Title:

Observations on the Implementation of a General Purpose Spatiotemporal Risk Analysis System Supporting Black Swan Theory

Authors:

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Every day, thousands of US government personnel are directly supporting risk analyses for proposed plans covering unfamiliar geographies, not only using imprecise data models, created by multiple organizations, with uncertain model parameters, but also having little capacity to communicate complex geo-temporal patterns that are critical for mission success with fellow information creators, analysts, and planners across the globe. Over the past decade, the University of Illinois at Urbana-Champaign, Colorado State University, and the US Army Corp of Engineers' Engineer Research & Development Center has been collaborating to construct a neighborhood-scale social, infrastructural, and environmental modeling system that quantifies the uncertainty of all input data, propagates that uncertainty through tightly coupled space-time models, and visually presents uncertainty information and intuitive insights to planners and analysts. The `Framework Incorporating Complex Uncertain Systems' (FICUS) is a computational framework that supports all the functions of a general purpose geographic and temporal analysis system with a focus on risk analysis. FICUS represents demographic (Ehlschlaeger et al. 2016) and transportation information at atomic units to minimize the `Uncertain Geographic Context Problem' (UGCoP, Kwan 2012). FICUS has geospatial and temporal analysis components that propagate uncertainty using the Object Modeling System as its computational framework (David et al. 2013). It contains interdependent urban infrastructure network models to forecast network failures (Lu et al. 2018) designed to demonstrate feedback loops between changes in infrastructure and effects on the population. FICUS has ability to tightly couple models from R, Python, and NetLogo as well as most popular programming languages. The FICUS server displays uncertainty using dynamic maps (Burkhalter et al. 2018). It takes a multi-verse approach to representing uncertainty by requiring all data to be plausible representations of reality replicated across multiple universes. Uncertain model parameters are also stochastically realized throughout the multi-verse, and dynamic mapping allows end users to choose how information is presented to best understand the range of the possible. The FICUS map server allows multi-site multi-user simultaneous multi-map interactions, including exploratory data analysis with `brushing and linking' capabilities allowing collaborating users to quickly see best case, worst case, and the less probable cases from any theme or location. The more improbable cases are often known as `Gray Swans' in Black Swan Theory (Taleb 2010). Gray Swans must be understood in decision making to understand potential circumstances when planned activities go wrong. FICUS is free and open source software that works on any computer supporting Docker, an open platform for building, shipping, and running distributed applications. The multi-verse map analysis is typically performed on high performance computers, with users visualizing results from any browser, including those on smartphones. This presentation will discuss the theoretical and practical benefits of using an uncertainty quantifying, uncertainty propagating, and uncertainty visualizing geographic information system for risk analysis with a case study in the Philippines. We will focus our discussions on the techniques that minimize or can even eliminate UGCoP, calibration and validation in a multi-verse risk analysis paradigm, and cognitive issues of understanding risk using Black Swan Theory.

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Dear Geospatial Software Institute Workshop II Organizers,

Dr. Olaf David and I are hoping to attend this workshop. We believe the GSI Workshop should include discussions on the following **scientific issues**: 1) Eliminating the Uncertain Geographic Context Problem, which is caused, in part, by legacy geographic data models and algorithms designed 40+ years ago for much more primitive computers. 2) Improving extraneous cognitive load techniques for geographic analysis. Understanding complex social models, for example, will require visualizing dozens of thematic attributes that vary across spatial social groups. In other words, advancing cartographic theory to better handle the big data cognitive load issues. And 3) Distributed computing, communication, and visualization issues. High performance computers can quickly generate terabytes of information, but how will groups of people spread across the world collaboratively interact with this information?

The position paper we offer outlines the problem when geographic information creators seldom interact with data collectors nor the analysts and consumers of that information. The information systems described in our position paper contain hundreds of covariated geo-temporal themes with heteroskedastic uncertainty effects, which if not understood will cause mistaken assumptions about reality. We hope these discussions will help guide develop geo-temporal software that reduces the scientific problems we face.

Sincerely,

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HIGHER EDUCATION:

Institution	*Dates Attended*	*Degree & Major*	*Date Conferred*
University of California at Santa Barbara	1993 - 1995	Ph.D. Geography	1998
University of Illinois at Champaign-Urbana	1979 - 1985	BLA Landscape Architecture	1985

EXPERIENCE:

Title	*Dates*	*Organization*
Adjunct Instructor	2015 – present	Geographic Information Systems, John Hopkins University
Adjunct Professor	2009 - present	Department of Geography, University of Illinois at Urbana-Champaign
Geographer DB-4	2008 - present	Engineer Research Development Center – IL (ERDC-CERL)
Geospatial Science Consultant	2008	The PERTAN Group: http://www.pertan.com/
Associate Professor, tenured 2007	2003 - 2007	Department of Geography, Western Illinois University
Director	2003-2007	McDonough County GIS Center
Associate Professor, tenured 2003	2003	Department of Geography, Hunter College
Assistant Professor	1997 - 2002	Department of Geography, Hunter College
Assistant Research Professor	1995 - 1997	Department of Geography, University of Cincinnati
Staff Instructor	1994	Department of Geography, University of California at Santa Barbara

PUBLICATIONS, refereed, relevant to workshop:

"Sparse-Data Forecasting of Megacity Growth," by James D. Westervelt, Charles R. Ehlschlaeger, Jeffrey A. Burkhalter, Carey L. Baxter. Journal of Military Operations Research, 2017, 22(3):21-34.

“Mapping Neighborhood Scale Survey Responses with Uncertainty Metrics,” by Charles Ehlschlaeger, Yizhao Gao, James Westervelt, Robert Lozar, Marina Drigo, Jeffrey Burkhalter, Carey Baxter, Matthew Hiett, Natalie Myers, Ellen Hartman. Submitted 11/11/2015, Published 12/2016 by the Journal of Spatial Information Science, 13:103-130.

"Visualizing Spatial Data Uncertainty Using Animation," by Charles R. Ehlschlaeger, Ashton M. Shortridge, and Michael F. Goodchild. Submitted to Computers in GeoSciences in September, 1996. Accepted October, 1996. Published Vol. 23, No 4, 1997.

PUBLICATIONS, non-refereed, relevant to workshop:

“Integrated analytic simulation tools to support emergency management” Society of Photo-Optical Instrumentation Engineers (SPIE) Defense & Security Conference, Orlando FL. DOI: 10.1117/12.2306523, authors: Burkhalter, J. A., C. R. Ehlschlaeger, D. M. Morrison, N. R. Myers, O. Yanfeng, L. Lu, A. Petit, O. David, F. Serafino, Z. Jiang, D. Patterson, April 2018.

“The Key Role of Human Geography, Culture, and Language in Effective Communication,” OSD-SMA White Paper edited by Gwyneth Sutherlin authored by Mr. John DeRosa, Dr. Charles Ess, Dr. Charles Ehlschlaeger, Mr. Robert Jones, Dr. Dianne Loyet, Ms. Christine MacNulty, Ms. Angie Mallory, Mr. Shoqi Maktary, Ms. Yusra Mushtaq, Dr. Amjed Rasheed, Dr. Jason Spitaletta, and Dr. Gwyneth Sutherlin, June 2017.

“From Data to Decision with Analytic Frameworks: Presenting Data Errors and Uncertainties for Operational Planning,” by Charles Ehlschlaeger, David Browne, Natalie Myers, Jeffrey Burkhalter, Carey Baxter, Yizhao Gao, Dandong Yin, Mathew Hiett. Published in Military Intelligence Professional Bulletin PB 34-16-3 Vol 42(3), December 2016.

“Modeling Intimate Partner Violence and Support Systems” book chapter, by Marina V Drigo, Charles R Ehlschlaeger, Elizabeth L Sweet, in Ecologist-Developed spatially-Explicit Dynamic Landscape Models, pp 235-253, publisher Springer Link, March 2012.

PROFESSIONAL ACTIVITIES

Technical Director on programs funded for $9,000,000+, covering research in agent based modeling, demographic analysis, uncertainty quantification, big data analysis, social behavior, social media analysis, exploratory data analysis, and cartographic visualization, from 2011-2018.