Simulation and Analysis Center

The OZ Wargame Integration Toolkit: Supporting Wargames for Analysis

Deborah Duong, Lauren Murphy, Will Ellerbe

OSD PA&E Simulation and Analysis Center

Got a Wicked Problem?

- **Irregular Warfare (IW) analysis** is a "Wicked Problem"
  - IW: Battlegrounds of social concepts
    - Legitimacy
    - Popular Will
  - Many perspectives
  - Seems unsolvable
- Two complementary approaches to analysis:
  - **Human**: Wargaming
  - **Machine**: Simulation
- **The Oz Wargame Integration Toolkit**
  - A solution that takes the best of both approaches
  - Integrates wargames, simulations, rule-based systems, and data
  - Enables scientifically rigorous analysis of wargames

OSD PA&E Simulation and Analysis Center

Human vs. Machine

Analysis of the Social World	
Subject Matter Experts (SMEs)	Computer Simulation
Can understand human contexts	Limited and forced understanding
Can recognize new situations	Newness (emergence) not well developed
Hard to get statistical significance (exception: Massive Multiplayer Online Gaming)	Easy to repeat
Human variance requires more repetitions	Can hold all else the same
Individuals stove-piped	Scalable and crosscutting: incorporates knowledge from many disciplines
Can not connect micro to macro	Can compute micro-macro complexity

"If I only had a (computer) brain"

"If I only had a (human) heart"

OSD PA&E Simulation and Analysis Center

Synergies between Human and Machine in Oz

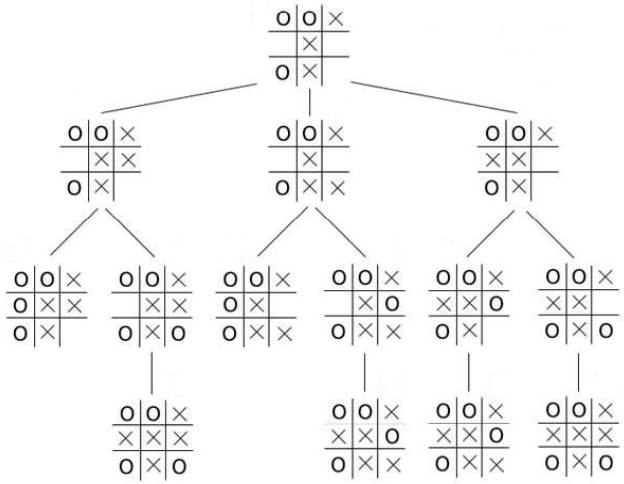
- Oz supports achieving statistically significant patterns
  - Allows branching and keeps track of the branches
  - Keeps track of hierarchical categorizations of moves in an “ontology”
    - Enables post-game statistical analysis and data-mining
  - Streamlines the move input and adjudication process
    - Players select from available moves in a menu
    - Computer models suggest adjudications that humans may check
    - Rapid entry of ontologies, rules, models, and data
    - Human resources may be applied to more repetitions of the game

- Oz does not limit human creativity
  - Free moves are allowed in the war game
    - Players may suggest new categories
    - Text descriptions are stored
    - In extended games, computer modelers have time to incorporate new moves into their models
    - New moves are easily expressed in ontology and rules
  - Human adjudicators have the final say over model suggested results

OSD PA&E Simulation and Analysis Center

Statistics through Branching

- For example, every time a particular action is done, or a particular player makes a move, give it to another player
  - For pair-wise comparison, or random block design experiments
    - Fewer repetitions needed
  - "Holds all else the same" by giving the same history up to the branching point
- Done behind the scenes
  - Players only see history that they should see
  - Perception is preserved
  - Oz file sent through email
- Necessary part of the Scientific Method
  - Done in the United Kingdom and the Army War College



OSD PA&E Simulation and Analysis Center

Statistics through Ontology Technology

- Ontology: A way to categorize data into general and specific categories
  - Intuitive interface for input through Protégé open source software
- Facilitates significant level of aggregation for Statistics and Data Mining
  - There might not be enough data on specific terrorist acts, but it may be significant on a general level
  - Provides gradient for data mining techniques (like MPICE, CAST, ACTOR, FORESITE)

OSD PA&E Simulation and Analysis Center

Finding Patterns in Creative Actions

Q. How can we use statistics if Irregular Warfare Analysis is Wicked?

- Doesn't human creativity make actions unique?

A. We aren't studying uniqueness, we are studying patterns

- Unique actions still fall into types
- Statistics measure coerciveness of action
  - Defined by a **lack** of variance in response
- Medical statistics deal with similar levels of variation

OSD PA&E Simulation and Analysis Center

The Game World vs. the Real World

Q. But we aren't using real data!

A. We are finding patterns in our best SME and model estimates
   - Strategic role-playing helps players to "be there"
   - Statistical comparisons with real data can eliminate "game bias"

   Statistics tease out the effects due to the game itself from the effects due to the idiosyncrasies of the players

OSD PA&E Simulation and Analysis Center

The Model Composition Problem

Q. Isn't the social computation in your automated adjudication another wicked problem?

- What do you do with many perspectives?

A. Yes, we are forced to compose social simulations

- One simulation can't hold the entire social world
- Each social scenario is a unique combination
  - Impractical to simulate from scratch
  - Needed for quick-turnaround analysis
- Since social scientists disagree, all perspectives of every discipline need to be tested

… and we are applying advanced technologies to the problem

OSD PA&E Simulation and Analysis Center

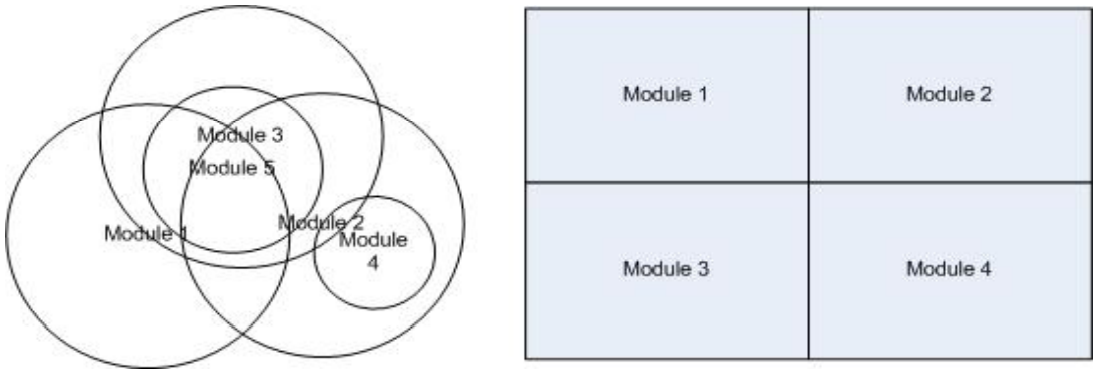
Composition through Ontology Technology

- Ensures Multi-Resolutional models can speak to each other
  - Makes a mapping between simulations possible
    - An action at a lower level for a lower resolutional model is automatically mapped to a higher level for a higher resolutional model
    - Hub and Spoke scheme is used
  - Integrates simulations through the MVC (model view controller) software engineering design pattern
    - Multi resolutional software agrees to a data model, and consistency with that agreement is enforced
    - Data Model is not buried in the control logic of the simulation
- Enables consistent integration with data in databases, of different ontologies
- Facilitates appropriate levels of description for rules
  - A deep ontology allows a rule to be general or specific, as appropriate

Simulation and Analysis Center

Problem: Consensus Among Social Models

- The social disciplines are different views at the same phenomena
  - Overlap: the same ***or highly correlated*** events are covered in two or more simulations
  - Conflicts typically occur in areas of overlap
- In Oz, models may be synchronized at areas of overlap
  - Many conflict resolution/synchronization schemes may be used
    - Human adjudication
    - Weighted voting schemes
      - Weeds out bugs in replicated models
    - Constraint satisfaction
    - Coevolution

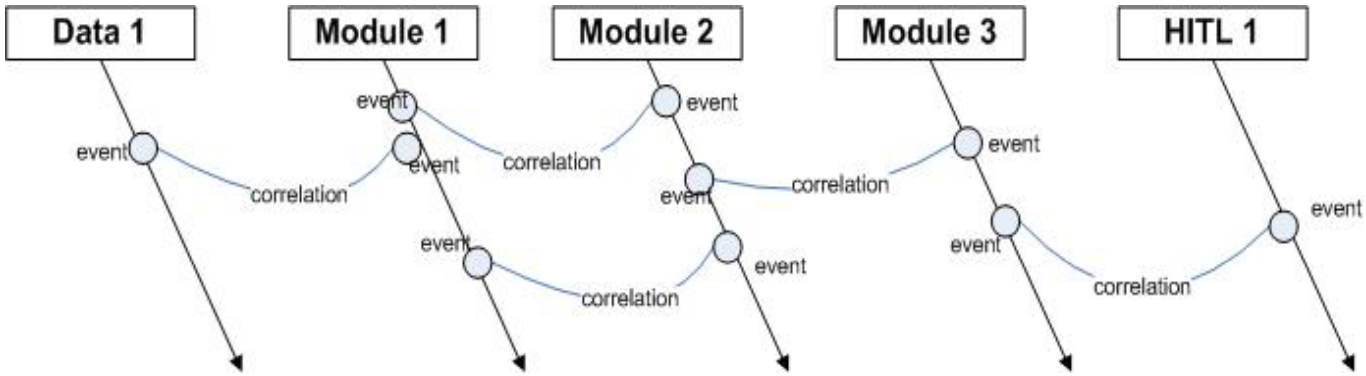


Social models overlap, as on the left, instead of fitting neatly together, as on the right

OSD PA&E Simulation and Analysis Center

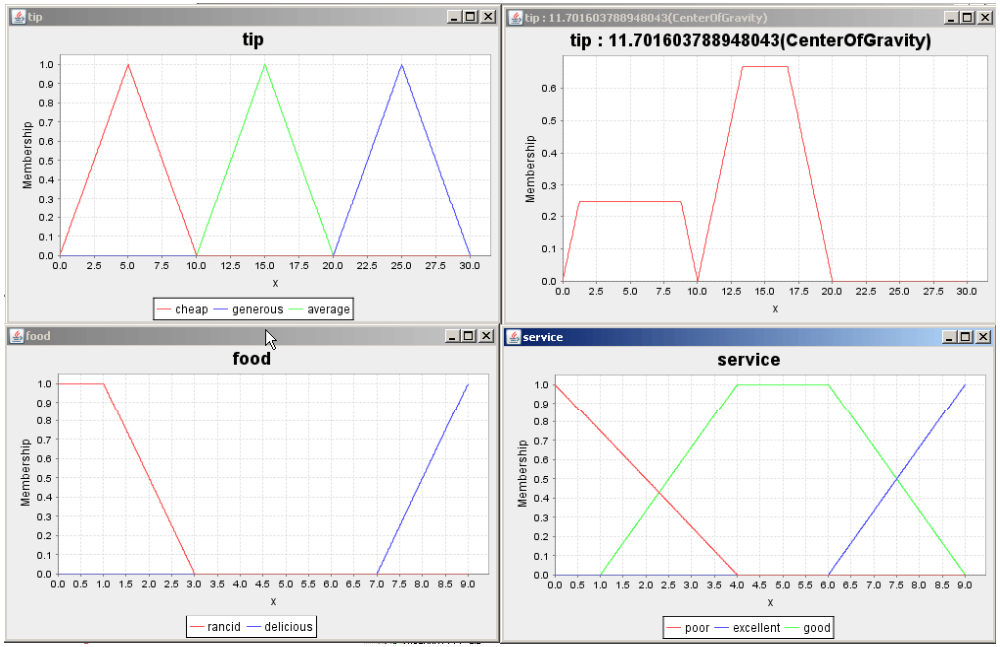
Model Consensus through Rule-Based Systems

- In Oz, the social literature itself helps achieve consensus
  - Both types of social literature are used
    - Social theory/causal models drive simulation modules
    - Correlative studies designate weighted areas of overlap
- Correlative rules automate integration and validation
    - Models and model combinations that best fit patterns in data are best
      - We can not expect models to predict events, but we can expect them to match patterns
- Fuzzy rulesets model correlative studies
  - Exactly matches the data of correlative studies
    - Weight of rule taken from correlation coefficient
  - Robust with respect to contradictory data
  - Fuzzy Cognitive Maps implement constraint satisfaction conflict resolution



Data Aggregation with Fuzzy Rules

- Combines real-valued model results into PMESII adjudications
  - Correlative Data are Social Indicators
- Scalar: Can determine degrees of change
- Intuitive interface for input with verbal descriptions of phenomena
  - Open source JFuzzyLogic
- A rule from PITF correlative data:
  - If a state's factionalism is high, and its democracy is partial, then its stability is low
  - Calibrated to data



If the food is delicious and the service is excellent, then the tip is generous

OSD PA&E Simulation and Analysis Center

Using Oz for a War game

- Oz was used in the Africa Study, the major study of IW using wargames and models in the Department of Defense. Oz enabled:
  - The moves and effects of a wargame to be quickly entered, including rules about legal moves
  - Filtering of historical moves for reference and display of only the moves players are supposed to see
  - Data mining of the result of the game
- With the modification currently being implemented, Oz will enable SOCOM wargames to
  - Automate the crosstalk between models with hub and spoke ontology translation
  - Suggest a consensus of models with fuzzy ruleset
  - Measure success with fuzzy ruleset
  - Automatically explore the space of possible outcomes

OSD PA&E Simulation and Analysis Center

Summary

- Oz is unique because it
  - Integrates wargames, simulations, rule-based systems and data for the purpose of analysis
  - Branches the game and records it for statistical and data mining analysis
  - Streamlines the process of using many wargame adjudication modules
  - Does not limit human creativity
- Oz can do these things because it uses
  - Ontology technology
    - Facilitates statistics, rules, and semantic integration of multi-resolutional models
    - Open source software, Protégé, allows easy entry of a variety of wargames
  - Fuzzy rule technology
    - Encodes data from correlative social studies to integrate and validate causal theories encoded in simulations
    - Open source software, jFuzzyLogic, allows easy entry of rules

Questions?