Gaps, Tools, and Evaluation Methodologies for Analyzing the Global War on Terror

Dr. Deborah V. Duong

Improving Cooperation Among Nations in Irregular Warfare Analysis

11-13 December 2007

Definition of Irregular Warfare

- **"A violent struggle among state and non-state actors for legitimacy and influence over the relevant populations. IW favors indirect and asymmetric approaches, though it may employ the full range of military and other capabilities, in order to erode an adversary's power, influence, and will"**

Irregular Warfare Joint Operating Concept, OSD and Joint Staff, Version 1,p 4.

- **Irregular Warfare emphasizes social phenomena**
  - "legitimacy" and "influence" are studied in the social sciences

Different Analysis Techniques Needed

- **Modeling and Simulation necessary for analysis of Course of Action and Resource Allocation**
- **Conventional Warfare models use simple physics equations to back decisions on courses of action and resource allocation**
  - Simple equations tell us, n airplanes are needed against m tanks
  - They can not tell us, n civil affairs officers are needed against m priests
  - But we still need to back our decisions!
- **Irregular Warfare models should incorporate complex social phenomena like "legitimacy" and "influence" to guide our decisions**
  - Social Science, not Physics, speaks to these subjects
  - Different modeling techniques are needed to represent the human phenomena

Gaps in IW warfare modeling

- **Needed: Definition of**
  - Gaps in IW warfare modeling
  - Technologies capable of filling those gap
  - Reasons to believe these technologies have credible answers

Gap: Modeling RED C2

- **Modeling and Simulation Analysis**
  - Monte Carlo analysis is needed to describe a varied and complex space of outcomes under uncertainty
  - The space of irregular warfare is varied and complex
  - To explore the space in a statistically significant manner, many runs are needed
  - Dilemma: It is hard to achieve a statistically significant number of runs with any technique which uses a human-in-the-loop
  - Therefore, constructive simulation is needed.
- **Constructive simulations need an intelligent, adaptive, opportunistic enemy.**
  - Enemy should
    - React to new combinations of situations based on goals
    - Learn from and adapt to BLUE reactions

GAP: Modeling Green PMESII

- **Computational Social Science needed for any analysis**
  - Humans-in-the-loop can play an opportunistic red well, but…
  - Not even SMEs can play the reaction of the GREEN populace well
  - SMEs tend to be stove-piped, and can not walk through the effects of micro level interactions on macro level social phenomena
  - The Social World is so complex we need computers to walk through all the implications of lower level facts
- **But, Social science theories, unlike physics theories, are not agreed upon**
  - Therefore, Social Science Theory should be modular, re-combinable input
    - Important for the government's objectivity
    - Making the space MORE complex, and MORE in need of a computer
    - Analysis becomes the search for robust strategies
      - » Which is in line with GWOT resource allocation goals

GAP: Modeling Green PMESII

- **Computational social science is HARD… and models have cut corners…**
  - Models are computationally convenient, ad-hoc, not capturing the essence of theory, and not scientifically careful
  - Models should reflect social theory in proportion to its occurrence in social science literature
    - Examples of computationally convenient models (physics or math based):
      - » power law, social network (graph theory) , netlogo/cellular automata/spatial, fluid dynamics and system dynamics, contagion (yes, the majority of the field…)
    - Models should adapt to the needs of social theory and not visa versa
  - Social theory should appear completely in models and not in pieces
    - Since you can find a theory for any relation, pieced together models are ad-hoc
    - Extraneous relations (representing gaps in theory) should be minimized
  - Models often conflate the input assumptions with the output analysis
    - For example, explaining institutions (behaviors in common) with contagion (making everybody copy each other)

GAP: Modeling Green PMESII

- **IW Social phenomena that are hard to model:**
  - Fluid social structure and social change
    - Simulating effects of terrorist micro actions on macro social structure (ie “state failure) and visa versa
    - Difficult to be true to both theory and data
    - Needs micro macro integration (multi-resolution) simulation
  - Information Warfare
    - Ideas are not fluid levels rising and lowering as we see in physics-based models
      - » IO models based on physics are not scientifically valid: they assume we can change hearts and minds, without walking through how
    - Second-order cybernetics are needed: Models of modelers
    - Interpretive social science is needed: changing interpretations of meaning, self-fulfilling prophecy, and culture based perceptions
  - Social Networks
    - Not graph theoretical analysis, but the development of connections agents have to one another with differing influences
    - Not really hard… but… not really done…

Tools that address the Gaps in IW modeling

- **War-gaming**
  - Insight is gained by walking through situations
  - However, analysis needs statistically significant results, which are hard to get with Human-In-The-Loop techniques
    - So, war-games may be branched
    - Computer can assist in rapid adjudication and “keeping all else the same”
    - Statistics can tease out the effect due to the interactions from bias brought to the game
- **Agent-Based Simulation**
  - Works same way as war game: by walking through situations
  - However, can do many more micro simulations than war games can, and compute macro level effects, for green PMESII simulation
  - Agents are essential for simulating networked relations
  - Agents are needed to simulate game theoretical and artificial intelligence based techniques

Tool: Agent Based Techniques

- **Game Theory**
  - Agents can react to each other based on their perceptions of other agents perceptions … modeling modelers as needed in IO warfare
  - Agents can find equilibria
    - Nash equilibria…- solutions where no competing party can do better
    - Shelling points – cooperative solutions
    - These are great states to cajole a situation into for COA analysis
  - Signaling theory finds payoffs for communication, needed in IO warfare
- **AI techniques**
  - Expert systems: agents can hold modular rulesets that represent behaviors of social groups they belong to
  - Uncertainty: agents can have perceptions and actions based on probability theory (bayesian networks) or “qualitative” reasoning (fuzzy systems)
  - Machine learning techniques: Agents can learn how to deal with new situations and generalize about them using neural networks and genetic algorithms, or more advanced co-evolutionary techniques

Tools: Integrative Methods

- **System Dynamics Techniques**
  - Captures homeostatic nature of natural and social systems
  - Integrates phenomena through modeling the feedback between phenomena
  - But not good for modular switching in and out: more of a static “spaghetti” program
  - Cant simulate networks and change in structure, but good for simulations that use “even mixing”
  - Good for macro level processes that do not need feedback from the micro level
- **Integrative Toolkits**
  - Since so many theories and strategies need recombination for exploration of the IW space, toolkits must address integration issues
  - Models of different social phenomena are interdependent, and are different ways of viewing the same thing
  - Models of micro and macro level (multi resolution) phenomena are also different ways of viewing the same thing
  - Integrative toolkits need to find consensus and resolve conflicts between models that are different ways of viewing the same thing
  - Feedback, as in the NSF DDDAS (Dynamic Data Driven Application Systems) program is promising

Evaluation Methodologies

- **Clearly describe the model**
  - Starting assumptions
    - Anything you start with that “matters” to output distributions
      - » Code: Sometimes discrete makes a difference, sometimes not
        - > Docking may be used to uncover hidden assumptions
      - » Parameters
        - > Better models have fewer
      - » Input Data
    - Important to ensure that conclusions don’t follow directly from assumptions
  - Process
    - Should be like the referent process
    - Causal tracing can be done in emergent systems with a computer
  - Output Distributions
    - Define referent
      - » Use theory to define pattern of interest
      - » Social world is full of arbitrary phenomena, that shouldn’t be measured against