



Nexus Network Learner

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Nexus

- A project of OSD/PA&E Simulation and Analysis Center
- Nexus is a set of Cognitive Agent Social Models
 - Cognitive
 - Perception is modeled
 - Agent
 - Individuals act autonomously according to perceptions of utility
 - Social
 - Agent perceptions and actions form social structures
 - Model
 - A system forms
 - The system represents generally accepted social phenomena
 - Nexus can be instantiated to a particular scenario for analysis
- Two models presently exist in Nexus
 - Nexus Schema Learner
 - Group Level Agents the model Coherence in Social Psychology
 - Nexus Network Learner
 - Individual Level Agents that model Resources flowing through Social Role Networks



Composition Needed in Social Models

- To analyze a social environment in quick turnaround fashion
- Instead of having the world in a single simulation, choose several small, general, building block models from a library to build a scenario
 - Different social theories may be switched in and out
 - Necessary for objective treatment of conflicting theories
- Models need to resolve conflicts
 - One way to resolve them is Adaptive Simulation
 - Models to adapt to each other, and adapt to the data
 - To make a coherent picture of the social environment



Nexus Models are Made for Composition

- Generality
 - Theory is generally accepted and universally applicable
 - Nexus Network Learner
 - Social Role Networks
 - Resource flows based on utility
 - Nexus Schema Learner
 - Coherence and Cognitive Dissonance Theory
 - Both model Interpretive Social Science
 - Easily Instantiated to Particular Scenarios
 - Nexus Network Learner
 - Used to model corruption in the Africa Study
 - Could be used to model the flow of funds through Terrorist Networks
 - Nexus Schema Model
 - Used in 3 different studies of IW, both Kinetic and Non-Kinetic
- Flexibility
 - Nexus Network Learner easily ingests and adapts to data in a general manner
 - Real world data, initialization and live connection
 - Data from other models in a composition
 - Conflict Resolution of composed models through Adaptive Simulation



Nexus Network Learner: Generality

- Nexus Network Learner social theory is general
- Input to the simulation is general
 - Bayesian Network of traits and behaviors
 - Social Role Network that defines flows of resources
- Nexus Network Learner Learns in a general manner
 - Arbitrary resource allocation or network choice behaviors may be learned
 - Learning based on pragmatic utility
- Good for many IW Warfare Scenarios
 - We may often want to effect social structure change



General Theory: Interpretive Social Science

- People's thoughts matter
 - “Perception is reality” – Kilcullen
- Meaning is context-dependent
 - “Anything can mean anything” – Goffman
- Social structure comes from people's interpretations of their situations
 - To change social structure, you must change subjective interpretations
 - Agents may be quite pragmatic in their interpretations
- Interpretative Social Science exists across all of the social sciences. Nexus Network Learner uses:
 - Institutional Economics
 - Symbolic Interactionist Sociology
- Important in IW modeling
 - Change in social structure is what we seek to effect



Interpretive Social Science Used in Nexus Network learner

- From economics: The New Institutional Economics (NIE) (North)
 - Institutions (Social and Legal Norms and Rules) underlie economic activity and constitute economic incentive structures
 - Institutions come from the efforts of agents to understand their environment, so as to reduce uncertainty, given their limited perception
 - When some uncertainties are reduced, others arise, causing economic change
 - To find the leverages to social change, NIE would look at actor's definition of their environment, and how this changes incentives and thus institutions
- From sociology: Symbolic Interactionism (Mead)
 - Roles and Role Relations (such as in trade roles and trade relations) are learned, created during the display and interpretation of signs (such as gender, ethnicity, and other demographic characteristics)
 - Institutions (rules of trade) are commonly accepted interpretations of symbols, that start out as a subjective perception and engrained in society as an objective rule.



General Input Data: Traits and Behaviors

- A Bayesian Network that holds the demographic characteristics of a population
 - Determined traits such as gender, ethnicity, age
 - Situational traits such as employment
 - Behaviors such as propensity to steal or bribe
 - Attributes looked for in the choice of network partners, such as “look for ethnicity in employment”



General Input Data: Social Role Networks

- Networks, such as Kinship, Trade, and Bureaucratic
- Roles, such as Wife, Customer, Employee that belong to the networks
- Role Definitions
 - Corresponding role ,such as Parent and Child
 - Criteria for choosing a role, such as to choose a wife you must be a male of working age
 - Distribution for the number in a role, such as a Parent has a mean of 4 children and a standard deviation of 2
 - Derived roles, such as a Mother is a female parent
- Accounts that belong to roles
 - Roles are responsible for accounts, such as the employer is responsible for distributing the payroll, or the head of household is responsible for distributing the household budget
 - To distribute to another network, an agent may switch roles, such as an employer in the bureaucratic network becomes a purchaser in the trade network
 - Allocation distributions to other accounts, depending on traits, such as stealing
 - Exogenous accounts such as foreign aid
 - How each transactions effects utility of individuals



General Learning of Network Structure and Behaviors

- Which attributes to keep constant and which are learned are also input to the simulation
 - For example, gender and ethnicity are constant for an agent, but stealing is learned
- Agents start out with the behaviors that the Bayesian Network gives them, from country data
 - Network choices based on attributes
 - For example, choosing an employee based on whether a bribe is offered based on ethnicity
 - Behaviors based on attributes
 - For example, tendency to steal based given other traits like location, employment, income, etc.
- During the Simulation, networks are built and funds flow
 - Networks attrit and learned network choices are made
 - Funds are allocated through networks based on learned behaviors
 - The utility of choices are kept track of
 - Own or role relation utility is an input
- Agents learn other network choices and behaviors based on utility
 - Many new sets of behaviors and network choices are tested until the best are found



Performing Tests with Nexus Network Learner

- A wide variety of tests relevant to IW may be performed
- For example, new network formations and behaviors may be tested based on...
 - The effect of different utility functions
 - For example, make agents care only for self rather than larger social network
 - The effect of different penalties
 - For example, a penalty attribute that encodes different fines
 - The effect of different exogenous resources
 - For example, test resource rents or foreign aid
- Monte Carlo methods reveal if new structures are the result of different CONOPS
 - Nexus is stochastic and can give a confidence interval

Nexus Network Learner Flexibility

- As each agent learns, all the agents coevolve, making them very adaptive
 - Every agent has its own private learning algorithm
 - Their behaviors effect the larger social structure and the larger social structure effects their behaviors
 - Micro-Macro Integration is modeled
 - They can adapt to data from other simulations and to initial country data as well
- The learning algorithm in each agent makes the adaptation to data flexible
 - BOA (Bayesian Optimization Algorithm) can start learning from initial data
 - In the calibration phase. agents to adapt to initial data, so that they generate it though their perceptions and motivations
 - Thus they “explain” the data, going from correlation to cause
 - This greater ability to ingest data also allows them to meld with other simulations in a composition
 - Together, composed simulations create a coherent picture of the social environment
 - Conflicts are resolved through mutual adaptation



Open Source Software

- A wide variety of open source software help Nexus Network Learner to Adapt and be General
 - Weka Data Mining Toolkit:
 - Bayesian Networks
 - Easy Entry of Country Data through Graphical User Interface
 - Any data can be easily converted to Bayesian Networks
 - Visualization of Statistical Data
 - Repast Agent Based Development Toolkit
 - Easy Entry of Agent Behaviors
 - Visualizations of Social Networks using Jung

Use Case: Modeling Corruption

- Corruption in African Society is said to be the result of conflicting social networks
 - Kinship Network vs. Bureaucratic Network
 - Kinship Network has patron-client roles and many obligations
 - Bureaucratic Network has merit-based impersonal roles
 - Rules on how choose network relations (based on merit?) and how to distribute resources (based on kin obligations?) differ
 - Nexus Network Learner could easily model Kinship, Bureaucratic, and Trade Networks
- Nexus Network Learner could easily represent the roles and role relations of both networks
 - Includes 65 roles, including roles and role relations important to matrilineal and patrilineal ethnicities
- Nexus Network Learner could easily represent the corrupt behaviors which change distribution of resources in the networks
 - There are said to be eight basic types of corruption, that Nexus models with basic stealing and bribing behaviors, that occur in different sectors, and during both network choice and transactions
 - Nexus models the moving of funds from Bureaucratic to Kinship networks based on behavior traits
- Ways to move from the rules of Kinship to the Rules of Bureaucracy may be explored
 - Different penalties, utilities, and exogenous funds may be entered to explore the effects of DIMEFIL actions



Summary

- Nexus Network Learner is a robust, general, flexible tool for modeling Social Role Networks and resource flows through those networks
 - Usable in a wide variety of IW scenarios
- Nexus Network Learner can get to the crux of the issues in IW because it models agent motivations and interpretations
- Nexus Network Learner easily ingests real world data because it can adapt to it
- Nexus Network Learner works well in a composition of other simulations because it can adapt to them
- Nexus Network Learner offers Monte Carlo exploration of the effects of DIMEFIL actions on Social Structure