



U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Biophysics Based Measuring & Modeling of Social Dynamics

Dr. Lisa Troyer

Program Manager, Social & Behavioral Sciences, Life Sciences Division

Army Research Office/Army Research Laboratory

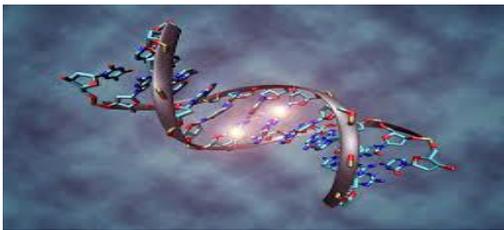


MEASURING & MODELING SOCIAL DYNAMICS

Why Army Research on Social Dynamics?



- Conflict is costly in terms of lives, resources, future opportunities, optics
 - Conflict is an inherently social problem
- DoD is first-responder in humanitarian crises, with little advanced warning about where those crises will occur – cultural, normative, political, economic context
- Increasing evidence of severe potential of **non-kinetic threats**:
 - Adversarial disruption of: Economic, Political, Religious, Cyber, Health
- Social systems reflect complex, multilevel, multiplex interdependencies
 - We need to think “from (deep within) cells-to-societies”
 - We need to think about interfaces among physical, natural & social systems



From Cells to Societies



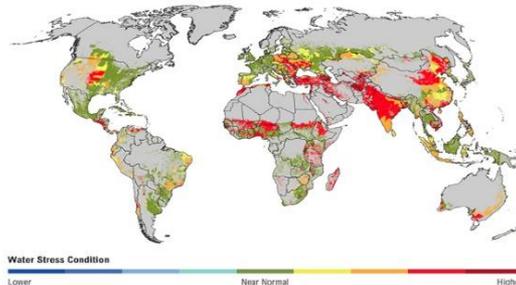
MEASURING & MODELING SOCIAL DYNAMICS

Potential Army Payoff of Social Science

- What if the Army could...
 - Determine the next region of sociopolitical instability (and the one after that... and the one after that...)?
 - Predict where, when, why, how the next violent extremist group will emerge?
 - Advance security by managing threats to social systems arising from disturbances in natural and physical environments?
- Addresses Army Modernization Priorities
 - Soldier Lethality – esp. Situational Awareness
- Addresses National Defense Strategy
 - Countering Coercion & Subversion, Enhance C4ISR Capabilities, Advance Overmatch in Global Operations

Army Leadership in Basic Social Science Research

Water stress will increase in many agricultural areas by 2025 due to growing water use and higher temperatures (based on IPCC scenario A1B)





U.S. ARMY
RDECOM
ARL RESEARCH LABORATORY

MEASURING & MODELING SOCIAL DYNAMICS



Why Social Science is Hard (Not Soft)

- For every outcome there is an “intuitive” explanation
 - Once you explain, it all makes sense – but there are multiple explanations that make sense
- Social science is hard because most social phenomena:
 - Are emergent from interface of shifting social, physical, and natural dynamics,
 - Which occur over large spatial and temporal dimensions
 - Change in different spaces, different points in time impacts others with enormous cascading effects
 - Are difficult to investigate in controlled settings,
 - Are challenging to measure at collective levels



But... Advances Across DoD Are Generating Promise



MEASURING & MODELING SOCIAL DYNAMICS

How Army Is Approaching Social Science

- Social Dynamics Underlying Social Conflict Are Not Accurately Modeled; Validated Basic Scientific Theory Is Lacking
- Current state-of-the-art research on social collectives is insufficient:
 - Depends on aggregation of individual behaviors, which generates erroneous predictions
 - Does not account for relational impact of actors and groups on one another or impact of natural and physical (built) environments on social collectives
 - Research methods relying on individual recall are inadequate, generate bias, and results are rarely replicated
 - Models rely on invalid statistical assumptions that lack recognition of how social processes evolve and scale, lacking predictive capability
 - Peer-reviewed research is seldom validated, replicated, or reproduced to establish confidence in existing tools/knowledge

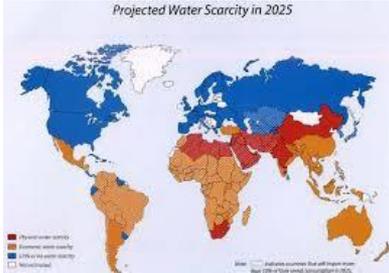


Emergence of Large-Scale Social Conflict Is NOT a Function of Simple Aggregation of Individual Human Behavior



U.S. ARMY
RDECOM
ARL RESEARCH LABORATORY

MEASURING & MODELING SOCIAL DYNAMICS



How Army is Approaching Social Science

- Impacts of Changes among Natural, Physical (Built), and Social Systems over Time, Space, and Levels of Analyses are Difficult to Measure
 - Building integrated validated data archives that measure interdependencies among natural, physical, and social
 - Developing measures of social conflict to account for interdependencies among social collectives, natural environments, and physical infrastructures
 - Addressing gaps in knowledge of spatial and temporal cause-effects across social, natural, and physical systems
 - Improving standards for assessing integrity (e.g., reliability, validity) of measures of social dynamics

Water Scarcity Models - 2025



ISIL dams prevent access to Euphrates to exert control over civilians



Impact of Changes in Natural & Physical Systems on Social Dynamics is Neglected

Non-state adversarial groups seize mineral resources in fragile states with local support in resource-stressed environments

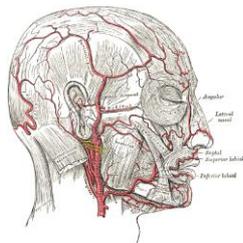


U.S. ARMY
RDECOM
ARL RESEARCH LABORATORY

MEASURING & MODELING SOCIAL DYNAMICS

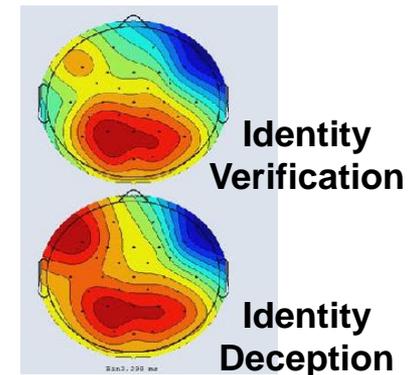
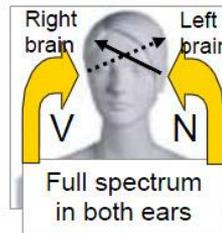
Success Stories: New Approaches to Sensing Social Dynamics through Objective Measures – Micro Sensors

- Advances in biophysiological measures & models of human **SOCIAL** dynamics
 - Vocal spectrum, thermography, brain imaging, pupillometry
 - Document: **Social** influence, diffusion of emotion in a collective, propensity for conformity, in-group empathy
 - Epigenetic predictors of social behavior
 - Genetic bases for aggression triggered by **social** conditions
- Basic scientific evidence that social dynamics are embodied in physiological and biological processes



N = nonverbal signal
(vocal frequencies < 350 Hz)

V = verbal signal
(vocal frequencies > 550 Hz)



New Sensing Technologies to Link Individual to Collective Dynamics



U.S. ARMY
RDECOM
ARL RESEARCH LABORATORY

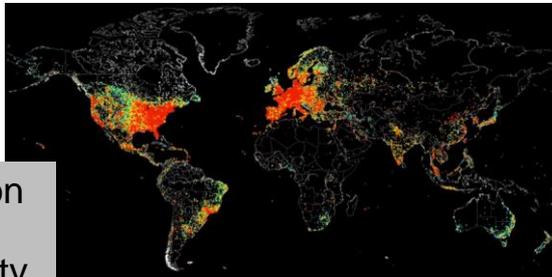
MEASURING & MODELING SOCIAL DYNAMICS

Success Stories: New Approaches to Sensing Social Dynamics through Objective Measures – Macro Sensors

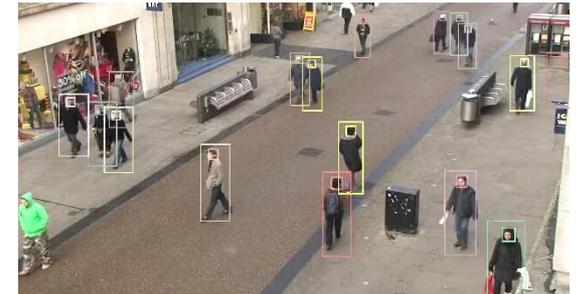
- Investment how macro sensing approaches enable tracking of shifts in large-scale collective behavior
 - Utility use
 - Geo-mapping of resource changes
 - Satellite imaging of correlates of social activity
 - Computer visioning to track social clustering
 - Internet & cellular loads to identify activity shifts
- Develop integrated archives from macro sensor data to facilitate development of measurement & analytic research



Satellite tracking of population movement to enable new models of migration



Tracking population activity through Internet connectivity



Computer visioning to track crowd dynamics – identifying cliques and hostile collectives

New Sensing Technologies Create Opportunities to Develop Measures of Population Dynamics

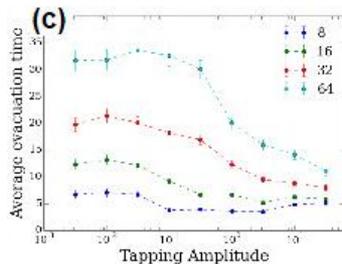


U.S. ARMY
RDECOM
ARL RESEARCH LABORATORY

MEASURING & MODELING SOCIAL DYNAMICS

Success Stories: New Approaches to Modeling Collective Dynamics & Complex Systems

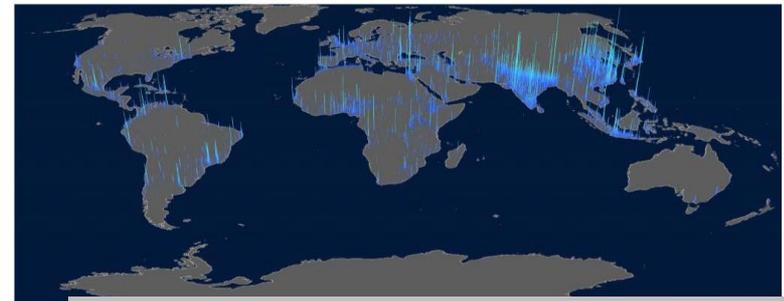
- Investments in research to develop complex systems models extending research on macro-sensing to develop new predictive theories of social dynamics
- Macro-models of real-time population ecologies based on geo-spatial sensing
- Development and validation of swarming, flocking, herding models inspired by physics & biology
- Predictive models of social dynamics drawing on epidemiology (e.g., mortality modeling of large-scale threatening events)
- Value-chain models to identify resource interdependencies across time and space



Modeling effects of sensory inputs on crowd behavior



Enabling New Models to Predict Emergence of Social Conflict



Visualization models of expansion of built up areas of earth over last 40 years



MEASURING & MODELING SOCIAL DYNAMICS



Ongoing Challenges

- Development of social science theory, measurement, modeling
- Data management (when is too much, too much?)
 - Make it manageable for the operators/analysts/decision leaders
- Knowledge vs. Tools
 - Transition is EXCEPTIONALLY difficult to track & measure in social science – mostly in the form of knowledge about how social systems operate
 - Tools come with risk of oversimplification, user bias
- Improving the Pipeline
 - Training next-generation of defense social scientists
 - “All-hands” approach – improve involvement of underrepresented groups
 - Enhancing multidisciplinary team approaches to social science
 - Enabling global science through support of international collaborations

***Human Groups Are NOT Out of the Loop:
Designers, Operators, Interpreters, Decision-Makers***



U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Biophysics Based Measuring & Modeling of Social Dynamics

Dr. Lisa Troyer

Program Manager, Social & Behavioral Sciences, Life Sciences Division

Army Research Office/Army Research Laboratory