



Agent Based Simulation

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How can Simulation help Social Science?

- Computer Simulation Technology can make social science “science”
- Social science theory posits cause and effect relationships to explain mysteries, but can not demonstrate if these relationships are even possible
 - For example, Adam Smith’s “Invisible Hand” in Economics
- Simulation can explain social mysteries by demonstrating how one phenomena can cause another
 - To tell “how” we must compute from assumptions
- The reasons we may believe Simulation are the same reasons we believe scientific experimentation
 - Ockham's Razor and strength of causal relationship
 - If we accept the assumptions and from them we compute many different phenomena, it is unlikely we chose the wrong set.



What is an Agent-Based Simulation?

- “Agent-Based Simulation” (ABS) is broadly defined
 - An ABS is a simulation in which entities have “agency”
 - Agents can perceive and behave in their environment based on goals
- Agent-Based Simulation is used for modeling living systems
 - Biological and social systems
 - Non-living systems are mindless, and therefore don’t have “agency”
- The concept of “emergence” is important
 - Agents behave according to one set of rules
 - New patterns “emerge” from individual behaviors
- Two Dimensions describe the types of Agent-Based Simulations
 - Cognitive vs. Reactive Agents’
 - Data-Centric vs. Theory-Centric

Cognitive vs. Reactive Agents

| Agent Types | |
|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Cognitive | Reactive |
| Meaning changes | Meaning is Hard Coded |
| Interpretations come from Autonomous Perception | Interpretations come from Copying other Agents |
| Learn based on Experiences | React the same way every time |
| Coevolves: behavior changes social structure while social structure changes behavior | New starting conditions form different patterns but rules of behavior do not change during the simulation |
| Heavy Computation | Light Computation |
| Typically uses Machine Learning Techniques | May use static rules |



Data-Centric vs. Theory-Centric Agent-Based Simulations

| Agent Based Simulation Types | |
|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Data-Centric | Theory-Centric |
| Concerned with modeling a single instance of what actually happened and will happen | Concerned with modeling what is possible, based on theoretical principles |
| Is initialized with the detailed data of a scenario | Starts with a random “primordial soup” from which data emerges |
| Purpose is to explore plausible next states given the initial state | Purpose is to model causes of states |
| Stopping start: the initial state is not necessarily something that could emerge from the simulation itself | Running start: Difficult to match to a particular data set: data must be “grown” from a previous state |
| More descriptive: to fit data, correlations tend to be enforced without the modeling of cause | More causal: No data to fit, only relations between events |



Why Agent Based Simulation?

- Simulates Causality Better
 - Computes from relatively few assumptions
 - Instead of directing the results, we explore them
 - Explains patterns in the real world by re-creating how they came to be (instead of simply describing them)
- Many of the most relevant social mysteries are Micro-Macro Integration problems
 - Micro level and Macro level of social sciences do not explain each other
 - Emergence in Agent-Based Simulation is Micro-Macro Integration
 - Needed to know the effect of our actions on societies
- By simulating individuals, the crux of the problem in IO and Psyops can be represented
 - Perception and Motivation
 - Psychological phenomena
- Generalities can be made
 - When “rules” (individual behaviors) play out realistically in many different circumstances, we have a good predictor of how they will play out in new circumstances

Problems with agent based simulation

- Problems with drawing generalities from instances
 - Artifacts
 - The phenomena may not come from the assumptions, but the way we have represented the assumptions
 - For example, If I represent learning with a neural net, I don't want the results to depend on peculiarities of the neural net that are not characteristic of human learning
 - Replication can help
 - Use many different kinds of learning, to prove the generality of the result
 - When you compute from assumptions most, its harder for the simulation to reflect a particular instance in the real world
 - Primordial soups explain in general but do not explain specifics
 - The instance of the real world is arbitrary
- Technology of Artificial Intelligence in representation of human behaviors important to the social phenomena



Nexus: a cognitive agent simulation of Popular Support

- A Social Group Agent for each ethnic, insurgent, or government group
- Social Group Agents interpret and reinterpret actions in context
 - Of the actions that have happened before
 - Of ideological similarity to the actor
 - Of the network of support that agents have for each other
- In the light of new actions, Social Group Agents can
 - Reassign blame for past actions
 - Change belief in the trustworthiness of other agents
 - Declare new support levels for other agents
- Social Group Agents have a historical consciousness and reinterpret blame for actions

Social Group Agents

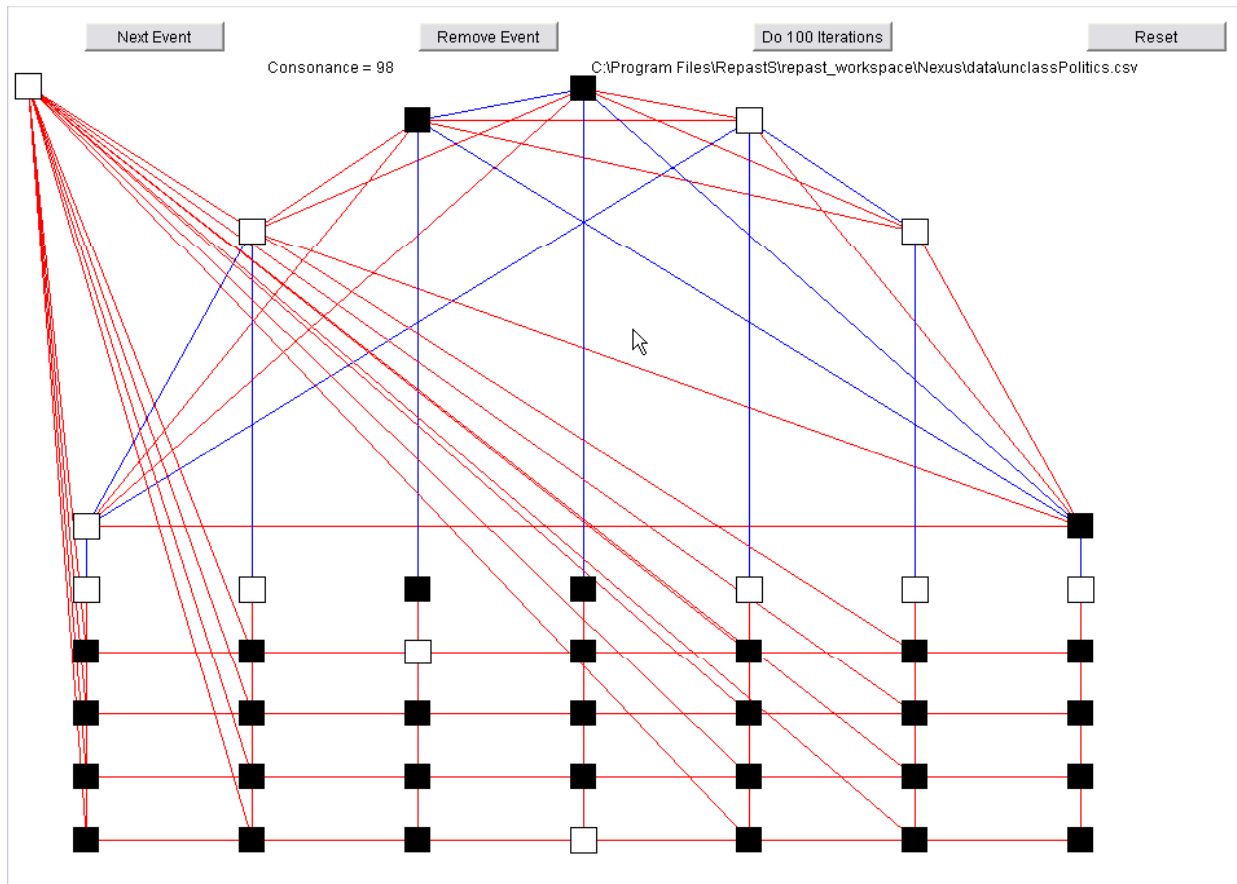
- Each agent has a “group mind” (or you can say... it’s the leader’s mind...).
 - This “group mind” fits in with SME statements of group opinion.
- This group mind is a constraint satisfaction neural network, used to compute group support of other agents
- Constraint satisfaction neural networks simulate coherence
 - **Duong, Deborah Vakas.** *A System of IAC Neural Networks as the Basis for Self-Organization in a Sociological Dynamical System Simulation.* Master’s Thesis, The University of Alabama at Birmingham, June 1991. <http://www.scs.gmu.edu/~dduong/behavioralScience.pdf>. (published 1995)
 - **Thagard, Paul.** *Coherence in Thought and Action.* Cambridge Ma: MIT Press 1999.
 - **Read, Stephen and Lynn Miller.** “On the Dynamic Construction of Meaning: An Interactive Activation and Competition Model of Social Perception,” *Connectionist Models of Social Reasoning and Social Behavior.* London: LEA 1998.



Social Group Agent Simulation Loop

- **All groups compute their support for all other groups**
 - Group A computes support for group B, with neural net, based on:
 - the past actions of group B
 - what other groups group B supports
 - how close group A is in ideology to group B
 - The neural net takes into account not only the historical actions of a group but the action of their friends, and their friend's friends, etc., into a coherent picture that looks at higher order relations
 - The enemy of my enemy is my friend: from Heider's balance theory
 - Cognitive Dissonance when triad rules are broken
- **All groups make public declarations of support.**
 - There is a hook for adding "believed support" if it differs from public declarations.
- **Groups modify their neural nets according to their new beliefs of public support.**
- **Groups act based on their objectives**
- **Groups re-compute support, etc.**

Each Social Group Agent Mind is a Boltzmann Machine Neural Network

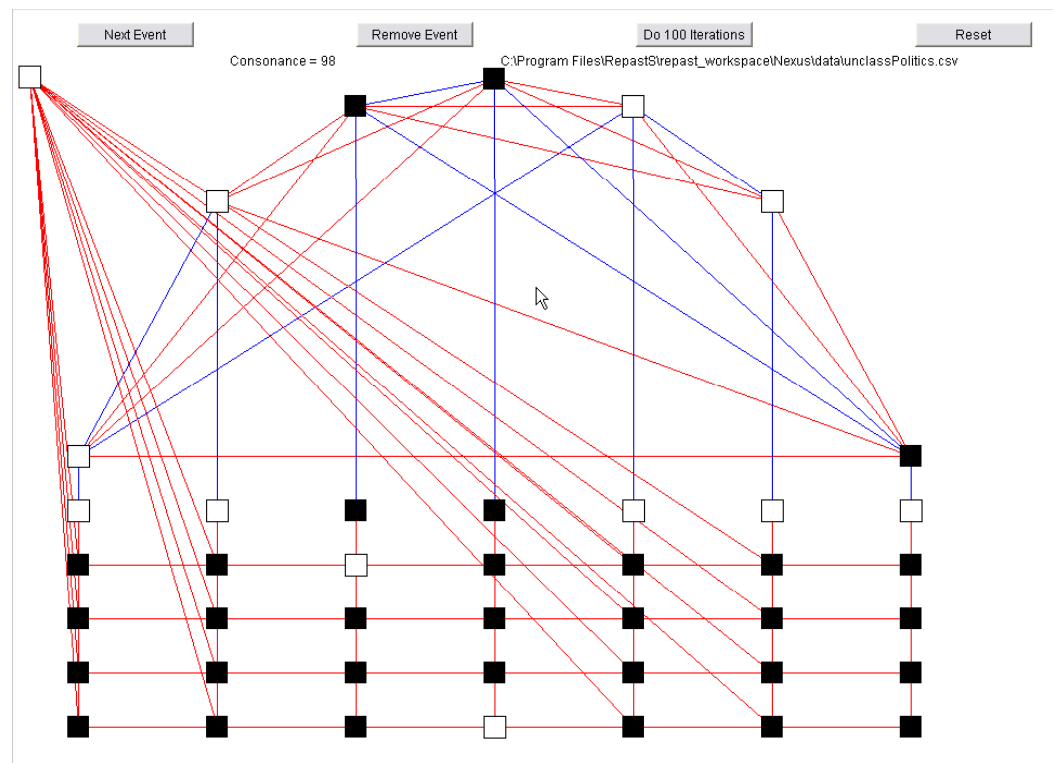


The Boltzmann Machine

- A Constraint Satisfaction Neural Network
 - Nodes may represent states of the world
 - Links may represent how much evidence of one state supports evidence of the other state
 - An Ising Spin model, similar to the Hopfield Network
- Stochastic: Uses Simulated Annealing
 - Nodes are turned on randomly at first
 - Each node computes its activation based on (activation of nodes linked to it X weight at synapse)
 - Randomness dissipates slowly so that network can settle on more consonant states
- Represents a Paradigm of consonant states
 - Nodes compute activation over and over until all converge on a steady state
 - Settled upon state represent an internally consistent set of evidence, and a consensus of the evidence on the state.
 - Can represent a paradigm shift, a change in belief in who is responsible for the group's problems

Architecture of Nexus' Neural Networks

- Columns are social groups
- First Row: Support Nodes
- Second Row: Trust Nodes
- Remaining Rows: Blame Nodes for Salient Historical Events
 - One event per row
 - Ordered: bottom are future events
- Evidence Node
 - Court-type “Proof” they’ve witnessed, before the minds spin
- Ideology Node (not pictured)
 - Ideological similarity of groups
 (connects to the trust nodes)





Nexus' Social Group Agents act in accordance with psychological theories of coherence

- **Social Group Agents seek a coherent picture of events**
 - Agents may reinterpret the blame for events in the past depending on present beliefs
 - Agents choose alliances according to a coherent picture
 - Coherence includes consonance with historical events, in an ongoing story
 - Higher order vulnerabilities in support network may be brought to light
 - Useful in campaigns to strengthen or weaken support
 - Works by way of cognitive dissonance theory, or the minimization of incoherent facts
- **Nexus has lots of explanatory power for a variety of Irregular Warfare Scenarios**
 - For example, Insurgent-agents may incite Rodney King incidents, make videos of it and distribute it, planned by looking ahead to what actions would advantage them. They choose Rodney King because they see that to keep an alliance with population, government agents would be forced to prosecute police, separating police from government.
 - Groups can represent countries and Gandhi type protests can represent actions that cause them to try to keep ideologically similar to their allies, so their allies will trust them.
 - Gandhi's tactics wouldn't work for Nazis, because the Nazis allies were outwardly brutal
 - It could model why an ideology that is dissonant may become popular, for example, a Nazi insurgency succeeding in a civilized country. Humiliation by enemies after WW1 was so strong, and Germany wanted to preserve superior identity so much, that moral dissonance could be minimized.