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San Diego

Spatial Obfuscation of GPS Travel Data

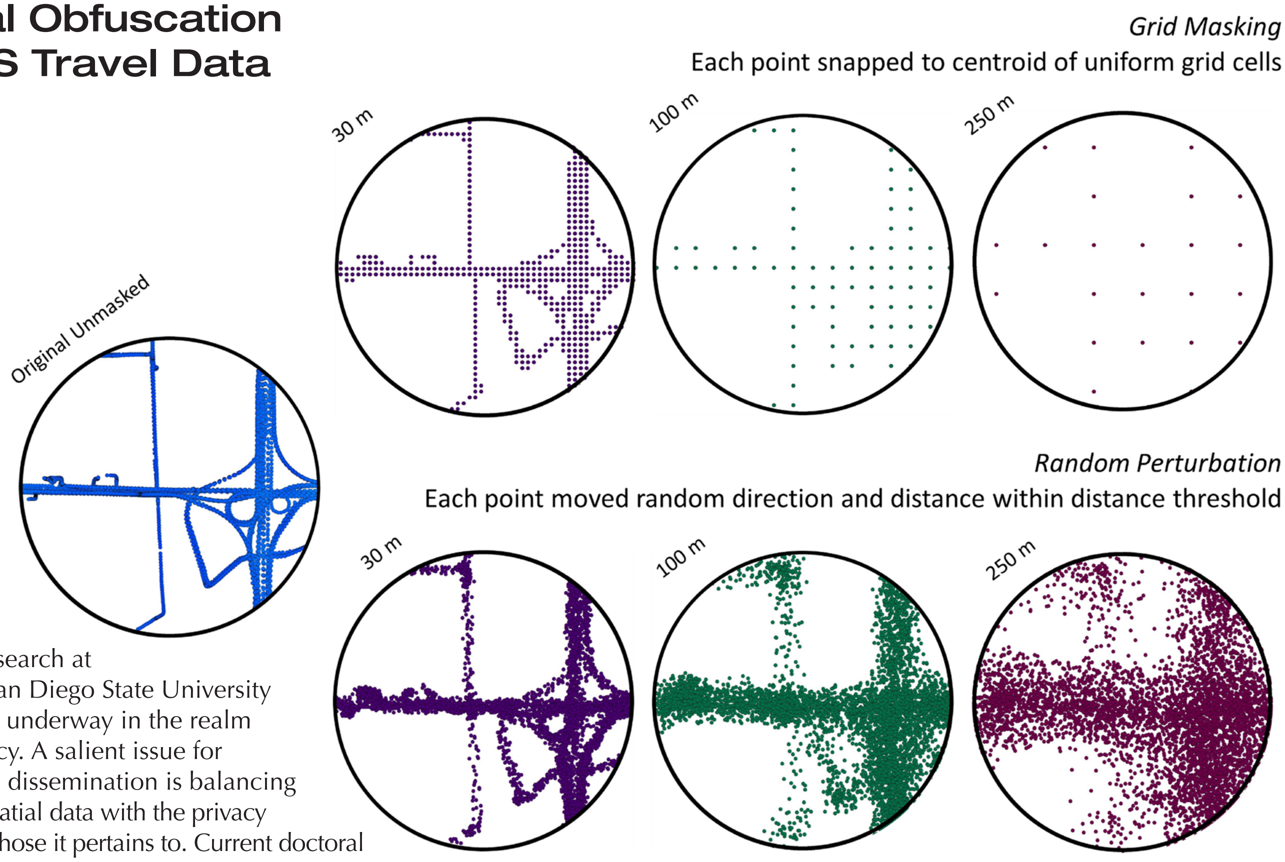

Figure 1. Example obfuscation techniques with distance thresholds

Research at San Diego State University is underway in the realm of geoprivacy. A salient issue for information dissemination is balancing access to spatial data with the privacy interests of those it pertains to. Current doctoral student Dara Seidl, advised by Dr. Piotr Jankowski and Dr. Ming-Hsiang Tsou, tested the efficacy of two obfuscation techniques for GPS trajectory data across the greater metropolitan regions of Chicago and Atlanta. As access to robust spatial data expands in the digital age, the value of privacy often comes into competition with the values of data sharing and data quality. The purpose of this research was to identify protective geomasking thresholds for trajectory data that strike a balance between pattern preservation and privacy protection.

Location is a strong personal identifier, and trajectories have even higher identifying power than isolated points. A 2013 study finds that only 4 location points over 15 hours are needed to uniquely identify 95% of individuals (de Montjoye et al. 2013). In 2009, more than 34,000 U.S. adults were victims of stalking by GPS (Baum et al. 2009). Precise spatial data are nevertheless important for accurate research and applications such as travel demand forecasting and disease etiology. Aggregation of data points to polygonal regions or centroids can impact cluster detection and distort analyses (Kwan et al. 2004).

This study tested two geomasking techniques on GPS data from household travel surveys, obtained via secure remote access from the National Renewable Energies Laboratory (NREL) Transportation Secure Data Center (TSDC). The GPS data sets contain waypoints for every second of travel, including origins and destinations, and are coded by trip number. The first method employed, grid masking, overlays a regular grid over data points and snaps each point to the centroid of the cell it falls within (Leitner and Curtis 2006). In the second method, random perturbation, each point is moved a random distance and direction within a specified distance threshold (Kwan et al. 2004). Both methods were applied in this study with distance thresholds of 30, 100, and 250 meters to examine the sensitivity of increasing the distance threshold, as shown in Figure 1. All iterations were conducted on both the greater Chicago and greater Atlanta data sets.

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INSIDE

SAVE THE DATE
Please join us at the 2015 ESRI International User Conference in San Diego, California, July 20–24.

Year of the Drone

While CSU researchers have been using unpiloted aircraft systems (UAS) for quite a few years and many significant innovations have arisen from our campuses, this research has come front and center during this past year, and interest is only growing. There are now nearly as many UAS choices as piloted aircraft, with many unpiloted units at hobbyist prices. The decreasing size and increasing quality of camera options that can be mounted on small unpiloted aircraft has further opened up an unprecedented range of applications significant to the geographic information science community. The same very low cost and ease of use has also attracted a new, increasingly burgeoning community of amateur low-altitude remote sensors, leading to privacy and safety concerns.

While our research community understands the importance of employing reliable, safe and appropriate procedures for successfully conducting field research, and so the process of getting Federal Aviation Administration (FAA) approval (now required by the Chancellor's Office) should be straightforward, the rapid growth of new uses creates new challenges. As an academic group in a field built on innovations, we certainly want to encourage applications never envisioned before. But these innovations must work within the necessary constraints of very real privacy and safety issues.

In the past year, we successfully lobbied the California state legislature to amend a proposed UAS law (AB-1327) (since vetoed) to take our research needs into account. We also formed a new list-serve (CSU-UAS; email us to join), and held a two-day workshop on UAS at Cal Poly SLO. We are currently working with a Chancellor's Office task force hoping to facilitate legal FAA-permitted research applications that employ UAS. UAS-supported research is clearly vital to the mission of the CSU, providing perspectives and geospatial data never before possible. We look forward to exciting developments in the years to come.

San Luis Obispo

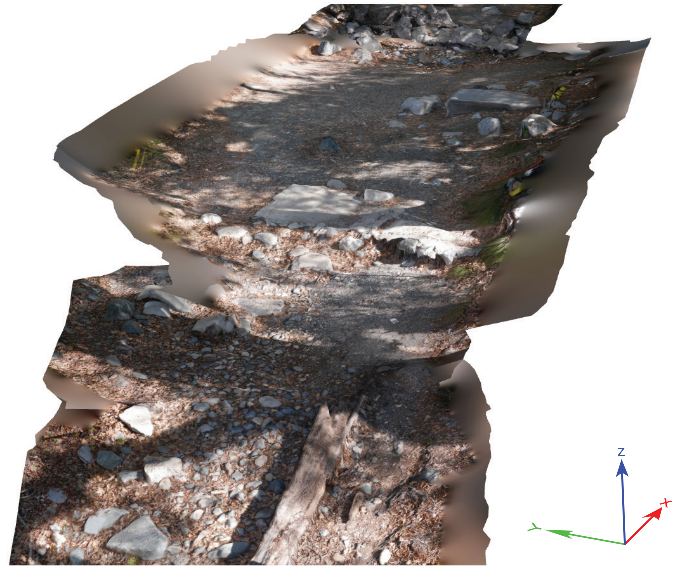

Figure 1. Photoscan result of subcanopy riparian survey in Cuesta Canyon.

The CSU GIS Specialty Center Unpiloted Aircraft Systems Workshop

Over 30 faculty, staff, and students representing nine different CSUs and a variety of subject specialties came together at Cal Poly State University on November 7-8, 2014 as part of a workshop that focused on Unpiloted Aircraft Systems (UAS). The conference participants were not UAS enthusiasts, but remote sensing scientists and instructors, discussing new paths of learning and how novel technology can be used for innovative research and curricular opportunities.

The collaborative forum provided a venue for active discussions on many timely topics. It included presentations on UAS applications, with one pioneer, Doug Stow (San Diego), looking back at more than 20 years of unpiloted and piloted platform development. Doug Smith (Monterey Bay) presented the results of photogrammetric precision testing of a quadracopter-mounted GoPro. Erin Questad (Pomona) brought results from ecological studies in Hawai'i. Jerry Davis (San Francisco) looked at an alternative to aircraft in testing the use of poles in imaging sub-canopy riparian areas (Figure 1).

Due to the rapidly evolving nature of this technology, the idea exchange was very lively, with hardware solutions on display and attendees eager to share their experiences and learn best practices from others. The hardware models primarily represented the micro end of the UAS continuum like those equipped with GoPro cameras, but included examples that ranged the size continuum up to piloted aerial imaging systems. Cost options were an integral part of the conversation. Some of the units discussed cost hundreds, instead of thousands of dollars, yet delivered useful imagery for research and teaching purposes.

CSU GIS Specialty Center *continued from previous page*

Discussion at the conference was not limited to hardware. Some of the most exciting developments have come from software that processes data products collected using UAS. Russell White (San Luis Obispo) led a discussion on data products and processing, reviewing tools ranging from open source options to traditional photogrammetry tools such as the ERDAS Imagine Photogrammetry Suite. There was also significant discussion about Agisoft Photoscan, the structure-from-motion program, which is probably the most widely used structure-from-motion program.

Subsequently, the discussion moved onto why the hardware, software, and data are needed, and the part they play in preparing our students as they embark on new paths and discover unique applications. Tom Mastin (San Luis Obispo) began the discussion with his presentation on curriculum opportunities, which considered how to translate traditional learning approaches to the new world of data UAS opens up. The availability of low cost UAS solutions makes it possible for photogrammetrists to do the jobs normally expected of aerial photography contractors, but the challenge is how to best fit this into curriculum.

Finally, the rapid growth of this technology, its increasing visibility in recent years, and its uses in a variety of governmental, private, and public domains warranted an open discussion of campus UAS policy issues. Sean Anderson (Channel Islands) shared his productive experiences working with his campus administration to develop policies that take into consideration all stakeholders with a positive outcome that supports student learning, faculty research, and the mission of the CSU system.

As the CSU moves forward with system-wide and campus UAS use policies, it is clear that UAS research experts need to be closely involved in the process. It is important for the CSU to provide leadership in the incorporation of the latest remote sensing technology through UAS educational and research programs.

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Top: Research presentation by Doug Stow.

Center: Partial group shot with an altered Canon camera capturing near infrared.

Bottom: Discussion on fixed wing and multirotor UAV designs.

Using GIS to Assist with Emergency Evacuation Planning

Geographic Information Systems (GIS) are driving forward a new level of applications to address the operational needs of emergency response, management and preparedness. Within all phases of emergency management, prevention / mitigation, preparedness, and response and recovery, GIS technology can play a unique and useful role. At CSU Monterey Bay we developed a GIS to enhance the operational effectiveness of emergency asset management and to update the evacuation maps for each building on campus. Our goal is to support the emergency management cycle by providing validated and accurate information to the public, first responders, and emergency managers.

This project arose from the need to create or update the emergency evacuation plans for each building on campus. The primary information to be collected was emergency assets and building floor plans. Emergency assets are any features related to fire protection, health, and safety. These include but are not limited to: fire extinguishers, fire alarm pull stations, first aid kits, automated external defibrillators (AED's), and emergency phones. Since building floor plans provide spatial reference for this project, the quality and accuracy of the data are imperative. Below is a snapshot of the geodatabase we developed (Figure 1).

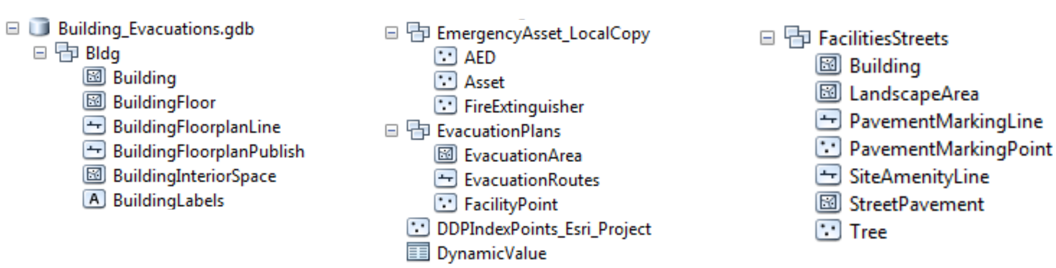

Figure 1. Geodatabase structure

CAD data was first obtained, manipulated and transformed into GIS data. This was an arduous process because CAD data standards had to be developed and assigned to each drawing. ESRI's ArcGIS for AutoCAD extension was used to create GIS feature classes within AutoCAD. Attribute data such as building IDs and floor IDs were also assigned to these feature classes in order to streamline the data loading process (Figure 2).

Because feature classes were created within the AutoCAD drawings, they were easily loaded into the geodatabase schema using the Object Loader. The ArcGIS Data Interoperability extension was then used to complete the spatial ETL process of Extracting, Transforming, and Loading data into a GIS database. After data were compiled into the GIS database, ArcGIS Attribute Assistant became an integral tool in auto-populating the correct attribute information while emergency asset data were being collected. Emergency asset data were collected using ArcGIS Online and the ArcGIS Collector application (Figure 3).

Once data collection and database construction were completed, the evacuation mapping process began by setting up data-driven pages and the layout of the evacuation plan. Data-driven pages allow users to isolate specific features within a layer. In this case, each building floor and all associated asset and evacuation data were isolated. Isolating data by floor made it much easier to deal with multi-story buildings because it eliminated the need to manually turn multiple layers on and off (Figure 4).

Evacuation maps were developed by using California Fire Code (CFC) and Occupational Safety and Health Administration (OSHA) regulations. Evacuation routes and assembly areas were designated by CSUMB's Emergency Manager with the assistance of each Building Emergency Coordinator (BEC). After the maps were exported they were distributed out to the BEC's for final review. Currently the finalized evacuation maps, approximately 1200, are being mounted in their proper location as specified in the CFC. In addition, all GIS data is being hosted online using ArcGIS Online secure web services and is being configured in Operations Dashboard. This allows us to pre-script queries so users may effectively ask questions or export pdf maps. Further work is needed to increase the usability of this feature.

In addition to the increased level of preparedness made possible by accurate emergency evacuation plans, city emergency response personnel may adopt such plans in order to specify locations and uses of critical infrastructure in the form of pre-plans. First responders use pre-plans to gather necessary information about buildings where an emergency is occurring. Information such as utility shut-off locations, fire alarm control panels, fire hydrants, and building dimensions are all critical to the effectiveness of the emergency management cycle.

The major benefit of utilizing GIS technology for emergency response planning is the development of a database that dynamically tracks and manages all emergency assets. Inspection and maintenance records can now be entered into the database along with any other critical information about an asset. The database allows users to verify the location of each asset, thus ensuring the locational accuracy. Another benefit is the ability to query and identify specific data, such as a particular model of fire extinguisher and display all existing locations. Moreover, the database provides an easy workflow for collecting and updating data to reproduce precise emergency evacuation plans.

However, the more challenging aspect of this project is the integration of geospatial tools into the workflow of facilities and emergency personnel. Additional training is required to assist in the adoption and maintenance of this critical information. In sum, initiating policies within institutions that allow GIS

Emergency Evacution Planning *continued from previous page*

to manage spatial phenomena can be profoundly effective. By utilizing this new and innovative technology, we are able organize and manage spatial infrastructure that produces greater levels of efficiency within emergency management.

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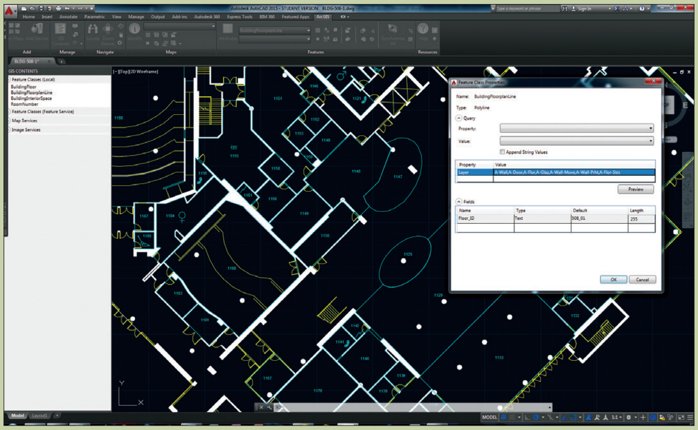

Figure 2. ArcGIS for AutoCAD Extension

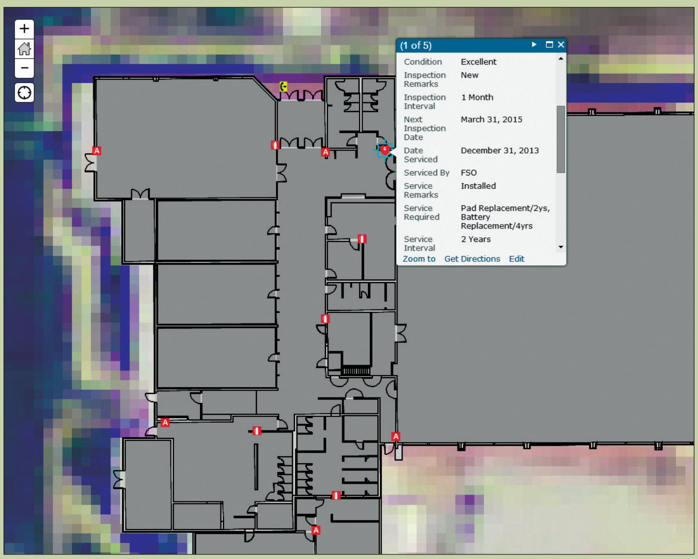

Figure 3. Screenshot from ArcGIS Collector on an iPad

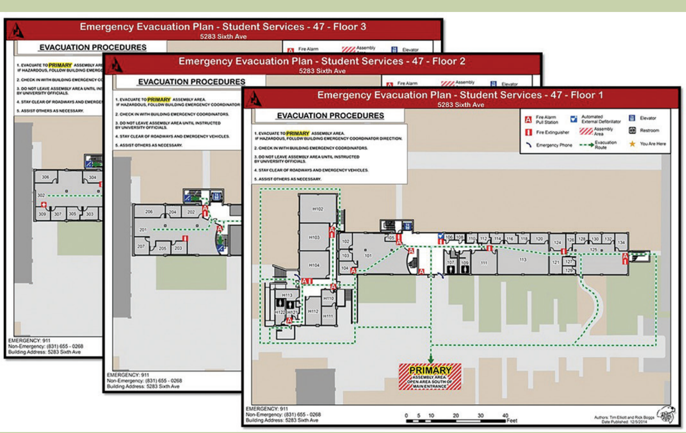

Figure 4. Emergency Evacuation Plans

Building a Center of Excellence *continued from back page*

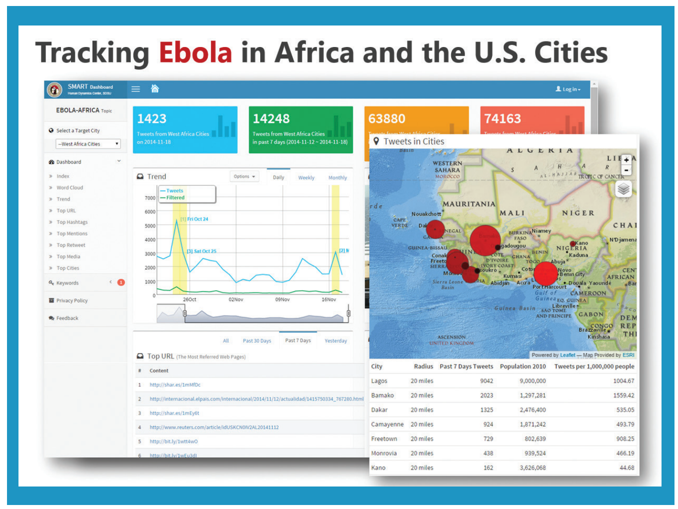

Figure 2. The Social Media Analytic and Research Testbed (SMART) dashboard developed by Dr. Chin-Te Jung at the HDMA Center, San Diego State University (http://vision.sdsu.edu/hdma/smart/ebola).

social media data in various aspects (such as weekly and monthly trends, top URLs, top retweets, top mentions, or top hashtags). You can check out the SMART dashboard in this link: http://vision.sdsu.edu/hdma/smart/ebola.

Several GIS faculty members at SDSU serve as key researchers in the HDMA Center. Dr. Piotr Jankowski is one of the co-founders and board members for the HDMA Center. Dr. Atsushi Nara is the Associate Director of the HDMA center. The Center also currently hosts one post doc (Dr. Chin-Te Jung), three Ph.D. students, and five MS or MPH students.

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CSU Stanislaus-Gallo Partnership Expands Study Opportunities

As part of our commitment to community engagement in the northern San Joaquin Valley and Foothills, our six-county service region, the Geography program at CSU Stanislaus has formed a partnership with the GIS program at E & J Gallo Winery. E & J Gallo is one of the largest companies in the CSU Stanislaus service region to develop several GIS programs. E & J Gallo's wide-ranging GIS/Remote Sensing Corporate Group serves Grower Relations, Land Acquisition and Legal, Environmental, Winegrowing, and Transportation and Logistics divisions. Viticulture research includes projects on site-specific management. E & J Gallo has wineries 20-25 km north and south of the CSU Stanislaus campus and vineyards throughout the CSU Stanislaus service region. Given the proximity of Gallo holdings to our campus, students have an excellent opportunity to apply their geospatial skills. The Geography program at CSU Stanislaus has a geospatial concentration, with classes in cartography and visualization, GIS, and remote sensing. It also has topical classes such as agricultural geography, sustainable agriculture, and geography of wine.

In spring 2014 the Advanced GIS and Remote Sensing students completed a field exercise mapping the manifold valves and flush outs in Merced County vineyards. With the adoption of precision viticulture and site-specific management of vineyards, viticulturists increasingly rely on spatial information to improve resource use while increasing yields, through variable application of water, fertilizer, and pesticides. One of the first steps in adopting site-specific practices is to map the infrastructure. In some vineyards the underground water systems were built decades ago and field managers did not keep standardized records on the pipe locations. Students worked with E & J Gallo field managers and researchers to develop a data collection protocol and then collected manifold valves and flush out locations using handheld GPS receivers. This field trip provided students the opportunity to work under the direction of professional researchers and managers.

To gain practical experience, several current and former students have interned with E & J Gallo's GIS Program. The Geography program at CSU Stanislaus requires three-units of professional development, but due to economic conditions in the San Joaquin Valley, few paid internships are available near the CSU Stanislaus campus. The E & J Gallo opportunities have become a key professional entry point for many of our students. Interns have worked under the supervision of Martin Mendez -Costabel, Ph.D., a wine and grape supply manager, and Luis Sanchez, Ph.D., a senior research scientist. Internship projects include using satellite images to inform irrigation rates and mapping grape harvester yield monitor data to determine variations in grape yields across a vineyard. These projects and the high quality of supervision have helped the students apply knowledge they gained in the classroom in a practical setting. Many interns have gone on to become permanent E & J Gallo employees or work for other private companies, such as PG & E. Two former students currently work as full-time employees for E & J Gallo's GIS/Remote Sensing group.

Finally the CSU Stanislaus Geography program has worked with the E & J Gallo GIS program to bring speakers to the campus. E & J Gallo sponsored GIS Day lectures by Forrest Melton, Ph.D., a senior research scientist at CSU Monterey Bay and NASA Ames Research Center and Susana Crespo, an Agricultural Specialist at ESRI.

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Photo: Jennifer Helzer

Photo: Maegan Salinas

Photo: CSU Stanislaus Office of Communications & Public Affairs

Top: CSU Stanislaus student mapping vineyard manifolds.
Center: Maegan Salinas (right), former CSU Stanislaus student and E & J Gallo intern, holding a UAV used in viticulture research.
Bottom: GIS Day at CSU Stanislaus.

Privacy of the route was tested based on the collocation of the route with others in the data set. A raster collocation index was generated with a cell size of 150 meters based on the travel velocity and sampling rate (Meratnia and de By 2002). Route privacy preservation was measured by the k-anonymity of the trajectory, as represented by the proportion of the route that was collocated with other trajectories in the data set. Values were normalized by the population density of the region. Spatial pattern preservation was evaluated using Pearson's correlation coefficients taken from kernel density estimations with a 50-meter cell size.

The results of geomasking for route confidentiality demonstrate that the 250-meter grid masking threshold preserves trajectory anonymity best in both study areas. These results are depicted in Figure 2. As the distance threshold increases for random perturbation, route uniqueness increases. This is because the randomization of locations by distance and direction leads to fewer collocations between trajectories. In both study areas, route anonymity dips between 30 and 100 meters for grid masking, and then rises again at 250 meters. This suggests unforeseen underlying dynamics, perhaps explained by greater divergence from road areas at this distance threshold.

As expected, as the distance threshold increases, the correlation between the unmasked and obfuscated spatial patterns decreases. These results are shown in Figure 3. The rate of correlation decrease is faster for grid masking than for random perturbation. Spatial correlation at the 250-meter level for grid masking is markedly weaker than for any of the other combinations tested. Based on the results, it is suggested that if a 50-meter resolution is needed for analysis, 30-meter or 100-meter distance thresholds for random perturbation should be applied.

As an extension of this research, more quantitative measures of masking success are needed to evaluate tradeoffs in privacy. A future research direction is analyzing which kinds of study questions could be accurately answered with obfuscated data. Additional geomasking techniques that weight displacement distances based on underlying settlement patterns have the potential to better preserve the balance between spatial pattern and privacy preservation. Furthermore, the ability of viewers to reverse engineer obfuscation techniques to infer identities should be examined.

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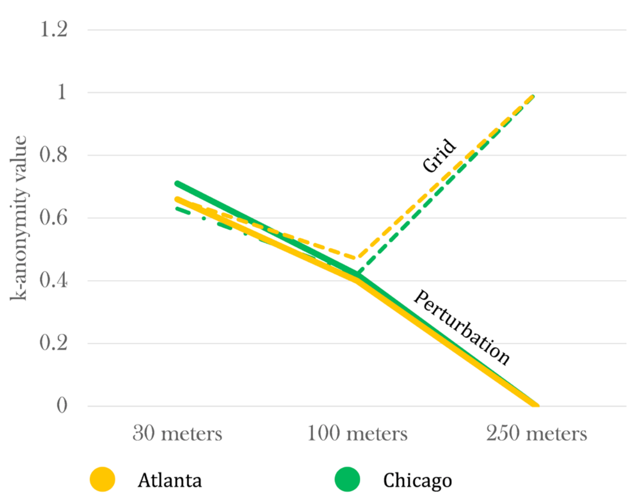

Figure 2. Normalized mean k-anonymity values by obfuscation threshold.

Region	Technique	30 m	100 m	250 m
Chicago	Grid	0.985	0.789	0.399
	Perturbation	0.968	0.934	0.838
Atlanta	Grid	0.982	0.866	0.442
	Perturbation	0.984	0.944	0.819

Figure 3. Pearson's correlation coefficients between original and masked kernel density estimations

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Building a Center of Excellence for Human Dynamics in the Mobile Age

On May 7, 2014, the Center of Excellence for Human Dynamics in the Mobile Age (HDMA) was officially established at San Diego State University. This new center, hosted by the Geography Department, is one of the four research areas of excellence competitively selected from 28 proposals via a campus-wide call for the SDSU strategic plan in 2013. The Center for Human Dynamics in the Mobile Age (http://humandynamics.sdsu.edu/) focuses on research opportunities arising from the convergence of new developments in spatial science, mobile technology, big data, social media, public health, and social behavioral research. There is a growing recognition of the importance of spatial and temporal dynamic relationships in explaining processes relevant to human behaviors, public health, urban dynamics, and social activities. The new HDMA center will facilitate the transformation of social and behavioral science research from qualitative analysis to computational modeling, simulation, and prediction applications using quantitative and qualitative methods. Figure 1 illustrates the inter-connected research areas in the HDMA Center: Human Dynamics, Spatial Science, Mobile Technology, and Big Data.

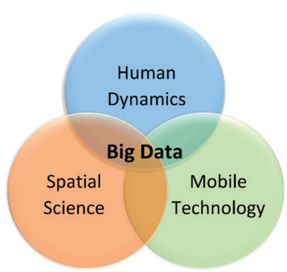

Figure 1.

The HDMA Center makes use of social science approaches and computational methods (GIS, agent-based models, machine learning techniques, and simulation models) from multiple disciplines and creates synergetic solutions for prominent issues in our society, including public health disparities, disease outbreaks, traffic problems, crime rates, city development, immigration, social movements, population changes, and urban design. Our two key missions are 1) to transform academic research into innovative technology solutions for solving real world problems, and 2) to analyze real world problems and data for building transformative scientific theories and new computational models.

Figure 2 (see page 5) illustrates an example of our innovative software product, called Social Media Analytic and Research Testbed (SMART) dashboard for tracking Ebola outbreaks in West Africa using Twitter APIs. The SMART dashboard is a geo-targeted search tool for Twitter messages to monitor the diffusion of information and social behavior changes that provides an automatic procedure to help researchers to 1) search social media messages geographically in cities; 2) filter noises (such as removing redundant retweets and using machine learning methods to improve precisions); 3) analyze social media data content from a spatiotemporal perspective, and 4) visualize

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