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Human Terrain Data – What Should We Do With It?

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Abstract

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Disciplines

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Comments

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Human Terrain Data – What Should We Do With It?

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ABSTRACT

What are we in the Modeling & Simulation (M&S) community to do with the volumes of 'human terrain' data now being published by the military and others in databases of the demographics and needs/values/norms of populations of interest? This paper suggests that the M&S community would be remiss if it did not rise to this challenge and suggest next steps for the use of this Human Terrain (HT) data resource. These datasets are a key asset for those interested in synthesis of two major agent-based modeling paradigms – the cognitive and the social – as this paper argues. We pursue this argument with a case study integrating a cognitive agent environment (PMFserv) and a social agent environment (FactionSim) and applying them to various regions of interest (Iraq, SE Asia, Crusades) to assess their validity and realism.

1 INTRODUCTION AND PURPOSE

Thought leaders in the military, and indeed funded programs, are focusing on the needs, values, preferences, and customs/norms of local peoples in order to better understand their allegiance and to determine how to influence them in 'hearts and minds' campaigns against local adversaries: e.g., see Chiarelli (2006), Petraeus (2005), Kilcullen (2004), among others. This is what McFate & Jackson (2005) call "human terrain" -- the human population and society in an environment of interest (area of military operations) characterized by sociocultural, anthropologic, and ethnographic data and other non-geophysical information about that human population and society. Of interest is to model how Diplomatic, Intelligence, Military and Economic (DIME) actions might effect the Political, Military, Economic, Social, Informational, and Infrastructure (PMESII) Systems of the region of interest.

As an example of this cultural sensitivity, consider the US Army's 'human terrain' program which is assembling database and presentation tools that will help them to understand and deal with "human terrain". Human terrain information is open-source derived, unclassified, referenced (geospatially, relationally, and temporally) information. It includes the situational roles, goals, relationships, and rules of behavior of an operationally relevant group or individual.

According to Kripp et al. (2006), the early phases of Human Terrain (HT) systems are oriented at creating "constantly updated, user-friendly ethnographic and sociocultural database of the area of operations that can provide the commander data maps showing specific ethnographic or cultural features. The HT's tool kit is mapping software, an automated database and presentation tool that allows teams to gather, store, manipulate, and provide cultural data from hundreds of categories. Data will cover such subjects as key regional personalities, social structures, links between clans and families, economic issues, public communications, agricultural production, and the like. The data compiled and archived will be transferred to follow-on units."

In this talk we pose the question of what could the field of modeling and simulation (M&S) add to the topic of human terrain? Specifically, we are particularly interested in human terrain as a complex social system and hence we want to explore the question of what can agent-based simulation offer? That is, if we use the data of human terrain systems to help model the 'parts' and their micro-decision processes, can we observe macro-behaviors emerging that are useful for analysts to know about? Finally, if we want to model and simulate a social system from the bottom up, then it seems that we need to approach it with agent technology that covers both the social processes that influence people as well as cognitive processes that people use in reasoning and emoting over their fates. That is, we are curious about what can 'socio-cognitive' agents offer to the study of human terrain or social systems?

Sun (2004) provides a useful survey of the respective fields of social agents and cognitive agents and shows that there are very few environments that straddle both topics to provide socio-cognitive architectures. In this paper, we therefore illustrate one such architecture and provide some insights into how it works, what it is useful for, and whether its outputs provide any validity. While this is relatively mature, COTS software, we close with discussion of future research needs so such tools will better support human terrain analyses.

2 COGNITIVE AGENT MODELING

This section presents PMFserv, a Commercial Off The Shelf (COTS) human behavior emulator that drives agents in simulated gameworlds. It was developed over the past 8 years at the University of Pennsylvania. PMFserv agents are unscripted, but use their micro-decision making as described below to react to actions as they unfold and to plan out responses. For each agent, PMFserv operates its perception and runs its physiology and personality/value system to determine fatigue and hunger**,** injuries and related stressors, grievances, tension buildup, impact of rumors and speech acts, emotions, and various mobilization and collective and individual action decisions. The result is emergent macro-behaviors.

A performance moderator function (PMF) is a micro-model covering how human performance (e.g., perception, memory, or decision making) might vary as a function of a single factor (e.g., sleep, temperature, boredom, grievance, etc.). PMFserv synthesizes dozens of best-of-breed PMFs within a unifying mind-body framework and thereby offers a family of models where micro-decisions lead to emergence of macro-behavior within an individual. None of these PMFs are 'home-grown', but instead are culled from the literature on behavior science. One can turn on or off different PMFs to focus on those aspects of interest to the current users.

What follows is a listing of some of the major PMFs in the collection. This talk will overview these and their derivation and synthesis into a unified whole (PMFserv). Interested readers should consult Silverman et al. (2006a, 2007a) for details.

2.1 Major PMF Models Within Each PMFserv Subsystem:

Perceptual System (world markup services)

- Gibson Affordance Theory (world markup, perceptual types, activation dynamics)
- Perceptual cues and stimuli – (Brunswikian Social Judgment Theory)
- Janis-Mann Coping Style/Stress (5 stress-based levels for focus of attention)

Value System Module (Captures a person's values, culture and personality)

- Goal-Standards-Preference (GSP) Trees
- Bayes Importance Estimators
- Multi-Attribute Utility Functions
- Affective Reasoning -- Cognitive Appraisal

Personality Profiling Tools (Well established instruments now encoded with GUI sliders)

- Hermann Political Leader Profile Instrument
- Modified Maslow-Follower Profile
- Hofstede Cultural Factors Instrument
- UN Globe Study Cultural Factors

Social Relationship Module

- InGroup Hierarchy Designator
- InGroup-OutGroup Alignment/Trust/Credibility
- Automated Motivational Congruence Assessment (correlation between GSP trees)
- Identity Repertoire Theory/Automated Group Membership Updating/Group Exit-Enter Barriers
- Eidelson 'Dangerous Ideas' Model (sacred values, grievances, injustices, distrust)
- Hirschman Model (Exit, Voice, Loyalty) – Produces Civil Rights Demand Curve (Phase Shifts)

Physiology/Stress Module (reservoir metaphor, calibrate to actual individuals, automatically updated)

- Nutrition, Digestive Processing, Muscle Energy and Wastage
- Fatigue Processes, Homestatic Need for Sleep, Adrenalin, Drugs
- Injuries – blunt/acute, lethal/non-lethal (chemical, biological, restraint, etc.)
- Three types of stress (effective fatigue, time pressure, event/emotion stress)
- Integrated Stress computation (infers 1 of 5 coping styles for perception and decisions)

Decision Processes/Choice Module

- Subjective Expected Utility & Best Response Curves
- 5 Stress-Based Coping Styles (3 of them are algorithms of Nobel Prizes)
- Campaign Plans & State Transition Nets
- Model of Others' Model of Me (Intentionality)

Socio-Cultural Game Leader-Follower Theory

- Group Leader-Follower Role(s)
- Rival Ingroup Leaders –assignment, updates
- Ingroup-to-Outgroup Alignment Model
- Dynamic Realignment
- Insurgency Model (selects 1 of 3 Mao stages)
- Tribal Credo (enemy of my enemy is my friend)

PMFserv has been deployed in a number of applications, gameworlds, and scenarios. A few of these are listed below. To facilitate rapidly composing new casts of characters we have an Integrated Development Environment (IDE) in which one knowledge engineers archetypical individuals (leaders, followers, suicide bomber, financier, etc.) and assembles them into casts of characters useful for editing scenarios. The talk will overview the IDE and explain the knowledge engineering methodology we follow to assure the highest internal validity of the profile of a given agent.

Domestic Applications	International Applications
*Consumer modeling: - buyer behav -ad campaign *Petworld - pet behav. *Gang members -hooligans *Crowd Scenes - milling - protesting - rioting - looting	*Intifadah Recreation (leaders, followers) – Roadmap sim *Somalia Crowds – Black Hawk Down (males, females, trained militia, clan leaders) *Thailand recreation (Buddhists vs. Muslims - radicalization) *Iraq DIME-PMESII sim – 3 ethnic groups, parliament (leaders and 15,000 followers) *Urban Resolve 2015 – Sim-Red (multiple insurgent cell members/roles/ missions) *Many world leaders profiled

Many of these past applications have movie clips, Tech Reports, and validity assessment studies at www.seas.upenn.edu/~barryg/hbmr . Several historical correspondence tests show PMFserv mimics decisions of the real actors/population with about 80% correlation: e.g., see Silverman et al. (2006b, 2007b).

3 SOCIAL AGENTS, FACTIONS, AND THE FACTIONSIM TESTBED

The previous section overviewed the modules of a cognitive agent as well as some of its parts that give it a social orientation. In this section we turn to additional modules that turn the cognitive agent into a socio-cognitive one. Specifically, we introduce FactionSim, an environment that captures a globally recurring socio-cultural training 'game' that focuses upon inter-group competition for control of resources (Security/Economics/Political Tanks). This implements PMFserv within a game theory/PMESII Campaign framework. Many of the applications listed above have this game embedded in them. Each group of agents manages a:

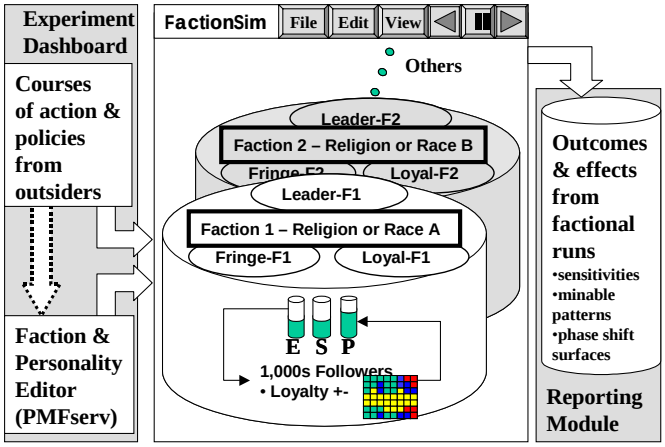
Security Model (Skirmish, Urban Lanchester)
- Power-vulnerability Computations
- Skirmish Model (force size, training, etc.)
- Urban Lanchester Model (probability of kill)

Economy Model (Harrod-Domar model)
- Black Market
- Undeclared Market
- Formal Capital Economy

Political Model (loyalty, membership, grievance, etc.)
- Institution Sustainment Dynamics
- Follower Social Network - Cellular Automata
- Small World Theory/Info Propagation

This environment facilitates the codification of alternative theories of factional interaction and the evaluation of policy alternatives. FactionSim is a tool where you set up a conflict scenario in which the factional leader and follower agents all run autonomously and are free to use their micro-decision making as they see fit. You are the sole human player interacting to try and use a set of DIME actions to influence outcomes and PMESII effects.

Figure 1: Models and Components that must be synthesized for a FactionSim Testbed



Factions are modeled as in the center of Figure 1 where each has a leader, two sub-faction leaders (loyal and fringe), a set of starting resources (Economy, E, Security, S, and Politics, P), and a representative set of over 1,000 follower agents. A leader is assumed to manage his faction's E- and S- tanks so as to appeal to his followers and to each of the other tribes or factions he wants in his alliance. Each of the leaders of those factions, however, will similarly manage their own E and S assets in trying to keep their sub-factions and memberships happy. Followers determine the level of the P-tank by voting their membership level(a topic discussed later in this paper). A high P-tank means that there are more members to recruit for security missions and/or to train and deploy in economic ventures. So leaders often find it difficult to move to alignments and positions that are very far from the motivations of their memberships.

FactionSim allows one to edit the profiles of all the factions of interest to a given scenario including:

Faction = { Properties {name, identity repertoire, demographics, salience-entry, salience-exit, other}

Alignments {alignment-matrix, relationship valence and strength, dynamic alliances}

Roles{leader, sub-leader, loyal-follower, fringe-follower, population-member},

Resources(R) = Set of all resources, r: {econ-tank, security-tank, political support-tank} }

$r_{r,f}$ = {Resource level for resource r owned by facton f, $r_{r,f}$ ranges from 1 to100}

$\Delta_{r(a,b)}$ = {Change in r on group a by group b} = Δ_r

T = Time horizon for storing previous tank values

Dev-Level = {Maturity of a resource where 1=corrupt/dysfunctional, 3=neutral, 5= capable/effective}

Actions (A) = { Leader-actions (target) = {Speak (seek-blessing, seek-merge, mediate, brag, threaten), Act (attack-security, attack-economy, invest-own-faction, invest-ally-faction, defend-economy, defend-security)}

Follower-actions(target) = {Go on Attacks for, Support (econ), Vote for, Join Faction, Agree with, Remain-Neutral, Disagree with, Vote against, Join Opposition Faction, Oppose with Non-Violence(Voice), Rebel-against/Fight for Opposition, Exit Faction } }

Despite efforts at simplicity, stochastic simulation models for domains such as this rapidly become complex. The strategy space for each leader facing only two other leaders grows impossibly large to explore. As a result, FactionSim's Experiment Dashboard (left side of Fig.1) permits inputs ranging from one course of action to a set of parameter experiments the player is curious about. On the bottom left is the profile editor of the personalities for the leaders and sub-leaders, and of the key parameters that define the starting conditions of each of the factions and sub-factions. Certain actions by the player that are thought to alter the starting attitudes or behavior of the factions can flow between these two components – e.g., a discussion beforehand that might alter the attitudes of certain key leaders (Note: this action is often attempted in settings with real Subject Matter Experts, or SMEs, and diplomats playing our various games).

All data from PMFserv and the socio-cultural game is captured into log files. At present we are developing an after action report summary module as well as analytical capabilities for design of experiments, for repeated Monte Carlo trials, and for outcome pattern recognition and strategy assessment.

3.1 Enhancing the Economic Models of FactionSim

The first few years of PMFserv research focused on each of its modules. Similarly, the advancement of FactionSim focus on different resource management models. At present we are focusing on improving the economic models that govern a PMFserv agent's reasoning about the economy. For example, the FactionSim described above makes use of the Economic

Tank of each group as a set of poker chips. To make this more sensitive and dynamic, we have been recently adding models from developmental economics. Thus each of our agents now has a wallet and makes savings and investment decisions, including contributions to the tribal leader. Further, each of our factions or groups maintains a treasury. With the Lewis (1979) model (actually the LRF model) and extensions made by Hart and De Soto (1989), this suggests there are two primary sectors in developing lands – the small, but more modern, elite-sector and the large, poor agrarian sector. We hope to explore how such a dual structure will allow FactionSim to handle more of the causal parameters that allow shadow economies to flourish, and which in turn, permit the insurgent movements around the globe to find foot-soldiers that can be paid to do their bidding. Likewise, profiles of religious terrorists, such as the 100s of Jihadists that Sageman (2004) has profiled, also show that for some at least, it is due to disillusionment at lack of finding employment in the elite sector (despite being educated to do so) and grievance that finds fulfillment in the religicized politics of Al Qaeda and similar movements. The latter is a PMFserv-relevant topic, which coupled with the developmental economics models of FactionSim, we believe offers a capability for modeling both of these important threads for understanding insurgent dynamics and PMESII effects. Some of the latest economic modeling results will be given in this talk.

4 EXPERIMENTATION AND EXPLORING SIMULATED SPACE

In a talk for a simulation conference, I would be remiss if I did not address stochastic and Monte Carlo issues. A number of experiment plans are often attempted depending on the community's practice, several of which we list below along with an indication of how we may deploy that experiment plan. In general, we design all forecasting studies as Monte Carlo experiments:

- Window Experiments -- In the automated data mining community where the terabytes of data preclude any one model attempting to fit the entire dataset, one often uses windowing so that diverse portions of the dataset lead to different models being fit to it. Our ensemble can use different portions of the common dataset for the different models. This will give us a version of the windowing approach.
- Initial Condition Experiments – Since there is noisiness in the HT data that will be extracted and fused from diverse sources (automated scarping of newsfeeds/websites/ datasets, regional experts, public datasets, etc.) it makes sense to experiment with alternative starting conditions around a range of reasonableness for key parameters that affect strength and/or issues with different groups.
- Perturbed Internal Parameters – Internal parameters involve things like causal relations, sacred values, strength of grievances, and internal personality parameters, among others. Since these are internal to the system under study, any model of them always relies on assumed parameter settings. It is worth rerunning the forecasts with perturbations on selected parameters around a reasonable distributional form.
- Exogenous Effects Experiments – Nations are social systems that invariable are linked to outside forces, forces that are often beyond their direct control. We will in some instances be interested in

repeating runs with altered outside influences to capture the range of likely (and some low probability) events.

All our tools (FactionSim, PMFserv, and PS-I) are equipped or are currently in the process of being equipped with model controllers on the front end and warehouse type capabilities on the backend to support the running of such experiments.

5 CONCLUDING REMARKS

In summing up, our community would be remiss if it did not try to respond to thought leaders in the military who are struggling with how to promote deeper thought, rehearsal environments, and analytic capability about cultural issues and local population needs/wants. They have funded programs that collect HT data and conduct link analysis and social network studies. At the same time, they are unsure of what kinds of human behavior modeling to engage in beyond that, though simultaneously there is a need for DIME-PMESII .

In this paper, I have argued that the HT datasets are an invaluable resource that will permit us in the human behavior M&S field to more realistically profile factions, and their leaders and followers. This in turn could help us to instantiate tools for those interested in analyzing alternative competing hypotheses for DIME-PMESII studies.

A parallel development has been the scientific struggles of those interested in unifying multi-resolution frameworks that permit modeling "deep" but few cognitively-detailed agents able to interact with and influence 10,000s of "light" socio-political agents. This is necessary if we are to have "socio-cognitive" agents useful for the types of analysis and training/rehearsal M&S worlds envisioned here. One such socio-cognitive agent toolset (FactionSim built atop PMFserv) has been described in this paper.

Such toolsets will only be useful to the extent they offer valid recreations of the actual leaders, followers, and populations of interest. In terms of validity of the current socio-cognitive agent synthesis, this research has tried to explore its robustness and cross-sample fitness. FactionSim agents passed validity assessment tests in two conflict scenarios attempted to date — (1) a group of 21 named Iraqi leader agents in 5 factions passed a Turing Test after extensive subject matter expert evaluation and (2) a separatism movement recreation involving a SE Asian leader (Bhuddist) and Muslim followers passed separate correspondence tests (correlations of over 79% to real world counterparts). Validity is a difficult thing to claim, and one can always devise new tests. A strong test, however, is the out-of-sample tests that these agents also passed. Thus the SE Asian leader and followers were trained on different data than they were tested against. Further, the complete structure of the model of the leaders was originally derived in earlier studies of the ancient Crusades (Silverman et al. 2005) and this was transferred to the SE Asian and Iraqi domains. The only thing updated was the values of the weights for the value trees and various other group relations and membership parameters – derived from open sources. So the structure of the leader model also survived and passed two out-of-sample tests relative to the Crusades dataset. While these may not be the ultimate tests, they are sufficient for our purposes and in order to consider the descriptive agents to be components useful for analytic experiments.

'Correctness' is more about the generative mechanisms inside the agents than whether any given predictions are accurate. If the generative mechanisms are roughly 'correct', one can have trust that experiments on agents will yield useful insights about the alternative policies that influence them. That is why one attempts to add cognitive capabilities inside of social agents. A caution to those attempting simulations with Human Terrain data – start with best of breed models (higher internal validity), then conduct adequacy tests, validity assessments, and replication of results across samples. Even after all that, social system simulations will rarely yield precise forecasts and predictions. Rather, their utility lies in exploring the possibility space and in understanding mechanism and causalities so that one can see how alternative DIME actions might lead to the same or unexpected PMESII effects.

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