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Geospatial video for field data collection

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A B S T R A C T

Geospatial video, also known as mobile mapping or spatial video, is an emerging technology that combines Global Positioning Systems (GPS) with video. This approach enables increased efficiency in field data collection, as well as the ability to survey locations over multiple time periods in order to analyze spatiotemporal phenomena. In addition, unlike existing survey methods, this approach generates archival data so that places can be revisited through the video. This archival aspect allows the data to be used for subsequent investigations, even for studies not related to the initial research question. The integration of spatial video into a Geographic Information System (GIS) enables these data to be used as a source for mapping diverse environments. This paper introduces spatial video technology and then provides case studies of its applications from post-disaster recovery.

Introduction

Though videography can be used in many ways and by a variety of disciplines, in essence it is the use of video cameras to capture moving images; in addition to the visual component, audio may also be collected. This technology was introduced in the early 1950s for use in Hollywood productions (Kiger, 1972) and was subsequently employed by researchers, particularly in the areas of anthropology and sociology (Rosenstein, 2002). In this regard, its earliest use was as a method to capture human behavior and as a data collection approach for interviews. Overall, Rosenstein (2002) identifies three uses of videography in social science research: observation, feedback, and distance learning. Taking a similar methodological approach, scientists have long used videography to document rare animal behavior in the wild, as well as to capture the geography of physical landscapes as they relate to animal habitat and activities. However, with the convergence of Global Positioning Systems (GPS) and declining costs in videography components (cameras, tapes, hard drives), as well as rapidly improving sensor development (Tao, 2000), the resulting technology now holds even greater promise as a field data collection tool across a variety of disciplines, particularly geography. This technology is adept at capturing spatiotemporal change and providing a geospatial frame for data archiving. The purpose of this article is to introduce geospatial video as a tool for research in geography and allied disciplines through the use of two case studies, both drawn from post-disaster environments. The first utilizes this approach to study the neighborhood recovery process after the 2007 firestorm in Southern California and the second case study employs geospatial video as a tool to document cultural resources in the Holy

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Cross neighborhood of New Orleans after Hurricane Katrina. Though used in different places and for different purposes, these case studies demonstrate the variety of applications for geospatial video.

Several geospatial video systems have been used in research and in resource management; some of these are experimental and proprietary, while others are commercial and therefore more widely available. Two systems have been used in the work presented in this article: 1) the Spatial Video Acquisition System (SVAS) and 2) Red Hen Systems VMS 300 and Geovideo Toolbar for ArcGIS. The Spatial Video Acquisition System (SVAS), which is the name given to this technology by the authors of this paper, was developed by the National Center for Geocomputation (NCG) in Maynooth, Ireland, and was employed in partnership with the World Health Organization Collaborating Center for GIS for Public Health (WHOCC) at Louisiana State University (LSU) (Curtis, Mills, Kennedy, Fotheringham, & McCarthy, 2007; Curtis, Mills, McCarthy, Fotheringham, & Fagan, 2010; Mills, 2008, 2009; Mills, Curtis, Fagan, & Core, 2008). Whereas the SVAS is being developed with a research group, the Red Hen Systems equipment and software are commercial products. Essentially, both models are a ground-level remote sensing technology. They are composed of digital video cameras synched to a GPS unit; each frame of the video is linked to a coordinate so that the video can be played in a Geographic Information System (GIS) environment and will align with other spatial data (Figs. 1 and 2; Supplemental Material). Though this approach has yet to be widely used as a research tool, its two main components, GPS and video, are commonly employed technologies. Indeed, even without GPS, video has been spatially referenced in other ways for studying spatial patterns in the environment. Examples of where such an approach may be useful to geographers, as well as the earlier steps toward the current technology will be discussed, followed by the case studies.

Videography as a field data collection technique

"Technology both allows greater complexity in the way that urban systems function and empowers researchers to measure and monitor this increased complexity" (Longley, 2002: 237) This situation certainly exists in post-disaster urban environments; use of spatial video in these places is one approach to improve monitoring of processes and, eventually, to improve understanding of geographic phenomena. Of course, such progress is not limited to post-disaster environments alone, but many areas of research may benefit. Several areas of interest to applied geographers are especially well-suited to such an

Fig. 1. Configuration of the geospatial video system. (a) GPS linked to (b) video cameras mounted on vehicle windows.

Fig. 2. An example of the integration between geospatial video and GIS. The brown points are the path driven with the geospatial video system. The polygons are parcels; points are house locations and red points are houses that burned during the Witch Fire. The blue arrow represents the location of the vehicle. The image displayed is a house being rebuilt on the right-hand side of the vehicle. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

approach, in particular, Public Participatory GIS (PPGIS), medical and health geography, urban problems such as foreclosures and crime, and environmental justice. PPGIS, especially work with geonarratives, is rapidly gaining ground in its use of geographically linking video to places and experiences to enrich spatial understanding, particularly through qualitative and mixed-methods approaches (Kwan, 2007; Kwan & Ding, 2008; Madden & Ross, 2009). Medical and health geography are also prime subfields which could benefit from incorporating a mobile mapping approach, in particular the emerging fine scale and ecological studies that take into account multiple levels of influence on health outcomes, such as individual activities and factors in the neighborhood environment (Evans, 2003; Flowerdew, Manley, & Sabel, 2008; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Kawachi & Berkman, 2003). A related concern in environmental justice studies is the need to disaggregate data to acquire fine-scale inventories of places at risk (Frumkin, 2005; Maantay & Maroko, 2009) and to document the existence of hazardous sites and their surroundings. Environmental justice studies may also draw on geonarratives to enable residents to define the problem spatially or to add additional context to exiting maps. Finally, urban geographers who focus on issues related to the built environment, such as foreclosures (Crump et al., 2008; Wilson & Paulsen, 2008), and crime/fear of crime (Doran & Lees, 2005; Pain, MacFarlane, Turner, & Gill, 2006) may also find this technology appropriate for their research.

The idea of using ground-based remote sensing, specifically videography for field data collection is not new. Indeed, this method has been used in studies of the physical environment, in particular aerial videography (Doyle, Krauss, Wells, & Roberts, 1994). What is new, however, is linking GPS to a spatially referenced database underlying the video, which in essence makes it a field notebook for observations. However, as opposed to the field notebook of old, this one enables improvement through replication, longitudinal data collection, objectivity, and integration into a GIS for spatial analytical investigations.

Since the seminal work of Sampson and Raudenbush (1999) on physical and social disorder in Chicago neighborhoods, sociologists have drawn on video as a way to record urban built environments. They note the benefits of video for archival purposes, revisiting neighborhoods to verify coding procedures or to extract additional variables not analyzed in previous investigations (640). Their application has guided geospatial video use in the study of the post-disaster environment, and of recovery in particular. Furthermore, as noted by Kwan (2002), integrating video into a GIS provides a mechanism through which to include qualitative data. In so doing, GIS use is distanced from its traditional positivist applications, enabling different interpretations of the built environment, especially its impact on emotions.

Recently, geospatial video has been used as a medium through which to survey the built environment for disaster planning (Montoya, 2003) and to obtain damage assessment (Adams, Mansouri, & Huyck, 2005; Adams et al., 2004; Huyck, Matsuoka, Takahashi, & Vu, 2006). This technological advance, linking GPS to video, is also gaining recognition in the physical sciences, especially when the spatial phenomenon under investigation is difficult to capture due to location or dynamism. For example, Riegl, Korrubel, and Martin (2001) needed a method for collecting data on location, species, and health status of coral in the Arabian Gulf, and therefore developed an underwater geospatial video system by linking video to GPS. This enabled coverage of a large area which otherwise would have been difficult to acquire through visual surveys by divers. Drawing from this approach, Lirman et al. (2008) used geospatial video to monitor underwater habitat. They employed a georeferenced video system, Shallow Water Positioning System (SWaPS), which allowed the capture of locations of benthic communities in Biscayne Bay; again what was previously a difficult task achieved through visual surveys conducted by divers. This underwater video system allowed them to understand the geography of these communities in relation to salinity. Similar to Curtis, Mills, McCarthy, et al. (2010), Lirman et al. (2008) find that a spatial video system makes data collection more efficient, replicable, and archival.

Even with these potential areas of application and the examples of early uses of the technology, geospatial video has yet to be fully employed as a tool for field data collection for social science investigations in fine-scale built environments. For example it would be particularly useful to study the impact of foreclosures on neighborhoods, on indicators of gang activity and their relationship to perceptions to safety, and exposure to urban health risks such as the work conducted by Feng (2006) and Jarrett et al. (2006). In essence, geospatial video has untapped potential to be a part of the research toolbox. The previous examples and the following case studies provide an intellectual and methodological base from which geographers can draw ideas for additional applications.

Case studies

Damage assessment and post-disaster recovery

In the months after Hurricane Katrina devastated the Gulf Coast of the United States, politicians, academics, and the impacted residents began asking questions about the state of recovery, specifically where it was occurring and what characteristics were indicative of its presence. The result was a variety of responses, but with little actual data, especially at geographic scales useful for assessing neighborhood recovery. What was needed was a method to collect such fine-scale information in a replicable frame. Recovery is, arguably, one of the least studied phases of disasters (Mileti, 1999). Its spatial aspects, in particular, are poorly understood (Mills, 2008). However, having the ability to identify the variables that indicate recovery and to locate their presence in a post-disaster environment has implications for the equitable rebuilding of neighborhoods, the targeting of social services and health services to returning individuals, and a better understanding of the components of resiliency to extreme events. A number of quantitative variables have been used as proxies for recovery, such as the opening of services, e.g. childcare centers, hospitals, grocery stores. Though such metrics capture city-wide recovery of services and infrastructure, the scale is too coarse to characterize comprehensive recovery at the neighborhood level, which is believed to be a building block of city and regional recovery (Campanella, 2006). It is in this environment that a new methodological approach was needed to study recovery. As a result, geospatial video was chosen as an appropriate tool to capture data in this dynamic post-disaster environment.

A benefit of this system is that it enables analysis of both spatial and temporal elements (Curtis, Mills, McCarthy, et al., 2010). For example, if one neighborhood is driven at four different times over the course of a year, then the houses in the neighborhood can be coded based on their recovery status at each time. Empirical work in New Orleans indicates four stages of residential recovery: damaged structure/remains, cleared lot, emerging structure, and complete structure. These phases are then coded as a Recovery Score (RS) of one through four (Curtis, Mills, McCarthy, et al., 2010) (Fig. 3). Using the RS, improvement, stagnation, and decline can be captured for disaster-impacted neighborhoods. One result might be an animation that shows the progression or decline of each house and then of the neighborhood as a whole. Such an approach has been employed in Orleans Parish, Louisiana after Hurricane Katrina and in San Diego County, California after the 2007 Southern California firestorm. This method has enabled researchers to systematically collect both temporal and spatial data on recovery.

Continuing with the theme of geospatial video as an ideal mixed methods tool, data collection on neighborhood recovery in New Orleans is often performed in the presence of local residents who provide the vehicle and then ride along and comment about the recovery in their area. Invaluable insight is gained through this approach, for example discussing why a particular structure continues to stand as only a frame without any further construction (in this particular case, the owner was an elderly man who became ill while rebuilding; due to his illness and subsequent death, the house remained as only a wooden frame until a relative re-initiated rebuilding). With the New Orleans project, the participant commentary is recorded and their comments are then coded into the attribute table of the images along with the Recovery Score. This approach provides some explanation to what is being viewed in the video and adds context to the spatiotemporal pattern of recovery observed in the resulting maps. It also permits the inclusion of participant-defined problems in the neighborhood, such as overgrown yards and debris piles (Fig. 4). This is also an approach for understanding the environmental stressors that

Fig. 3. Sample images demonstrating each Recovery Score (1–4).

emerge in recovery (Curtis, Mills, Kennedy, et al., 2007). This method has the potential of being a more inclusive technology by not only advancing our spatial understanding of recovery, but also being used to address community needs. Indeed, GPS-tagged audio commentary made by community collaborators during the data collection process has been used to not only create a GIS-based social record of the post-Katrina neighborhood, but has also been used to improve the quality of data used in investigations into how neighborhoods recover.

Building on the work in New Orleans, students from the University of Southern California (USC) and from California State University Long Beach (CSULB) have been assisting in using geospatial video to map neighborhood recovery after the 2007 Southern California firestorm in San Diego County. From February 2008 through April 2009, students have used geospatial video in neighborhoods impacted by the Witch Fire; of particular interest are two neighborhoods in the Rancho Bernardo area that experienced extensive burning and subsequent recovery activity (Fig. 5). The videos were collected at four periods throughout the study and were then integrated into ArcGIS using Red Hen System's GeoVideo Toolbar for ArcGIS. Using this software, the neighborhoods could be revisited, in essence allowing the user to virtually drive the environment even if s/he was not involved in the initial data survey (Fig. 6). Each parcel was then coded using the Recovery Score (RS) developed after Hurricane Katrina. The result was that, for each time period, a spatial pattern of recovery is visualized (Fig. 7). These data were then used in a study of exposure to wildfire damage where exposure is defined in the longer-term sense of returning residents continuing to look out on fire damage. This psychosocial exposure was calculated as the line of sight for each house, which is possible to achieve in three-dimensions using data from the spatial video rendered in ArcScene. In order to calculate these exposures a buffer of line-of-sight distance was applied around the centroid of each parcel, and with the number of houses that burned and the number of houses that are stagnant in their recovery (they have had the same RS for each time period) calculated for each buffer. From these calculations, each centroid was classified by the percentage of burned homes (Fig. 8) and stagnant homes in its line of sight (Fig. 9). This is an example of the fine-scale analysis that would be difficult to undertake without the data collected through geospatial video.

Cultural resources in the holy cross neighborhood of New Orleans

Whereas in the previous example geospatial video is used solely as a field data collection approach that generates variables for analysis, this method can also be used for data visualization and archiving. These applications are demonstrated by the

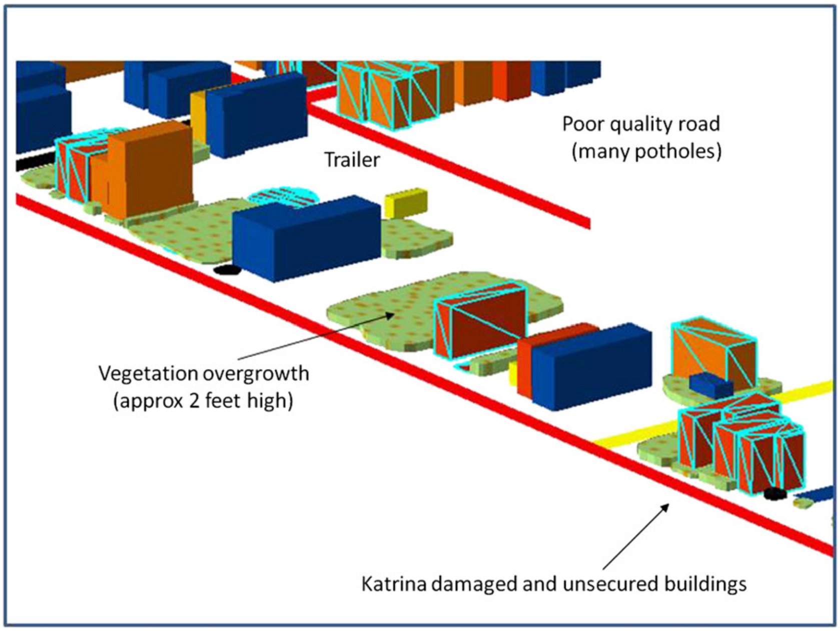

Fig. 4. Using geospatial video to map a resident's geonarrative of the post-disaster environment.

case study of cultural resource mapping in the Holy Cross neighborhood of New Orleans. In the following example, cultural resource mapping means recording the architectural heritage of a neighborhood. This project is premised on the assertion that documentation is fundamental to successful heritage conservation, and accurate, comprehensive documentation of historic assets is essential for the effective integration of heritage conservation into a broad range of resource management and planning activities, particularly in places that are subject to a high risk of natural or human-induced disaster. Based on this premise, a systematic approach was needed that could be used to rapidly and inexpensively capture the data that characterize large areas of heritage assets, for instance, extensive cultural landscapes, streetscapes, and districts.

The Holy Cross Historic District (HCHD) in the Lower Ninth Ward of New Orleans is just such a place (Fig. 10). As one of New Orleans' many historic neighborhoods listed on the National Register of Historic Places, the HCHD was once a thriving 19th Century residential community a short distance downriver from the New Orleans French Quarter. The neighborhood had suffered a decline in social and economic vitality in the latter part of the 20th Century. Although somewhat dilapidated, it had retained a high degree of its historic architectural integrity in spite of changing demographics, neglect, and vulnerability to natural hazards such as the severe flooding and wind damage caused by Hurricanes Betsy (1965) and Camille (1969). Because

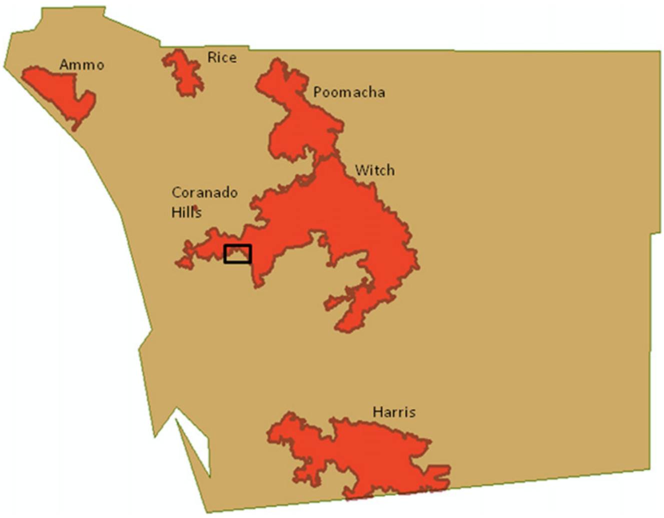

Fig. 5. The red polygon represent the areas burned by the six major fires of the 2007 firestorm. Within the Witch Fire, two neighborhoods provide the study sites in the Rancho Bernardo area of San Diego County, California. Their location is indicated by the black box in the southwestern portion of the Witch Fire perimeter. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

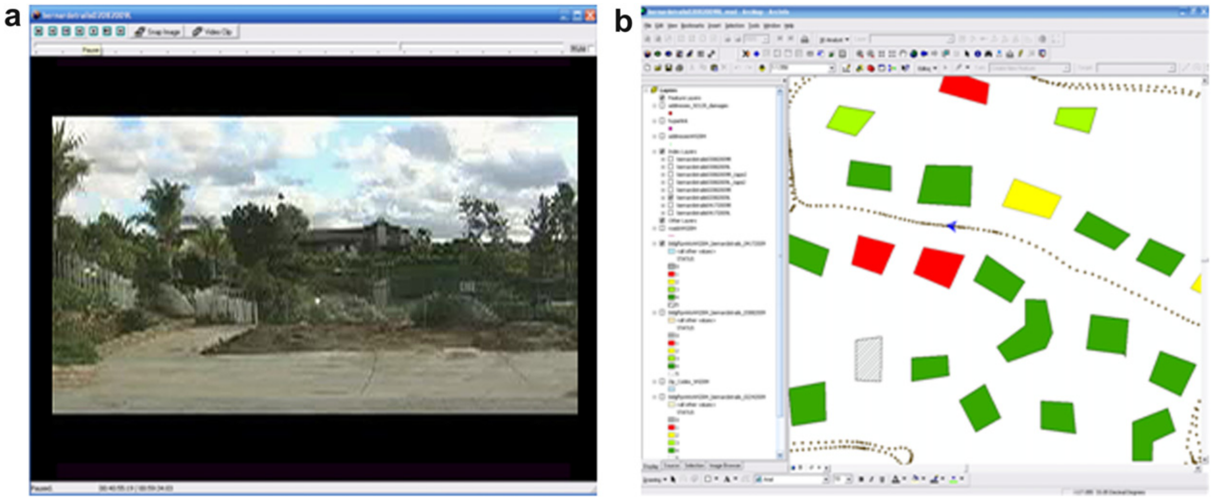

Fig. 6. Geospatial video survey of neighborhood recovery. The video (a) is used to code the attribute table of building footprints in the GIS in (b). Red = RS1, Yellow = RS2, Light Green = RS3, Dark Green = RS4. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of its demonstrated durability, affordability, and the appeal of its historic architecture, the early years of the 21st Century had witnessed a renewed residential interest in Holy Cross, and an active neighborhood organization was working with local preservation advocacy groups to promote investment and repopulation through rehabilitation of historic residential properties.

In recent years, and especially after Hurricane Katrina, the Holy Cross neighborhood, local residents, neighborhood organizations, universities, federal agencies, and faith-based organizations have begun the slow process of restoration. The New Orleans Preservation Resource Center has worked with local residents to restore residential structures; university groups funded by the U.S. Department of Housing and Urban Development (HUD) have worked with local residents to build new homes in the area. University outreach efforts also worked with neighborhood associations and housing groups to assist in planning and restoration efforts. Louisiana State University is one of these university-based groups working in the Holy Cross neighborhood. They developed a decision support system based on a comprehensive GIS to provide information to decision makers concerning the building stock in the Holy Cross neighborhood. The survey points of structures in the neighborhood, the boundary of the Holy Cross historic neighborhood, streets and roads, and a high resolution image taken following Hurricane Katrina are displayed in Fig. 11. Survey points on the map are linked to a database that reflects information on the location, historical and cultural structure characteristics, degree of damage, status of the structure for livability, and geographic coordinates.

Since 2006, LSU researchers have made multiple trips to Holy Cross and acquired many hours of spatial video recordings. This experience has been used to test our methods and gradually improve our configuration of low-cost equipment and our documentary approach. By Spring 2009, we were sufficiently confident of the stability of our spatial video platform and, with renewed interest by the Louisiana Division of Historic Preservation in our approach, we once again comprehensively documented the HCHD.

Each spatial video record of the HCHD (recorded on digital video tape) was first processed on a video editing software platform to ensure maximum image resolution and quality. The images and associated spatial data were then imported into a spatial analysis software platform, where georeferenced images were captured from the spatial video stream in 1 second increments. Once captured, the digital video record was converted to an Internet-enabled format so that it may be viewed online through Internet Explorer. The browser interface provides a continuous multi-window portrait of each spatial location within the HCHD. As a consequence, this documentary data constitutes a graphic, “street-view” record of every structure and streetscape in the HCHD. The dataset contains both still images and video clips, all of which are georeferenced. This means that the images can be located in a map or aerial photograph of the HCHD. The data were also exported to a conventional GIS platform (ArcGIS), where they can be merged with various other data sets in order to assemble a comprehensive digital record of the HCHD. Additional information may also be inserted into each structure’s record by reviewing the spatial video data, for example, information on the building type, architectural style, date of construction, physical condition, historic significance, and legal status of each structure (Fig. 12).

The foundation for a detailed, digital survey of the Holy Cross Historic District is now complete. The technology configured for this project has facilitated the development of a rapid, cost-effective approach to recording a large number of structures or other heritage resources located in a historic district or cultural landscape. The project was designed and assembled on a standard GIS platform so that the Louisiana Division of Historic Preservation can merge the data sets when they are finally delivered to the State by the Federal Emergency Management Agency (FEMA). The GIS-enabled data may be accessed through

Fig. 7. The spatiotemporal pattern of neighborhood recovery after the 2007 firestorm in the Rancho Bernardo study area. RS1 = red, RS2 = yellow, RS3 = light green, RS4 = dark green. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Arc-Reader or through the ArcGIS platform. This approach provided a continuous, georeferenced video recording of the streetscapes of the HCHD, including each individual standing structure and property. This approach permits a user to view each HCHD residence and property from several angles, either as still images or continuous streaming video formats. The spatial video survey provides an invaluable record of the state of an historic district at various times during its recovery from Katrina (based on repeated trips from 2006 to 2009). The product is a permanent record which will be available for comparative studies years in the future by architects, planners, historians and others who are concerned with the sustainability of a historic New Orleans neighborhood. This digital record can also be enhanced in a variety of ways, including damage assessment surveys, field interviews, and archival research and traditional scholarship concerning the architectural and cultural significance of the neighborhood and its individual structures. When such a record is fully assembled, it will provide

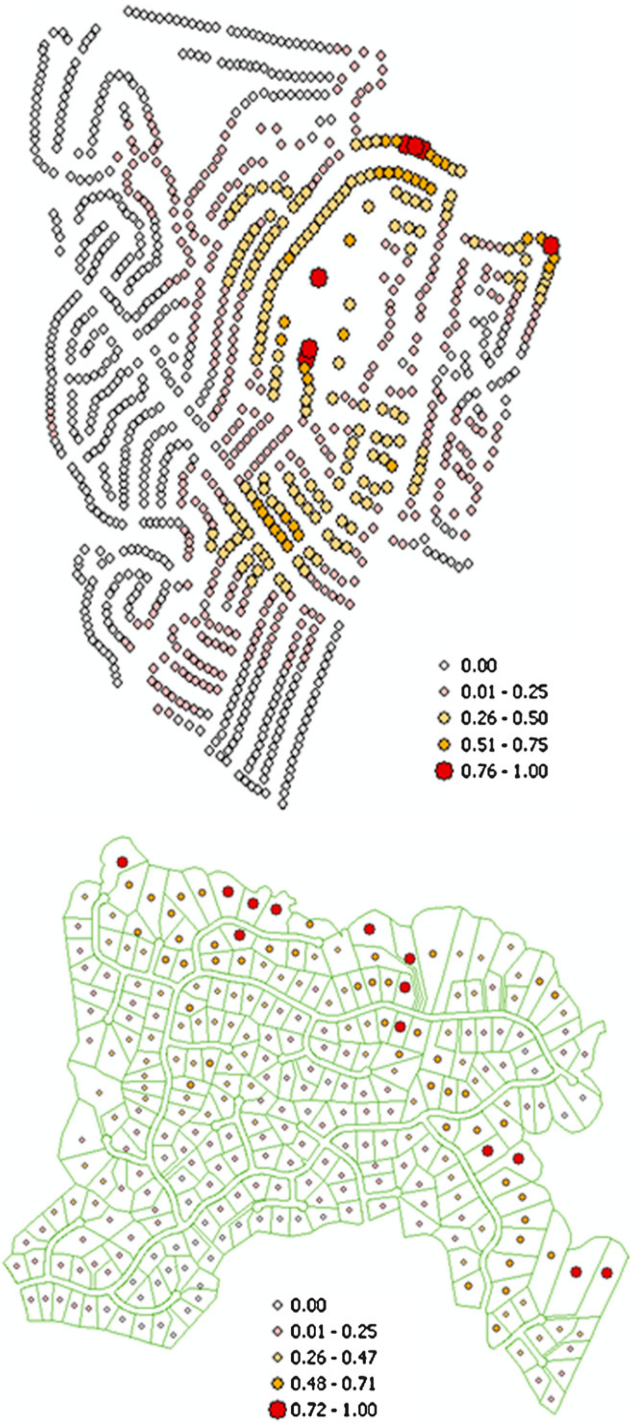

Fig. 8. Percentage of burned houses in the line of sight of each house for each of the two study areas.

a broad-based foundation for assessment and for policy decisions regarding future funding for recovery of the HCHD and a model for monitoring and maintaining the integrity of vulnerable and threatened historic districts and cultural landscapes.

Discussion

Though the mobile mapping system has been employed in different places and for different purposes in post-disaster environments, several common themes are evident that extend more broadly to other potential geographic applications:

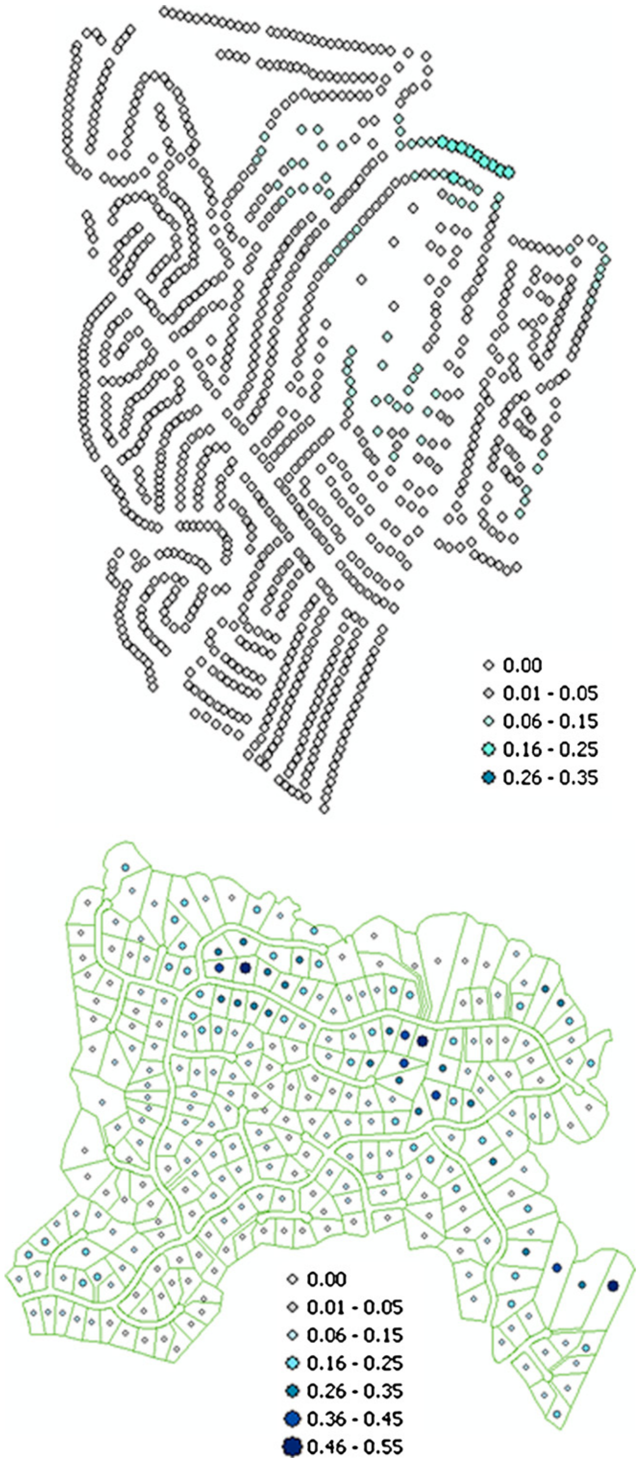

Fig. 9. Percentage of stagnant houses in the line of sight of each house in the two study areas. Stagnation is determined as a house that has maintained the same RS (1,2, or 3) for each data collection period from February 2008–April 2009.

planning, advocacy, and archiving. In both the Holy Cross neighborhood of New Orleans and in San Diego County, data collected through mobile mapping has the potential to be a source of information for planning the re-development and future of these places. Being able to see progress or decline in fine-scale can enable decision-makers to spatially target projects. Again, using the video by itself or as a data source from which to map recovery, local residents can use this resource to identify

Fig. 10. The Holy Cross neighborhood of New Orleans is highlighted in red.(For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

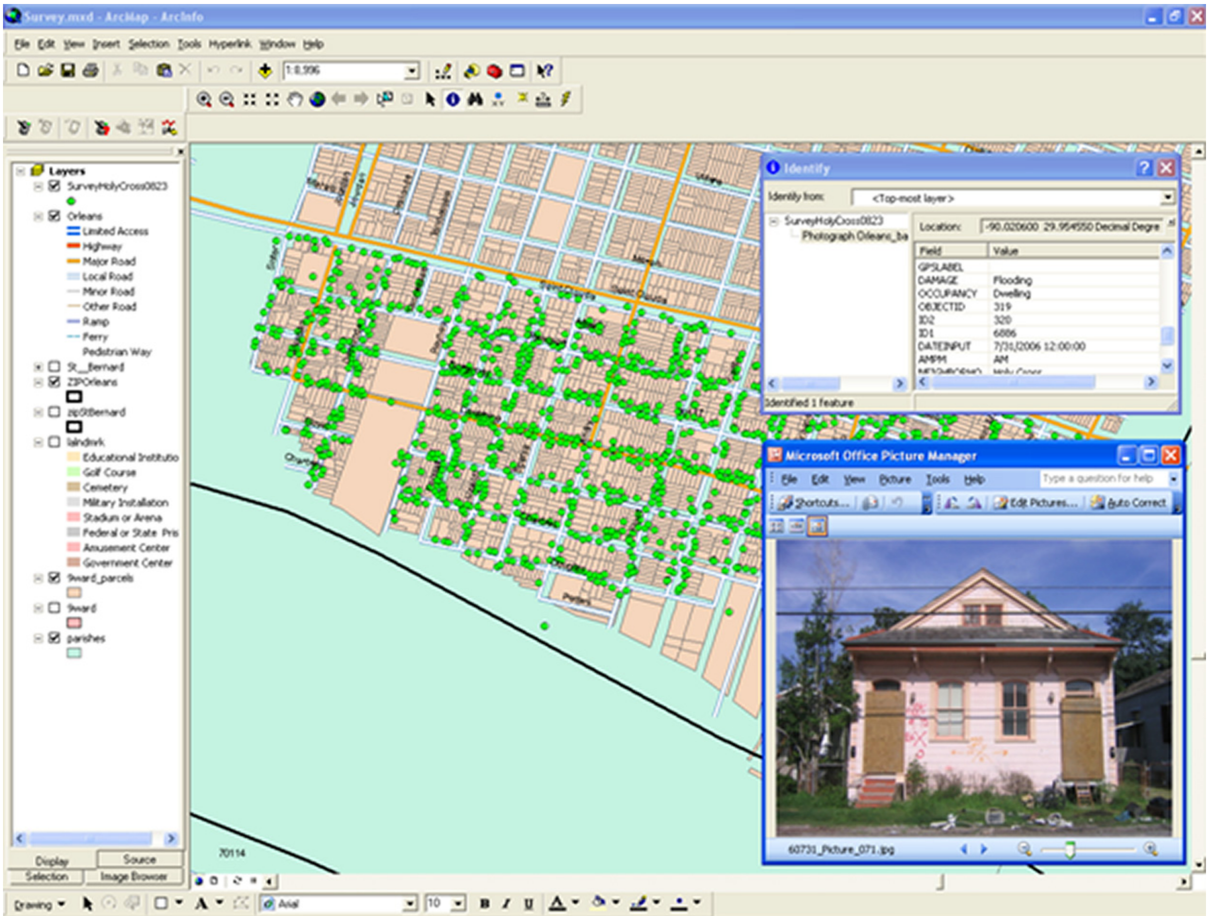

Fig. 11. Survey points of structures in the neighborhood, the boundary of the Holy Cross historic neighborhood, streets and roads, and a high resolution image taken following Hurricane Katrina. Survey points on the map are linked to a database file that reflects information on the location, historical and cultural structure characteristics, degree of damage, status of the structure for livability, and geographic coordinates.

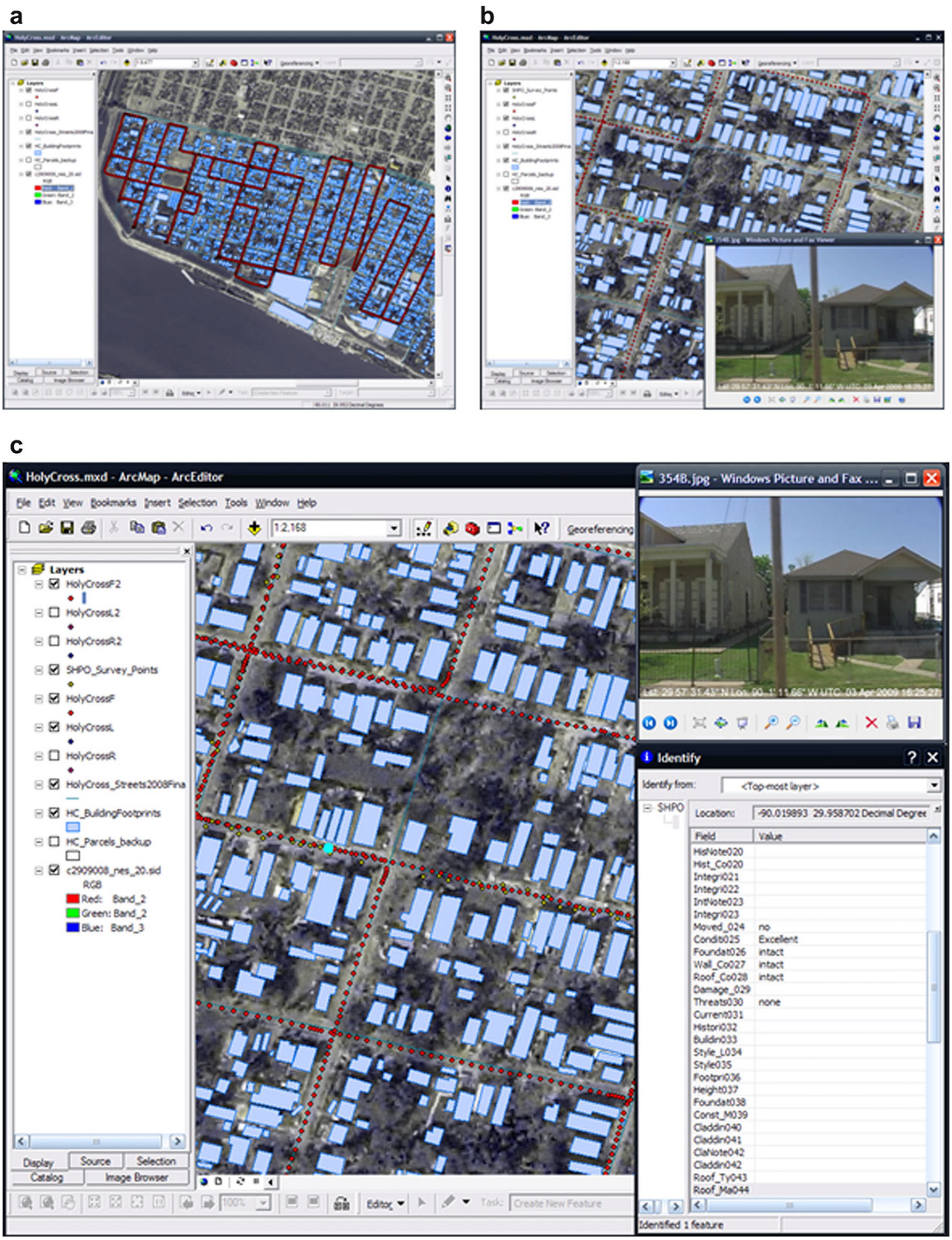

Fig. 12. By viewing the geospatial video in (a) and (b), additional information on each structure may be added to its record (c).

their neighborhood concerns. They can then use this visual documentation to advocate for changes and apply for grants to non-profits and government agencies. A final common theme between these two applications is the spatial-archival quality of the video. Specific places can be revisited repeatedly. Unlike many surveys that rely on data collectors making decisions about how to code what they observe in the environment, this approach enables validation as researchers can access the raw video at any time to verify what is being coded. Furthermore, revisiting these videos in the future opens the possibility of using these data again to investigate phenomena that have not yet been discovered or considered. In essence, mobile mapping results in the development of a spatial-historical record.

Although the projects in Holy Cross and San Diego County have drawn common benefits from the use of geospatial video, they also face a common problem. Both projects aim to share the data with a broad audience, one that is not necessarily accustomed to using geospatial technologies. Therefore, the dissemination and visualization components of the video are a concern. The video can be viewed through standard software, but visualizing the video embedded with its location in the map is more problematic. Again, proprietary software does exist for this purpose, but as the goal is access by a broad user group, a better solution is needed. Developing a web-based viewer for geospatial video is a next step. Such a viewer should draw on the user-friendliness of related technology like Google Maps Street View and developments in Location Based Services (LBS) that assume a "naïve user" (Jiang & Yao, 2006). However, despite this limitation, the benefits of this technology are plentiful and untapped in the area of disaster management specifically, and more broadly in geography and allied disciplines.

This paper has briefly shown the potential value of using geospatial video as a fine-scale data collection tool. At a minimum it is a way to document observations, whether or not they will ever be incorporated into a GIS for analytical purposes. In essence, it is a spatially contextual field notebook. Furthermore, with the emergence of online journals that allow the incorporation of multi-media as article links, this form of data capture can illustrate a point with greater content than a static image. Geospatial video can also be used to generate datasets for use in both qualitative and quantitative analyses. In this respect it can be a dataset for primary data that would otherwise be difficult or impossible to obtain. For example, in post-Katrina Louisiana, repopulation has proven to be a difficult variable to capture. Some sources, such as the Greater New Orleans Community Data Center (GNOCDC) use vacancy data from the United States Postal Service (USPS) as an indicator of repopulation. However, this dataset admittedly has some limitations. Identifying where people have permanently returned is difficult without use of neighborhood surveys of "lights on at night," for example, or consistent upkeep of lawns, or presence of pets, all of which can provide a more holistic set of indicators for permanent return to the domicile. In this respect, geospatial video opens the opportunity to capture unique datasets, which can then lead to new hypotheses about post-disaster recovery. Local inventories of the built environment can be developed from geospatial video, which, in the area of emergency management, can lead to better pre-event planning through improved "what if" models, for example through FEMA's HAZUS-MH modeling program. Given the ability to archive these video files, geospatial video can facilitate longitudinal investigations in a study area, essentially acting as a ground-based change detection technique.

Furthermore, due to the relatively low cost of the software and hardware components, this technology is feasible and accessible, making it a viable candidate for use in PPGIS investigations. For example, currently in New Orleans, members of the faith-based community are using geospatial video to collect data on the neighborhoods around their places of worship. This project is based upon students training local residents on the use of geospatial video, while religious leaders guide the location of data collection. Though the processing of these files requires some training, the results can be fed back into a user-friendly environment, such as Google Earth. These characteristics argue for increased use of geospatial video as a community resource. In the case of post-disaster recovery in New Orleans, many residents were displaced at great distances from their homes. Having an online georeferenced video resource displaying conditions in their neighborhoods would have been a notable improvement in assisting residents in making decisions about return and being informed, in general (Mills, 2009).

In addition, geospatial video can be employed into a variety of environments, not just for urban neighborhoods but also rural areas, and even along water bodies, for example to collect data on coastal or river bank development. It is also an improvement on other methods of urban field data collection, such as survey techniques that combine geotagged photography with Personal Data Assistant (PDA) surveys. Not only does it reduce the time spent in the field and the number of people in the field, but it is also a useful field data collection technique in areas where walking the streets may not be safe whether from environmental issues or crime.

Though geospatial video provides a number of benefits as discussed above, it also has at least two limitations that should be considered, such as GPS error and questions of privacy. Geospatial video is reliant on the same standards of signal reception as any standard GPS receiver. Therefore, issues of signal degradation or error that are common in an urban environment are considerations, for example, tall buildings leading to multi-path error. In addition to potential GPS error, another issue requiring consideration is the privacy component of the data collected with this technology (Curry, 1997). In the case studies, only visible data on the landscape is being captured (what can be seen from a public roadway), but based on what may be visible, this could be argued to be human subject information. Criticisms have been leveled at a similar technology, Google Maps Street View, for its data capture and display. These criticisms can also be directed toward the use of geospatial video in an urban environment. However, as with many geospatial tools, the development of this technology has the potential to provide answers to challenging questions regarding urban environments and therefore should continue to be employed in a variety of areas of study (Klinkenberg, 2007; Olson, 1996).

Conclusions

Geospatial video enables field data collection of spatiotemporal phenomena that would otherwise prove difficult to capture. From this perspective, it has the potential to provide answers to longstanding inquiries, as well as to generate new questions. Whatever can be seen with the human eye can be captured, and then visualized and analyzed in order to gain knowledge of spatial phenomena in the human and physical environments. Furthermore, drawing on Kwan (2002), geospatial video has the potential to change the way existing investigations are undertaken, yielding more inclusive and qualitative approaches. In conclusion, geospatial video combines two approaches common to geographic investigations: GPS and video. The convergence of these technologies raises ethical concerns about appropriate use, but also opens opportunities to explore what would otherwise be difficult spatial phenomena to study. Geospatial video has the potential to be a powerful tool for science, social science and for geography in particular.

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Appendix. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi: 10.1016/j.apgeog.2010.03.008.

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