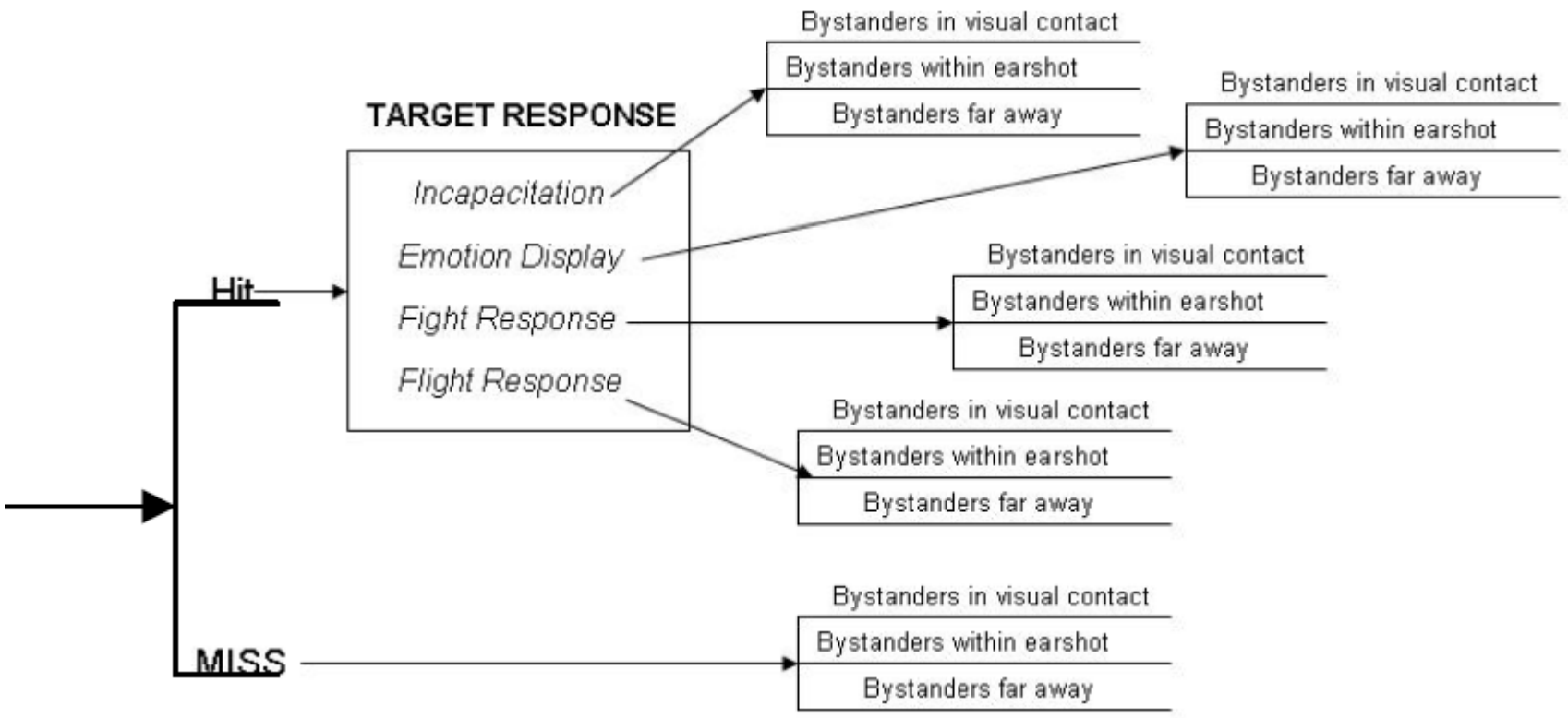
Verification

- Need to articulate specific model
  - List of relevant factors
  - Interrelationships among the factors
- Need to articulate assumptions
  - Identify relevant scenarios

Crowd Model



Model Detail



Validation

Validation is defined as:

The process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation.

Validation considers the question "Have we built the right model?"

Cook & Skinner, 2005
The Journal of Defense Software Engineering

Validation

Need to make/use against real world observations

- Challenge is to measure
- Challenge is to find recorded measures
- Beware of circularity
  - Can't use same data that you've built the model for validation
- Requires control over factors

QUESTIONS??

- Thu 6 Aug 10:30-10:55 PM Monroe
- **“Social Network Analysis of Crowds”**

- Thu 6 Aug 2:30-2:55 PM Madison
- **"Results from Experimentation on Driver Behavior at Controlled Entry Points"**

- Thu 6 Aug 5:00-5:25 PM Grand Dominion 3
- **"Empirical data sets for agent based modeling of crowd scenarios“**

- Thu 6 Aug 4:00-4:25 PM Grand Dominion 4
- **"Data Sources for Human Behavior“**

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- **"Subject Matter Experts from Academia”**

TBRL Presentations

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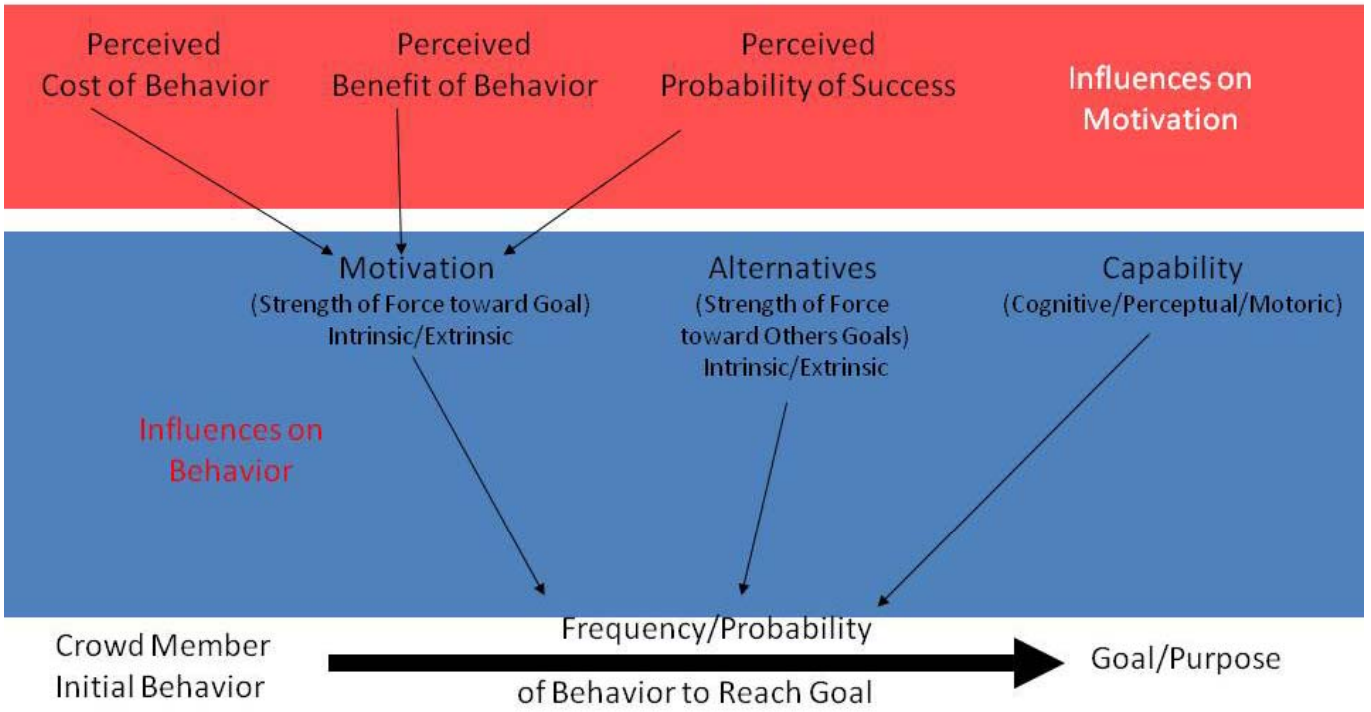
Back up slides

Conceptual Model for Crowd Behavior

Theoretical Model

Mechanisms of Non-Lethal System Effects on Crowd Members



Information Sources

- Technical Reports
  - DTIC
  - NTIS
  - May be too specific
  - May not include social science information
- Books/Textbooks
  - Academic Library Catalogs
- Journal Articles
  - Academic Databases

The Search for the Algorithm

- Theories
- Identification of variables
- Associations among variables
- However, these type of information sources are unlikely to have algorithms or constants specific enough for a model

The Search for the Algorithm: Data Sources: Less Costly

- Public Archives of Survey/Census Data
  - Pro: Nice clean data ready for analyses
  - Con: Need to search for relevant metrics measures
- Questionnaire/Interview with participants (Retrospective)
  - Pro: Relatively easy to collect data
  - Con: Forgetting/Distortion/Bias
- Analysis of Videorecordings of Events
  - Pro: Relatively easy to buy data
  - Con: Coding not established, biased, and limited view

The Search for the Algorithm: Data Sources: Hard Core

- Real-Time Observation or Interview
  - Pro: Validity of data
  - Con: Relatively difficult to collect data, have to wait for event
- Controlled Laboratory Experiments
  - Pro: Customizable control of factors
  - Con: External validity may be weak
- Natural Experiments/Real-Time Observation or Interview
  - Pro: Validity of data / control of factors
  - Con: Rare to have events that differ in small number of factors you are interested in